MONITORING PROGRESS IN NATIONAL INITIATIVES ON DIGITISING INDUSTRY

Country report

Germany

July 2019

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Summary

According to the 2018 DESI Report, Germany belongs to the Medium performing cluster of countries in terms of digitisation. The country ranks 14th out of the 28 EU Member States in digitalisation according to the DESI index, same as in 2017. According to the Digital Economy Index, which is an international performance index, the country ranks 6th behind USA, South Korea, UK, Finland and Japan. In the past five years, digitisation in particular of the manufacturing industries has reached a high significance and awareness in Germany under the label "Industrie 4.0". Germany's greatest weaknesses regarding digitisation include the shortage of skilled workers, the network infrastructure, and a relatively strict regulatory framework.

Germany is the largest national economy in Europe in terms of GDP and the third largest exporter in the world. Throughout the last years, the country has experienced a steady economic growth which according to OECD forecasts can be expected to continue. Meanwhile, unemployment rate remains relatively low in Germany. Besides, the German economy is characterised by a high number of SMEs. 99% of German companies belong to mostly family-owned medium-sized companies. In addition, the start-up scene is well distributed across the country.

Considering challenges and the changing economy in the EU, the German government has a well-coordinated approach to facilitate the digital transformation of the indutry and has been launching several initiatives that compliment each other and cover all aspects of digitalisation. Thes initiatives altogether cover all pillars of the Digitising European Industry (DEI) initiative and provide the basis for a complex digital transformation of the Germany industry. The overall funding of initiatives is estimated to be around EUR 2.7 billion.

Beside the large number of bilateral and trilateral collaborations with other European countries (Pillar 1 of the DEI), national initiatives along the different DEI pillars brought high hopes and awareness in Germany. The pioneering Platform Industrie 4.0 that looks at future-related issues in the areas of digitalisation (Pillar 3 of the DEI) whereas the overarching program of Mittelstand Digital aiming to assist small and medium sized companies in their digital transformation (Pillars 2 and 3 of the DEI). Under Pillar 2, initiatives are estimated to cover a funding amount of EUR 2.6 billion. Pillar 3 has a funding amount of approx.EUR 204 million. The Vocational Training 4.0 aiming to tackle the digital skillgap in Germany is supporting this as well in Pillar 5. For Pillar 5, the overall funding of initiatives is estimated to be at least EUR 98 million. Pillar 4 is covered by a number of Working Groups, among them the Competition Law Commission 4.0 which is an expert group aiming to modernise competition law for the future, digital economy. These are supported by a large pool of specific initiatives e.g. Labs Network Industry 4.0, the Innovation Hub Initiative as well as a number of different research programs.

Most initiatives have been recently launched, but the Industry 4.0 Platform and the Mittelstand Digital are already well developed and provide several opportunities for German companies to prepare themselves for the digital transformation. As for the future, Germany continues to push for the digital change of the industry which is well reflected in the Coalition Agreement from December 2018.

Table 1 below presents an overview of the main initiatives identified in Germany, that will be further detailed in this report. Table 2 presents a short SWOT analysis of the German economy on digitalisation.

Table 1: Overview of initiatives

Initiatives	Starting year	Overall strategy/DEI Pillar/support mechanism	Type of initiative	Sectors targeted	Digital technologies targeted	Size of companies targeted	Budget
Digital Strategy 2025	2016	Overall strategy	Overall strategy	All	A	All	N/A
Industry 4.0 Strategy and Platform	2010 and 2013	Strategy and Platform	Strategy and Platform	All, mainly manufacturing	All	All	EUR 4 million per year Funding from BMBF and BMWI is complemented by financial and in-kind contributions from industry.
Shaping Digitalisation - Implementation Strategy of the Federal Government	2018	Overall strategy	Overall strategy	All	All	All	N/A
Coalition Agreement between CDU, CSU and SPD	2018	Agreement	Agreement/Strategy document	All	All	All	NA
AI Strategy	2018	Strategy	Strategy document	Industry	Artificial Intelligence	All	NA
Mittelstand Digital	2012	Pillar 2&3	Digital network	All	All	SMEs	EUR 200 million available until 2018
Research program Industry 4.0 Test Environments for SME (I4KMU)	2016	Pillar 2&3	Research program	Industry	All	All	National funding EUR 100.000
Labs Network Industry 4.0	2016	Pillar 2	Lab Network	Industry	All	All	N/A
Digital Innovation Hubs	2016	Pillar 2	Hub Network	Industry	All	All	Through the innovation hubs, start-ups will be provided with EUR 2 billion of new public funding available over the next few years. An advisory board has been

Initiatives	Starting year	Overall strategy/DEI Pillar/support mechanism	Type of initiative	Sectors targeted	Digital technologies targeted	Size of companies targeted	Budget
							established to consult the government concerning the digital hub initiative.
Research Factory for Microelectronics Germany	2017	Pillar 2	Factory	Microelectronics	All	All	The investment program with a total of around 400 million EUR. Since reunification, this is the largest investment in research for microelectronics in Germany.
Competition Law Commission 4.0	2018	Pillar 4	Expert panel	All		All	N/A
Industry 4.0 Working Groups	2013	Pillar 4	Working Groups	Industry	All	All	N/A
RAMI 4.0 "reference architecture model industry 4.0"	2015	Pillar 4	Standardisation initiative	Industry	All	All	N/A
Vocational Training 4.0	2016	Pillar 5	Training Program	Industry	All	SMEs	2016 – 2019. EUR 84 million
Mittelstand Digital Competence Centres	2015	Pillar 5	Competence Centres	Industry	All	SMEs	EUR 1 billion available until 2018
Future of the German Mittelstand	2017	Pillar 5	Action Program	Industry	All	SMEs	EUR 14 million
Innovation vouchers (“go digital”, “go inno” and “KMU innovative”)	2017	Support mechanism	vouchers	All	All	SMEs	N/A

Table 2: SWOT of Germany on digitalisation

Strengths: • Advanced digitalisation of the industry, particularly in manufacturing • Stable and expanding economy with a growing employment rate • Significant awareness and investments (both public and private) regarding Industry 4.0	**Weaknesses**: • Urban-rural digital divide concerning fast Internet coverage and connections • Shortage of ICT professionals and skilled workers • Relatively strict regulatory framework • Low level of eGovernance • Fragmented start-up scenery
Opportunities: • Investing into SME digitalisation as 99% of all German companies belong to mostly family-owned medium-sized companies • Having strong federal actors (ministries) that push forward digitalisation and coordinate different initiatives • Launching initiatives designed for the specificities of the German economy such as Mittelstand Digital addressing the high number of SMEs	**Threats**: • Without adjusting the regulatory framework to the digital age further digitalisation might be difficult • Given that the industrial sector plays a major role in Germany, it is also particularly vulnerable to digital changes. • High risk of job automation, with a total of 54.2% of jobs at risk of automation (OECD)

1 General context

The objective of this report is to analyse the current status of national initiatives on digitising industry in Germany. The analysis has been conducted against the background of the Digitising European Industry (DEI), which was the first industry-focused initiative of the Digital Single Market launched by the European Commission in 2016.

Similar country reports will be produced for each of the 28 EU Member States. These national reports allow to:

- Monitor the development of national initiatives on digitising industry;
- Compare different national approaches; and
- Identify best practices of national initiatives.

Monitoring and reporting on the development of the existing national initiatives is an important element of the DEI initiative, and this report should be seen as part of it.

For more details about the DEI and our methodological approach for the country report, please consult the document attached that presents the overall methodological approach applied in all country reports.

1.1 Economic context and status on digitisation

General economic context

Germany is the largest national economy in Europe in terms of GDP and the third largest exporter in the world (1.2 trillion EUR in goods and services). The German economy continued to grow in 2017, with a real GDP growth rate of 2.2 % driven by private consumption and investment. Employment growth continued, spurred by increased labour demand and supply. Employment grew by 1.3 % in 2016 and 1.5 % in 2017. According to an OECD forecast, economic growth is projected to remain solid, and the unemployment rate will fall further.[1]

Industry plays a key role in the German economy, with a contribution of 25,7% to the total GDP.[2] An important element of the German economy is that 99% of German companies are SMEs and mostly family-owned medium-sized companies. The start-up scene in the country is geographically fragmented.[3] Whereas major European economies tend to have one central city where economic development and innovation forces concentrate, in Germany the start-up scene is well distributed with no clear standing out centres meaning that neither Berlin nor Munich, Hamburg or Frankfurt are especially standing out. German companies tend to be scattered throughout the country.[4]

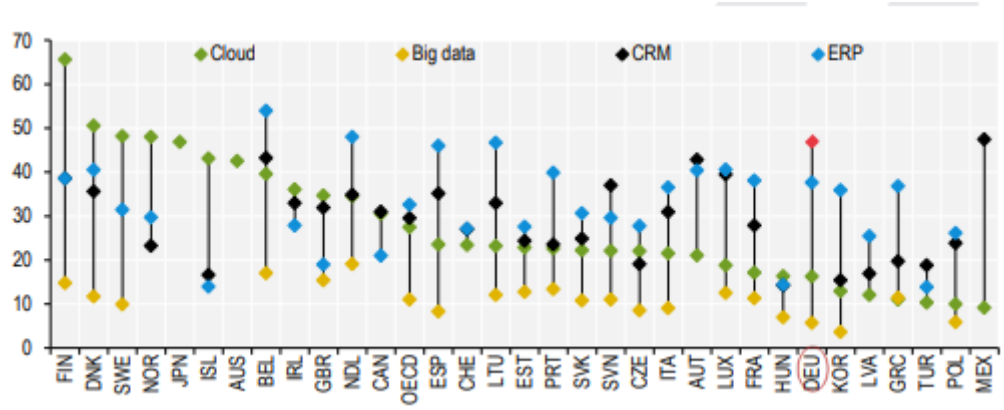
Status of digitisation

The digital economy is a significant sector in Germany. According to the Digital Economy Index, which is an international performance index[5], the country ranks 6th behind USA, South Korea, UK, Finland and Japan. According to this index, the links between the ICT sector and other areas of the economy are stronger in Germany than in any of the other countries, followed by Finland, South Korea and the USA. The reason for this is that the intensity of use of new digital technologies and services is especially high in the private sector in Germany.[6] Germany's ICT experts also demonstrate high innovation levels. In the past five years, digitisation in particular of manufacturing has reached a high significance and awareness in Germany under the label "Industrie 4.0". Besides, Germany has established itself as an international microelectronics force, accounting for more than half of European microelectronics volume. This is important as

microelectronics and microsystems are central to the implementation of the broad array of industry 4.0 solutions However, according to the Digital Economy Index, innovation is considered higher in Finland, UK, France and USA. Germany's greatest weaknesses for digitisation include the shortage of skilled workers, the network infrastructure, and a relatively strict regulatory framework. Also, broad parts of the population are lacking interest in technology.[7,8]

Germany specialises in many technologically advanced industries, including complex business services and high-tech and medium high-tech manufacturing. However, according to the OECD, the country has relatively slow uptake of cloud and big data technologies which are key for fully leveraging the possibilities of the Internet of Things, and its digital infrastructure and skills need improvement. The gap in connectivity and adoption of productivity-enhancing technologies is particularly large between large firms and small- and medium-size enterprises (SMEs), as well as between large cities and rural areas.[9]

Figure 1: Enterprises using selected ICT tools and activities, in percent of all enterprises with ten or more persons employed, 2017

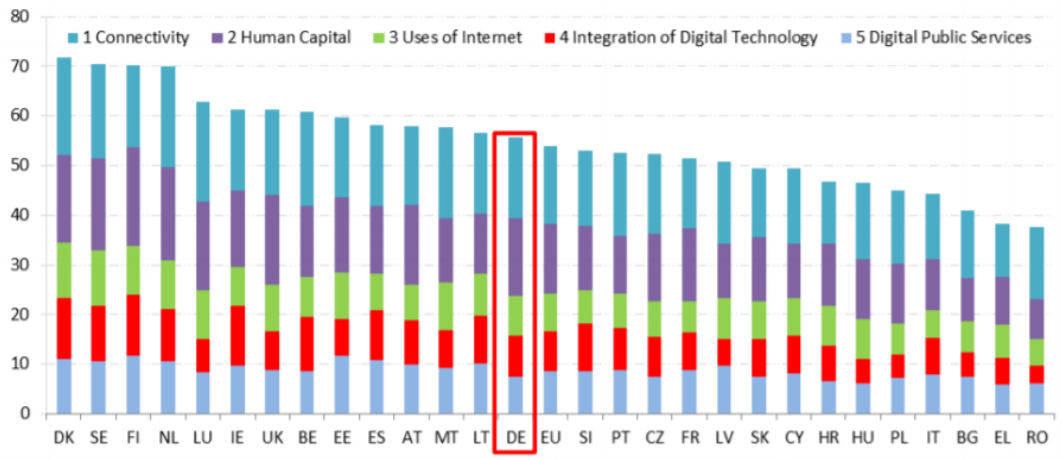


Source: OECD 2018

According to the 2018 DESI Report, Germany is among the medium-performer countries in terms of digitisation, ranking 14th out of the 28 EU Member States, same as in 2017. Germany is performing well as regards fixed broadband take-up and prices. However, there is an urban-rural digital divide concerning fast Internet coverage and the share of fibre connections is very low throughout the country. With regards to digital skills, Germany ranks 7th in the EU, however a shortage of ICT professionals may hamper the potential of Germany's economy. The country's greatest digital challenge is to improve the online interaction between public authorities and citizens. With only 19% of the population being eGovernment users, Germany ranks 25th among the Member States in this respect.[10] Besides, the country reached a low ranking in the use of Open Data with only 51% of the population using it (rank 20).[11]

The figure below presents Germany's ranking in the 2018 DESI.

Figure 2: The Digital Economy and Society Index (DESI) 2018 ranking



Source: The Digital Economy and Society Index (DESI) 2018 Country report - Germany

As regards Germany's readiness for future production, the assessment carried out by the World Economic Forum in 2018 scores Germany with 7.6 out of 10 for drivers of production. A breakdown of drivers is provided in the figure below:

Figure 3: Germany's readiness for future production

Drivers of Production **7.6**

Driver	Weighting	Rank	Score /10
Technology & Innovation	20%	8th	7.2
Human Capital	20%	7th	7.5
Global Trade & Investment	20%	8th	7.3
Institutional Framework	20%	14th	8.2
Sustainable Resources	5%	13th	7.8
Demand Environment	15%	4th	7.5

Source: World Economic Forum, Readiness for the Future Production Report 2018

The table below summarises some of the economic and digital indicators for Germany.

Table 3: General economic and digital indicators for Germany

	% GDP from manufacturing	% GDP growth	DESI position – and change	DESI sub-indicators Human Capital, Use of Internet, Integration of Digital Technology in 2018
Germany	25.7% (2017)	2.2% in 2017	14th in 2018 (no change compared to 2017)	• Human Capital: 8th (no change compared to 2017) • Use of Internet Services: 14th (18th in 2017) • Integration of Digital Technology: 12th (14th in 2017)

1.2 National strategy on digitising industry

Industry 4.0 is at the very core of Germany's efforts to sustain its global leadership in innovation and manufacturing. Germany is a pioneer in recognizing and strategically embracing the technological trends around manufacturing as drivers of the development. Industry 4.0 has become a symbol of the country's determination to secure its future as one of the world's leading manufacturing hubs. Digitalisation of the industry is therefore set as an important priority in a number of strategy documents evolved throughout the last years.[12]

The first act of legislation that can be linked to Germany's present Industry 4.0 strategy which was issued in 2006 as the "**Hightech Strategy**" (HTS). This was launched by the German Ministry of Education and Research to strengthen and secure a leading position in research and innovation and as a global production hub. The strategy aims to enhance linkages between research and the private sector, improve conditions for start-ups and SME innovation, accelerate diffusion of innovative technologies, strengthen Germany's position internationally and invest in people. Besides, the strategy also focused on fostering innovation through cross-cutting technologies.[13]

In 2010, the Federal Ministry for Economy and Energy introduced the first holistic strategy for the digital transformation, Deutschland Digital. **Deutschland Digital** was set as a framework for all ICT-related government interventions. It was business-oriented, intended to strengthen the country's position as an ICT location.[14]

In 2010, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety published an update of the Hightech Strategy in the form of "**Hightech Strategy 2020**". The updated document focused on global challenges instead of the specific technological trends. The strategy introduced five key terms: climate and energy, health and food, mobility, security, and communication. To benefit all the key areas, the document put forward cross-cutting interventions. Also in 2010, the German government developed an Action Plan, called "**Action Plan HTS 2020**" to define the ten strategic initiatives linked to the five priority areas of the strategy. A final update to the HTS was published in 2014, this time coordinated by the German Federal Government itself and not through one of its ministries. The update reiterated Germany's commitment to leadership in global innovation and to strengthening its status as a leading industrial and exporting nation.[15]

In 2014, the **Digital Agenda** (DA) was developed by the Federal Ministry for Economy and Energy, the Federal Ministry of the Interior, Building and Community, and the Federal Ministry of

Transport and Digital Infrastructure. The Mittelstand (small and medium-sized enterprises) was identified as a priority sector whose digital transformation needs to be supported.[16]

The figure below summarises the succession of strategies.

Figure 4: The policy process of developing Industry 4.0 in Germany

Source: United Nations (2018): What can policy makers learn from Germany's Industrie 4.0 Development Strategy?

Industry 4.0 Platform

The Platform started as an industry initiative, and was set up by the industry associations BITKOM, VDMA and ZVEI in 2013. Partners included ABB, Bosch, Telekom, FESTO, Hewlett-Packard, IBM, Infineon, Phoenix Contact, SAP, Siemens, ThyssenKrupp, Trumpf, Volkswagen and Wittenstein. The secretariat was chaired by VDMA, located in Frankfurt and virtually represented by BITKOM. The Platform was officially launched at the Hannover Fair 2013. In its original form, it included the following four working groups: strategy and framework, reference architecture, standardisation and norming, research and innovation, and security of networked systems. At that time, the platform was a mechanism for the implementation and coordination of industry 4.0. When the Platform started to gain importance, other stakeholders decided to join, and although the government did not have the goal to join in the beginning, it eventually also decided to participate and to expand the group to improve coordination, collaboration and uptake. While the business associations continued to run the platform, the federal ministries, BMWI and BMBF also played an increasingly active role in its development. They provided a strong political leadership and contributed to defining the agenda. Although the platform mainly relies on voluntary activities, BMBF and BMWI have jointly allocated EUR 200 million in funding.[17]

Today, the platform is led by the federal ministers of BMWI and BMBF together with representatives from industry, associations, science and the trade unions. The platform's technical work is carried out in five thematic working groups (reference architectures, research & innovation, security, legal framework, education and training).[18]

The Platform contributes to facilitating the digital transformation by:

- Providing a platform to promote networking and learning by interested private sector stakeholders. For example, it grants partners access to literature and knowledge about Industry 4.0. The task is supported through a showcase of best practices around Industry 4.0 applications. The Platform also coordinates the work of Labs Network Industry 4.0
- Mediating and coordinating the standardisation process. The RAMI4.0 project is embedded within the Platform. The platform also facilitates coordination between RAMI4.0 and the Standardization Council through, for example, the publication of updates on progress in the standardization process and the results.
- Supporting the internationalisation strategy; it is the body responsible for signing cooperation agreements and facilitating access for German organisations to participate in Industry 4.0 efforts. The Platform further promotes the concept of Industry 4.0 with roadshows abroad.[19]

In addition, Germany clearly aims to develop autonomy and leadership in various high technology fields, such as IT security, big data, cloud offerings and service platforms. Besides the strategy framework, the federal ministries have also launched a few initiatives in these areas. Among many others, the Federal Ministry for Economic Affairs and Energy (BMWI) has announced plans to implement the recommendations developed by the five working groups of the platform Industry 4.0, particularly in the areas of standardisation, legal framework, IT security and work. Furthermore, the Federal Ministry of Economic Affairs and Energy announced the introduction of a EUR 1 billion funding program in microelectronics. Other innovations are especially intended in the area of data economy and in SME based research. Concerning infrastructure development, the government has initiated the "Network Alliance for a Digital Germany" that will invest EUR 8 billion in broadband network deployment (“Gigabit society”). Other strategies set priorities in skills development, and in eGovernment (“Digital Administration 2020”, “Open Government Partnership Action Plan 2017-2019”).[20]

The national strategies and the wide range of initiatives are all aligned with the priorities defined in the smart specialisation strategy, covering all aspects of the digital transformation. The priorities put forward in the smart specialisation strategy are the following[21]:

- Digital economy and society
- Intelligent mobility
- Healthy life
- Innovative work environment
- Sustainable economy and energy
- Civilian security

The table below presents the main elements of the current strategy framework.

Table 4: Overview of national strategies on digitising industry

Name	Industry 4.0 Strategy and Industry 4.0 Platform	Digital Strategy 2025	Shaping Digitalisation - Implementation Strategy of the Federal Government	Coalition Agreement between CDU, CSU and SPD	AI Strategy
Type	Strategy and Platform	Strategy	Strategy	Agreement	Strategy
Starting date	2010, 2013	2016	2018	2018	2018
Objective	Industry 4.0 was already part of the High-Tech Strategy 2020 Action Plan. With the Industry 4.0 Strategy, the Federal Government took up the rapid social and technological development in this area and laid down structures for the cooperation of all actors in the innovation process in Germany. The platform aims to develop joint recommendations for all stakeholders, that serve as the basis for a consistent and reliable framework. The platform will initiate alliances and networks at the precompetitive stage which support the evolution of the entrepreneurial skills in Germany. The platform aims to identify all relevant trends and developments in the manufacturing	Developing capabilities and using new tools to make a digitised Germany possible. It aims to enable the German economy to respond to new challenges but also to ensure its leading position both in quality and technology for years to come, by combining traditional competitive advantages with the newest technology, modern methods and specific support programmes.	The strategy embraces five fields of action: digital skills, infrastructure and equipment, innovation and digital transformation, society in digital change and the modern state. The fields of action bring to life the many advantages offered by digital change so that people experience them first hand. The implementation strategy offers specific solutions for every challenge, along with implementation plans. It will be regularly updated, and the achievement of its goals will be measured and reviewed.	The Agreement defines objectives for all sectors such as economy and competitiveness, social policy, migration and security, agriculture, energy and transport. For most topics, it contains political statements in the national, European and worldwide context as well. With regards to digitalisation, the agreements define that Germany's digital infrastructure will become a "gigabyte network" by 2025, using proceeds from the sale of universal mobile telecommunications systems and G5 licences. The parties also agreed to improve mobile coverage and drive forward a 5G network.	• Making Germany and Europe global leaders on the development and use of AI technologies and securing Germany's competitiveness in the future. • Safeguarding the responsible development and use of AI that serves the good of society. • Integrating AI in society in ethical, legal, cultural and institutional terms in the context of a broad societal dialogue and active political measures.

Name	Industry 4.0 Strategy and Industry 4.0 Platform	Digital Strategy 2025	Shaping Digitalisation - Implementation Strategy of the Federal Government	Coalition Agreement between CDU, CSU and SPD	AI Strategy
	sector and to combine them to produce a common overall understanding of Industry 4.0.				
Ministry/ ministries in charge (website, contact person)	Ministry of Education and Research, Ministry for Economic Affairs and Energy https://www.hightech-strategie.de/de/The-new-High-Tech-Strategy-390.php The platform is steered and led by the federal minister for economic affairs and energy, Peter Altmaier, the federal minister of education and research, Anja Karliczek, and high-ranking representatives from industry, science and the trade unions.	Federal Ministry of Economy and Energy https://www.de.digital/DIGITAL/Redaktion/EN/Publikation/digital-strategy-2025.html	Federal Government https://www.bundesregierung.de/breg-de/themen/digital-made-in-de	Federal Government https://www.cdu.de/system/tdf/media/dokumente/koalitionsvertrag_2018.pdf?file=1	Economic Affairs Ministry, the Research Ministry and the Labour Ministry https://www.de.digital/DIGITAL/Redaktion/EN/Meldungen/2018/2018-11-16-federal-government-adopts-artificial-intelligence-strategy.html
Scope of the strategy/ action plan	All sectors, mainly manufacturing	All sectors are under the scope	All sectors, but mainly digital infrastructure is under the scope	All sectors	Artificial Intelligence
Measures included in the strategy/	The Plattform Industrie 4.0: • develops core concepts in working groups on how to tackle challenges on	• Creating a gigabit optical fibre network for Germany by 2025 • Launching the New_Start-up_Era: Assisting start-ups	The implementation strategy describes the implementation process of all the initiatives regarding digitalisation It includes summarising the main	• Tax incentives for small and medium-size businesses that are engaged in R&D activities;	• Developing the AI capacity and infrastructure • Supporting companies establishing testbeds

Name	Industry 4.0 Strategy and Industry 4.0 Platform	Digital Strategy 2025	Shaping Digitalisation - Implementation Strategy of the Federal Government	Coalition Agreement between CDU, CSU and SPD	AI Strategy
action plan	the pathway to Industrie 4.0. • provides concrete recommendations for academics, companies and politicians. • supports SMEs with specific service offerings, such as the online map of use cases, the compass for Industrie 4.0 orientation, the online library and with their engagement in the Transfer-Network Industrie 4.0.drives national and international exchanges through numerous bilateral and multilateral cooperation – particularly in the areas of IT security and standardisation.	and encouraging cooperation between young companies and established companies • Creating a regulatory framework for more investment and innovation • Encouraging “smart networks” in key commercial infrastructure areas of our economy • Strengthening data security and developing informational autonomy • Enabling new business models for SMEs, the skilled craft sector and services • Utilising Industry 4.0 to modernise Germany as a production location • Creating excellence in digital technology research, development and innovation • Introducing digital education to all phases of life	goals of each measure and links for the most important documents.	• A world-class, comprehensive digital infrastructure; • Providing digital skills as a key skill for all ages; • A world of work that empowers, secures and improves the quality of life for people in the digital age • A regulation that creates competition and competitiveness; • More security in cyberspace; • More citizen-friendly through a modern, digital administration; • A legal framework that guarantees civil liberties, balances freedom and security while allowing for more innovation.	• Develop data protection rules

Name	Industry 4.0 Strategy and Industry 4.0 Platform	Digital Strategy 2025	Shaping Digitalisation - Implementation Strategy of the Federal Government	Coalition Agreement between CDU, CSU and SPD	AI Strategy
		• Creating a Digital Agency as a modern centre of excellence			
Overall funding and distribution by volume and source of funding (public/private, EU/national)	EUR 200 million from BMBF and BMWI that is complemented by financial and in-kind contributions from industry	N/A	N/A	N/A	N/A

Additional measures in the Coalition Agreement:

Mittelstand:

The coalition will launch a new investment program "Digitization of the middle class". The goal is to invest specifically in digital technologies and know-how. Small and medium-sized enterprises should be supported with the nationwide funding program "go-digital".

E-government:

The Federal Government wants to check all laws for their digital suitability and make them e-government-capable. According to the coalition agreement, this includes "another, ambitious review of the written form requirements". This could mean that more and more contracts and other documents, the validity of which is still required for handwritten signatures, may be signed electronically in the future.

With a digital portal network for citizens and businesses, the Federal Government intends to "provide easy, secure and also mobile access to all administrative services". For this purpose, suitable centralized and decentralized administrative portals should be networked. Plan is to link a citizen account with it. This allows citizens to gain insight into which of their data is available to the state and which authority has access to it. The goal is that the citizen can control the handling of his personal data himself.

The Federal Government plans to anchor a so-called opt-in solution, which establishes the right of citizens to consent. This allows authorities to digitally link data through shared registers and unique, cross-register identifications. The advantage for the citizens is that they only have to authenticate themselves once to authorities on the Internet and do not have to do this again with every new authority.

Electronic identity card:

The electronic identity card should "become a universal, secure and mobile authentication medium". The declared intention of the coalition is to make the practical use of the identity card much more user-friendly. Further private and public areas of application are to be developed.

IT security:

The federal government wants to make simple and secure solutions for electronic identification and end-to-end encryption available to everyone. Citizens will then be encrypted using common standards to communicate with the administration.

It is planned to promote the distribution of safe products and the development principle "Security by Design". Politics wants to work with businesses to develop IT security standards for Internet-enabled products. The introduction of a quality assurance label for IT security should make compliance with the standards transparent.

Furthermore, the coalition seeks to better protect security-related key technologies from sell-out and takeover.

Measures included in the AI Strategy

The Federal Government’s AI Strategy sets out a number of different measures designed to help achieve three major objectives:

1) Making Germany and Europe global leaders on the development and use of AI technologies and securing Germany's competitiveness in the future.

- Further develop the existing Centres of Excellence for AI research at supra-regional level, establish additional ones and incorporate them all into a national network of at least twelve centres and application hubs.
- Create at least 100 additional professorships for AI to ensure that AI has a firm place within the higher education system.
- Work with France and drive forward the development of a Franco-German research and development network (virtual centre) that is based on existing structures and the particular skills possessed by each of the two countries.
- Make AI one of the priorities for the envisaged Agency for Breakthrough Innovations.
- Form a European innovation cluster providing funding for cooperative research projects over the next five years.
- Have the 'AI trainers' based at the Mittelstand 4.0 Centres of Excellence contact at least 1,000 companies per year.
- Support companies as they establish test beds.
- Double the budget for EXIST in 2019. EXIST is a support program of the Federal Ministry of Economics and Energy (BMWi) aimed at improving the entrepreneurial environment at universities and research institutions.
- Create new funding opportunities for venture capital and venture debt and launch a Tech Growth Fund Initiative.
- Set incentives and create an environment that makes it easier to share data voluntarily and in a way that is in line with data protection rules.

2) Safeguarding the responsible development and use of AI that serves the good of society.

- Establish a German AI observatory.
- Initiate European and transatlantic dialogue on the human-centred use of AI in the world of work.
- As part of a National Further Training Strategy, develop a broad-based set of instruments to foster the skills of the workforce.
- Use the results of a new skills monitoring to inform and develop the Skilled Labour Strategy in the fields of digital skills and new technologies such as AI.
- Safeguard the possibilities for works councils to engage in codetermination when it comes to the introduction and use of AI.
- Fund in-company-based test beds for AI applications in the world of work.
- Fund AI applications to benefit the environment and the climate, and develop assessment principles for this. Our goal is to initiate 50 flagship applications in this field.

3) Integrating AI in society in ethical, legal, cultural and institutional terms in the context of a broad societal dialogue and active political measures.

- Invite data protection authorities and business associations for a round table and work together to develop joint guidelines for developing and using AI systems in a way that is compatible with data protection rules and to highlight best practice examples.
- Provide funding for the development of innovative applications that support self-determination, social inclusion, cultural participation and the protection of citizens' privacy.
- Establish a Digital Work and Society Future Fund to get the message out and to promote multidisciplinary social technology design.
- Further develop the Learning Systems Platform to become the Artificial Intelligence Platform hosting a dialogue between government, science and commerce with civil society.

1.3 EU cooperation in the field of digitising industry initiatives

Germany takes part in many international cooperation activities on digitalisation. Tackling cross-border opportunities and challenges of digitalisation is the central idea of the Federal Government and the German Industry 4.0 Platform (see Section 2.1 for more details on the Industry 4.0 Platform). Numerous bilateral and multilateral cooperation address forward-looking questions and help to shape international debates on the digital transformation of production[22]:

Germany-Italy-France

The first cooperation talks between the three national initiatives were conducted at the high-level conference "Digitising Manufacturing in the G20" in March 2017 in Berlin. Since then, a joint action plan has been developed which identifies various measures and planned outcomes. On June 20, 2017, the plan was approved by the board of the cooperation at a first joint meeting in Turin, Italy.

France

The cooperation is closely linked to Europe-wide activities and focuses on application scenarios and application examples, technology and test infrastructure, standardisation as well as training and changes in competence requirements and work organisation. The cooperation between the two initiatives was decided in October 2015.

Italy

On 18 January 2017, then-Federal Minister of Economics Sigmar Gabriel and his Italian counterpart Carlo Calenda were invited to the German-Italian Economic Conference entitled "Making use of the potential of digitisation for businesses - investing in our future", including Chancellor Angela Merkel and Italian Prime Minister Paolo Gentiloni and over 220 high-level representatives of companies and public institutions. Subsequently, a key issues paper was adopted.

The Netherlands

The aim of the cooperation is to sustainably promote, support and implement joint initiatives in the respective industrial sectors - considering the innovative strength of both countries.

Among other things, the cooperation will cover the following topics: standardisation including administrative shell, industrial cyber security, Industry 4.0 applications, qualification and training, research and development, legal framework conditions and digital business models. Furthermore, common use cases are planned between the German Labs Network Industry 4.0 and the Dutch Smart Industry Network - the two test facilities have already worked together successfully in the past. The cooperation was agreed on October 11, 2018.

Germany-Austria-Switzerland (DACH)

The focus will be on promoting collaboration in test centres and developing use cases, especially with regard to the needs of SMEs. In addition, the initiatives will continue and deepen their exchange of information on Industry 4.0, on reference architectures and standards.

On April 23, 2018, the cooperation with Industry 4.0 in the DACH region was agreed during the Hannover Fair which involves a regular exchange between the platforms with two meetings a year. A first, important step of the cooperation is the participation of the country platforms at the annual conference of the platform in Austria on 12.12.2018.

The Czech Republic

The aim of the agreement to intensify cooperation on the topic of Industry 4.0 between the Federal Ministry of Education and Research (BMBF) and the Czech Ministry of Industry and Trade (MPO) is primarily the cooperation of science and the promotion of innovation partnerships of industry, especially of the SMEs.

The first agreement was already concluded in October 2015 in Prague. In August 2016, a joint innovation lab for human-robot collaboration was agreed in Prague. In October 2016, a partnering event for companies and research partners from both countries on the topic of Industry 4.0 took place in the context of the SME Conference "SME Innovative: ICT".

Besides, the European Commission has found that an integrated project jointly notified by France, Germany, Italy and the UK for research and innovation in microelectronics, a key enabling technology, is in line with EU State aid rules and contributes to a common European interest. Therefore, in December 2018, the European Commission approved EUR 1.75 billion funding for this project that aims to unlock an additional EUR 6 billion in private investment. The project should be completed by 2024 (with differing timelines for each sub-project).[23]

Also, in December 2018, the Commission adopted a coordinated plan on artificial intelligence. There is a close link between the German national initiatives of digitalisation of industry and measures envisioned in the coordinated plan.[24] Finally, Germany is a member of the ECSEL Joint Undertaking - the Public-Private Partnership for Electronic Components and Systems.

2 Other policy support to digitising industry

2.1 Boosting innovation capacity

The main measures to promote the digital transformation of the industry and boost innovation capacity (Pillars 2 and 3 of the DEI) are presented in the table below.

Table 5: Overview of initiatives to boost innovation capacity

Name	Mittelstand Digital	Research program Industry 4.0 Test Environments for SME (I4KMU)	Labs Network Industry 4.0	Digital Innovation Hubs	Research Factory for Microelectronics Germany
Type	Digital network	Research program	Lab Network	Hub Network	Factory
Starting date	2012 (Mittelstand 4.0 2015-)	2016	2016	2016	2017
Objective	The Federal Ministry for Economic Affairs and Energy has the goal to strengthen the competitiveness of small and medium sized enterprises. The mixture of regional centres and thematic centres includes all divisions and industries.	The aim is to support SMEs through the promotion of pilot projects by means of industry 4.0 test environments at German research institutes, adaptation to digitised processes and the research and development of new digital products.	It aims at supporting the German mid-sized sector in taking a leading role in the global digitalisation. Members can experience and test new technologies, innovations, and business models in test centres in the environment of Industrie 4.0 and review their economic feasibility prior to their market launch. The cooperating test centres offer an ideal environment – with minimal financial and technical risk and absolutely no competitive pressure.	It seeks to support the establishment of digital hubs in Germany. The underlying idea of establishing hubs is that cooperation between companies and business start-ups within a confined area will boost innovation, especially in the digital age.	Research capacities are networked for the first time nationwide, in order to gain more weight internationally as a microelectronics location. The BMBF finances
Relevant for Pillar 2[25] or Pillar 3[26] or both	Pillar 2&3	Pillar 2&3	Pillar 2	Pillar 2	Pillar 2
Short description	Mittelstand Digital informs small and medium-sized enterprises about the opportunities and challenges of	It provides funding for research and development projects in the areas of Industry 4.0, Internet of things and cyber-physical systems.	The initiative aims to provide catalyst between theory and practise: • Knowledge transfer into practice	At the Digital hubs, start-ups, scientific institutions, SMEs, industry and the government co-operate and evolve to centres of	Investments in Microelectronics are seen by the German government as a great opportunity to drive critical IT developments

Name	Mittelstand Digital	Research program Industry 4.0 Test Environments for SME (I4KMU)	Labs Network Industry 4.0	Digital Innovation Hubs	Research Factory for Microelectronics Germany
	digitisation. Mittelstand 4.0 competence centres throughout Germany help with expert knowledge, demonstration centres, networks for the exchange of experience, events and practical examples.	Projects (4/2017 – 03/2018): • ACTOS - Intuitive operation of assistance systems and automated evaluation of work steps by the use of low-level sensors (Bremen) • BaseCON_Test - Test support for IP compatible solutions for Ambient Assisted Living and Home automation applications; baseCON product development (St. Georgen) • ExpertSHARE - Collaborative real-time expert service in tool construction based on control, simulation and machine data (Aachen) • FAST 4.0 - Factory Analysis	• National and international networking of companies and test labs • Transparency, orientation and education through individual workshops • Reasonable and low-risk practical tests in companies and established research institutes • Recommendation for action to politicians	the digital transformation. BMWI is working on establishing a common label and a hub agency for the large German hubs that act as flagships in order to ensure the best possible networking of hubs throughout Germany and thus improve the transfer of know-how between each of them. Since the launch of the Digital Hub Initiative at the IT Summit 2016, selected hubs in 12 locations have started their work. They are focused on various priorities (artificial intelligence, chemicals, healthcare), all with a close connection to the digital transformation of the economy.	and for strengthening an important key industry, also with respect to economic growth and jobs. The German government has set up a strategy paper about the microelectronics industry for the timeframe 2016-2020. The priorities of the strategy on microelectronics is the result of an agenda process that was started in June 2014 through a position paper of the Federal Government. The national priorities are also in line with a number of European initiatives (especially ECSEL) that is supported by the German government

Name	Mittelstand Digital	Research program Industry 4.0 Test Environments for SME (I4KMU)	Labs Network Industry 4.0	Digital Innovation Hubs	Research Factory for Microelectronics Germany
		and Control 4.0 (Hanover)			
Granting organisation	Federal Ministry for Economic Affairs and Energy	Federal Ministry of Education and Research	Founded by companies related to the Plattform Industrie 4.0 in cooperation with the federations Bitkom, VDMA, and ZVEI.	Federal Ministry for Economic affairs and Energy	Federal Ministry of Education and Research (BMBF)
Participating organisations	NA	NA	Collaboration with both the Plattform Industrie 4.0 and the Standardisation Council Industrie 4.0 (SCI4.0).	NA	A total of 13 participating university research facilities are equipped with state-of-the-art equipment and systems.
Sectors targeted	SMEs in all sectors	Industry	Industry	Industry	Industry
Technologies targeted	All	All	All	All	All
Funding (split by private/public and national/EU), state period/annual funding	EUR 40 million per year; EUR 200 million available until 2018	The funding of the Federal Ministry of Education and Research covers up to 50% of the expenses (maximum funding EUR 100.000), and the duration of the project is limited to 12 months. Funds from the grant should be used to achieve the project objectives for a research and development contract with the operator of an industry 4.0 test environment.	NA	Through the innovation hubs, start-ups will be provided with EUR 2 billion of new public funding available over the next few years. An advisory board has been established to consult the government concerning the digital hub initiative.	The investment program with a total of around 400 million EUR. Since reunification, this is the largest investment in research for microelectronics in Germany.
Current status of initiatives	Ongoing	Ongoing	Ongoing	Ongoing	Ongoing

The "Mittelstand Digital"

The "Mittelstand digital" program consists of three initiatives that aim to support SMEs in mastering the challenges of digitisation:

- ***"Simply intuitive – usability for the SME sector"*** helps small and medium-sized businesses to improve the quality and usability of operational software.
- ***"E-standards: optimize business processes, ensure success"*** accelerates the development, trialling and dissemination of e-standards with the aim of strengthening the international competitive position of small and medium-sized businesses.
- Under the initiative ***"Mittelstand (SME) 4.0 – Digital Production and Work Processes"***, Mittelstand 4.0 Competence Centres raise awareness about automatization, provide information and training for business leaders and staff members across the country and show them solutions in practice in their demonstration factories, offering a hands-on approach for testing out the digital transformation (see also Section 2.3). The Mittelstand 4.0 Agencies pool the latest knowledge on overarching issues of digitalisation like cloud-computing, communication, trade and processes and share this information via multipliers such as business chambers and associations.[27]

Research program Industry 4.0 Test Environments for SME (I4KMU)

BMBF has initiated a program for Industry 4.0 test environments for SMEs.[28] The platform Industry 4.0 hosts an interactive map which now lists a total of 55 test bed centres all over Germany. Prominent examples are the SmartFactoryOWL (Lemgo), the demonstration plant (WZL) Aachen or the SmartFactory Kaiserslautern as well as the Robotics and Mechatronics Center (Oberpfaffenhofen). Current initiatives include the "Track and Trace" testbed (Industrial Internet Consortium; SAP) or the Learning factory (University of Braunschweig).

Regional Initiatives

Next to the federal level, some significant initiatives in the area of Industry 4.0 have also been initiated by the Deutsche Länder, by industry or by research organizations, including:

- Bayern Innovativ GmbH is Bavarias' organisation for innovation, technology and knowledge transfer. It supports players from industry and science in all stages of the value chain by providing customised services to boost innovation dynamics. Bayern Innovativ operates at the interfaces of various industries and technologies. The goal is to build an ecosystem of dynamic networks to accelerate the innovation process. In addition to the organisation's own clusters Energy Technology, Automotive and New Materials, activities focus on "crossclustering" with other Bavarian clusters and networking with key players in the Bavarian innovation landscape.
- The Cluster BICCnet has the mission to secure the growth of information and communication technology (ICT) in Bavaria. It is initiated by the Bavarian State Ministry of Economic Affairs and since 2016 integrated into the Centre Digitisation Bavaria.
- Allianz Industrie 4.0 is a network initiated and supported by the Ministry of Economic Affairs of Baden-Württemberg. Together with their partner organizations, the initiative bundles the competences of production and information and communication technology and accompanies industrial SMEs in the direction of industry 4.0 and offers various regional funding mechanisms. The coordinating office is located at the VDMA-Landesverband Baden-Württemberg.
- Baden-Württemberg has furthermore worked out a "Roadmap Economy 4.0" with investments of EUR 16 million, e.g. in four "Digital hubs".

- The state government of Northrhine-Westfalia is funding various projects such as a vocational education and training infrastructure "Lernfabrik 4.0 mit Lernfilialen" ("Learning Factory") which is part of the technology network and excellence cluster “its OWL”22.
- In Saxony, the state government has worked out a digitisation strategy "Digital Saxony. The government wants Saxony, which is already strong in chip production (“Silicon Saxony”) to develop into one of the most technologically, economically and culturally leading regions in Europe. The strategy focuses on the implementation of the Internet of Things, Industry 4.0, Mobility 4.0 and Mobile Networks of the Future (5G).[29]

Impacts, challenges and perceptions

According to the Digital Economy Monitor 2018, industrial companies are improving in terms of the use of mobile digital devices, as well as the use of digital infrastructures (such as the use of internet). The improvements are also clear with regard to internal processes. In 2016, only 46% of industrial companies said they had highly digitalised internal processes; in 2018, this has increased to 58%. With regard to digitalisation, industry has reversed a trend. In 2016, almost half of all industrial companies indicated (48%) that they considered digitalisation unnecessary. That figure in 2018 was only 29%. The percentage of companies using AI solutions in Germany still remains to be negligible as only just under 5% of companies in the commercial sector use AI applications.[30]

According to a survey by the Bitkom association, 36% of companies ranked German industry among the international leaders when it comes to digitalisation. 44% considered it to be in the middle range and 13% believed German industry to be among the digital stragglers, but none considered it beaten.[31]

Further impacts include that according to the KfW Research institute one in four small and medium-sized enterprises have expanded their digitalisation in the past three years. The share of SMEs with completed digitalisation projects is similar to the proportion of SMEs that innovate, both being around 26%. However, the share of SMEs with completed digitalisation projects correlates strongly with the size of the enterprise. In small enterprises with less than five employees the rate is slightly lower, around 24%. In large SMEs with 50 and more employees it is much higher, 45%.[32]

Based on our interviews with government and industry representatives, Germans are aware that they have strong actors such as the federal ministries who push for a digital transformation. They are also aware that this transformation will come either way and that they must be prepared for what will be needed in the future. Based on industry feedback, the German industry finds government support extremely helpful (5 on a scale from 1 to 5) but not too well coordinated (3 on a scale from 1 to 5). The level of digitisation and innovation is perceived as moderate (4 on a scale from 1 to 5). Mittelstand Digital is a well-known initiative among SMEs and it is positively perceived as being a complex program that does not just provide standard solution but focuses on different approaches for the different sectors. Businesses in Germany are changing their business models due to the changing environment. According to stakeholders, the main challenges are the digital infrastructure in Germany (e.g. broadband) and the need for further clarification as to how specific technological developments, such as AI, can be used in different sectors, such as craft.

2.2 Regulatory framework for digital age

Over the past few years, Germany and the Federal Cartel Office have moved to the forefront of competition law enforcement in the digital arena. In 2017, the German legislature passed a far-reaching reform of Germany’s competition law (the Act against Restraints of Competition) which sought to provide a “regulatory framework for the digital economy”. Besides, there are two new

initiatives indicating a consensus that competition law must address competition concerns more comprehensively and earlier, before a company has a dominant market position. If adopted and implemented, recent proposed changes to competition law could have far-reaching implications, particularly for companies with a digital platform business model.[33]

The table below presents an overview of the main regulatory initiatives for a digital age (Pillar 4 of the DEI).

Table 6: Overview of main initiatives for a digital regulatory framework

Name	Industry 4.0 Working Groups	RAMI 4.0 "reference architecture model industry 4.0"	Competition Law Commission 4.0
Type	Working Groups	Standardisation initiative	Expert panel
Starting date	2013	2015	2018
Objective	Six working groups stand for the technical and content-related results of the platform.	Provides guidelines for the correct implementation of industry 4.0 applications.	Developing proposals to modernise competition law.
Short description	Experts from businesses, associations, works councils and academia develop pre-competitive concepts, solutions and recommendations on key topics of Industrie 4.0 – from standardisation and IT security to economic, legal and social dimensions.	RAMI 4.0 is an architectural Model for Industrie 4.0. RAMI was developed by the Plattform Industrie 4.0 founding associations ZVEI, VDMA and BITKOM together with VDI/VDE-GMA and DKE	This high-level panel of experts will be tasked with developing proposals to modernise competition law to meet the demands of the data economy, the dissemination of platform markets and so-called 'Industry 4.0'.
Sectors targeted	Industry	Industry	All

Competition Law Commission 4.0

The Competition Law Commission 4.0 was announced on 10 September 2018 by the German Federal Ministry for Economic Affairs and Energy. This high-level panel of experts will be tasked with developing proposals to modernise competition law to meet the demands of the data economy, the dissemination of platform markets and so-called 'Industry 4.0'. Despite being a German initiative, the Competition Law Commission 4.0 is developing recommendations for EU competition law by autumn 2019.[34]

Industry 4.0 Working Groups

- Working Group "Reference Architectures, Standards and Standardisation": this working group is working on a lingua franca for the industrial internet. It develops concepts that form the foundation of future standards. Their considerations set an important framework for standardisation procedures - at national and international level.
- Working Group "Technology and Application Scenarios": it formulates scenarios to describe the changes in the industry in concrete pictures. It determines new trends and technologies in exchange with the professional community, classifies them into their meaning and transfers them to the work of the Working Groups.
- Working Group "Security of Networked Systems": it develops basic concepts, recommendations for action and concrete application examples for a secure, networked

industry, to anchor IT security as a central key factor of global value chains in international standards, but also in the awareness and competence portfolio of companies.

- Working Group "Legal Framework": it accompanies the implementation of Industry 4.0 legally. It provides legal certainty through recommendations for action, concrete application examples and scenarios as well as information events.
- Working Group "Work, Training and Further Education": with practical recommendations and best practices, the working group presents perspectives for designing qualified, digitised work and serves as a practice-oriented "sounding board".
- Working Group "Digital Business Models in Industry 4.0": focuses on the basic principles of digital business models in Industry 4.0 and on how to create an ideal breeding ground for digital business models in companies and in the economy as a whole.[35]

Impacts, challenges and perceptions

The objective of the Digital Agenda 2014-2017 was to introduce a market-friendly and growth-oriented regulatory framework.[36] However, based on feedback from the government and industry representatives consulted, the current regulatory framework is still relatively strict. This will need to be adjusted for the digitised future to facilitate the digital transformation of German businesses. On the other hand, there is a fear that the digital regulation and pricing may harm competition. According to the Germany's Monopolies Commission. the constantly evolving digital marketplace may have led to overregulated media and platforms – as well as a need to watch out for pricing algorithms that enable collusion.[37]

The legal framework will need to be set to clarify issues such as access and ownership of data. In the past years, data and internet regulations were the ones mainly in focus especially with regards to digital security. The job market may open for those working in cybersecurity to make sure new regulations are adhered to and cyber attackers deterred. Additionally, companies might start to invest and expand in their data teams, creating more demand for data specialists. However, the content of the future German digital regulations or how they shall be implemented is not defined yet.[38]

2.3 Skills development

The table below presents an overview of the main initiatives to develop digital skills (Pillar 5 of the DEI).

Table 7: Overview of main initiatives to develop digital skills

Name	Mittelstand Digital Competence Centres	Vocational Training 4.0	Future of the German Mittelstand
Type	Competence Centres	Training Program	Action Program
Starting date	2015	2016	2017
Objective	The Federal Ministry for Economic Affairs and Energy has the goal to strengthen the competitiveness of small and medium sized enterprises. The mix of regional centres and thematic centres includes all divisions and industries.	To develop new measures for a future - oriented, attractive and competitive vocational training and to connect them with other BMBF initiatives on digitisation. The initiative also supports the Digital Agenda of the Federal Government.	To promote the spirit of entrepreneurship, to strengthen the financing of start-ups and tackle skills shortage. Besides, the Action Plan aims to strengthen innovative capacities and SMEs in structurally weak regions.
Short description	Mittelstand 4.0 competence centres throughout Germany help with expert knowledge, demonstration centres, networks for the exchange of experience, events and practical examples. The Federal Ministry for Economic Affairs and Energy enables the free use of all offers of Mittelstand-Digital.	The activities of VET 4.0 include the BMBF Program "Digital Media in Vocational Education". This will contribute to the modernisation and strengthening of VET. Innovative, digitally supported education, communication and information solutions are developed to meet the requirements for learning and working in the digital society. Accompanying this is the development of concepts to strengthen the media literacy of employees and organisations in order to optimally use learning with digital media. In addition to the target group of learners, the focus is also on the specific qualification of pedagogical specialists. Nationwide, at least 1,200 trainers are trained in the company training context.	To ensure that the German Mittelstand can remain healthy, strong and innovative in the face of the challenges sketched out above, the Economic Affairs Ministry, which is responsible in the Federal Government for SME policy, is implementing measures in ten fields.
Granting organisation	The Federal Ministry for Economic Affairs and Energy	The Federal Ministry of Education and Research, Federal Institute for Vocational Education and Training	The Federal Ministry for Economic Affairs and Energy
Participating organisations	Actors from companies, associations, unions, science and politics	N/A	N/A
Sectors targeted	Industry	Industry	Industry
Funding	EUR 1 billion available until 2018	N/A	EUR 14 million
Current status of initiatives	Ongoing	Ongoing	Ongoing

Vocational Training 4.0

The Federal Ministry of Education and Research launched an initiative called Berufsbildung 4.0, which, in cooperation with the Federal Institute for Vocational Education and Training, aims to develop new measures for a future oriented, attractive and competitive vocational training in Germany. The initiative also supports the Digital Agenda of the Federal Government. One of the key elements of “Vocational Training 4.0” is a new research initiative "Qualification for Skills and Competences for the Digitised Work of Tomorrow", which is jointly supported by the two mentioned ministries and by several companies. Jobs that are affected by digitisation are examined in selected professions about work processes, activities and qualification requirements. The aim is to recognize at an early stage how qualifications of skilled workers need to change and to establish an early detection system. The initiative also examines the importance of digital skills of trainees and trainers for a successful management of vocational training. Another component of “Vocational Training 4.0” is a special program for the promotion of digitisation in intercompany vocational training centres and competence centres. Vocational training centres supplement the company's training in many sectors through practical courses. They are competent partners especially for SMEs which cannot provide all the necessary training contents themselves. The program supports selected equipment of the training centres in the field of digitisation, such as the purchase of 3D printers or CNC machines, that automatically manufacture workpieces thanks to modern control technology.[39]

Mittelstand 4.0

This funding initiative lends digitalisation support to SMEs and the craft industry with its regional Mittelstand 4.0 Competence Centres. They help businesses to first gauge at what stage of digitalisation they are currently at, develop together with the company an individual digitalisation road map and assist it in the selection and implementation of suitable measures. The centres are also at hand to advise companies on whether a technical solution is economically viable and which security aspects must be considered.[40]

Future of the German Mittelstand

In its program “Future of the German Mittelstand”, the Ministry for Economic Affairs and Energy describes the following measures in skills development, that predominantly target SMEs:

- Intensive campaigning for “dual” vocational training and the reporting of more training opportunities in companies.
- The programme “Support for SME with finding the right people for training places and with integrating foreign skilled workers” has been expanded to include further advisory elements: in total about 310 consultants partly funded by the Ministry are helping SMEs to recruit young talents and assist them in integrating foreign trainees and foreign skilled workers.
- Adapting the training regulations to the rapid advances in technology and particularly to the demands deriving from digitisation.
- Teaching social skills as part of vocational training.
- A new “Study and Work” initiative seeks out innovative ideas of regional networks of higher education institutions, companies, chambers, employment agencies and other social partners, with a view to improving the integration of foreign graduates at German higher education institutions into the regional labour market.[41]

Impacts, challenges and perceptions

Based on industry perception, the availability of digital skills as moderate (4 on a scale from 1 to 5). German adults are in the top tier when it comes to digital skills, with 37% of people scoring at an intermediate level in problem-solving in technology-rich environments, which comes with a low digital skills gap. By contrast, Germany is facing high risk of job automation, with a total of 54.2% of jobs at risk of automation. The relatively low share of workers with computer-based jobs does limit the job stress and worries about work when not working associated with digital jobs. The exposure to disinformation is one of the lowest in OECD countries (9%).[42]

According to the OECD, improving opportunities for life-long learning and better anticipating skills needs is critical to Germany's ability to seize the digital transformation. Germany is among the countries with a higher-than-average share of jobs at high risk of automation and, like the rest of the OECD, has experienced job polarization. While overall participation in adult learning is average, the participation gap in adult learning between high-skilled and low-skilled adults is much larger in Germany than in most OECD countries. Tackling skills at multiple entry points will be essential – from ensuring the education system equips students with solid literacy, numeracy and problem-solving abilities, as well as basic ICT skills and soft skills, through to anticipating changing skills needs to adapt curricula and guide students' choices, to improving the effectiveness of lifelong learning and training for adults.[43]

2.4 Support mechanisms

Tax incentives

Germany is not listed in the OECD compendium for tax incentive schemes, therefore tax incentives for R&D are overall not implemented. However, in 2017 it was announced that Germany wants to raise the gross domestic expenditures on R&D (GERD) from 3.0% to 3.5% which would mean additional expenditures of 3.7 billion EUR. It was also announced that this should be reached via tax incentives for technology-based R&D. In the past years, several political initiatives to introduce tax-based R&D funding in businesses have been launched but so far, they have not been successful.[44]

Innovation Vouchers

In 2017, the Federal Ministry for Economy and Energy has launched the funding program "go digital" which aims to support SMEs with less than 100 employees to advance their own digitisation in three areas which are: IT security, digital marketing and digitised business processes. Funded enterprises can get expertise and support from authorised consulting firms, starting with an analysis (phase 1), and then their projects for concrete transformation measures (phase 2) can be funded. In phase 1, interested professional ICT consultant business are certified. After their authorisation, starting in fall 2017, SME can submit applications.[45]

The program "go inno" also funded by the Federal Ministry for Economy and Energy, funds management and consulting services for the preparation and execution of product developments and technical process innovations. Services may only be provided by authorized consultants. After a potential analysis (step 1, e.g. strength and weakness profile; capacity requirements), a realization concept is worked out. Project management services are as well eligible.[46]

In its program "KMU-innovativ", the Federal Ministry of Education and Research wants to simplify the application and approval of grants for innovative SMEs in specific technology fields that are particularly important for Germany's future. A central piloting service has been set up to help SMEs solve all questions and reliable processing periods provide planning security.[47]

Technology transfer in structural weak regions

With the program “WE!” (“WIR!”) the Federal Ministry of Education and Research has created new impetus in regions with challenges in structural change. Launched in August 2017, the program is part of the new High-tech strategy of the government. WE! is aimed at broadly based regional alliances of a wide range of actors, which jointly identify fields of innovation. With new strategic approaches, they are to transfer the existing innovation potentials of their region into the future. With the program, the region's profile will be strengthened and new perspectives for structural change will be opened.[48]

Broadband

As Germany is facing challenges in connectivity and network gaps, the country is investing into broadband development. High-performance broadband networks are the foundation and driver of digitisation and are therefore indispensable for a digital future. SMEs are reliant on high-performance networks, not just in urban areas, but also in rural areas. The Federal Government was providing a total of EUR 2.1 billion up to 2018 for the nation-wide roll-out of broadband at 50 Mbit/s. On top of this there was approx. EUR 665 million from the regional governments, the funding coming from their share of the Digital Dividend.[49]

Structural Funds

According to the ICT Monitoring Tool, Germany is planning the following ICT Investments under ESIF with relevance to ICT or smart manufacturing research and dissemination:

- EAFRD - ICT in rural funds: EUR 224million.
- 05 - ESF 2nd theme - Enhancing the accessibility, use and quality of information: EUR 35 million.
- 015 - Intelligent Energy Distribution Systems at medium and low voltage levels (including smart grids and ICT systems): EUR 67 million.
- 044 - Intelligent transport systems (including the introduction of demand management, tolling systems, IT monitoring, control and information systems): EUR 71 million.
- 046 - ICT: High-Speed broadband network (access/local loop; >/= 30 Mbps): EUR 58 million.
- 048 - ICT: Other types of ICT infrastructure/large-scale computer resources/equipment (including e-infrastructure, data centres and sensors; also, where embedded in other infrastructure such as research facilities, environmental and social infrastructure): EUR 1.5 million
- 078 - e-Government services and applications (including e-Procurement, ICT measures supporting the reform of public administration, cyber-security, trust and privacy measures, eJustice and e-Democracy): EUR 2 million.
- 079 - Access to public sector information (including open data e-Culture, digital libraries, eContent and e-Tourism): EUR 7 million.
- 081 - ICT solutions addressing the healthy active ageing challenge and e-Health services and applications (including e-Care and ambient assisted living): EUR 16 million
- 082 - ICT Services and applications for SMEs, living labs, web entrepreneurs and ICT start-ups): EUR 33 million.

The abovementioned funding is summing up to a total of EUR 595 million.[50]

3 Conclusions

The following table provides an overview of how the different digitalisation initiatives implemented in Germany have been funded.

Table 8: Breakdown for the financing of initiatives

	Pillar 2	Pillar 3	Pillar 4	Pillar 5
	Digital Innovation for all	**Partnerships and industrial platforms**	**Regulatory framework for digital age**	**Preparing for digital future (skills)**
Industry 4.0 Platform		EUR 4 million per year		
Mittelstand Digital	EUR 200 million available until 2018			
Research program Industry 4.0 Test Environments for SME (I4KMU)	EUR 100.000			
Labs Network Industry 4.0	NA			
Digital Innovation Hubs	EUR 2 billion			
Research Factory for Microelectronics Germany	EUR 400 million			
Competition Law Commission 4.0			NA	
Industry 4.0 Working Groups			NA	
RAMI 4.0 "reference architecture model industry 4.0"			NA	
Vocational Training 4.0				2016 – 2019: EUR 84 million
Future of the German Mittelstand				EUR 14 million
Support mechanisms: Innovation vouchers	N/A			
Total spending	**Approx. EUR 2.7 billion**			

Germany is the largest economy in Europe with a significant and advanced digital industry. It has a wide network of cooperation with European and non-European countries in the field of digitalisation. The German government clearly treats digitalisation as an important priority, which is best reflected in the high number of measures implemented, the investments and international cooperation.

Nevertheless, the country is facing a few challenges regarding digitalisation, such as the shortage of skilled workers and ICT professionals, the gaps in Internet and network connectivity, the strict regulatory framework, the geographically fragmented start-up scene and the slow uptake of cloud and big data technologies. Besides, the gap concerning the adoption of productivity-enhancing technologies is particularly large between large firms and SMEs, as well as between large cities and rural areas. Last but not least, the country is among the countries with a higher-than-average share of jobs at high risk of automation and has already experienced job polarization.

To address these issues, the federal and regional governments in Germany have been active in the last few years and put forward measures to boost innovation capacity and the knowledge transfer towards Germany companies. Germany has very active actors on the federal level that push towards a digital transformation. The Platform Industry 4.0 (Pillar 2 of the DEI) looks at future-related issues in the areas of digitalisation and it has developed into one of the world's largest networks for the digitisation of industry. The aim is to tap the enormous potential of digitisation for the German goods-producing industry, and particularly for SMEs, in conjunction with other stakeholders. The platform also organises network events across Germany, at which companies – particularly SMEs – receive information on the digital transformation and are made aware of Industrie 4.0. An online map helps companies to find out about specific examples of applications of Industrie 4.0, e.g. in their region. The overarching program of Mittelstand Digital (Pillars 2 and 3 of the DEI) aims to assist SMEs in the digital transformation as 99% of German companies are SMEs. The Vocational Training 4.0 aims to tackle the digital skill gap in Germany. German adults are already in the top tier when it comes to digital skills but initiatives under Pillar 5 of the DEI help small companies adjust to the digital future These are all supported by a large pool of specific initiatives e.g. Labs Network Industry 4.0 (Pillar 3 of the DEI), the Innovation Hub Initiative (Pillar 2) as well as a number of different research programs. As Germany still has a relatively strict regulatory framework, a number of Working Groups and Expert Groups have been established, such as Competition Law Commission 4.0 and the Working Groups of Industrie Platform 4.0, to provide recommendations for a more flexible and growth oriented regulatory framework.

These initiatives altogether cover all pillars of the DEI and provide the basis for a complex digital transformation of the Germany industry. All the initiatives are well advertised and monitored in order to achieve an effective outcome. The targeted funding schemes and the complex framework provided by the German government have proven to be efficient in a number of ways. Industrial companies are improving in terms of the use of digital infrastructures, SMEs have expanded their digitalisation in the past three years and the industry is aware of the government support to facilitate digitalisation. However, there is still a large portion of companies that considers digitalisation unnecessary. Besides, AI solutions in Germany still remain negligible. The constantly evolving digital marketplace also resulted in overregulation in many fields. To ease the digital changes in the industry, a more flexible regulatory environment may be needed.

Among the wide array of initiatives, one program particularly stands out by targeting the large number of SMEs and their slow uptake of digital technologies. The program called "Mittelstand Digital" aims to provide complex guidance for SMEs in digitalisation and therefore operates Competence Centres to inform and provide training for SMEs about the opportunities and challenges of digitisation.

Box 1: Good practice

Mittelstand Digital

Mittelstand 4.0 competence centres throughout Germany help with expert knowledge, demonstration centres, networks for the exchange of experience, events and practical examples. The program consists of three initiatives that aim to support SMEs in mastering the challenges of digitisation:

- "Simply intuitive – usability for the SME sector" helps small and medium-sized businesses to improve the quality and usability of operational software.
- "E-standards: optimise business processes, ensure success" accelerates the development, trialling and dissemination of e-standards with the aim of strengthening the international competitive position of small and medium-sized businesses.
- Under the initiative "Mittelstand (SME) 4.0 – Digital Production and Work Processes", Mittelstand 4.0 Competence Centres raise awareness about automatization, provide

information and training for business leaders and staff members across the country and show them solutions in practice in their demonstration factories, offering a hands-on approach for testing out the digital transformation. The Mittelstand 4.0 Agencies pool the latest knowledge on overarching issues of digitalisation like cloud-computing, communication, trade and processes and share this information via multipliers such as business chambers and associations.

With the new Coalition Agreement from December 2018, the German government continues to define Mittelstand as the backbone of its economy. The government plans to continue supporting SMEs on their way to digitisation through exchange programs, expansion of competence centres, information programs or mentoring programs.

To conclude, the table below provides a general overview of the main digitalisation initiatives implemented in Germany, the level of take-up and perception of their impacts as well as the overall progress Germany has made so far with regard to digitalisation. The table illustrates the applications, usages and outcomes of the main initiatives all clustered by relevant pillar of the DEI.

Table 9: Total input output overview

		Pillar 2	Pillar 3	Pillar 4	Pillar 5
		Digital Innovation for all	**Partnerships and industrial platforms**	**Regulatory framework for digital age**	**Preparing for digital future (skills)**
Application	Name of key initiatives (start dates in brackets)	Labs Network Industry 4.0 (2016), Digital Innovation Hubs (2016), Research Factory for Microelectronics Germany (2017)	Platform Industry 4.0 (2013)	Industry 4.0 Working Groups (2013) RAMI 4.0 "reference architecture model industry 4.0" (2015) Competition Law Commission 4.0 (2018)	Mittelstand Digital Competence Centres (2015) Future of the German Mittelstand (2017) Vocational Training 4.0 (2016)
		Mittelstand Digital (2012), Research program Industry 4.0 Test Environments for SME (I4KMU) (2016)			
	Funding (total amount and period)	EUR 2.6 billion available until 2018			2016 – 2019: EUR 98 million
	Industries addressed	All	All, mainly targeting SMEs	All	All, mainly targeting SMEs
	EU programme involved	NA	NA	NA	NA
Usage	Perception of initiative	The usefulness of the initiative is perceived as strong (5/5)		NA	The usefulness of the initiative is perceived as strong (5/5)
	Take-up	12 DIHs	NA		NA

		Pillar 2	Pillar 3	Pillar 4	Pillar 5
		Digital Innovation for all	**Partnerships and industrial platforms**	**Regulatory framework for digital age**	**Preparing for digital future (skills)**
Outcomes	Perception of outcomes	The level of take-up of digital technologies is perceived as elevated (4/5)	The level of innovation in digital industries is perceived as elevated (4/5)	NA	The level of innovation in digital industries is perceived as elevated (5/5)
	Outcome metrics	DESI overall ranking: 14th (2017 and 2018)		Between 2015 and 2017, total capex spending in Germany increased by 9,94%.	The proportion of enterprises employed with ICT specialists among all enterprises decreased by 2% between 2015 and 2017. In the same period, the share of enterprises providing training to develop ICT skills decreased from 30% (2015) to 28% (2017).
	Change in outcomes	From 2017 to 2018, Germany fell back in the DESI ranking on integration of Digital Technology from the 12th to the 14th			
End-goal	Productivity growth	Between 2008 and 2016, the labour productivity growth in Germany increased by 0, 3%.			
Summary		The German industry and government have been particularly active in launching initiatives to facilitate the digitalisation of the industry. With setting up the Industrie 4.0 Platform and establishing targeted funding schemes in all aspects of digitalisation, the country became a pioneer in digital transformation. The initiatives that cover all DEI Pillars and address issues in a comprehensive way have been continually developed throughout the last years and have been proven to be effective in terms of boosting innovation and addressing the digital skill gap in SMEs. The adjustments of the regulatory environment are still under process, Working Groups have been established to provide recommendations.			

ANNEX 1 List of stakeholders interviewed

Type of stakeholder	Name of organisation
Associate	Federal Ministry for Economic Affairs and Energy
Research Associate	Federal Ministry for Economic Affairs and Energy
Head of Department	Central Association of German Crafts

ENDNOTES

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