Federal Ministry
of Labour and Social Affairs

SKILL AND VOCATIONAL DEVELOPMENT NEEDS
OVER THE PERIOD TO 2030

A Joint Situation Report by the
Partnership for Skilled Professionals

Table of contents

List of figures

List of tables

Foreword

The German economy is prospering and growing – and the labour market is also doing very well. We cannot rest on our laurels, however. We should instead look to the future and make sure that our economy will remain successful even in changing conditions and that everyone will take a share of our prosperity. For we are living in a time of sweeping change: as well as demographic trends, digitalisation in particular poses new challenges for businesses and workers. Although technological advances will not destroy jobs on a massive scale, as is often claimed, tasks are changing in almost all occupations – and, with them, the requirements which workers face.

To secure our prosperity and competitiveness, we must therefore work together to ensure that skilled workers continue to have the right skills and qualifications in future. Matching supply and demand in the labour market in times of structural change will be the key challenge for economic and labour-market policy in the coming years. It is the only way for us to remain successful and internationally competitive. For workers, too, vocational development is the best route to the future working world, and the best protection against unemployment. Those who engage in lifelong learning to keep up with technological advances will be able to work and play a role in a company for longer while staying healthy and motivated. In other words, vocational development makes sense for both companies and employees.

Shaping the future working world to benefit businesses and workers is a challenge for society as a whole. First, we need to jointly assess the situation: what is the state of play, and what skill and vocational development needs can we foresee for the future? Trade unions, employers' associations and the Federal Government have sought to answer these questions together in the framework of the Partnership for Skilled Professionals. I am delighted that we can now present a situation report by the Partnership for Skilled Professionals on skill and vocational development needs over the period to 2030.

Our study highlights ways in which the working world is changing and sets out a vision of the future in 2030 that we consider a positive aim and that we want to make a reality together. A future in which the transformation of the German labour market has been successfully accomplished. This situation report examines what indications of changing and newly emerging fields can be identified, and highlights the trends regarding general and sector-specific shifts in skill needs. This is then used to deduce vocational development requirements and the conditions for the successful transformation of the labour market.

As you read this study, you will find that we do not offer any forecasts. Instead, this situation report sets out trends regarding the changes ahead, without being able to describe the future working world in detail at this stage. It is therefore essential to continue to systematically monitor changes and regularly review whether we are on the right track. We all have a part to play in this context. We must work together to secure the future supply of skilled labour.

Thorben Albrecht
Permanent State Secretary at the Federal Ministry of Labour and Social Affairs

1

Seeking the new in the working world

1. Seeking the new in the working world

Digitalisation, globalisation, greater flexibility – the future of work is being widely discussed at present. Public debate is dominated by forecasts of the potential for automation. While past waves of automation primarily resulted in the replacement of mechanical tasks, the new stage of automation concerns nearly all routine tasks at all skill levels. In particular, many people are surprised and, in some cases, worried by the use of algorithms to automate cognitive tasks. Occupation-based forecasts suggest that almost 50 % of existing jobs could potentially be automated in OECD countries over the next 20 years. The estimates offered by task-based studies are significantly lower, however. In any case, the extent to which this potential is actually leveraged will not depend solely on what is technically feasible; it will also depend on business, cultural, ethical and legal factors (Acemoglu and Restrepo, 2017).

A task-based perspective also reveals that jobs which are not acutely threatened by automation are still confronted by the digitalisation with shifts in the tasks they involve. For example do digital assitance systems enable workers to focus on more complex acitivities. Given the potential for rationalisation opened up by the possibility of automation, the public debate includes some pessimistic views of the labour market. More optimistic voices point out that technological change is constantly creating new jobs and fields of work. But what might these be? And how can workers, businesses and policy-makers prepare for the resulting skill and qualification requirements?

A rule of thumb in futures-research is that people tend to overestimate the effect of new technologies in the short run, but underestimate the effect in the long run. This is also the case in the current debate on the future of work. A recent survey of workers in the United States showed how the long-term effects of the labour market's transformation may be being systematically underestimated: 63 % of workers expect machines to replace much of the work currently carried out by humans in future, and yet 80 % expect their own job to remain largely unchanged over the next 50 years (Pew Research 2016). How are these contradictory expectations likely to affect decisions on initial and continuing training in the short to medium term? Particularly given the necessary investment in initial and continuing training by individuals, organisations and the state, it is vital to predict future skill needs as accurately as possible, in order to avoid misallocations in initial and continuing training and to prevent future mismatches between the supply and demand of skills.

As part of this study, numerous forward-looking studies, reports and articles have been evaluated; more than 150 new and changed fields have been analysed; in-depth interviews have been conducted with more than 40 experts from business, academic, administrative and policy-making circles using a two-round Delphi method; and future developments in six sectors have been analysed. This study provides a situation report on observable changes in the world of work and paints a picture of a desirable future in 2030 in which the transformation of the German labour market has been successfully accomplished. The study examines what indications of changing and newly emerging fields can be identified, what general and sector-specific shifts in skill needs are emerging, and what vocational development requirements and conditions for success can be identified for a successful transformation of the German labour market in the context of rapid technological change. The study also shows that familiar aspects of the working world are in the process of disappearing, but the new is not really here yet.

2

The working world: constantly changing

2. The working world: constantly changing

Employers and workers are facing a high level of pressure for change in Germany. That said, change is not a new but a familiar phenomenon in the working world; it is one of the few megatrends which span centuries. This is to some extent because the working world is part of complex economic and social systems, and is therefore affected by changes in a large number of areas. New technologies, changes in international trade relations, new business models, demographic change – all of these factors influence the form which work takes. What, then, are the forces currently driving the transformation of the working world (chapter 2.1)? And what cross-sectoral trends over the period to 2030 can be identified (chapter 2.2)? What changes can be expected in specific selected sectors as a result (chapter 2.3)?

2.1 Forces driving change

Technological change and a new stage of automation

A brief look at the technology-induced transformations of the working world over the past 200 years shows that change is a constant in the working world: the steam engine in the late 18th and early 19th century or the assembly line in the first half and industrial robots in the second half of the 20th century all resulted in sweeping transformations of the working world. A few decades ago, the digitalisation of the working world began, ushering in another wave of change. In the manufacturing sector, computer-integrated production paved the way for greater flexibility. Computers changed office work forever. The growing digital transformation of the economy and thus also the working world is a continuation of this process.

Driven by technological advances, especially in the field of artificial intelligence, several studies have been published in recent years which examine the potential risk posed by the automation of work (see part 1 of the Annex for a detailed overview and comparison of the most relevant studies). The starting point was the study published by Osborne and Frey in 2013, which

concluded that 47 % of the jobs which exist in the United States today will be automatable in the next 10 to 20 years as a result of the continuing process of digitalisation. Other studies which took Osborne and Frey's method and applied it to other countries arrived at similarly high automation risks. Bonin et al. (2015), for example, concluded that in Germany there is a high automation risk for 42 % of employees, while ING-DiBa (2015) arrived at the even higher figure of 59 %. The main difference between these studies and studies which reach far lower percentages is the methodology used: studies which take an occupation-based approach (Osborne/Frey 2015, Bonin et al. 2015) – i.e. looking at the potential for occupations to be automated, rather than individual tasks within an occupation – result in significantly higher estimates of the number of jobs at risk of automation than studies which take a task-based approach (Bonin et al. 2015 examine both the occupation-based approach and the task-based approach; Arntz et al. 2016, Dengler/Matthes 2015, Chui et al. 2015). The latter approach is based on the assumption that individual tasks, rather than occupations, are at risk of automation. For example, even occupations which are regarded as highly automatable contain individual tasks which cannot (yet) be carried out by computers (Arntz et al. 2016). If individual tasks are examined rather than entire occupations, the conclusion is that around 12–15 % of existing jobs in Germany are highly likely to be automatable (Arntz et al. 2016, Bonin et al. 2015, Dengler/Matthes 2015, OECD 2017; see also Figure 2).

All of the studies referred to above concentrate on the threat to jobs posed by modern technologies, with less attention being paid to other important factors which influence future employment trends. Yet even a high potential for certain tasks and occupations to be automated does not mean that this potential will necessarily be exploited. Almost all occupations which exist today also include tasks which can be automated using technologies which are already available. This is true of both low-paid and high-paid occupations, and of workers with both low and high levels of education (Chui et al.

2015, Dengler/Matthes 2015, Bonin et al. 2015). Any replacement of human work by machines invariably also depends on ethical and legal hurdles, on how adaptable occupational profiles and workers are, and on wage and investment costs (Bonin et al. 2015). For example, the modelling carried out in the Economix study on the labour market of 2030 shows that even accelerated digitalisation, if properly enacted in society and the economy, can have a significant positive impact on growth, productivity and employment (Vogler-Ludwig et al. 2016). The forecasts, which not only quantify the potential risk posed by digital technologies but also take into account the positive effects on demand caused by product innovations, lower costs and price reductions, allay fears of a technology-induced

wave of unemployment. For example, the modelling shows that a quarter of a million additional jobs and a 20 % reduction in unemployment are possible (Vogler-Ludwig et al. 2016).

A majority of the studies published in recent years conclude that the polarisation of employment which has been observed since the 1990s will continue as a result of technological change. In other words, the authors expect a decline in employment for codifiable, routine tasks in the middle skills segment, on the one hand, and on the other hand – at least in the near term – an increase in non-routine manual tasks and complex, non-routine cognitive tasks (Bonin et al. 2015, Arntz et al. 2016, Frey/Berger 2015, OECD 2017).

Figure 1: Estimated change in workforce size, 2014–2030, broken down by qualifications (in 1000s)
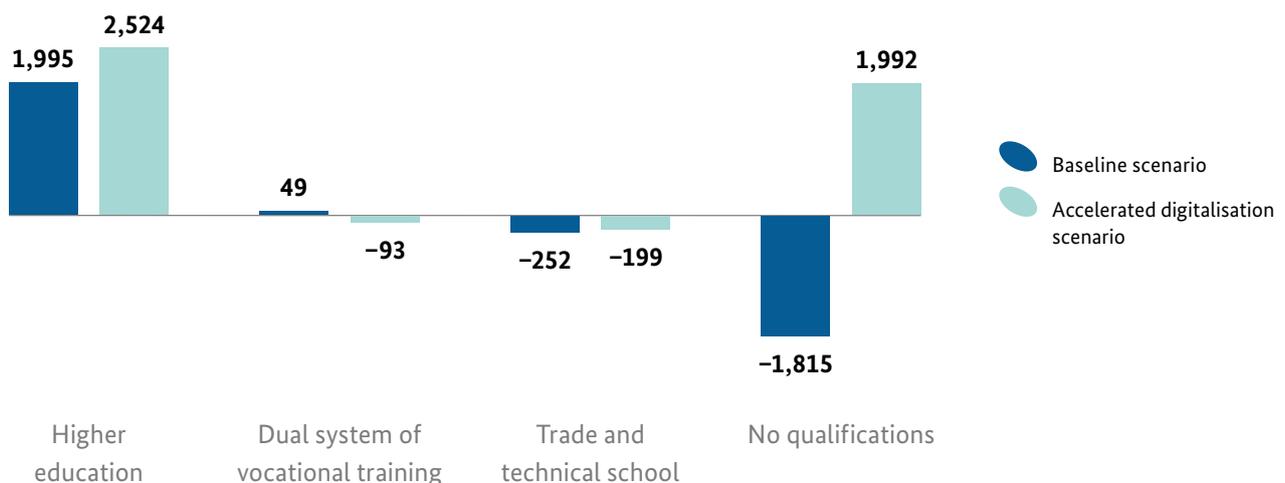
Source: Own diagram based on Vogler-Ludwig et al. 2016.
* The baseline scenario reflects current trends on the supply and demand sides of the labour market. The accelerated digitalisation scenario is based on the assumption that policy-makers, businesses and society drive forward and accept a more intensive use of digital technologies.

Figure 2: The risk of automation in OECD countries in the next 10 to 20 years (in %)

Jobs at risk of significant change

Jobs at high risk of automation

OECD average: Jobs at risk of significant change

OECD average: Jobs at high risk of automation
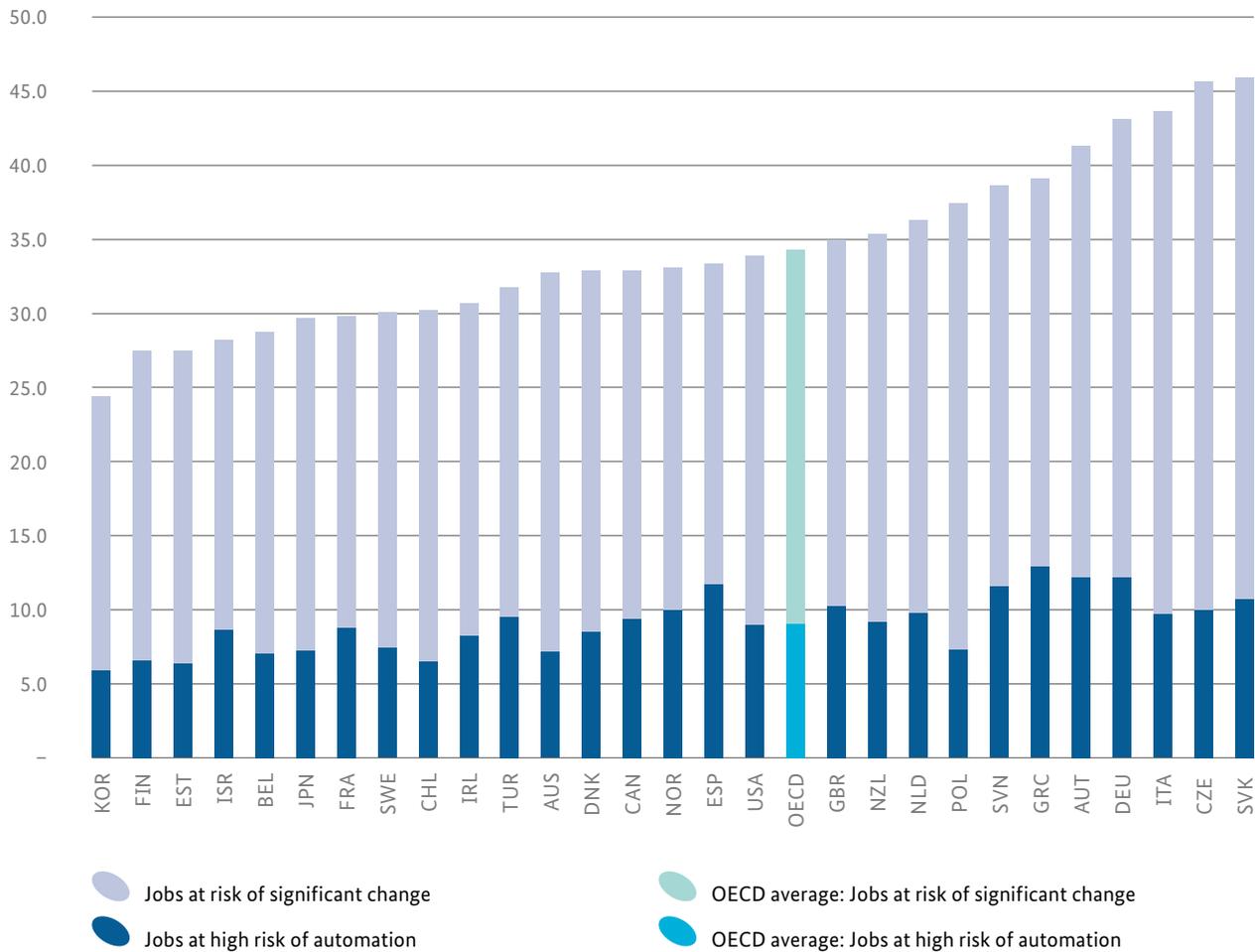
Source: Own representation, based on OECD 2017.

As the Economix study estimates the effects on specific skill levels by examining not only the potential risks but also the flexibility of workers and companies in adapting, its forecast for the period to 2030 does *not* show any polarisation of skill needs (in the sense of a reduction in demand for mid-level skills and a simultaneous rise in demand for both high- and low-skilled workers; see Figure 1). This shows that the aggregate employment growth or loss in the course of digitalisation depends, among other things, on the one hand on the adaptability of the institutions which make up the labour market and education system. On the other hand, it depends on businesses' innovativeness and competitiveness. Studies show, for example, that in the European Union the creation of one job in the high-tech sector can result in up to five new jobs in the local

service sector (Goos et al. 2015). This also reflects experiences in the United States (Moretti 2010).

All labour market studies agree that it is routine tasks with low skill levels (elementary occupations and skilled occupations equivalent to skill levels 1 and 2 in the German Classification of Occupations), in particular, which are at high risk of automation (Dengler/ Matthes 2015, Vogler-Ludwig et al. 2016, Arntz et al. 2016). In addition, low earners are particularly affected.

It should be underlined, however, that this predicted trend depends to a large extent on the specific occupational segment in question (Dengler/Matthes 2015, Vogler-Ludwig et al. 2016). For example, Chui et al.

(2015) show that even high earners engage in occupations which contain a significant proportion of tasks which can already be automated today. This is true of 20 % of the tasks of top managers in the United States, for instance. These tasks include analysing reports and data, preparing operating instructions and examining status reports. By contrast, few tasks carried out by a low-earning landscape gardener, for example, could be automated.

Overall, a further shift in demand for labour towards those with a higher education degree and away from workers without vocational qualifications is expected over the period to 2030. The demand for workers with a degree could rise by around 2.5 million by 2030, while the demand for workers without vocational qualifications could shrink by almost 2 million (see Figure 1). Alongside technological advances, the costs of tasks with low skill requirements are another factor which encourages the automation of low-skilled work (Arntz et al. 2014). The high level of wage inequality in Germany also ensures that automation or greater use of machines even for more complex, high-skilled tasks is becoming more profitable (Arntz et al. 2014).

All in all, the impact of digitalisation and the automation of tasks will vary greatly depending on occupational field and skill level (see Figure 3). The proportion of workers in Germany who are working in an occupation with a high potential for substitution varies between the German *Länder* (federal states), from 8 % in Berlin to more than 20 % in Saarland. In this context, it can be seen that the importance of manufacturing in a *Land* correlates with the proportion of workers with a high potential for substitutable tasks (Buch et al. 2016, Dengler/Matthes 2015).

Figure 3: The extent to which human work can be replaced in selected occupational segments, proportion of tasks which could already be performed by machines today (in %)
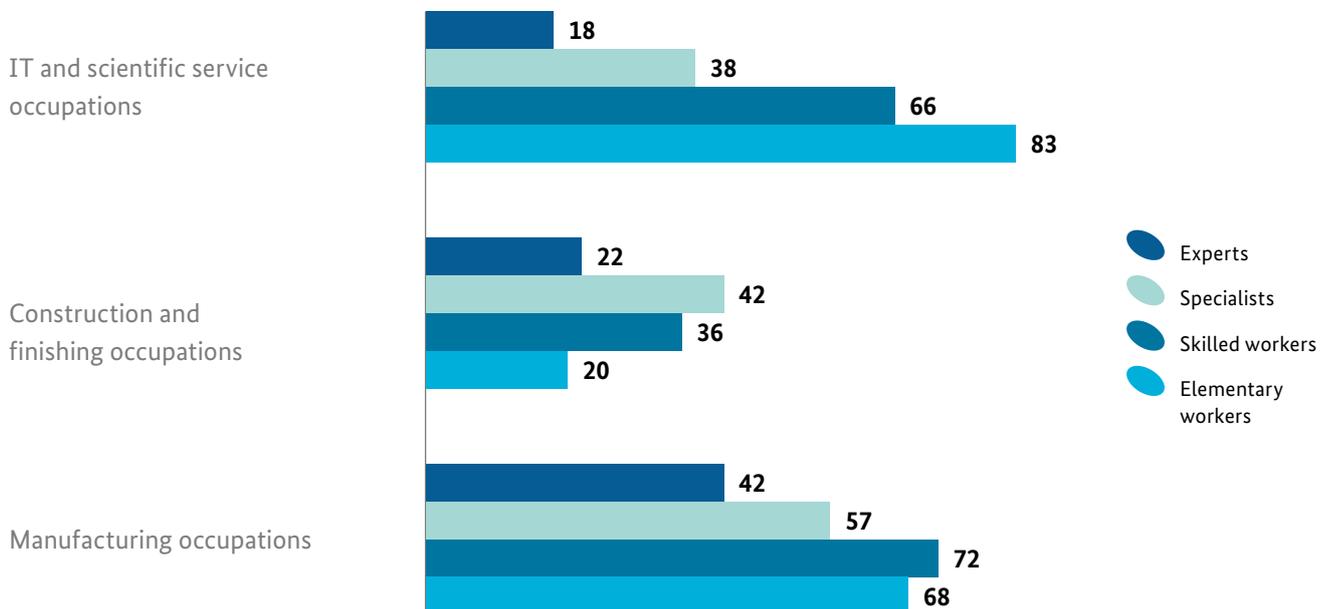
Source: Own representation based on Vogler-Ludwig et al. 2016.

A look at the employment trends in the individual sectors shows that there will be significant shifts in employment from downstream sectors (i.e. simple manufacturing, commerce and service occupations) to upstream sectors (traditional industrial sectors, but also IT services, business services, and research and development). Accordingly, there will be an increase in demand for IT occupations, occupations relating to business management and organisation, and occupations in the field of advertising and marketing. At the same time, there will be an increase in demand for mechatronics, machine and vehicle technicians, particularly as a result of Industry 4.0 trends. However, there is expected to be a negative impact on employment in a large number of manufacturing occupations, and in transport, sales and simple health care occupations (Vogler-Ludwig et al. 2016).

Globalisation and international competition

Over the period to 2030, digitalisation will drive forward closer and closer integration of formerly walled-off national markets: a digital global market is emerging, one with which the national economy is interconnected to an ever greater extent (German Bundestag 2013). As geographic distance becomes less significant, new realities are emerging which are having both positive and negative effects on the German economy and working world. Both businesses and individuals are experiencing a decline in their planning security in this complex and volatile context. This increases the pressure to adapt in a flexible and agile manner in the global competition for comparative competitive advantages and innovative edges (Gebhardt et al. 2015). Businesses are responding to the growing volatility by boosting their ability to react. They are doing so primarily by injecting more flexibility into their procedures and structures (Bennet/Lemoine 2014). The emergence of digital platforms is resulting, for example, not only in new relations between businesses and their customers, but also between businesses and their staff as well as between employees. This results in higher levels of flexibility being required of employees (Eichhorst/Tobsch 2014). At the same time, digital technologies are paving the way for dispersed value creation based on a division of labour at a global level. On the one hand, the growing international mobility of digitally connected work is leading to greater global competition for skilled labour, but on the other hand it is also allowing the coordination of organisational units across international borders. The option of relocating work is

reducing the demand for low-skilled workers in the German labour market, while demand for high-skilled workers is growing in relative terms (Arntz et al. 2014). The growth in complexity in a globally and digitally interconnected economy thus poses new demands in terms of the actions of and systems used by managers, who increasingly work with teams in multiple regions of the world and across company boundaries. While not all companies and sectors are affected by these changes to the same extent, the increase in dynamism and complexity is nonetheless pushing many management systems to their limits (Hollmann/Patscha 2015). A more recent phenomenon which is also driving forward a shift away from traditional organisations and towards internationalisation is "crowdworking" or "clickworking". "Crowdworking" and "clickworking" are an Internet-based form of work which does not take place within an employment relationship and is usually similar to a contract for work and services (Centre for European Economic Research 2014). The work usually consists of project-based micro-tasks in the field of data processing, research, design or text production. This enables projects to be broken down into their smallest components and then processed by individuals from around the world via online platforms. This gives businesses access to an immense global pool of knowledge and skills and to tailored services which can be accessed flexibly and as needed. In Germany, this form of working relationship is still a marginal phenomenon – just 3 % of German companies use crowdworkers, according to the latest figures (Bertschek et al. 2015). As new digital information and communication technologies pave the way for a modularisation of tasks, however, this could change significantly as digitalisation continues over the period to 2030, especially in the service sector, but also in the creative economy and in knowledge work.

New business models

Innovations and new opportunities for value creation are increasingly emerging on the boundaries of traditional sectors, as when customers are placed centre stage, solutions do not stop at traditional sector or segment boundaries. In the economy of the future, the decisive factor in competition will not, therefore, be size, but rather the ability to intelligently combine value-adding processes and players in such a way as to offer customers the greatest possible added value in the form of individual, flexible product and services bundles. Moreover, customers are no longer convinced to

purchase a product because of its individual features, but instead expect a complete product and services package, which in turn requires the involvement of players from outside the sector. It is less and less common for companies to see themselves simply as reactive systems affected by their environment; instead, they are increasingly playing a proactive, integrative role, adopting innovative business models which result in new markets and change their environment (Z_punkt 2014). In the interconnected economy, cooperation is becoming increasingly important – whether between competitors, between business and academia, or between companies and their customers. The growing interconnection and digital transformation of the economy is leading to new value-adding models and patterns, both formal and informal in nature. Value creation increasingly takes place within value-adding networks (Federation of German Industries 2012).

In this context, online platforms are playing an ever more important role; they serve as virtual marketplaces and bring together decentralised providers and customers. By reducing the transaction costs for market participants, they offer simple access to markets in a way which was inconceivable in the "offline economy". Digital technology, in combination with mobile devices, allows simple, convenient, on-demand consumption. This is paving the way, firstly, for a disruption of traditional linear consumption and service models. Secondly, the "Collaborative Economy" makes it possible to commercialise previously unexploited goods or services which were once provided free of charge. The platforms finance themselves via a transaction fee, usually a proportion of individual transactions, or via subscription models. Uber is the predominantly discussed example in the field of taxis and mobility, Netflix in the on-demand video market and Airbnb in the hospitality industry. Many other examples also exist (European Commission 2016; see also Demary and Engels 2016 and Sundararajan 2016). The possibility of using digital technologies to scale what is offered at near zero marginal cost (Rifkin 2015) favours the development of large platforms with a quasi-monopoly in the market or segment in question (Parker et al. 2016). Critics describe this development as the emergence of a "platform capitalism" in which companies with a secure monopoly could, in the not too distant future, dictate almost any rules to the participants in their marketplace (Lobo 2014, Morozov 2015). Platforms for services – such as TaskRabbit or Amazon Mechanical Turk – already show how platforms are creating new exchange structures for the organisation of work. While critics highlight the precarious working conditions for micropreneurs, current studies show that, in the EU, most of the individuals offering their services on platforms are doing so as a sideline and primarily out of interest in the work. In the United States, by contrast, the focus is on income generation, followed by the possibility of flexible working hours and working from home; but even in the US, the income from work on Internet platforms accounts for a relatively low proportion of household income in the majority of cases (European Commission 2016a).

Platforms play an integrative role in value-adding processes. They often create value-adding networks which did not previously exist in that form. The role of the integrator in value-adding networks – a role which needs not to be played by a platform – generally promises attractive returns. Building an attractive ecosystem which draws in both successful network partners and high-potential customers is an important prerequisite for this. More and more often, we are seeing the digitalisation wave result in formerly IT-centric providers and new technological start-ups moving out of their original field in an attempt to conquer other markets (e.g. Google's work on driverless vehicles). In these cases, traditional providers often experience disruption and a significant loss of market share. The digital value-adding networks which have been so successful in the Internet economy will thus also be essential for "traditional" industry in the future. They enable the development and use of new potential for adding value and boosting flexibility. It is also important to mention that some market participants are returning to a vertical integration model. This is illustrated by electric vehicle manufacturer Tesla, for example in its entry into battery production or its takeover of energy start-up Solar City. Even so, when it comes to battery production, Tesla also has a partner, Panasonic, with a long-established presence in the battery business.

Digital value-adding networks require established, traditional companies to become more agile from the inside. In this context, flexible forms of cooperation and temporary partnerships are relevant for companies of every size as well as for business founders. To some extent, however, the legal framework for this is still lacking. These new forms of cooperation offer a way for young

entrepreneurs, in particular, to supplement solo entrepreneurial initiatives with collegial structures and to expand the range of products or services they offer.

Demographic change

Younger generations' new perspectives, expectations and needs, as well as higher levels of immigration and ongoing demographic change in society are important additional factors which are shaping the future working world. Demographic and labour market researchers have long been drawing attention to the fact that our ageing society is leading to a shrinking population and a decline in the potential labour force. In 2035, almost 11 % of Germany's population will be aged 80 or over, compared to just under 6 % in 2015 (UN 2015). According to forecasts, the decline in the labour force caused by our ageing society can only be partially offset by the anticipated levels of immigration. In addition, targeted measures are necessary to integrate migrants into the German labour market (Vogler-Ludwig et al. 2016). Demographic change is thus, alongside digitalisation, one of the key driving forces in Germany's societal and economic development.

2.2 Cross-sectoral trends in the working world over the period to 2030

In light of the significant changes in our economy and society, the working world in Germany is undergoing a multidimensional transformation. This extends to the culture, content and intensity of work, the way in which it is organised, the forms it takes, and workers' values and expectations concerning work. The various dimensions of this transformation are having a combined effect on skill requirements and qualification needs.

The working world is not a homogeneous system, however. Work varies depending on the sector, organisation, field or region. Some sectors will adapt more dynamically than others to new technical possibilities and changes in the wider environment. Taking a cross-sectoral view, the working world in Germany is changing in a largely asynchronous manner; the speed and scale of the transformation processes vary from sector to sector. While some sectors (or individual organisations) are playing a pioneering role, change is slow to take hold in other sectors (or organisations) due to structural or cultural factors. While some fields will undergo

significant change or even disappear by 2030, others will remain essentially unaffected. This difference in the pace of change will increasingly also be visible within individual companies, depending on their size.

The predictions below describe the main cross-sectoral trends in the working world over the period to 2030. They are the outcome of a two-round Delphi survey of experts from policy-making, administrative, business and academic circles. The predictions outline the general direction of change in relation to important dimensions of the working world (work content and intensity, forms of work, etc.). However, as the transformation of the working world is taking place asynchronously, the actual extent of the change over time will, in some cases, vary significantly depending on the organisation and sector in question.

1. Work will become more flexible and complex

Globalisation and the digital transformation will drive forward greater flexibility regarding working time and location. Companies' – but also employees' – growing need for flexibility will increasingly erode traditional boundaries between personal and working life. In many sectors, the trend towards more complex, interconnected value-adding processes will continue. Work will increasingly be organised as projects which require cooperation beyond traditional team, hierarchical and company limits, resulting not only in greater flexibility, but also in what could be described as a "breakdown of the boundaries" on work processes. Conventional linear value creation models and agile, interconnected value creation will increasingly exist in parallel within organisations; tensions can be expected as a result. In fields where it is necessary for workers to be present at a specific location and/or at specific times, the natural "limits of the breakdown of the boundaries on work" will be reached when it comes to greater flexibility in how work is organised; natural team processes will also continue to make it necessary for workers to be present at a specific location at times. When it comes to flexible approaches to working, significant differences between sectors will remain in future.

2. Employment will become more varied

With the rise in more interconnected and flexible value creation models, types of employment will also become more varied. The standard employment relationship is expected to remain the most important form of

employment, but there will be greater opportunities to choose alternative forms of work over the course of working life and in specific life phases. This will result in a further increase in the importance of both individual and organised negotiation processes. While the rise in automation will tend to place workers in a more difficult negotiating position, demographic change will have the opposite effect. However, in future, workers' success in negotiation processes will probably depend more heavily on them having suitable skills and qualifications than is the case today.

3. Work will become more challenging and demanding in terms of content

In future, technology will be used more and more in all areas of work. However, it will increasingly be automated and run in the background, meaning that greater use of technology will not necessarily require a greater understanding of technology, depending on the field of application. The growing automation of routine tasks and intelligent assistance technologies will free workers from the need to carry out onerous, arduous and less appealing tasks, creating space for more complex and interesting tasks. This will make a further intensification of work and an increase in parallel work processes more probable. As a result, the variety of skills required by workers will increase.

4. Work will be made easier thanks to assistance systems, but also replaced and in some cases "hollowed out"

The help provided by technical assistance systems will also enable working conditions to be improved and will help to keep workers healthy. Thus technological change can indeed contribute to a humanisation of work. However, technological replacement of human work in some fields will also lead to a reduction in demanding tasks in work processes. In some sectors

and fields, the process of replacement by robots and algorithms will probably also include complex transitional phases in terms of the organisation of work and labour demand, with workers facing corresponding challenges in adapting to this.

5. Workers' value systems will continue to become more varied

There is already a high level of variation in workers' value systems today. This is expected to increase further in future. Workers will have higher expectations regarding work content, working conditions and how work is organised. Yet depending on their personal preferences, their expectations will diverge on a qualitative level. Greater variety in value systems will tend to result in more individualised views on what constitutes an ideal working world. Every worker will in future define for himself or herself what "good work" means. This will add another dimension to diversity in workforces, alongside age differences, cultural diversity, etc., and this could cause tensions, particularly in flexible or temporary team constellations. Diversity management will become more challenging.

2.3 Trends in the transformation of six selected sectors

The speed and scale of change in the business and working world vary significantly from sector to sector. To gain a better picture of the extent of this variation, this section will look at the trends in the transformation of individual sectors. Six sectors have been selected for this in-depth sectoral analysis; taken together, they account for around 70 % of workers (see Table 1). This sector-specific analysis is based on the statements made in the Delphi survey and in additional interviews with sector experts.

Table 1: Number of workers in the six sectors analysed, 2016

Sector	Number of workers	Proportion of workers
Industry, manufacturing and production	7.81 million	18 %
Crafts (focus on construction and electrical engineering)	5.36 million*	12 %
Banking and insurance	1.17 million*	3 %
Business services (focus on the creative economy)	5.88 million*	14 %
The public service	4.65 million*	11 %
The health care industry	5.33 million*	12 %
Germany	43.5 million	100 %

* Data for 2015.

Sources: Own representation based on Federal Statistical Office 2017, Statista 2016.

2.3.1 Industrial manufacturing and production

Pressure to boost process efficiency is a constant in the field of industrial production. The major challenges of the past two decades – which remain key – have been automation and greater flexibility in production. Automation, in particular, has already led to changes in required skills and workforce structure today.

Drivers of change
- As the Industry 4.0 paradigm increasingly takes hold, manufacturing processes will be controlled automatically, with a large proportion of optimisation and configuration processes carried out by the machines and systems themselves. Ideally, products will control their own passage through the production process in future.

- Robots are becoming more and more advanced; they are leaving the cages in which they repeatedly performed individual work steps at high speed, and are becoming "colleagues" which can be deployed flexibly, work hand in hand with humans, and learn different tasks (collaborative robots).

- Demand for customised products will continue to rise, with batch sizes of one increasingly becoming a reality in production processes.

Changes to the working world
Production, knowledge and development work will be closely connected in future. In manufacturing, indirect tasks such as planning, control, quality control, software development and integration will become much more important, while the actual physical production tasks will constitute a smaller proportion of the work. Production processes which can be controlled in real time and which are fully digitally interconnected will allow individual production steps to be adjusted flexibly, boosting custom manufacturing. Production processes will increasingly be interconnected across the boundaries of individual companies – in other words, from an individual company's perspective, they will involve both supplier networks and downstream value-adding stages. All in all, this will enable companies to react (more) rapidly to customer wishes. As processes become more dependent on technology and more interconnected, work will become more demanding. Workers will require an understanding of the system as a whole,

beyond their own tasks, to be able to operate and control the machines. Controlling and maintaining complex systems will also require advanced programming capabilities. Skilled workers and specialists will in some cases require skills which were previously only expected of experts, or they will have to work more closely with experts than before. Even for simple tasks, the ability to operate human-machine interfaces will become more important.

2.3.2 Crafts – focus on electrical engineering and construction

Much of the craft sector specialises in installing and implementing industrial products for individual customers. The craft sector mostly consists of small businesses which usually work closely with customers, and so it can respond with a relatively high degree of flexibility to changing technical requirements and changes in customer wishes.

Drivers of change
- Increasing complexity of technology, above all due to the fusion of IT and electronics / electrical engineering.

- Increasing complexity of collaboration on projects with other trades and value-adding partners.

- Problems recruiting the next generation due to demographic change and high numbers of people going to university.

Changes to the working world
The craft sector's focus on non-routine tasks means a low degree of automation. The effects of technological change can be felt in the sector, but will not lead to major structural changes. In electrical engineering, tasks will become more complex at the intersection with IT. There will be greater specialisation within crafts. Innovations will enable craft businesses to move into emerging growth fields. In construction, technological innovation will especially affect project management with other trades, for example in the framework of Building Information Modelling (BIM). In general, smart digital communication and management technologies will become more important in collaboration and

process coordination. Craft businesses will increasingly cooperate in value-adding networks so that they can offer complete packages, such as turnkey construction. Assistance technologies will become more and more important as aids in managing the growing complexity of the technical issues.

Industrial production and the craft sector will become more and more similar in terms of the need for flexible, individual work. The competition for skilled staff will continue to increase. Self-employment is an established step in setting up a craft business. However, the digitalisation of the working world risks exacerbating the trend in the craft sector of a worrying rise in the number of solo self-employed individuals who offer their services on terms which distort competition. It is essential to closely examine these effects of the platform economy and to consider social-policy action, especially with regard to provision for old age.

2.3.3 Banking services – focus on retail banking

Retail banking has been experiencing upheaval for several years. Bank mergers and the automation of services in the form of self-service machines and online banking are placing pressure on branch use. Virtual banks and fintechs (finance technology start-ups) with data-based business models are placing traditional banks under increasing competitive pressure.

Drivers of change
- Growing demand from customers for banking services to be available anytime, anywhere, similarly to what they are used to in e-commerce and other sectors.

- Increasingly complex regulatory requirements regarding infrastructures and services on the basis of new technological developments. The introduction of instant payments, in particular, requires the introduction of new, standard IT infrastructures.

- High cost pressure as a result of persistently low interest rates, regulatory limits on fees and growing competition is driving the automation of back office business processes. In response, banks are trying to expand their higher-margin advisory business.

Changes to the working world

The working world in banks is on the brink of becoming a highly automated digital technology industry, with even self-service machines being steadily replaced by virtual online services. This transformation will include a gradual further automation of back office business process.

There will be a rise in demand for more highly skilled advisory tasks relating to complex financial issues, and in the need for legal specialists to internally oversee regulatory requirements (e.g. compliance officers). Banks will expect workers to have higher qualifications; traditional skilled workers such as bank clerks will increasingly need additional qualifications in order to succeed in the labour market. New fields and types of work are emerging in the development, implementation and management of digital solutions, data security and data analysis.

2.3.4 Business services – focus on the creative economy

The creative economy – with the focus here on the advertising and communication market – is characterised by the fact that creatives constantly have to reinvent themselves. Creative potential often emerges from collaboration in new teams which bring together different types of input. Digital platforms enable workers in the creative economy to come together with ever lower transaction costs. There is, at best, limited added value to integrating many value creation steps in a single business.

Drivers of change
- The platform economy is paving the way for new forms of flexible, situation-specific cooperation and project implementation.

- The tools used in this type of work – e.g. software for creating communication tools (printed products, films, events, etc.) – are changing rapidly, as are communications media (e.g. social media), and thus also the forms and means of communication.

Changes to the working world
Business structures in the creative economy will remain small or shrink further. There will be a rise in micro-

preneurs and solo self-employment, as individuals will be able to join forces quickly to form temporary project teams and develop creative ideas within innovative team line-ups. It will also be possible for worldwide campaigns or events to be carried out effectively by local partners, with multinational companies no longer being required. Value creation will increasingly take place in flexible networks which cross the boundaries of the creative economy as well as national borders. The key challenges in future will be having a sense for new trends, the ability to engage in creative collaboration in constantly shifting teams with people from different cultures and disciplines, organisational skills and project management, and the capacity for entrepreneurial thinking from the customer's perspective. The degree of automation will be very low (with the exception of process-supporting tools, such as algorithms for digital video processing or 3D printing for custom products).

2.3.5 The public service

The public service contains a large number of different fields and areas of work with varying potential for automation, e.g. routine processes in the public administration which currently involve a great deal of paperwork (notification procedures, public procurement, approval procedures and application systems); the recording of process data, e.g. environmental data from companies; documentation processes when recording evidence in the field, such as data on accidents; and policy advice. The various processes are affected by change to hugely differing extents.

Drivers of change
- Need to boost performance and efficiency in order to avoid staff shortages.

- Making it easier for individuals and companies to contact the authorities to deal with administrative matters.

- High costs of introducing new IT-systems.

Changes to the working world
E-government initiatives will aim to enable individuals and businesses to access the public service's administrative processes and services online; they will seek

to make these services more customer-friendly and, in the process, simplify internal procedures. Routine processes can be supported by algorithms, for example when it comes to examining tax cases or invoices, or compiling the key data from tenders in procurement processes. This will enable administrative officers to make more flexible use of their time, to concentrate on difficult cases and carry out spot checks on the automated analyses. The human-machine interface will become more complex in the public administration. Recording information digitally in the field will eliminate the need for the data to be manually transferred into computer systems. Data security and data protection issues will be of vital importance for data handling in the public service.

2.3.6 The health system

The health system is divided into the high-tech field of medicine – particularly in the case of intensive care and operations – and the low-tech field of long-term care. Due to demographic change, there is expected to be high cost pressure and a significant growth in demand for long-term care services.

Drivers of change
- Growing demand for health and long-term care services as a result of demographic change.

- Shortage of skilled workers and experts as a result of demographic change and the intense psychological and physical demands of the work, both in long-term care and in general and specialised medicine.

- Digitalisation and a shift to using robots are permeating certain stages of medical treatment and long-term care.

Changes to the working world
While the technological transformation will significantly change the possibilities in medicine and long-term care, the fundamentals of work in these areas will only change to a limited extent. Digitalisation will enable routine tasks, such as monitoring vitals and documenting care, to be carried out automatically and constantly; this will relieve the burden on staff and give them more time to engage with and pay attention to patients. Real-time data analysis will become possible; algorithms will help to identify deviations from what is expected, as well as newly emerging symptoms. There will be greater disease prevention options. Digital monitoring solutions will pave the way for decentralised care and telemedicine services. Home carers will need broad caring qualifications dovetailed with medical qualifications. In general, closer integration and cooperation will be needed between the various health care service providers.

Robots will be able to assist carers with individual steps in their work (such as lifting) and thus contribute to a humanisation of their work. New treatments will be based on cutting-edge biomechanical, biotechnological and sensory technologies, developed through trans-disciplinary collaboration. Doctors who are involved in their development and application will require medical and technical transdisciplinary skills. There will be a rapid increase in the use of robots in operating theatres. In addition, it will be possible for specialists to be involved "remotely", i.e. participate in procedures carried out in distant operating theatres.

3

*A **successful transformation:** the high-road scenario for 2030*

3. A successful transformation: the high-road scenario for 2030

3.1 Methodology overview

The "Situation report on future skill needs" study develops exploratory scenarios for the long-term future of the working world in Germany. By describing alternative futures in the form of scenarios, it paves the way for a discussion about future skill needs and qualification requirements, and about what action needs to be taken. Scenario planning is highly suited to systematically identifying and describing complex visions of the future. In general, scenarios combine positive and negative aspects and thus encourage reflection on risks and opportunities, options for action and strategies.

In the discussion about the desirability of possible futures for the business and working world of 2030, the normative high-road scenario was selected as the model of a desirable future of work against the backdrop of the transformations in technology, the economy and society. The high-road concept is based on the model of the institutional foundations of comparative advantage for economic models in international competition developed by Hall and Soskice (2001). The strengths of the German economic and social system are primarily its focus on social partnership, the economy's strong focus on exports, a strong SME sector and companies' high level of innovativeness, as well as the dual vocational training system and workers' high skill levels. The vision set out in the White Paper Work 4.0 also refers to this concept; the comparative advantages of the high-road economic model are to be used in the digital transformation to ensure that an internationally competitive business sector can continue to safeguard the foundations of "decent work".

As a contrast to this positive scenario, this chapter also outlines a low-road scenario. It describes a vision of the future in which many efforts to manage the transformation of the economy and the working world have failed. Like the high-road scenario, this alternative vision of the future is intended to encourage reflection and discussion. However, it does not serve as a basis for the analysis in subsequent chapters.

3.2 The high-road scenario

Summary – key aspects of the high-road scenario

The digital transformation of the economy paves the way for high productivity gains. International competition has intensified further, but the German economy is successfully holding its own with the help of innovative products and services, and is growing dynamically. Businesses have taken a forward-looking approach, have continuously driven forward innovation, and thus have avoided severe disruptions in the market. Value creation has become more complex: to a much greater extent, value is created by means of systematically interconnected, hybrid products and services, which are produced by agile value-adding networks of businesses from various sectors. This provides the flexibility which is needed to respond to volatile and fast-paced markets. Initial and continuing vocational training programmes have been developed further and have become more attractive. The competition between higher education and vocational training has abated, and at the same time they have become more closely integrated. This allows a better match to be achieved between skills supply and demand, and makes it possible to adapt to the changing requirements resulting from technical and structural change. Employment histories have become more flexible, with careers being focused more on life phases and planned individually, as part of a forward-looking approach.

Vision of the working world in 2030

This scenario is described from the perspective of the world in 2030.

Economic and social situation in 2030
The German economy is internationally competitive and growing dynamically. The digital transformation of the

economy has paved the way for strong productivity gains which, together with rising exports and domestic sales, have contributed to dynamic economic growth in Germany. Due to businesses' forward-looking adaptation, a very large number of companies survived the structural transformation, although most companies now have a very different structure and focus.

In the course of the structural transformation, the number of workers in industry has declined slightly, while employment in many service fields is rising. The number of workers in the field of business services has undergone especially strong growth – in terms of the growth rates – while in absolute terms, the social professions recorded the strongest increase.

Economic growth and negotiations between the social partners are facilitating an inclusive working world with fair incomes, opportunities for personal development and job security, despite what have in some cases been major changes in fields of work and shifts in occupations. These changes are resulting in some individuals facing challenges in adapting to sometimes major challenges. The prerequisite for successful structural change is engagement in ongoing continuing training and lifelong learning at all skill levels and creating the necessary conditions and framework for this.

High levels of employment and good incomes are the prerequisite for growth in domestic sales, which supplements the economy's focus on exports and can, to some extent, offset global market fluctuations. Social partnership and co-determination remain important pillars of the German business and working world. Skilled labour shortages have been largely mitigated by successful initiatives to activate the potential labour force, integrate migrants and promote skills. In addition, widespread use of assistance technologies is reducing workloads in many sectors, which is helping to ensure that workers remain in better health.

Businesses in 2030
In 2030, businesses in most sectors are characterised by a high level of digital permeation and internal processes which have been optimised for efficiency. They operate in closely interconnected business ecosystems and have to act in flexible and agile ways.

The need for greater flexibility in the workplace has increased significantly. Growing international competition goes hand in hand with volatile demand and a high level of adaptation pressure. In the service sector and commerce, customer demand for constant availability of goods and services has made flexible work processes even more widespread, for example in the form of highly flexible deliveries in online commerce or flexible household-related services. New ways of organising work developed by the social partners, together with a suitable legal framework which is geared to flexibility, are enabling businesses to cope with their flexibility requirements and give employees greater control over their working time.

Workers in 2030
Individual, forward-looking career planning has become mainstream and is carried out by workers in all phases of life. In an interconnected and flexible economy, flexible work histories are regarded by the majority of workers and employers as a way of balancing their goals in life. Individuals choose forms of employed and self-employed work to suit their life phase. Employment with social insurance coverage remains the norm, and employees and organisations jointly find solutions to shape the volume of work in line with the needs of both sides. Phases of self-employment are on the rise and are integrated into the social security system.

Employment models which incorporate a life-phase approach and flexible work processes take account of organisations' need for greater flexibility and individuals' needs. Flat hierarchies and entrepreneurial approaches make work content more demanding, but the implementation of work projects more flexible.

Developments over the period to 2030
Incremental structural change – forward-looking business development
The structural transformation of the German economy and the working world continues. Sectors and occupations are gradually transformed by the digital revolution and the continuing tertiarisation of the economy, as well as by the the energy transition and the shift to resource- and energy-efficient economic activity. Thanks to forward-looking business strategies and economic policies, the technological and structural transformation

is anticipated and steps to adapt are taken in good time; co-determination is adapted in light of new challenges. This enables companies to systematically reorganise their business areas in such a way as to largely avoid disruption, but with much of their value creation continuing to take place in Germany. This enables competitiveness to be maintained in key sectors. It also allows initial, further and continuing vocational training to be adapted at an early stage to meet changed skill requirements. The trust and cooperation between employers and employees and the institutions which represent each side has played a major role in coping with ongoing, sweeping structural change in the labour market. The social partners and policy-makers in the field of economic and innovation policy work jointly to develop and implement new technologies and business areas and corresponding education programmes for workers.

Innovation processes
The public sector supports developments, e. g. by providing a legal framework which gives the social partners sufficient scope for flexible regulations, and by stepping up its innovation efforts in the field of digital and transport infrastructure and innovation funding for SMEs. Financing partners enable even smaller companies to access investment funds.

Innovations, especially in relation to the digital transformation, lead to an optimisation of organisations' processes. This boosts the competitiveness of German companies. The innovation processes progress differently from one industry to another; an industry-specific and sector-specific innovation gap can be observed. Companies are made aware of the impending technological advances, prepare strategically for the transformation, and can thus shape it in a targeted and organisation-specific way. Following some initial teething troubles, the digitalisation of company processes is implemented very consistently even by small and medium-sized businesses. SMEs act in a highly flexible way and are involved in value-adding networks with rapid processes, flexible production technologies and individual offerings.

Shifts in company processes
Innovations are having a significant impact on how organisations' processes are designed. There have been advances in the automation of production, for example,

especially with regard to non-routine tasks; once-isolated data collection processes are virtually linked; data processing in bookkeeping and administration is automated, etc. In this context, the human-machine interface is becoming more relevant in these processes in many jobs, including in office and knowledge work.

Business models are changing. The digitalisation of processes is boosting the significance of individual value offerings which customers have helped to design. Growing use of Big Data means that forward-looking solutions are becoming more important. A large proportion of goods and services are marketed and provided in the form of systemically interconnected, hybrid offerings, i.e. products are offered as combinations of products and services or purely as services. This requires complex interactions between companies of all sizes acting together within value-adding networks.

Intensification of globalisation and competitive pressure – organisations' growing need for greater flexibility
A trade-friendly international economic policy fosters continuing growth in global trade. Despite a significant intensification of international competition, the export-oriented sectors of the German economy generally do well. In the SME sector, the degree of internationalisation increases further; digital platforms mean that SMEs and micropreneurs are also increasingly active in international business. Exports account for a large proportion of German economic growth. The volatility in international markets caused by growing competition from Asia and other emerging economies, as well as by fluctuations in demand and more complex value-adding models, poses a major challenge for companies.

Within companies, employees are given greater freedom in order to boost the companies' agility and adaptability. To ensure that rising workloads are not the result of individuals taking on greater responsibility, legal regulations have been established and steps relating to the organisation of work have been taken in order to protect workers' health and safety, while taking into account organisations' needs. This has led to workers taking on greater individual responsibility. For many employees, the fact that they have gained a greater say and control over their work, together with the boost to their self-efficacy, also eases the burden on them at a time when their working and personal lives are becoming increasingly complex.

Attractiveness of the vocational training system and of opportunities for continuing vocational education and training

Initial and continuing vocational training have retained their role in providing the skills required in the labour market. It remains the case that around half of school leavers each year enter higher education. However, qualifications acquired via the dual vocational training system, which have cemented their status as a future-oriented alternative on a par with a degree, are equally sought after; the difference in earning prospects compared to a bachelor degree has, on average, narrowed even further. In many occupations requiring vocational training, particularly in combination with subsequent career advancement training, earnings are actually significantly higher than for those who hold academic qualifications. Flexible continuing vocational training programmes are, alongside regulated career advancement training, another avenue for members of the potential labour force to regularly expand and update their skills. Both systematic vocational development to adapt workers' skills and migration of skilled workers, specialists and experts have a role to play in meeting skill needs. The social partners have made a significant contribution to safeguarding employment by offering tailored, in-company further training programmes.

Changes in career paths

Individuals are, on average, intrinsically more motivated to undertake further and continuing training, and this is accompanied by a significant increase in workers choosing – but also being forced by structural change – to change fields and to move to different locations. Even groups who were previously at a disadvantage with regard to continuing training, such as low-skilled individuals and older employees, gain targeted opportunities for career advancement as a result of vocational development or skill upgrading. A proactive attitude to career management is also softening the tangible impact of the progressive automation of routine manual and knowledge-based tasks.

Coordination with past and potential employers and interaction in self-organised support networks is key in ensuring the success of this flexible career management. This is supported by a legal framework which makes it easier to move flexibly between different forms of work, as well as by relevant solutions agreed by the social partners.

3.3 The low-road scenario

The low-road scenario brings together a logical combination of key factors which call into question the long-term preservation of the German economic and social system. This scenario presents an alternative to the vision offered by the high-road scenario. The developments which lead to the low-road scenario are plausible and possible – just like those leading to the high-road scenario. The low-road scenario sets out developments in the event of polarisation in the labour market and conflict between the social partners.

Key aspects of the low-road scenario

The pace of innovation in Germany has slowed, R&D investment is in decline, and the digital permeation of the business and working world is progressing slowly by international standards. Economic growth is stagnating in Germany. Due to market volatility, organisations have a strong need for greater flexibility. The trend towards higher education is unchanged and fewer people are entering the dual vocational training system. This is leading to tangible problems in terms of skills mismatches in the labour market.

Economic and social situation in 2030

The digital permeation of the business and working world has progressed at no more than a moderate speed. Past forecasts predicting a high-tech economy and a massive wave of automation have proven to be overly optimistic. This is due to a relative decline in investment and engagement by German businesses and the government by international standards, as well as infrastructure deficits, particularly outside of agglomerations.

By international standards, the German economy has become less competitive. Protectionist tendencies lead to more trade barriers compared to 2017. Export-driven sectors have become somewhat less important in the national economic structure in relative terms. As domestic demand is also weak, economic growth is stagnating.

The labour force participation rate has risen due to an increase in female labour force participation, longer working lives and a higher employment rate for older workers. At the same time, the total labour force has declined in absolute terms from 45.5 million to 43 million people as a result of demographic change. There is a widening gap between the employment prospects of a few sought-after specialists in bottleneck occupations and those of other workers. The social partnership model has become much less significant. Inequality in the labour market is also leading to tensions within society.

Businesses in 2030

The implementation of Industry 4.0 concepts and digitalisation strategies in services are only standard in a few industries. By international standards, innovative business models are not very widespread in Germany. The slow implementation of digitalisation has affected the pace of innovation in all sectors.

The need for greater flexibility by organisations has significantly increased. Greater demand volatility and adaptation pressure in competition is requiring businesses in export-oriented sectors, as well as in the fields of commerce and services, to make changes in how they organise their work and in forms of employment.

Companies determine their forms of employment and pay structures individually. Those which offer their employees unattractive working conditions over the long term face high levels of staff turnover and low levels of job satisfaction.

Significant problems exist in terms of skills mismatches in the labour market, leading to tangible shortages of skilled labour. The trend towards higher education has resulted in further growth in the proportion of graduates in the labour market, and it has proved impossible to halt the decline in apprentice numbers in the dual vocational training system. The number of low-skilled individuals has risen.

Workers in 2030

In a challenging economic context, it is becoming more and more difficult to balance workers' preferences and the business constraints faced by organisations as a result of customer wishes. Particularly in increasingly flexible value-adding networks, the traditional negotiation processes between the social partners are becoming much more difficult. The tensions between the social partners have increased significantly in general.

Collective bargaining coverage has continued to decline. Individuals' ability to negotiate has come to play a much more important role in the design of employment contracts.

The rise in automation and the internationalisation of labour markets are placing constant pressure on workers in Germany. In most fields, a high level of willingness to embrace change – in terms of both location and work content – is a precondition for further employment chances. In turn, a lack of willingness by employees to embrace change is putting the commercial basis of many SMEs at risk by frustrating their digitalisation efforts. However, workers are tending to take a wait-and-see approach to this trend, due to the lack of any framework for active, forward-looking career planning. As a result, only a minority can take suitable steps in response to changes in their environment. Due to growing problems in terms of skills mismatches, this attitude is leading to disruption in employment histories which, in many cases, could have been avoided. It is consequently becoming more difficult to successfully navigate the rapidly changing labour market. It is not uncommon for the workers concerned to experience long adjustment phases in which unemployment alternates with short-term employment or, out of necessity, phases of self-employment, before they find a stable new career path.

4

Skill needs in 2030: widespread shifts

4. Skill needs in 2030: widespread shifts

Like the working world as a whole, occupations and fields also undergo constant change. There is variation between different companies and sectors in this context, and in some cases even between a single group's various sites. Whether as a result of new trade relations, changed business models or technological advances – new tasks emerge while others vanish. New tasks, in turn, require new skills, and changed skill needs result in a shift in the demand for labour.

Digitalisation is currently an important driver of this shift. A study by the German Association for Information Technology, Telecommunications and New Media (Bitkom) underlines how this trend has affected German companies over the past ten years (Bitkom 2016): around 10 % of the companies surveyed stated that certain types of job had disappeared in their company in the course of digitalisation over the past ten years, while more than twice as many companies confirmed that they had introduced new types of job over the same period as a result of digitalisation. The types of job which had disappeared included post room officers, stenographers and telephone switchboard operators, among others.[1] By contrast, jobs which involve more complex tasks and skill requirements have emerged, such as data mining specialists, "feel good managers", or 3D printing specialists. The shift to more complex tasks and corresponding skill requirements will continue in the coming years, according to the companies surveyed by Bitkom.

With regard to the outlook for 2030, this view is supported by the results of the analyses and expert surveys carried out in the process of producing this situation report. The high-road scenario depicts a future working world in which skill needs become more demanding and complex due to highly dynamic innovation, continuing intense international competition, and new value creation models. The scenario also describes a labour market in Germany in which the stakeholders have largely succeeded in shaping the impending transformations, and in which skills demand and supply is essentially balanced in 2030. This chapter looks at the probable shifts in skill requirements caused by the developments outlined in the high-road scenario, in the view of the experts consulted from business, policy-making and academic circles.

Analyses of future needs inevitably involve a degree of uncertainty. That said, the predictions outlined in this chapter about how skill needs will develop are regarded as highly probable both in the literature and in the view of the experts surveyed for this project. For the sake of readability, this chapter will therefore generally phrase these predictions as developments which "will" happen, rather than "are expected" or "likely" to do so.

4.1 Skills and types of task

The term "skill", as used in this study, is based on the definition developed in the OECD Skills Strategy, which ensures that international literature and data can also be used. According to the OECD Skills Strategy, "skill" means the bundle of knowledge, attributes and capacities that enables an individual to successfully and consistently perform an activity or task; skills can be built upon and extended through learning and practice (OECD 2011).

---

1 The positions mentioned here are based on the information provided by the companies surveyed in the Bitkom study; the authors do not intend to give the impression that these positions have already vanished entirely from the German labour market.

Table 2: Types of task, based on the Eurofound classification

Types of task		Description and subcategories

Work content	1. Physical	Tasks aimed at the physical manipulation and transformation of material things
		   a. Strength
		   b. Dexterity

	2. Intellectual	Tasks aimed at the manipulation and transformation of information and the active resolution of complex problems
		   a. Information processing
		      i. Literacy
		      ii. Numeracy
		   b. Problem-solving
		      i. Information-gathering and evaluation of complex information
		      ii. Creativity and resolution

	3. Social and interactive	Tasks whose primary aim is interaction with other people
		   a. Serving/attending
		   b. Teaching/training/coaching
		   c. Selling/influencing
		   d. Managing/coordinating

Methods and tools	4. Methods	The forms of work and personal organisation used in performing the tasks
		   a. Autonomy
		   b. Teamwork
		   c. Routine

	5. Tools	The type of technology used at work
		   a. Machines (excluding information and communication technology)
		   b. Information and communication technology

Source: Based on Eurofound (2016).

The tasks which make up occupations and job profiles form the basis for the skill requirements for labour demand. In recent years tasks have increasingly become the focus of labour market research in the framework of the discourse about automation potential. The concept of tasks allows a structural analysis of labour demand: the widespread types of task can highlight not only the technical aspects of production processes in an economy, but also the organisational and social aspects. A study published in 2016 by the European Foundation for the Improvement of Living and Working Conditions (Eurofound 2016) proposes an integrated concept for analysis of tasks across occupations; it combines cognitive, manual and service-oriented tasks, defined in terms of work content, with tasks defined in terms of the work methods and tools used (see Table 2). In this context, work content, on the one hand, and work methods and use of technology, on the other, constitute two axes for structured observation of tasks in occupations.

2 With the exception of the group of armed forces occupations.

The concept of tasks serves its purpose as a stepping stone to an analysis of changes in occupations or jobs. The Eurofound study uses an index-based evaluation to quantify task intensity in the EU member states for occupational groups, using the ISCO-08 classification[2]. In this context, task intensity refers to the relevance of a certain task for a major occupational group, which the Eurofound study calculates using indices. The task intensities can be displayed as a heat map (see Figure 4). In this context, several patterns are visible with regard to skill levels. As the skill level rises, intellectual, social interactive, and method-related tasks become more important. Routine tasks are an exception; they are strongly represented for skilled workers, in particular. The use of information and communication technology (ICT) also rises with the skill level, while physical tasks and the operation of machines (excluding ICT) become less important.

Figure 4: Heat map of task intensities for major occupational groups in the EU

EUROFOUND HEAT MAP 2016 (adapted)	Task classification												
	Physical		Intellectual		Social and interactive				Methods			Tools	
	Strength	Dexterity	Information processing	Problem-solving	Serving and attending	Teaching	Selling and influencing	Managing and coordinating	Autonomy	Teamwork	Routine	Machines (excluding ICT)	ICT
Managers													
Professionals													
Technicians and associate professionals													
Clerical support workers													
Service and sales workers													
Skilled agricultural, forestry and fishery workers													
Craft and related trades workers													
Plant and machine operators, and assemblers													
Elementary occupations													

(Row group label, left column: **Major occupational groups**)

Note:

The relevance ranges from dark blue = no relevance, to dark red = very high relevance.

0 = no relevance   100 = very high relevance
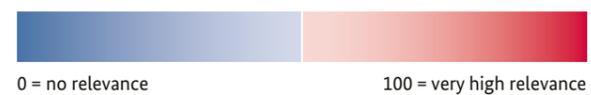
4.2 Shifts in general skill needs

This study uses Eurofound's integrated task-based approach as a basis for analysing the shifts in what tasks are in demand due to the developments in the working world and the wider context, as well as the resulting skill requirements. Unlike the Eurofound study's quantitative evaluation of the present day, this study uses the structure of the five types of task to develop a qualitative assessment of future skill needs. In this context, the ten ISCO-08 major groups are, for reasons of clarity, reduced to four occupational groups: professionals, highly skilled workers, skilled workers and elementary occupations. The delineation of these groups is based on the ISCO skill levels (see Table 3).

In the course of the two-round Delphi survey, the experts consulted were asked for a qualitative analysis of future skill needs in these four groups. The results of the survey are set out below, supplemented by examples from research on new and changing fields. In practice, work content and the methods and tools used are interlinked. It is thus difficult to describe changes in intellectual tasks, for example, without reference to the tools or methods used. Consequently, work content and methods and tools must be examined together.

Table 3: Occupational groups examined

ISCO skill level	ISCO-08 major groups, general equivalent		ISCO-08 major groups
1	Elementary occupations	9	Elementary occupations
2	Skilled workers	4–8	Plant and machine operators, and assemblers
			Craft and related trades workers
			Skilled agricultural, forestry and fishery workers
			Service and sales workers
			Clerical support workers
3	Highly skilled workers	3	Technicians and associate professionals
4	Professionals	1–2	Professionals
			Legislators, senior officials and chief executives

Source: Based on ILO 2012.

4.2.1 Physical tasks will continue to decline

In the experts' opinion, physical tasks will continue to decline across all skill levels. Further use of robots in production processes, but also in other highly physically demanding areas today, such as logistics, will reduce the demand for tasks dominated by strength or dexterity.

In addition to automation solutions, the growing introduction of physical assistance systems will play a major role. Over the period to 2030, collaborative robots and exoskeletons will reduce the physical demands in the fields of manufacturing and construction. This will primarily, but not solely, affect skilled workers and those in elementary occupations. A quick glance at technical developments in the health care sector shows that more highly skilled occupational groups will also be affected: while assistance systems will reduce the burden on (highly) skilled workers in the field of long-term care, there will also be a rise in the number of medical procedures involving robots (see also chapters 2.3.5 and 4.3.5). While overall demand for physical skills will continue to decline, the demand for skills involved in operating sophisticated physical assistance systems will rise. It can be assumed, however, that skilled workers and those in elementary occupations, in particular, will not require complex technical skills to operate these systems, as the assistance systems will be very user-friendly and the control processes will primarily run in the background – for example in the case of collaborative robots.

4.2.2 Automation of knowledge work – between support and replacement

Increased use of algorithms in knowledge work will, in the experts' view, have a similar effect on intellectual tasks as the increased use of robots and physical assistance systems will on physical tasks. In this case, it will primarily be (highly) skilled workers and professionals who are affected.

Particularly in the case of clerical support workers, affordable solutions from the field of robotic process automation will replace a large proportion of the routine tasks currently carried out by humans. It is true

that the automation of routine tasks will also free up time for more complex tasks. For example, freeing up insurance officers' time could enable them to examine difficult cases more closely (see also chapters 2.3.1 and 4.3.1), which requires critical reflection, complex work and, in certain circumstances, also creative work. However, digitalisation is also creating new fields and skill needs; at the level of skilled workers, for example, this is due to the spread of precision agriculture approaches for skilled agricultural workers and due to the increasingly widespread use of networked technologies in the field of building management systems for craft and related trades workers (see chapters 2.3.3 and 4.3.3).

Greater use of algorithms will increasingly also affect routine tasks and simple research tasks in professional occupations, for example in the form of automated file analysis in law firms, or automated or machine-assisted diagnosis when imaging techniques are used in the health care sector. Advances in the field of artificial intelligence will also pave the way for growing use of cognitive assistance systems, which can provide help in assimilating and evaluating information and decision-making in complex situations.

Almost all workers will have to deal with human-machine interfaces. In general, digitalisation will make basic digital skills – significantly expanded compared to today – a precondition for employability. The experts surveyed believe that the ability to deal with vast amounts of information and data will become more important at almost all skill levels. Dealing with "Big Data" (or, more generally, with data sets which the human eye alone cannot process) will in many cases be considered a basic digital skill thanks to easy-to-use software solutions, while at the same time highly complex analytical requirements will lead to a further increase in the use of specialists in this field. In addition, demand for specialised digital skills in the field of programming and process design will continue to soar. This includes the ability to transfer, across disciplinary boundaries, the results of scientific research in a useable form for industry or services. Last but not least, the high pace of change in the field of digital technologies will also increase the need for workers at all skill levels to be willing and able to learn, for example in the field of data protection.

4.2.3 Soaring demand for social and interactive skills in a highly interconnected and service-oriented world

The experts consulted believe that digital assistance systems will further increase the degree of work intensity and multitasking possibilities for professionals and highly skilled workers, in particular. This makes effective personal organisation even more necessary in order to be able to successfully handle more complex work content and processes. Working in networks within a single company and across company boundaries will become more important, resulting in a greater need for communication and organisational skills. Increasingly complex products and services also require greater collaboration in interdisciplinary teams, with a need for specialised technical knowledge and a capacity for interdisciplinary thinking and communication. In complex work contexts, systemic thinking is another ability which will become more important, to allow tasks to be understood in their wider context, and challenges in flexible value-adding networks to be considered critically and solved creatively.

Complex products also require more intensive advisory services. This, too, will mean that many skilled workers have to develop additional skills. For example, if digitalised production allows the (decentralised) manufacturing of highly customised goods, such as items of clothing, customers must be given more detailed information about the possibilities and challenges in order to avoid overstretch and disappointment. Irrespective of skill level, continuous education and training on

the job and outside of working hours will be essential. The ability to impart knowledge is becoming more important, and support must also continue to be provided for workplace learning.

In this context, leadership roles and the requirements faced by leaders are also changing. In flexible team constellations, many more workers than today will regularly take on responsibility in situational and lateral leadership contexts. In this context, leadership tasks are changing, as leaders will play more of an orchestrating than supervisory role. As mentors and "facilitators", leaders will motivate and empower staff to carry out their tasks as good as possible. This, too, will require strong social skills.

4.2.4 Conclusion: transversal skills will be particularly sought-after, but specialised skills will remain important

Figure 5 depicts the experts' qualitative statements as a task heat map, showing the expected future relevance of different types of task for the major occupational groups. Overall, the experts' views show a clear trend regarding how skill needs will develop in the context of digitalisation and automation: the automation of mechanical and cognitive work processes will shift the demand for labour towards fields with a high proportion of complex tasks requiring a mix of intellectual, social and organisational skills, while still requiring a high level of technical knowledge. This shift in skill requirements applies to all skill levels to a greater or lesser degree.

Figure 5: Heat map of future skill needs on the basis of qualitative assessments by the experts surveyed

HEAT MAP Task classification and occupational categories in 2030		**Task classification**												
		Physical		**Intellectual**		**Social and interactive**				**Methods**			**Tools**	
		Strength	Dexterity	Information processing	Problem-solving	Serving and attending	Teaching	Selling and influencing	Managing and coordinating	Autonomy	Teamwork	Routine	Machines (excluding ICT)	ICT
Major occupa-tional groups	Managers													
	Professionals													
	Technicians and associate professionals													
	Clerical support workers													
	Service and sales workers													
	Skilled agricultural, forestry and fishery workers													
	Craft and related trades workers													
	Plant and machine operators, and assemblers													
	Elementary occupations													

Note:
Relevance ranges from dark blue = no relevance, to dark red = very high relevance.

- 0 = no relevance
- 1 = almost no relevance
- 2 = low relevance
- 3 = intermediate relevance
- 4 = high relevance
- 5 = very high relevance

Source: Own representation based on Eurofound 2016. This graphic applies the qualitative assessments from the Delphi survey to the structural approach developed by Eurofound. The heat map should therefore not be regarded as a continuation of the original heat map published by Eurofound.

Hybrid skill profiles which combine entrepreneurial thinking and acting with creativity, social skills and technical expertise are expected to continue to ensure good employment prospects in the future working world, and will become the fundamental prerequisite for employability in more and more occupations and fields. Broad transversal skills must also be supplemented by in-depth expertise in a specific area, as set out in the "T-shaped model" of skills development.[3] Two factors, in particular, are responsible for this: on the one hand, the rise in work being organised on a project basis, with working groups and individuals facing growing responsibility and project-management requirements; and, on the other hand, the increased need for communication and coordination across the boundaries of working groups, companies and national borders. This also applies to micropreneurs, whose numbers may potentially grow, and whose actions must reflect personal organisation and entrepreneurial thinking.

Given the increase in cooperative processes and growing expectations that skilled workers, in particular, but also those in elementary occupations should assume responsibility and organise their own work, the shift in skill needs is causing a disproportionate rise in demand for social skills and a capacity for structured working. Demand for ICT skills is also rising at all skill levels, although this is expected to be mitigated by the development of easy-to-use hardware and software and unobtrusive, automated background processes.

The increasingly rapid transformation of the working world is requiring workers at all skill levels to show a readiness to change and an ability to adapt. Against this background the education system has a key role to play. If a wide spectrum of workers will be taking on more social and interactive tasks and dealing with complexity and ambiguity in the future, changes will also be needed to educational content and methods in order to better support the development of these skills. It is, for example, likely that different approaches to learning are to be used in future than those which are currently widespread in the world of initial and continuing vocational training. A more in-depth examination of the usability of informal learning, as well as new forms of formalised learning, will play a role in this context.

4.3 Shifts in sector-specific skill needs

While the shifts in general skill requirements can be described across sectors, trends in sector-specific skill requirements inevitably differ from sector to sector (see chapter 2.3 for an overview of the trends in the transformation in the six sectors examined in this report).

4.3.1 Industrial manufacturing and production

The (first) industrial revolution was not a one-off event; instead, it unleashed a wave of innovation in production which continues to this day and stretches into the future, driven by a succession of technological advances – from the introduction of the steam engine, to computer-integrated manufacturing, to Industry 4.0. In each case, the fundamental technical innovations have led to machines taking over manual work and have resulted in shifts in skill and qualification requirements.

The productivity gains in human work caused by machines will continue steadily over the period to 2030. Industry 4.0, which revolves around "networks of manufacturing resources (manufacturing machinery, robots, conveyor and warehousing systems as well as production facilities) that are autonomous, capable of controlling themselves in response to different situations, self-configuring, knowledge-based, sensor-equipped and spatially dispersed and that also incorporate the relevant planning and management systems" (Recommendations for implementing the strategic initiative Industry 4.0), is leading to the development of intelligent and rapidly adaptable product development, manufacturing and logistics networks. Materials are increasingly becoming capable of sending information to manufacturing machines

---

3 A skills profile is T-shaped if it combines generalist knowledge in various areas (the horizontal bar of the "T") with in-depth specialist knowledge in a specific area (the vertical bar of the "T"). Against this background, the literature refers to the "T-shaped model" or "T-shaped professionals".

and production sites – e.g. what type of processing is required or what the next logistical step is. This is contributing significantly to a more individual approach to industrial manufacturing, as the production process itself – and not just individual procedures or steps – is automated and integrated. This also enables robots to play a greater role, for example by supplying machines with the appropriate workpieces or materials.

The Industry 4.0 vision places the customer for each individual workpiece at the centre of the entire production process: manufacturing will in future be able to adapt to reflect the requirements of individual customers and orders. As part of the Industry 4.0 paradigm, planning and control tasks are shifting, or are expected to shift, towards decentralised, self-organising systems. In this context, decentralised work teams are expected to be given greater independent responsibility in the production process, which in turn makes greater skill requirements necessary at the local level. Staff will control production in teams which have greater powers and responsibilities than they do today. Taken together, these two factors – a greater focus on customers and the decentralisation of planning and control – will also make communication with customers part of the tasks of workers on the shop floor.

Another key change will be the introduction of robots which work with humans without a safety barrier (human-robot collaboration or man-machine interaction, MMI) and which can perform a variety of tasks. These lightweight robots will often be mobile and much smaller than traditional industrial robots, which repeatedly perform the same process steps at high speed behind safety barriers. It will therefore be possible to bring lightweight robots to different locations and deploy them flexibly. They will be equipped with touch-sensitive sensors to ensure that they do not injure any members of staff and that they can precisely recognise the exact position of the workpiece and the screws or welding spots. Humans will work hand in hand with the robots, and in this way the robots will, for example, improve workplace ergonomics. Artificial intelligence will mean that machines are capable of learning and can adapt to the special characteristics of the individual user. Speech and image recognition will in future enable almost natural communication between humans and machines. Nonetheless, workers will have to be specifically trained in MMI skills to

ensure that they can collaborate with machines safely and with minimal errors from the outset.

The virtual connection of process steps in Industry 4.0 manufacturing will lead to the emergence of interconnected value-adding networks which extend beyond the boundaries of companies, sectors and countries. Data-based process control and (partially) automated quality control will significantly lower transaction costs in future. The prerequisite for this is a high level of standardisation of the systems used by the different partners in the network, in order to ensure a high level of interoperability (see Kagermann et al. 2016). Modern information and communication technologies will pave the way for a global network of process steps, colleagues, customers and partners with data in the cloud. It will be possible to access the data from any location, bringing a new degree of freedom for flexible work organisation even in manufacturing, to some extent – a tendency which is already visible today, as remote maintenance and remote control become increasingly widespread.

Even if machines' communication interfaces become ever simpler, workers will also have to keep up with the increasingly technological and complex nature of the machines, and be able to understand production processes not just in terms of a single step, but in the context of the system as a whole, so that they can act correctly. The capacity for data reduction, analysis and interpretation will generally become more important in the world of digital production: to what extent a company is capable of identifying the data which is relevant for decisions among exponentially growing quantities of data will become an ever more important factor in industrial competition. Manufacturing workers will in future be expected to play a part in this, while data mining experts will also be needed.

A major challenge will also emerge from rapidly changing business models. Data-driven business models and the shift from products to combinations of products and services or pure services will bring about sweeping changes in the requirements for manufacturing and the relevance of manufacturing in a customer's value-adding processes. Innovations within individual sectors will also radically transform the tasks in production and manufacturing as a whole and result in corresponding changes in employment structures. For example,

the introduction of new drive technology in the car industry will make the manufacturing of power-train components less complex, while conversely the vehicle's digital connectivity and new functions – particularly (semi-)autonomous driving – will result in greater complexity and new design and development requirements.

In general, major structural shifts can be expected in the importance of tasks. There will be a decline in the relative importance of routine tasks, such as repetitive ones relating to monitoring and controlling machines, completing forms, etc., and of manual tasks, while abstract tasks will play a much more important role. It is already clear today that abstract tasks – IT tasks, programming, leadership, development, research, design, negotiating, etc. – are becoming much more important overall (Arntz et al. 2016). The closer integration of production, knowledge and development work referred to above will also require skilled workers, specialists and experts to work together more closely and coordinate with each other to a greater extent.

The use of artificial intelligence (AI) will in future allow the development of production systems which continuously improve themselves while running, and which can adapt to changing circumstances. During the transition to AI-driven production processes, at least, this will also lead to new quality control tasks performed in dialogue with the skilled workers who use the machines and with developers. This, too, will result in new and greater skill needs. Workers who today operate a machine and thus have a clearly defined range of tasks may tomorrow need to be able to control, correct and optimise a system which is capable of learning.

On the whole, "analogue" tasks – for example in the maintenance and servicing of machines – are not expected to become entirely irrelevant in future. Instead, workers will be required to have a wider skills profile, with traditional skills complemented by new, expanded skills.

4.3.2 Crafts – focusing on electrical engineering and construction

An electronics technician's work will become much more complex over the period to 2030 and will be used in more and more fields. As the Internet of Things becomes more widespread, digital networks with interconnected sensors will become even more important as central infrastructures in buildings and in industrial applications. The relevant fields of application, such as smart homes, smart buildings, Industry 4.0 and Economy 4.0, are invariably also fields for the crafts sector. The high innovation rate and short product life-cycles will mean that continuous adaptive learning is necessary in order to professionally install and maintain new products. It will be essential to take the feasibility of complex network installations in the context of a specific building or machine into consideration already at the planning stage. The development of virtual 3D models, as used today in the planning and design of new machines, will in future also be necessary when planning infrastructures and networks of buildings. Augmented reality assistants will in future guide electronics technicians through the implementation steps and help them to navigate the systems of conduits. Virtual reality (VR) will, firstly, allow buildings and products to be experienced before work begins on constructing them, which will enable low-cost planning adjustments. Secondly, VR will in future also allow detailed technical conduit and network planning in virtual space. As retrofitting is also an important task, the requirements regarding the documentation of installation work will be set ever higher, so that repairs and retrofits can be carried out efficiently.

In the interconnected world of the Internet of Things, more and more individual components will be equipped with sensors and be controllable via the network – whether they are refrigerators, awnings, skylights or production systems. Professional electronics work will thus become more important for almost all trades involved in construction. In addition, robots and drones will play a greater role in various fields – whether in manufacturing facilities or in agriculture – resulting in new fields of work for electronics technicians with different specialisations.

Electronics technicians' tools of the trade are also changing. Special connectors are already being produced using 3D printing today, while other specialised processes will become commonplace in future. The establishment of new transmission processes such as Li-Fi (light-based data transmission) will also result in new tools being required. Electronics technicians will in future collaborate very closely with IT specialists,

particularly networking specialists, as the complex technology will frequently have to be individually designed, and installation and maintenance experience will in turn play an important role in development and design.

Construction has always required cooperation between various different trades, which need to work together or after each other on a tight schedule. Construction companies will often act either as general contractors or craft partnerships, offering a one-stop shop for the various trades, up to and including turnkey construction. Planning documents will frequently be made available in electronic form, and this will form the basis for pricing, workflow planning, measurement and invoicing to increasingly be carried out electronically as well.

Architects supervising construction and managerial staff in construction companies will need to work with various sectors and be able to adapt to different fields' needs and specific characteristics. Integrated planning using models will provide a better overview of the work to be carried out, with precise, detailed specifications and simplified real-time project management. This ensures that, in the event of delays, subsequent construction processes can be automatically rebooked. Building Information Modelling (BIM) is the term used to describe the use of digital building models by various specialist designers, parties involved in the construction, and clients or subsequent building users. The aim is to avoid building data being recorded more than once, with the inevitable risk of transmission and communication errors, and to ensure that the digital building model can be used throughout the entire lifecycle. The necessary standardisation of BIM data models has now begun at the European level. That said, tools for electronic data exchange have already been available for some time, for example in the form of GAEB interfaces (GAEB: *Gemeinsamer Ausschuss für Elektronik im Bauwesen* – Joint Committee on Electronics in Construction).

Construction-related technologies will also be subject to ever shorter innovation cycles. This trend is illustrated by high-strength materials such as carbon concrete, nano-modified products such as aerogel insulation, or integrated building technology such as heating/cooling ceilings. RFID (radio-frequency identification) technology can be used to boost the productivity of construction processes – from the inspection of incoming goods,

to time recording, to component manufacturing. Prefabrication of components has also long helped to rationalise construction processes. In the past, however, there were narrow commercial limits to prefabrication, as each construction work is usually unique. As the digitalisation of design and manufacturing progresses, it may also be commercially viable to prefabricate unique items, as modern production systems for custom timber-frame house construction demonstrate.

In China and the Netherlands, the first examples of 3D-printed residential and functional buildings already exist today. Given the wide-ranging requirements to which construction works and components are subject in terms of structural stability, fire safety, thermal insulation, noise insulation, health and environmental protection, further advances will be needed before this technology can be used to produce entire structures.

Today's buildings must meet a wide range of at times contradictory requirements: they are expected to be safe and durable, resource-efficient and climate-friendly, comfortable and homely, environmentally friendly and healthy, but at the same time also economical and affordable. The designers and builders will thus have to resolve increasingly complex construction challenges. For example, an adaptive outer shell will control the heat flow; energy generation will be integrated into the building; water will be purified and treated in the building. Innovations of this kind will transform the requirements for technical handling and lead to collaboration with additional specialised trades.

Assistance technologies such as AR glasses will be used in future, while new aids to reduce physical strain when lifting and carrying heavy items will support work on construction sites – such as "exosuits" which significantly increase the worker's physical strength. This may enable older workers, in particular, to remain in work for longer. New types of safety clothing will also be commonplace on the construction sites of the future, such as protective clothing equipped with airbags, like those worn by some motorcyclists today.

On the whole, the main changes in the construction industry will focus on optimising the control of tasks and coordination with preceding and subsequent processes. Skill requirements will increase with regard to the implementation of complex technology.

4.3.3 Banking services – focus on retail banking

The banking sector is facing a major transformation. Retail banking will move away from in-branch services to online and mobile banking to a much greater extent than is the case today. The number of branches will accordingly decline in future, with the result that a large number of routine customer-facing tasks will vanish. In addition, internal back office processes will be further digitalised, and isolated systems will be largely integrated; manual bookkeeping-style processes and data entry will be unnecessary due to digital integration. Automated data medium exchange and paperless processing will become dominant. Due to the high complexity of the IT infrastructure and the financial products themselves, the importance of various partnerships between banks and external partners will continue to soar.

There will be a significant decline in the need for both (semi-)standardised customer advice sessions and manual data processing in the back office. Consequently, there is expected to be a sharp drop in the proportion of tasks which can be performed by bank clerks with no further specialisation.

Non-automated customer advisory services will in future concentrate on complex services. These will require specialised knowledge of the product range and highly developed advisory skills, including the use of various channels and aids. Advisory services will mostly be delivered virtually, and in some cases also in person at the customer's location. Depending on the bank's strategy, there will still be a limited number of flagship branches and customer centres. In all cases, the advisers will be required to have the ability to present financial products and their pros and cons in a clear and vivid manner, to enable customers to make an informed decision between various products. Persuasiveness and presenting skills will become more important as key skills for advisers.

In future, the advisory services provided by banks will be based on as full a knowledge as possible of customers' preferences and needs, gained even before the first advice session via an analysis of banking behaviour patterns, social media and information from Big Data analyses. In addition, the advisers will also take a proactive approach, based on data analysis, and offer customers banking services in advance of investment decisions or interim financing requirements. To this end, the advisers will have to work closely with data analysts, i.e. specialists in Big Data mining and social media research, or they may even be expected to have an in-depth understanding of the tools in the field of algorithm-based customer analysis.

As banking will in future take place primarily via digital interfaces, these interfaces must be as intuitive as possible to use, communicate seamlessly with background systems, and be protected against cyberattacks. Banks will need teams of skilled workers who can integrate customers' banking processes and information needs, UX design experts, software developers, online marketing experts and data security experts. Banking expertise will need to be combined with the skills required for customer-friendly design of the online interface and encryption technologies. Data protection and data security experts will play a pivotal role for the entire banking infrastructure, to ensure that customers' and employees' privacy rights and critical attack points can be permanently secured.

In view of the growing regulatory requirements, there will be a rise in the need for specialists with legal skills who can monitor and take responsibility for the development, introduction and oversight of the required processes. Compliance and money laundering are just two areas where the breadth and depth of regulation is constantly increasing and leading to new requirements. Here, too, a combination of banking skills and specialised skills in the legal field in question is needed.

As customers' personal digital devices will be their dominant interface with banks. The use of cash will gradually decline. Self-service machines and cash machines, although widespread today, will largely disappear, and with them related support tasks such as technical maintenance, restocking, etc.

4.3.4 Business services – focus on the creative economy

Only certain niche areas of the creative economy will be affected by automation in 2030. Instead, the industry will be characterised by better ways for creatives to collaborate in business ecosystems with other creatives

and customers. This and the need for new team constellations for different customers and topics will lead business sizes – which for the most part are already small today – to decline further, i.e. an increase in microenterprises. Competitive pressure will be very high: design crowdsourcing platforms like 99designs, where predatory pricing is common, will increase the pressure on prices charged by providers of creative services. Idea contests and competitive tendering will result in lower remuneration for actual creative output. Both of these trends will force the creative economy to develop new business models in order to tap into new revenue streams.

Workers in the creative economy will require wide-ranging skills with regard to entrepreneurial thinking and acting, personal organisation and project management. They will need good connections so that they are requested as a preferred cooperation partner in tenders, and so that they can secure suitable partners with a specific portfolio when putting together their own tenders. "Coopetition" – periods of collaboration with competitors – will become a matter of course. In projects themselves, project management involving network partners will be a special challenge, for which suitable project management tools and instruments for real-time collaboration will have to be used.

The actual tools used in creative work will constantly evolve and will repeatedly be replaced entirely as a result of innovations. The digitalisation of image and video technology has long since taken place; new lighting design possibilities using LED technology have caught on in recent years. New forms of perception and interaction in virtual or augmented reality are currently on the brink of a breakthrough. 3D printing is increasingly replacing traditional construction processes for the production of material objects. The capacity to continuously adapt to new technologies is a fundamental prerequisite in the creative economy. That said, it is also important to be proficient in old, analogue technologies and approaches, in order to actively play with them as breaks in the audience's perception and to use haptic, analogue experiences of "old" tools as creative inspiration.

Creatives, as people who bring together different perspectives and approaches and integrate ideas in diverse groups, will act as agents of change in many processes

(similarly to the open innovation concept) and will bring innovations to new sectors via their new ways of thinking and approaches. With cross-fertilisation of learning and innovation processes and the imparting of new experiences, the edges of the creative economy will merge with education, health care, tourism and coaching. Gamification designers will use game-based strategies ("serious games") to develop new approaches which medical professionals and therapists can use to bring about changes in behaviour.

Creatives must always have their finger on the pulse of new developments and will need to be able to monitor new ideas in various sectors and fields of application. They will need the ability to quickly gain an understanding of new topics and to transfer knowledge from one sector to another as cross-sector innovations, thus generating new impetus. Particularly in their role as agents of change, they will need a basic understanding of innovative processes and change management. This will require a combination of creative approaches and management skills, such as those currently being established in the framework of design thinking for business innovation, for example. As these tasks will often be performed internationally, language skills will also be necessary.

In the creative economy, formal professional qualifications and further training certificates will be of comparatively low importance. What counts will be, above all, output and references from successful projects. It will be important for creatives to organise their own continuing education and training, participate in MOOCs, and so on, in order to develop new ideas and keep up with changes in methods and tools. Social protection for solo self-employed individuals will also have a key role to play in this context.

4.3.5 The public service

The public service is a very varied and heterogeneous area of the working world. The focus here is on the tasks of the general services, i.e. political leadership and central administration, foreign affairs, defence, public safety and order, social welfare, policing, legal protection and revenue administration.

The public administration faces conflicting demands in the form of its financial framework, limited human

resources and new technical possibilities. Its "customers" – members of the public, but also businesses – expect official tasks to be carried out as simply as possible. This means, firstly, that it is necessary to cut bureaucracy, and secondly it offers the opportunity to streamline and accelerate communication processes and task completion.

By 2030, administrative processes can be expected to be based on more comprehensive data management (in the field of notification data, licences, etc.), which will take place seamlessly in digital processes. Thanks to the introduction of electronic procurement procedures, application processes and various types of electronic files, data will in future often be entered by customers, or entered only once by staff; this will eliminate the need to transfer data which has already been collected to digital systems, and will also eliminate related elementary tasks and routine processes involving large amounts of paperwork.

The key tasks in the public administration today include plausibility checks on data quality and consistency. These tasks, too, will be supported or even performed entirely by algorithms in future. Algorithms will allow preliminary screening of applications and thus identify the more complex cases for processing by specialists. Members of the public will benefit from new types of services: a large number of automated services will be possible, such as automatic reminders that licences, identity documents, etc., are due for renewal.

In addition, it will be possible to carry out data analysis to highlight important information and evidence of developments for policy-makers and the administration. In general, linking anonymised administrative data and freely available data – within the boundaries of data protection – will produce a wealth of knowledge. In order to actually leverage this knowledge, a growing number of analysts and data mining experts will be employed in the public service in future. This also has implications for working methods in policy advice and other fields based on evidence research.

In various processes, such as the continuous monitoring of massive amounts of notifiable data (for example environment-related emissions data from companies, tax-related data or bank transaction data), developing interfaces between IT-systems and adapting them to the specific requirements of different companies will be of central importance. Accelerating the exchange of process data by creating interfaces between public and company networks will require special data security and data protection skills.

Electronic management of files by multiple departments and, in certain circumstances, by multiple authorities, will make processes more transparent and allow them to be sped up as a result of parallel processing. In general, process automation will offer the potential to improve performance, allowing staffing shortages to be avoided.

It will be possible to organise licensing processes more transparently using digital technologies. Virtual communication methods will thus pave the way for new forms of public participation in state processes; however, employees in the public service will also face the challenge of shaping and moderating this virtual participation.

Due to investment constraints, digitalisation in the public administration will be a relatively slow but steady process. The ability to deal with constantly evolving IT-systems will increasingly become a prerequisite for all staff. Data processing will automatically handle less complex tasks, in particular, and this will help to enable staff to concentrate on more complex tasks and particularly relevant cases – in addition to carrying out spot checks on the automatically processed cases in order to constantly improve the quality of the algorithms. The new structures will increase officers' personal responsibility and teamwork. The staff will need wide-ranging data protection and data security skills, while IT experts will additionally need expertise in user-centric user interface design in order to model the virtual interfaces between the public administration and its customers in such a way that they are as user-friendly and easy to understand as possible.

4.3.6 The health system

In 2030, the health system will be heavily data-driven. Better sensors will allow the patient's condition to be continuously monitored and vital signs data to be analysed in real time. This will largely mean that health care workers do not need to carry out routine observations.

This health data will be used in diagnosis, and compared with data on patients in similar situations drawn from large, anonymised pools of patient data. Likewise, symptoms will be compared in near real time with the cases described in the medical literature. Doctors will thus receive a first opinion from these algorithm- and evidence-based expert systems, and will then form a second opinion based on the patient's medical history and a critical data assessment. The ability to analyse and interpret data will still be a central element of a doctor's work in 2030, although the variety of data will be significantly greater. It will remain the doctor's task to communicate the results to the patient in an empathetic manner. Rapid advances in wearable sensors will make it much simpler to monitor chronic illnesses, in particular. Telemedicine will undergo a massive expansion with reliable collection of health data. The technical aid of Ambient Assisted Living will allow even patients suffering from more serious illnesses or impairments to be cared for at home.

In the operating theatre, various support systems will play a more and more important role:

• 3D models of patients will help in operation planning.

• Imaging techniques will allow the simulation of even complex procedures.

• Remote-controlled micro-instruments equipped with sensors and actuators will be used in performing sophisticated, micro-invasive surgery.

• Surgical robots (like the da Vinci Surgical System today) will boost surgical precision: the doctor will be shown a magnified image of the operating field; support functions will correct tiny movements of the hand controlling the machine and allow high-precision incisions to be made, for example.

• Remote surgery systems will enable specialists who are not present to be involved in operations: they will be able to support the surgeon in difficult decisions or perform certain steps themselves by remote control.

In future, smart prostheses and orthoses will be available for patients, as well as nerve-stimulating replacements for human senses. The use of these systems will require advanced technical expertise on the part of the manufacturers of medical products, surgeons and staff providing care or treatment. New interdisciplinary medical and technical skills in fields such as biomechanics and biotechnology will be required.

The tasks of non-physician health care workers in medical institutions and long-term care facilities will become more differentiated: there will be tasks with greater skill requirements in the field of diagnosis, with medical staff attaching complex monitoring equipment and carrying out observations – supported by assistance systems which give users instructions in order to avoid errors in the observations which are taken. There will also be a growing number of specialised fields in relation to control, leadership and quality assurance tasks. These will give staff who have direct contact with patients more time to engage with and pay attention to them. Other tasks can be performed by those in elementary occupations. This differentiation will also enable staff to progress in their careers depending on their preferences and capabilities, but also as a result of new occupational opportunities, enabling care staff to remain in the profession for longer.

Technical aids will make work simpler in future for staff at various levels:

• Integrated data collection for the patient file will prevent redundant data entry.

• Augmented reality glasses will be capable of recognising patients and, accordingly, highlighting special care instructions from the patient file. This will make internal communication easier – e.g. in the case of shift work.

• New support technologies such as exosuits with "artificial muscle" systems or small, mobile, lightweight robots will make tasks involving lifting easier, for example.

In this field, technology will primarily be used to humanise onerous work, to boost the efficiency of routine data collection, and to improve communication and coordination, with the aim of enhancing personal contact with patients. The emotional components of working with patients and the ability to empathise with patients and encourage them will remain key

requirements for staff. At the same time, the level of basic technical understanding required will rise, as proficiency in relation to the human-machine interface will play an important role in more and more areas.

Linking the various health fields and areas of life will become ever more important for holistic health management. Medical care services will cooperate with nutritional, housing and leisure services, etc., and jointly develop an integrated service enabling even those suffering from chronic illnesses or age-related

impairments to live a self-determined life. The aim in this context will be to activate patients and persons receiving care. Prevention initiatives and systems to preserve health will become more important, with various care providers cooperating to offer targeted services.

In all areas of the health system, there will be higher requirements relating to data protection and data security issues, as growing use will be made of highly sensitive personal data.

5

Skilled labour policy in 2030: conditions for a successful transformation of the labour market

5. Skilled labour policy in 2030: conditions for a successful transformation of the labour market

Digitalisation and automation, as well as the emergence of new fields, will constantly influence and change the demand for labour over the coming decade and probably beyond. On the supply side, too, our ageing society and possible phases of higher immigration will lead to change. Nonetheless, given the technological transformation, the question of how to ensure continued employability will arise for a growing number of workers. In addition, the ongoing process of globalisation and climate change will play an important role. This development requires individual workers to be aware of the need for professional flexibility and ongoing vocational development. But companies also have an interest in maintaining their staff's productivity over the long term via systematic further and continuing training geared to their own skill needs. If it is possible to successfully minimise the gaps between labour supply and demand, between organisations' skill needs and the individual skills profiles available, this will be beneficial for all labour market stakeholders – a possible vision for skilled labour policy, looking ahead to 2030. Potential approaches will be outlined in this final chapter from a cross-cutting perspective, drawing on the conditions for a successful transformation of the labour market over the period to 2030 which were identified by the experts surveyed.

There exist already various monitoring instruments which study demand for different types of skilled labour (e.g. the STEM Meter, the Federal Employment Agency's skilled labour shortage assessment). However, there is no comprehensive, regular monitoring of future demand for skilled labour which continuously sets out demographic, regional, sector-specific and skills-related developments in a regularly updated forecast. To reduce the uncertainties outlined above regarding future demand for skilled labour and skills, new monitoring of future skilled labour needs has to be introduced.

This monitoring should take a cross-cutting look at the labour market and include a sector-specific and regional analysis in order to identify gaps at an early stage. Monitoring consists of several elements. First, a labour market forecast is required which can depict the dimensions referred to above – demographics, regions and skills. The findings could then be discussed at the political level and ultimately also feed into the work of the regional labour market stakeholders which play a role in securing the supply of skilled labour (e.g. chambers of commerce and industry, chambers of crafts, the social partners and their training institutions, investment promotion organisations and the Federal Employment Agency).

As well as organisations' skill needs, an analysis of the skills available should be included. A broad audit of skills supply and demand could also facilitate skills matching, which, among other things, would allow underemployment and involuntary part-time employment to be reduced.

Important starting points for the development of this kind of skilled labour monitoring are already identifiable in the specialist policy discussion on this subject: at the federal policy-making level, the activities of the Partnership for Skilled Professionals and the Alliance for Initial and Further Training are of central importance in this context. At the regional level, the networks for securing the supply of skilled labour should be singled out. When it comes to analysis tools, a foundation is offered in particular by the QuBe project on qualifications and occupations in the future, funded by the Federal Ministry of Education and Research and run by the Federal Institute for Vocational Education and Training (BIBB) and the Institute for Employment Research (IAB), and the ValiKom project, initiated by the German Confederation of Skilled Crafts (ZDH) and

the Association of German Chambers of Commerce and Industry (DIHK) in partnership with the Federal Ministry of Education and Research, which validates vocational skills acquired outside the formal education system. In addition, the chambers of industry and commerce already carry out skilled labour monitoring in many of Germany's *Länder* (federal states). These structures offer a starting point for establishing monitoring which provides useful findings with regard to securing the supply of skilled labour.

Against the backdrop of this situation report, the Partnership for Skilled Professionals' objectives and fields of action, agreed in 2014, remain of vital importance. We want to make it easier to balance work and family commitments, advance the employment and vocational development of older workers, support and welcome workers and jobseekers with a migration background, support young people and late starters who are interested in vocational training, maintain employability and shape the transformation of the

working world. If we are to continue to successfully secure the supply of skilled labour, we must reach joint agreement on constraints and initiatives in achieving this goal, maintain workers' long-term employability, further boost the "quality of work" in organisations, support collective agreements, and provide information and advice and promote networking between all stakeholders involved in securing the skilled labour supply.

Decisions on future steps towards achieving our goals will have to be taken in light of the findings of the monitoring. What is certain is that successfully shaping the transformation of the working world requires courageous action by all stakeholders. Individual workers, companies in their role as employers, works councils as representatives of employee interests, the social partners as mediators between the various sides, and policy-makers as regulators – they will all have to make a major contribution if the coming challenges are to be successfully overcome.

Annex

Annex

A.1 Overview of quantitative studies on work automation

Study	Time horizon	Key findings	Approach	Underlying assumptions
Occupation-based analyses of risk potential due to digital technologies				
Osborne/Frey 2013	The next 10–20 years	• 47 % of employees in the United States are at high risk of losing their jobs as a result of automation • Findings are not interpreted in terms of probability; instead, these jobs are described as being at risk • The potential for automation declines as the wage and education level rises	• Three engineering bottlenecks are identified, i.e. task categories which are difficult to automate (creative intelligence, social intelligence, as well as perception and manipulation) • A list of 702 occupations is drawn up with reference to these engineering bottlenecks • In a workshop, a group of machine learning experts selects 70 occupations which are regarded with a high level of confidence as being automatable • A statistical model is used to extrapolate the remaining 632 occupations from this assessment • The result is a probability of automation between 0 % and 100 % for each occupation • Finally, occupations are classified as having a low (below 30 %), medium (30–70 %) and high risk (above 70 %)	• Focus on the potential for automation of existing jobs • No analysis of the emergence of new tasks or factors which could prevent automation • Assumption that all tasks with engineering bottlenecks (see left) are difficult to automate • Implicit assumption that workers in the same occupational groups perform similar tasks
Bonin et al. 2015 (first part)	The next 10–20 years	• 42 % of German employees work in occupations with a high automation probability • The potential for automation declines as the wage and education level rises	• Occupation-based application of the 2013 Osborne/Frey study to Germany • The Osborne/Frey data is first applied to the International Standard Classification of Occupations (ISCO) and then transferred to a correspondence table from the Federal Employment Agency at the 3-digit level of the German Classification of Occupations (KldB)	• Assumption that tasks in the same occupations differ little between Germany and the United States • Technologies have the same influence on automation potential in Germany and the United States

| Study	Time horizon	Key findings	Approach	Underlying assumptions
ING-DiBa 2015	The next 10–20 years	• 59 %, or 18.3 million jobs in Germany, could be automated • Administrative occupations such as secretaries or administrative officers are at the highest risk (86 %), followed by elementary occupations (85 %); mechanics, vehicle operators and machine operators follow with 69 % probability • The potential for automation declines as the wage and education level rises	• The same approach as above, but with minor differences in the calculation and transfer from ISCO to the KldB • Occupations to which Frey and Osborne (2013) assigned no probability are not considered	• The same as above
		Task-based analyses of risk potential due to digital technologies		
Bonin et al. 2015 (second part)	The next 10–20 years	• 12 % of jobs in Germany (US: 9 %) are at high risk of automation • However, there are only minor differences in the task structures of occupations with a high and low automation potential • The potential for automation declines as the wage and education level rises	• Task-based application of the Osborne/Frey study, i.e. based on tasks in the workplace rather than occupations • Calculations based on the PIAAC database, which sets out task structures for occupations in OECD countries	• Assumption that only individual tasks, not entire occupations, are automatable • Workers with the same occupation perform different tasks in some cases • Technologies have the same influence on automation potential in Germany and the United States
Arntz et al. 2016	The next 10–20 years	• The same as for Bonin et al. 2015; same basis for calculations • However, this study relates to and compares all OECD countries		
Dengler/Matthes 2015	Automation potential in 2013	• 15 % of employees in Germany are exposed to a high risk of automation • The potential for automation declines as the wage and education level rises • However, it is not just elementary occupations which are at high risk of automation, but also skilled worker occupations • Manufacturing occupations and production engineering occupations have the highest potential for replacement (70 and 65 %) • The potential for replacement varies a great deal depending on the occupational segment and skill level	• Analysis of current rather than future automation potential • Task-based approach • The data source is the Federal Employment Agency's expert database BERUFENET • Examination of the proportion of routine vs. non-routine tasks in occupations • Higher relative weighting of individual occupations with high numbers of workers at the aggregate level • Calculation of the potential for replacement for each individual occupation	• Assumption that only individual tasks, not entire occupations, are automatable

Study	Time horizon	Key findings	Approach	Underlying assumptions
Chui et al. 2015	Automation potential in 2015	• From a purely technical perspective, 45 % of the activities performed by workers in the United States could be automated using today's technology • However, only 5 % of occupations could be entirely automated • 60 % of current occupations in the US could have 30 % or more of their constituent activities automated today • A high proportion of activities performed by those in the highest-paid occupations can be automated (e.g. activities consuming more than 20 % of a CEO's working time)	• Analysis of 2,000 work activities in various occupational fields in the US economy • Identification of 18 capabilities which are required, and assignment of relevant capabilities to the activities • Assessment of the automatability of these capabilities through the use of existing technology	• Assumption that only individual tasks, not entire occupations, are automatable
General labour market forecasts with regard to digitalisation				

Vogler-Ludwig et al. 2016
 	
Accelerated digitalisation scenario
	2030	• A quarter of a million more people in employment and a 20 % reduction in unemployment over the period to 2030
		
		• The cause of this is the productivity gains unleashed by digitalisation, which lead to new jobs
		
		• Less demand for skilled workers and elementary workers, and a shift of employment towards specialists and experts
		
		• In general, accelerated digitalisation will lead to greater demand for people with technology-focused and commercially focused qualifications
		
		• Digitalisation will lead to a decline in employment in downstream sectors and an increase in upstream sectors
		
		• The strongest gains will be in IT occupations, business management and organisation occupations, occupations in the fields of marketing and the media, purchasing, sales and commercial occupations, financial service providers, and facility operations and services occupations
			• The study not only looks at the potential risks resulting from digital technology, but also the positive demand effects of product innovations and lower costs and prices
			
			• In addition, the scenario is based on a large number of highly positive assumptions regarding greater use of technology and its effects on the economy and society (see column on the right, for example)
			
			• Assessment of the intensity of the effects of six technological fields on demand and productivity in 44 economic sectors
			
			• Forecasts of the number of workers in each sector
			
			• Conversion of the findings of occupation-based studies (see above) into indicators
			
			• Forecast for 2030, taking into account the net effects of demand and productivity impetus
				• Assumption that businesses and policy-makers will in future promote more intensive use of digital technologies (technological leadership)
				
				• Germany ranks among the pioneers of the digital world, particularly with regard to Industry 4.0
				
				• Assumptions with regard to employment:
				
				  • Extensive digitalisation of areas of work and life
				
				  • A greater division of labour for simple tasks, and a higher degree of specialisation for skilled tasks
				
				  • Support for retraining and continuing training
				
				  • Continuing increase in flexibility in work relationships
				
				  • Social protection for self-employed individuals
				
				  • Use of digital technologies to promote the vocational integration of those with fewer capabilities
				
				  • Emergence of new occupational profiles

A.2 Methodology in identifying key factors and future projections

This "situation report on skill needs" study develops exploratory scenarios for the long-term future of the working world in Germany. By describing alternative future development paths, scenarios raise awareness about potential changes in the general environment, i.e. they cover a range of possibilities. They help to identify and illustrate strategic aims, and offer guidance for decision-makers. Scenarios offer an ideal basis for reflection on long-term strategies and political measures.

Figure 6: Scenarios as alternative development paths which cover a range of possibilities

Excluded:
extreme events such
as wars, disasters

Range of possibilities

2016   2030
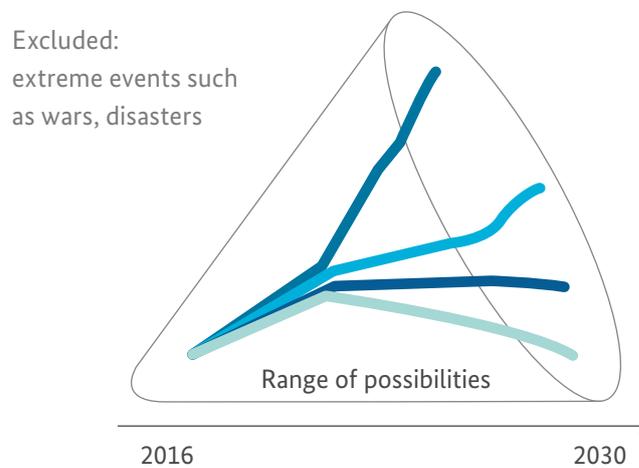
Source: Own representation.

Analysis of key factors

Scenario processes are based on key factors, i.e. influencing factors which describe a certain area or which have a significant impact on its future development.

In concrete terms: Key factors are central drivers of the working world and skill needs in Germany.

The value of key factors lies in reducing complexity: the selection of the most relevant influencing factors from a large number of parameters. This is achieved via what is known as a context analysis. The findings from the analysis of the literature, the survey of 34 experts in the framework of a Delphi analysis and the discussion at the situation report workshop with representatives of the Partnership for Skilled Professionals have been analysed to identify relevant influencing factors. A cross-impact analysis has been undertaken to identify how the key factors are interlinked and how they interact.

The key factors selected include economic and technical developments in Germany and the development of the potential labour force, including values and behaviour, in the labour market of 2030.

The following seven factors were selected:

Table 4: Key factors and brief definitions

Key factors	Brief definition
Germany's economic development in the international context	The development of the German economy over the period to 2030, driven by internationalisation, competition and structural change.
Rate of innovation and digital permeation of the business and working world	The pace of innovation in the context of digitalisation, particularly with regard to the degree to which tasks are automated and to the use of new technologies. Non-technical innovations, such as new business models and social innovations, also play an important role here.
Demographic change and the development of the potential labour force	The development of the potential labour force over the period to 2030 in the context of demographic upheavals such as the ageing of the labour force, the number of labour market entrants, the female labour force participation rate, and future immigration trends and effects.
Matching the potential labour force's skills	Ensuring the potential labour force's skills and qualifications match the changed requirements brought about by structural change.
Development of workers' occupational flexibility	Workers' level of self-determination regarding their flexibility in shaping their career path in relation to forms of employment, moves between fields within and between companies and sectors, and stages of their professional career across life phases.
Transformation of the organisation of work and forms of work	The transformation of how work is organised and working processes, focusing on negotiating processes between the social partners.
Development of value-adding processes	The development of new forms and models of value creation in the context of the Economy 4.0.

Source: Own representation.

Factors which relate to the design of initial, further and continuing vocational training and regulatory interventions are not included, as these factors are part of the Partnership for Skilled Professionals' options, which will subsequently be derived from the scenarios as forward-looking options for action.

Definition of possible development paths
For each factor, there are several conceivable development paths. These projections, as they are known, have been identified on the basis of an assessment of the analysis of the literature, the expert interviews in the framework of the Delphi analysis, and the discussion at the Partnership for Skilled Professionals workshop. Other possible future developments were also considered, and where possible underpinned by additional future studies sources.

To simplify matters, the projections have been sorted according to the developments which support a "low-road" strategy and a "high-road" strategy in terms of labour policy. Other possible alternative projections are generally also highlighted in order to cover other plausible developments.

Brief introduction to the concept of high-road and low-road strategies

According to Bluhm (2006), "high-road" and "low-road" strategies offer a simple means of reducing the complexity of empirical phenomena and emphasising insights. The two strategies should be understood as opposing archetypes. For the purposes of this project, we have drawn on the concept of the institutional foundations of comparative advantage for economic models in international competition, developed by Hall and Soskice (2001) , in defining the strategies. The strengths of the German economic and social system are primarily its focus on social partnership, the economy's strong focus on exports, a strong SME sector and companies' high level of innovativeness.

In this document, we define "**high-road**" **strategies** as the manifestation of a key factor (within the framework of plausible potential developments) which promotes a long-term strengthening of the German economic and social system.

"Low-road" strategies, by contrast, represent the manifestation of a key factor (again, within the framework of plausible potential developments) which would call into question the long-term preservation of the German economic and social system.

The key factors and projections were discussed at a workshop on 8 December 2016 in terms of the action required from policy-makers, employer and worker representatives, and other stakeholders for a successful, forward-looking labour and skilled labour policy.

In a further step, the projections of the key factors have been used as the substantive frameworks for the scenarios on the future of work and skill needs.

The key factors and their projections are briefly introduced below in what is known as a "morphological box". This then provided the "building blocks" for creating the scenarios.

The projections have been written from the perspective of 2030 and describe the situation regarding a given factor in the future. They are based on the analysis of the literature, the Delphi survey, and the feedback from partners in the framework of the survey on the key factors. The sources cited here are further references which were additionally consulted in formulating the projections.

The projections for the individual key factors have been combined to create consistent scenarios, concentrating on the high-road scenario, which is regarded by the social partners as the model of a desirable scenario for the business and working world in Germany.

Table 5: Morphological box for the key factors and projections

	Key factors						
	Economy and innovation		Potential labour force, structure, behaviour			Businesses	
	Germany's economic development in the international context	Rate of innovation and digital permeation of the business and working world	Demographic change and the development of the potential labour force	Matching the potential labour force's skills	Development of workers' occupational mobility	Transformation of the organisation of work and forms of work	Development of value-adding processes
Low-road	Stagnant growth	Relative stagnation	Decline in the potential labour force	Skills mismatches due to skills shortages	Lack of forward-looking approach, mobility driven by structural change	Growing gap in prospects	Extended transitional phase
Alternative	Slight growth	Disruptive breakthroughs			Forward-looking approach at individual level, limited mobility needs		Highly interconnected, integrator-centred
High-road	Constant dynamic growth	Incremental acceleration	Potential labour force remains stable	Better match between skills supply and demand	Forward-looking approach at individual level, occupational mobility as an opportunity	Democratisation of working processes	Highly interconnected and fluid

Source: Own representation.

Sources:

• Bluhm, K. (2006): Kostenorientierte Arbeitspolitik und lokale Bindung – Strategien deutscher Unternehmen in Mittelosteuropa. In: WSI Mitteilungen 8/2006, p. 440-445.

• Hall, P. A., Soskice, D. (eds.) (2001): Varieties of Capitalism. The Institutional Foundations of Comparative Advantage. Oxford: Oxford University Press.

A.3 Key factors and projections

The key factors presented here have been developed in a multistage process on the basis of the input and comments of representatives of the Partnership for Skilled Professionals, and were discussed at a joint Partnership workshop, focusing on the high-road scenario and the resulting conditions for success. The final version of the key factor descriptions can be found below.

A.3.1 Germany's economic development in the international context

This factor describes the economic framework for the labour market, which will tend to have an indirect impact on skill needs.

Definition

The development of the German economy over the period to 2030, driven by internationalisation, competition and structural change.

Low-road projection // Stagnant growth
The tendency towards protectionist policies visible in the second half of the 2010s continued well into the early 2020s. Although the global trade climate has warmed somewhat again since, there are still more trade barriers than in 2016. The German economy has also become less competitive by international standards. As a result, export-driven sectors are becoming less important in the national economic structure in relative terms. As domestic demand is also weak, economic growth is stagnating. In the course of the 2020s, growth and economic downturns were evenly balanced. GDP has only risen insignificantly compared to 2016. The proportion of workers employed in the service sector is rising; in particular, employment in the social field and in simple services is on the increase. By contrast, employment in industry is declining sharply.

Alternative projection // Slight growth
Driven by exporters' continuing strong position in global competition, reshoring in manufacturing and solid domestic demand, Germany's gross domestic product has grown in line with the average expected trend since 2016. Even short phases of economic slowdown have been unable to derail this trend. While employment in industry has stagnated in absolute terms, the number of workers in the field of business services and in the field of social professions has strongly increased.

High-road projection // Constant dynamic growth
The digital transformation of the economy has paved the way for high productivity gains worldwide (Berger/ Frey 2016). A global, trade-friendly economic policy has fostered further growth in world trade and thus also economic growth in Germany. The German economy has grown more strongly than expected. International competition has intensified further, but the export-driven sectors of the economy are successfully holding their ground for the most part. In the SME sector, the degree of internationalisation has increased further (Kay et al. 2014). The number of workers in industry has decreased, while employment in almost all service sectors is rising. The number of workers in the field of business services has undergone especially strong growth – in terms of the growth rates – while in absolute terms, the social professions recorded the strongest increase. Digitalisation has also paved the way for moderate productivity gains in the field of health and long-term care services.

Sources:

- Berger, T. / Frey, C.B. (2016): Digitalisation, jobs and convergence in Europe: strategies for closing the skills gap. Available online: http://www.oxfordmartin.ox.ac.uk/downloads/reports/SCALE_Digitalisation_Final.pdf
- Kay, R. / Holz, M. / Kranzusch, P. (2014): Mittelstand im globalen Wettbewerb. Internationalisierung als unternehmerische und wirtschaftspolitische Herausforderung. Friedrich-Ebert-Stiftung. WISO Diskurs.
- PwC (2015): The World in 2050. Will the shift in global economic power continue? Available online: http://www.pwc.com/gx/en/issues/the-economy/assets/world-in-2050-february-2015.pdf
- Vogler-Ludwig, K. / Düll, N. / Kriechel, B. / Vetter, T. (2016): Arbeitsmarkt 2030 – Wirtschaft und Arbeitsmarkt im digitalen Zeitalter. Prognose 2016. Szenario beschleunigte Digitalisierung. Economix Research & Consulting. Munich.

A.3.2 Rate of innovation and digital permeation of the business and working world

Definition

The pace of innovation in the context of digital-isation, particularly with regard to the degree to which tasks are automated and the use of new technologies. Non-technical innovations, such as new business models and social innovations, also play an important role here.

Low-road projection // Relative stagnation

The digital permeation of the business and working world has progressed at no more than a moderate speed. Past forecasts predicting a high-tech economy and a massive wave of automation have proven to be overly optimistic (see Vogler-Ludwig et al. 2016, base-line scenario). This is attributable in particular to limited investment by German businesses and government institutions in research and development, which was already resulting in a relatively weak innovation rate in Germany by international standards in the 2010s (Commission of Experts for Research and Innovation 2016). Progress was slow when it came to implement-ing Industry 4.0 concepts. By international standards, innovative business models are not very widespread in Germany. As early as 2015, studies indicated that Germany was at risk of missing out in terms of digital-isation: infrastructure deficits and a reluctance to embrace digital technologies were cited as the problem areas at that time (Accenture 2015, McKinsey 2015, etventure/GfK 2016). The hesitant implementation of digitalisation ultimately affects the pace of innovation across all sectors.

Alternative projection // Disruptive breakthroughs

The Internet of Things spread more rapidly than ex-pected, and building on that development, artificial intelligence (AI) applications, together with Big Data and robots, paved the way for enormous technological advances in the working world (OECD 2016). Con-sequently, many tasks have been automated. Many

occupational segments with high skill requirements and complex, cognitive tasks are also affected; for example, more than 10 % of occupations which require specialisation and expert knowledge are affected by automation (ING-Diba 2015). This produced pro-ductivity gains and cost savings which accelerated far-reaching implementation of new technologies in the German economy. In addition, AI and robots allow new, disruptive business models, e.g. new customer services which build on real-time customer information and Big Data analytics. Virtual products and working processes are much more widespread. This has led to radical change and upheaval in traditional sectors, especially banks and insurance companies as early adopters of this change, but also as a result of process integration in manufacturing. Other sectors followed this development with a slight delay. The new tech-nologies have led to the creation of many new fields and jobs. Continuous support for workers' "mental capital" is another factor which is contributing to this trend.

High-road projection // Incremental acceleration

Due to a longer transitional process, the technological transformation over the past 15 years has been steady, but not disruptive. Businesses have gradually driven forward the implementation of digital technologies, such as the Internet of Things and its potential appli-cations; financing partners have made it possible to access capital for investment, and the regulatory en-vironment has encouraged this development (see Accenture 2016, Acatech 2016, Federal Ministry for Economic Affairs and Energy 2016). The high degree of staff involvement in innovation processes and decisions on the introduction of new technologies has led to a high level of staff acceptance and support for these innovations. As a cross-cutting technology, digital-isation boosts innovation across all sectors. The public sector promoted this development by significantly stepping up its investment in the field of digital infra-structure, for example, and by supporting innovation by SMEs. The innovations have primarily focused on organisations' processes, such as ongoing automation of production and the use of assistance systems to support workers, the virtualisation and interconnection

of previously separate data collection processes, especially in bookkeeping, order management, etc., and improved communication within the company, with customers and with clients. In this context, the relevance of the human-machine interface is rising in many tasks in organisations' processes. Business models are changing to some degree, and the digitalisation of processes is leading primarily to new platform business models. However, innovation processes did not take place simultaneously in all sectors. While there is an industry-specific and sector-specific innovation gap, a large proportion of businesses in industries which were innovation followers regarding digitalised processes and new business models were already aware of the impending, and in some cases significant, technological advances. This enabled the – sometimes disruptive – changes to be constructively shaped via early vocational development for workers.

Sources:

- Acatech (ed., 2016): Kompetenzentwicklungsstudie Industrie 4.0 – Erste Ergebnisse und Schlussfolgerungen.

- Accenture (2015): Deutschland droht bei der Digitalisierung den Anschluss zu verpassen. Press release. Available online: https://www.accenture.com/de-de/company-newsroom-germany-may-miss-digitization-connection

- Accenture (2016): Fokussierung auf digitale Fähigkeiten und Technologien könnte deutscher Wirtschaft zu Wachstumsschub von 82 Milliarden Euro verhelfen. Press release. Available online: https://www.accenture.com/de-de/company-focus-digital-skills-technologies

- Commission of Experts for Research and Innovation (EFI) (2016): Gutachten 2016. Available online: http://www.e-fi.de/fileadmin/Gutachten_2016/EFI_Gutachten_2016.pdf

- Etventure, GfK (2016): Deutschlandstudie. Available online: http://www.etventure.de/deutschlandstudie/

- Federal Ministry for Economic Affairs and Energy (BMWi) (2016): Monitoring Report Wirtschaft Digital 2016. Available online: http://www.tns-infratest.com/WissensForum/Studien/monitoring-report_digitale_wirtschaft.asp

- ING-DiBa (2015): Die Roboter kommen – Folgen der Automatisierung für den deutschen Arbeitsmarkt. Available online: https://www.ing-diba.de/pdf/ueber-uns/presse/publikationen/ing-diba-economic-research-die-roboter-kommen.pdf

- McKinsey (2015): McKinsey-Studie zu Industrie 4.0: Deutsche Unternehmen trotz wachsen-der Konkurrenz zuversichtlich. Available online: https://www.mckinsey.de/mckinsey-studie-zu-industrie-40-deutsche-unternehmen-trotz-wachsender-konkurrenz-zuversichtlich

- OECD (2016): An OECD Horizon Scan of Megatrends and Technology Trends in the Context of Future Research Policy. Available online: http://ufm.dk/en/publications/2016/an-oecd-horizon-scan-of-megatrends-and-technology-trends-in-the-context-of-future-research-policy

- Vogler-Ludwig, K. / Düll, N. / Kriechel, B. / Vetter, T. (2016): Arbeitsmarkt 2030 – Wirtschaft und Arbeitsmarkt im digitalen Zeitalter. Prognose 2016. Szenario beschleunigte Digitalisierung. Economix Research & Consulting. Munich.

A.3.3 Demographic change and the development of the potential labour force

Definition

The development of the potential labour force over the period to 2030 in the context of demographic upheavals such as the ageing of the labour force, the number of labour market entrants, the female labour force participation rate, and future immigration trends and effects.

Low-road projection // Decline in the potential labour force

The above-average levels of net migration in 2015–2016 have returned to the long-term average for the pre-2015 period. Germany's population level shrank only to a limited extent from 2016 to 2030. The age structure is slightly younger than predicted in forecasts from the early 2010s. In the context of a realistic increase in the labour force participation rate (higher female labour force participation rate, longer working lives and thus also a further increase in the employment rate of older workers), the total labour force has declined from approximately 45.5 million in 2014 to around 43 million. The total population has declined from 81 million to 79 million people (Fuchs et al. 2016, lower confidence interval).

High-road projection // Potential labour force remains stable

As a result of sustained higher levels of net migration and, at the same time, a realistic rise in the labour force participation rate (higher female labour force participation rate, longer working lives), the potential labour force rose to almost 47 million by 2020, before returning to the 2014 level of approximately 45 million people in Germany in 2030 (Fuchs et al. 2016, upper confidence interval). The age structure is slightly younger. The total population has increased from 81 million to 83 million people (see also Deschermeier 2016).

Sources:

- Deschermeier, Philipp (2016): Einfluss der Zuwanderung auf die demographische Entwicklung in Deutschland. IW Köln. IW-Trends 2/2016. Available online: http://www.iwkoeln.de/studien/iw-trends/beitrag/philipp-deschermeier-einfluss-der-zuwanderung-auf-die-demografische-entwicklung-in-deutschland-280299
- Fuchs, J. / Söhnlein, D. / Weber, B. / Weber, E. (2016): Ein integriertes Modell zur Schätzung von Arbeitskräfteangebot und Bevölkerung. IAB Forschungsbericht 10/2016. Available online: doku.iab.de/forschungsbericht/2016/fb1016.pdf

A.3.4 Matching the potential labour force's skills

Definition

Ensuring the potential labour force's skills and qualifications match the changed requirements brought about by structural change.

Low-road projection // Skills mismatches due to skills shortages

The trend towards higher education has continued, driven by a greater focus on opening up paths to obtaining the higher-education entrance qualification and by support for higher pathways of initial and continuing vocational training. While the number of people with a bachelor's degree undertaking vocational training has increased, not least due to an expansion in dual study programmes, the trend towards higher education is resulting in significant skills mismatches in the German labour market. The content covered by the dual vocational training system has been continuously, flexibly adapted to take account of technological and organisational developments, meaning that vocational training still prepares people well for working life. However, the number of people entering the dual vocational training system has dropped far below the 2015 level of 500,000 (Bertelsmann Stiftung and Prognos 2015, "Accelerated trend towards higher education" scenario). At the same time, the number of potential low-skilled workers has also risen. This is rooted in the persistently high number of school leavers who do not successfully make the transition to a vocational training programme leading to a qualification, as well as refugees' vocational integration needs (Federal Office for Migration and Refugees 2016; Institute for Employment Research 2015). These skills mismatches lead to tangible skilled labour shortages.

High-road projection // Better match between skills supply and demand

Initial and continuing vocational training have retained their role in providing the skills required in the labour market. It remains the case that around half of school leavers each year enter higher education. However, the dual vocational training system, often in combination with a dual study programme, is also popular, not least because the difference in earning prospects compared to a bachelor degree has, on average, narrowed even further. Flexible continuing vocational training programmes are, alongside regulated career advancement training, another avenue for members of the potential labour force to regularly expand and update their skills.

Alongside adaptive training programmes for workers, the immigration of skilled workers, specialists and experts is a supplementary factor. One pillar is mobility within the EU, although annual net migration has declined from almost 400,000 in 2015 to just under 200,000 in 2030 following the economic recovery in the southern EU countries (Fuchs et al. 2015, baseline scenario). The recruitment of skilled workers, specialists and experts from third countries is now more successful as a result of various initiatives to support immigration (e.g. the blue card; Expert Council of German Foundations on Integration and Migration 2015). However, this continues to account for only a small proportion of net migration. As a result of the successful vocational development of the potential labour force and the continuous integration into the labour market and society of skilled workers, specialists and experts with sought-after bottleneck qualifications, the anticipated shortages of skilled and specialised workers have been significantly reduced and in some areas avoided.

Sources:

- Federal Office for Migration and Refugees (BAMF) (2016): Asylberechtigte und anerkannte Flüchtlinge in Deutschland Qualifikations-struktur, Arbeitsmarktbeteiligung und Zukunftsorientierungen. BAMF-Kurzanalyse, Ausgabe 01/2016.
- Bertelsmann Stiftung and Prognos (2015): Nachschulische Bildung 2030. Available online: https://www.bertelsmann-stiftung.de/de/themen/aktuelle-meldungen/2015/oktober/volle-hoersaele-leere-werkbaenke-studium-laeuft-ausbildung-den-rang-ab/
- Expert Council of German Foundations on Integration and Migration (SVR) (2015): Drei Jahre Blue Card: In Deutschland ein Erfolg, in Europa ein Flop. Available online: http://www.svr-migration.de/presse/presse-svr/drei-jahre-blue-card-in-deutschland-ein-erfolg-in-europa-ein-flop/
- Fuchs, J. / Kubis, A. / Schneider, L. (2015): Zuwanderungsbedarf aus Drittstaaten in Deutschland bis 2050. Published by the Bertelsmann Stiftung. Available online: http://iab.de/389/section.aspx/Publikation/k150323302
- Institute for Employment Research (IAB) (2015): Die Qualifikationsstruktur der Zuwanderer. Aktuelle Daten und Indikatoren. IAB.
- Zika, G. / Maier, T. / Helmrich, R. / Hummel, M. / Kalinowski, M. / Hänisch, C. / Wolter, M.I. / Mönnig, A. (2015): Qualifikations- und Berufsfeldprojektionen bis 2030. Engpässe und Überhänge regional ungleich verteilt. IAB Kurzbericht 9/2015. Available online: http://doku.iab.de/kurzber/2015/kb0915.pdf

A.3.5 Development of workers' occupational mobility

Definition

Individual design of career planning and working life in relation to forms of employment, mobility between fields of activity within and between companies and sectors, and stages of professional careers across life phases.

Issues relating to flexibility in terms of when and where work is carried out are dealt with in key factor 7, "Transformation of the organisation of work and forms of work".

Low-road projection // Lack of forward-looking approach, mobility driven by structural change

Automation and the internationalisation of labour markets are placing constant pressure on workers in Germany. In most fields, a high level of willingness to embrace change – in terms of both location and work content – is a precondition for further employment chances. However, workers are tending to take a wait-and-see approach rather than a proactive approach to this trend, with only a minority pursuing active, forward-looking career planning which takes changes in the wider environment into account. A particularly large number of older workers no longer have the necessary skills for this kind of personal, forward-looking approach. Younger generations are generally better equipped, but only a few pursue active, long-term career planning. As a result of growing problems in terms of skills mismatches, this reactive attitude is leading to disruption in employment histories which, in many cases, could have been avoided. This makes it harder to successfully navigate the rapidly changing labour market. It is not uncommon for the workers concerned to experience long adjustment phases in which unemployment alternates with short-term employment or, out of necessity, phases of self-employment, before they find a stable new career path. In these cases, the expected income from this (secondary) employment is often lower. Taken as a whole, the avoidable individual losses are macroeconomically relevant.

Alternative projection // Forward-looking approach at individual level, limited mobility needs

Work-related geographical mobility is slightly higher in 2030 than in 2016, but the increase is commensurate with the rise in the average level of educational attainment (in the early 2010s, around 25 % of all workers moved for work-related reasons at least once in their lives, rising to 40 % of workers with an Abitur (higher-education entrance qualification), Bertelsmann Stiftung 2013). Workers change jobs more frequently over the course of their lives, but the average duration for which workers remain with organisations has continued to increase. Most workers would like plannable career paths, and the public service and large companies are among the employers of choice. A forward-looking approach in individual career planning is much more widespread, not least due to the high need for security. The continuing process of automation has led to a moderate increase in changes between occupational fields, but in most cases this has been possible within organisations.

High-road projection // Forward-looking approach at individual level, occupational mobility as an opportunity

A life-phase approach to careers has become standard practice for the most part. Individual, forward-looking career planning has become mainstream and is practised by workers in all life phases. In an interconnected, flexible economy, flexible employment histories are regarded by a majority of workers and employers as an opportunity to balance their goals in life. Forms of employment and self-employment are chosen to suit the current life phase. Coordination with past and potential employers and interaction in self-organised support networks is key in ensuring the success of this flexible career management. Individuals are, on average, intrinsically more motivated to undertake further and continuing training, and this is accompanied by a significant increase in workers choosing to change fields and to move to different locations. A proactive attitude to career management is also softening the tangible impact of the progressive automation of routine manual and intellectual tasks.

Sources:

- Bertelsmann Stiftung (2013): Berufliche Mobilität - Studienergebnisse einer repräsentativen Bevölkerungsumfrage. Available online: https://www.bertelsmann-stiftung.de/fileadmin/files/user_upload/Studie_NW_Berufliche_Mobilitaet_2013.pdf
- Brenke, Karl (2015): Selbstständige Beschäftigung geht zurück. DIW Wochenbericht Nr. 36, 2015. Available online: https://www.diw.de/documents/publikationen/73/diw_01.c.513229.de/15-36-3.pdf
- KfW (2016): KfW-Gründungsmonitor 2016. Arbeitsmarkt trübt Gründungslust deutlich - Innovative Gründer behaupten sich. KfW Research.
- Stettes, O. (2016): Arbeitswelt und Arbeitsmarktreform der Zukunft. Welche Schlüsse können aus der vorliegenden empirischen Evidenz bereits geschlossen werden. IW. Cologne.

A.3.6 Transformation of the organisation of work and forms of work

Definition

The transformation of how work is organised and working processes, focusing on negotiating processes between the social partners.

Low-road projection // Growing gap in prospects

Organisations' need for greater flexibility has significantly increased. Businesses in export-oriented sectors are compensating for greater demand volatility and adaptation pressure in international competition by taking a more flexible approach to the organisation of work and forms of employment. At the same time, in the service and commerce sectors, customer demand for goods and services to be constantly available has further increased the spread of flexible work processes, e.g. through highly flexible deliveries in online commerce or flexible household-related services. In a challenging economic environment, many workers are in a weak negotiating position. In increasingly flexible value-adding networks, the scope of the traditional negotiation processes between the social partners is tested, and collective bargaining coverage has continued to decline. The tensions between the social partners have increased significantly. Individuals' ability to negotiate has come to play a much more important role in the design of employment contracts. Highly skilled individuals and workers in areas where there is a shortage of skilled labour can usually – but by no means invariably – achieve their negotiating objectives much more easily than workers in other situations, who have worse prospects and receive much less control over how their work is organised. Many workers receive only a limited amount of the personal flexibility they require in the working context. However, companies which offer their employees unattractive working conditions over the long term face high levels of staff turnover and significant recruitment problems. Job satisfaction has dropped. Inequality in the labour market is also leading to tensions within society.

High-road projection // Democratisation of working processes

Organisations' need for greater flexibility has significantly increased. Businesses in export-oriented sectors are compensating for greater demand volatility and adaptation pressure in international competition by taking a more flexible approach to the organisation of work and forms of employment. At the same time, in the service and commerce sectors, customer demand for goods and services to be constantly available has further increased the spread of flexible work processes, e.g. through highly flexible deliveries in online commerce or flexible household-related services. Close cooperation has allowed the challenges and tensions which emerged between the social partners to be resolved mostly to the satisfaction of all stakeholders, although in some cases painful compromises were necessary. Legal regulation for work in the digital era was essential in the process of reaching compromises. A life-phase approach to employment models and flexible working processes take into account both organisations' need for flexibility and individuals' needs. Workers at all skill levels benefit from this, albeit with restrictions in some cases in the field of low-skilled tasks. Larger companies have an advantage in this context, as they can implement flexible working models more easily. Within companies, members of staff are given greater freedom. This has increased the level of individual responsibility shouldered by workers, and in some cases it has also led to an increase in perceived workloads. But for many employees, the fact that they have gained a greater say and control over their work, together with the boost to their self-efficacy, also helps to ease the burden on them at a time when their working and personal lives are becoming increasingly complex. Flat hierarchies as well as entrepreneurial and game-based approaches are making work content more demanding and more flexible. This allows most of the disadvantages of flexible working processes to be minimised, while the benefits are experienced by both companies and workers.

Sources:

- Bertelsmann Stiftung (2015): Arbeits- und Lebensperspektiven in Deutschland – Pfade der Veränderung. Ergebnisse der Arbeit der Expertenkommission Arbeits- und Lebensperspektiven in Deutschland. Gütersloh.
- Centre for European Economic Research (ZEW) (2014): Auswirkungen der Digitalisierung auf Arbeitsverhältnisse. Kurzexpertise Nr. 50. ZEW. Mannheim.
- Federal Agency for Civic Education (bpb) (2014): Fachkräftemangel. Available online: http://www.bpb.de/politik/innenpolitik/arbeitsmarktpolitik/178757/fachkraeftemangel?p=all
- Federal Ministry of Labour and Social Affairs (BMAS) (2015): Monitor Mobiles und entgrenztes Arbeiten. Aktuelle Ergebnisse einer Betriebs- und Beschäftigtenbefragung. Available online: http://www.bmas.de/SharedDocs/Downloads/DE/PDF-Publikationen/a873.pdf?__blob=publicationFile&v=2
- German Trade Union Confederation (DGB) (2016): DGB-Jugend: Ausbildungsreport 2016. Available online: http://www.dgb.de/themen/++co++b536d92c-6f89-11e6-808e-525400e5a74a

A.3.7 Development of value-adding processes

Definition

The development of new forms and models of value creation in the context of the Economy 4.0.

Low-road projection // Extended transitional phase
The reluctance to implement digitalisation which was visible in the second half of the 2010s, particularly among small and medium-sized businesses in Germany, was slow to dissipate. Given the high level of investment required, many companies hesitated to introduce interconnected, function-integrating processes (PwC 2014) out of fear of misallocating scarce resources, while larger players moved more quickly. Due to the uneven pace of developments, system innovations could only be developed and marketed slowly. While this trend has improved significantly in recent years, Germany's value-adding networks lag far behind those of international competitors. Packages of products and services which are taken for granted in other countries are unavailable in many regions of Germany.

Alternative projection // Highly interconnected, integrator-centred
A large proportion of goods and services are marketed and provided in the form of systematically interconnected, hybrid offers. This requires complex and often cross-sectoral interactions between businesses of all sizes operating together in value-adding networks. Large, established companies and individual new, rapidly growing providers have used their lead in digitalisation to take on an integrative role as the most important node in one or more value-adding networks. As a result, market power is increasingly concentrated in the hands of the network integrators, while smaller companies in a supplier or service provider role have often lost some of their room to negotiate. This is particularly visible in the field of production and mobility, individual crafts, and digital services of all kinds, while this trend is much less pronounced in the health and long-term care sector.

High-road projection // Highly interconnected and fluid
A large proportion of goods and services are marketed and provided in the form of systematically interconnected, hybrid offers. This requires complex interactions between businesses of all sizes operating together in value-adding networks. However, initial concentration trends, which were driven by the central role of platforms acting as network integrators, gradually gave way in most sectors to greater competition between competing networks. Small and medium-sized businesses have also been very consistent in their implementation of the digitalisation of all business processes. In the framework of highly flexible value-adding networks with faster processes, more flexible production technologies and more individual offers, they are successfully standing up to the larger and less agile network integrators.

Sources:
- Cologne Institute for Economic Research (IW Köln) (2015): Industrie 4.0-Readiness. Forschungsvorhaben gefördert von Impuls-Stiftung und VDMA.
- Federation of German Industries (BDI) (2012): Deutschland 2030 - Zukunftsperspektiven der Wertschöpfung. Available online: http://www.z-punkt.de/uploads/default/114/2012_bdi_deutschland_2030_de.pdf
- Institute for Employment Research (IAB) (2016): Wirtschaft 4.0 und die Folgen für Arbeitsmarkt und Ökonomie. IAB Forschungsbericht 13/2016.
- PwC (2014): Fit for the future. Capitalizing on global trends. 17th Annual Global CEO Survey.
- Z_punkt GmbH (2014): Connected Reality 2025. The next wave of digital transformation. Trend Study. Available online: http://www.z-punkt.de/uploads/files/9/connected_reality.pdf

A.4 Dossier on new and changed fields

The following list of around 150 new and changing tasks and fields has been drawn up on the basis of an analysis of forward-looking studies, reports and articles, as well as the statements made by experts in the in-depth interviews conducted for this study, and supplemented by the findings of other foresight projects carried out by Z_punkt over the past year. This scanning can only capture a portion of developments and makes no claim to be exhaustive. In light of the emphasis which the outline for this project placed on the digital transformation, this collection is also dominated by fields in the context of digital technologies.

New/changed fields	Skills required	Sources
Transmedia marketing and journalism	• Task intensification and convergence: management, content creation, content distribution, engagement • IT skills (software knowledge, etc.) • Talent for storytelling • Initiative • Extensive social media skills • Technical and stylistic preparation of information • Knowledge of sales channels	IIT (2016)
Assistance in relation to algorithms and robots (manufacturing)	• IT skills • Knowledge of robots	IIT (2016)
Assistance in relation to algorithms and robots (maintenance)	• IT skills • Technical knowledge • Knowledge of robots	Z_punkt*
Assistance in relation to algorithms and robots (IT)	• Understanding of human nature • Understanding of human emotions, creativity • IT skills • Complex problem-solving	Daheim, C./ Wintermann, O. (2016)
Creative analysis of data from the Internet of Things	• Pattern recognition • Critical thinking • Talent for storytelling • Cross-sectoral expertise • Problem-solving skills • "Digital savviness"	Hunt, G. (2016)
Ethics of technology (definition and integration of ethical standards for new digital technologies)	• Legal and ethical expertise • Negotiating skills • Teaching skills • Critical thinking • Complex problem-solving • Cross-sectoral expertise • Strong communication skills	Microsoft (n.d.)

New/changed fields	Skills required	Sources
Biohacking (experimental trans-formation of biological systems and processes by means of gene manipulation, data analysis and programming)	• Biotechnological expertise • IT skills • Understanding of scientific and medical methodology (critical thinking) • Data analysis skills • Creativity and an eagerness to experiment • Entrepreneurial skills • Ability to think outside the box • Team skills, collaborative skills	Microsoft (n.d.)
Designing virtual habitats	• 3D modelling • Motion capturing • Creativity • Affinity for design • Architectural design • Storytelling	Microsoft (n.d.)
Social media-based content distribution	• "Digital savviness" • Creativity • Strong communication skills • Storytelling • Understanding of visual language • Understanding of cultural events	Microsoft (n.d.)
Video game designer	• Programming skills • Complex problem-solving • Centristic thinking • Creativity/art	Berger, T./Frey, C. B. (2016a)
Management tasks (new: data analysis and transformation of leadership tasks: - Results culture rather than a presenteeism culture - Support for the project team's independent work - Leadership tasks of motivating and supporting)	• Transversal skills • General IT skills (e-leadership – project management of digital solutions) • "Digital savviness" • Self-critical • Emotional intelligence • Strong communication skills • Team skills • Coaching and motivating staff • Understanding and dealing with flat hierarchies	Berger, T./Frey, C. B. (2016a) Expert survey*

New/changed fields	Skills required	Sources
Web design (new: types, platforms and management in the back-ground)	• Mobile development • Cross-platform development (Internet of Things integration) • DevOps • Creativity, innovativeness • Design-focused • Management skills (organisation, coaching, leadership tasks)	Berger, T./Frey, C. B. (2016a)
Implementation of cloud solutions	• Organisational and entrepreneurial skills • Critical systems thinking	European Commission (2016b)
Implementation of Big Data solutions and Big Data analytics	• Knowledge of technical infrastructure and network architecture • Skills relating to business data, data use (entrepreneurial skills) • Quality and risk management • Skills in the field of IT security, cybersecurity • Critical questioning and systems thinking • Complex problem-solving skills	European Commission (2016b)
Connecting material products to service platforms (implementation of the Internet of Things)	• Entrepreneurial skills • IT skills in the field of network connectivity, architecture and infrastructure • Systems thinking • Cross-sectoral expertise • Creativity	European Commission (2016b)
Virtual online teaching	• "Digital savviness" • Design, visual communication • Skills in the field of advertising, social media • Social skills (shift away from the all-knowing teacher to a supportive mentor) • Data analysis to adapt content and create personalised content	Grothaus, M. (2015)
Data-driven maintenance and servicing of machines / predictive maintenance	• Systems thinking • Data analysis skills • Critical thinking • Sense of responsibility	Caylar, P./ Naik, K./ Noterdaeme, O. (2016)

New/changed fields	Skills required	Sources
Digital management of automated quality control	• Process planning • Personal organisation • Sense of responsibility • Management skills (leadership skills, team skills) • Critical thinking • Robot control	Caylar, P./ Naik, K./ Noterdaeme, O. (2016)
Administration, office assistants	• IT application skills (including cloud apps, databases, social media) • "Digital savviness" • Foreign language skills • Social skills (strong communication skills) • Expertise in the industry in question • Financial expertise • Implementation-focused • Personal organisation	Hosking, R. (2015)
Personal data management advisory services	• Social skills • Data security and analysis skills • Hacking skills	Scanning for new job advertisements on http://berlinstartupjobs.com/
(Social media) video marketing	• Critical thinking • Skills in the field of VR/AR • Problem-solving skills • Organisational skills • Storytelling	
Online community management (supporting, moderating and managing online communities)	• Crowdsourcing skills • To have an eye for talents • Strong communication skills • Empathy and strong social skills • Moderation skills • "Digital savviness"	IIT (2016) CST (n.d.) Scanning for new job advertisements on http://berlinstartupjobs.com/
Mobile marketing	• IT skills (computer science, etc.) • Organisational and networking skills • Expertise in the field of mobile marketing • "Digital savviness"	Scanning for new job advertisements on http://berlinstartupjobs.com/
Carrying out crowdsourcing campaigns	• Skills in the field of social media marketing • Design and promotional skills • Strong communication skills	Mirza, A. (2010)

New/changed fields	Skills required	Sources
Employer branding / recruitment marketing	• Marketing/branding expertise • Social media skills • Data analysis • Social skills • "Digital savviness"	Hennige, S. (2015)
Social recruiting	• Social skills (knowledge of human nature, strong communication skills) • "Digital savviness"	Hennige, S. (2015)
User-specific presentation of information (curation) using algorithm-based processes	• "Digital savviness" • Computer-based development • Social skills (empathy, knowledge of human nature) • Creativity	IIT (2016)
Drone-based reporting	• Drone usage • Journalistic skills	IIT (2016)
Development of adaptive assistance / tutoring systems (as a component of human-machine systems, e.g. in manufacturing)	• IT expertise • Programming • Emotional intelligence • Creativity	IIT (2016)
Management of cyber-physical systems	• Technical skills (software and hardware) and application skills • Management skills (leadership qualities) • Complex problem-solving	IIT (2016)
Shop floor management	• Technical skills (software and hardware) and application skills • Management skills (leadership qualities) • Social skills	IIT (2016)
Skilled work in manufacturing (with tasks once reserved for engineers being carried by skilled workers)	• New: personal responsibility • Ability to deal with unforeseen situations • Capacity for analytical thinking • Data analysis • Systems knowledge • Human-machine collaboration • Experience is becoming more important • Social skills • Knowledge in the field of logistics, delivery conditions	IIT (2016) Ittermann, P./ Niehaus, J./ Hirsch-Kreinsen, H. (2015) TAB (2016)

New/changed fields	Skills required	Sources
Advisory services relating to service robots	• Social and communicative skills • IT skills and knowledge of robotics	CST (n.d.)
3D printing for disaster relief	• 3D printing skills • Creativity • Empathy	CST (n.d.)
Recycling of electronic waste (rare earths)	• Knowledge of production and recycling technologies • Creativity • Innovativeness	CST (n.d.)
Data-based psychotherapeutic services	• Knowledge of wearable technology • Quantified self • Social skills • Emotional intelligence	CST (n.d.)
Gamification applications design	• Social skills • Understanding of human nature • Affinity for design • Creativity	CST (n.d.)
Data-based monitoring of eco-systems and human influence	• Skills relating to the Internet of Things (installation, application, etc.) • Critical thinking	CST (n.d.)
Office operations management (new: organisation of in-house office workers, staff working from home, freelancers, international workers, etc.)	• Organisational skills, logistics • Coordination skills • Emotional intelligence, empathy • Intercultural skills	CST (n.d.)
Developing and managing an organisation's culture	• Communication skills • Social skills • Problem-solving skills • Organisational skills • Creativity, ability to think outside the box	CST (n.d.)
Monitoring automated transport systems	• Systems thinking • Problem-solving skills • Social skills	CST (n.d.)

New/changed fields	Skills required	Sources
Customer analysis and segmentation	• Data monitoring and analysis • Social skills • Analytical skills, critical thinking • Pattern recognition • Understanding of human nature and culture, intercultural skills • Knowledge in the fields of product development, UX, customer service, marketing	CST (n.d.)
Telesurgery	• Skills relating to the use of robots, ICT • Surgery	CST (n.d.)
Tracking online criminals	• Skills relating to ICT, social media, networks • Cybercrime knowledge • Ethical knowledge • Data analysis	CST (n.d.)
Wearable fashion design	• Materials research • Knowledge of ICT and computer hardware • Creativity	CST (n.d.)
IT-supported process controlling (intersection between IT specialists and process experts)	• IT skills • Organisational skills • Process knowledge and thinking • Structuring of technical processes • Individual responsibility • Cooperative qualities • Overarching knowledge	TAB (2016)
Transmedia e-commerce management	• Entrepreneurial skills • Creativity • Commercial skills • ICT skills	Schmidt, K. (2015)
Virtual guided tours using AR/VR	• Skills relating to virtual and augmented reality • Social skills • Storytelling skills	Schaub, S./ Schuppisser, R. (2015)
"Quantified self" health advice (advice based on health diagnoses, genetic data and vital signs data (Internet of Things and smartphones))	• IT skills • Social skills	Schaub, S./ Schuppisser, R. (2015)

New/changed fields	Skills required	Sources
Telemedical health counselling	• ICT skills • Installation, maintenance and use of healthcare robots (mechanical skills) • Management skills • Personal organisation • Social skills, empathy	Störmer, E./ Patscha, C./ Prendergast, J./ Daheim, C./ Rhishiart, M. (2014)
Digitalisation and automation of warehousing	• IT skills (Internet of Things, robots, drones) • Complex problem-solving • Personal organisation	Störmer, E./ Patscha, C./ Prendergast, J./ Daheim, C./ Rhishiart, M. (2014)
Digital technologies in retail stores	• Creativity • Social skills • Customer service skills • ICT skills (application, connecting offline and online systems, Internet of Things) • Data analysis	Störmer, E./ Patscha, C./ Prendergast, J./ Daheim, C./ Rhishiart, M. (2014)
Classification and crediting of qualifications acquired via digital platforms	• Expert knowledge of online and digital education (MOOCs, etc.) • Knowledge of the accreditation of qualifications • General knowledge of the education system • Ability to assess skills	Störmer, E./ Patscha, C./ Prendergast, J./ Daheim, C./ Rhishiart, M. (2014)
Development and management of digital production (3D printing) factories	• Advanced skills in the field of 3D printing • Generative manufacturing	Störmer, E./ Patscha, C./ Prendergast, J./ Daheim, C./ Rhishiart, M. (2014)
Data visualisation	• Analytical skills, critical thinking • Problem-solving skills	Störmer, E./ Patscha, C./ Prendergast, J./ Daheim, C./ Rhishiart, M. (2014)

New/changed fields	Skills required	Sources
Digital forensics	• Advanced IT skills (hardware and software, networks) • Legal expertise • Social skills	Störmer, E./ Patscha, C./ Prendergast, J./ Daheim, C./ Rhishiart, M. (2014)
Installation, retrofitting	• Social skills (strong communication skills)	Störmer, E./ Patscha, C./ Prendergast, J./ Daheim, C./ Rhishiart, M. (2014)
Construction planning using 3D modelling	• Creativity • IT skills	Störmer, E./ Patscha, C./ Prendergast, J./ Daheim, C./ Rhishiart, M. (2014)
Drone-based surveillance	• Knowledge of robotics (drones) • Surveillance and security technology expertise • IT skills	Stone, P. et al. (2015)
Predictive policing (analysis of data to calculate the probability of future crimes)	• Data analysis • Social skills (understanding of human nature) • Social media skills	Stone, P. et al. (2015)
Social network analysis for crime prevention	• Data analysis • Social skills • Social media skills	Stone, P. et al. (2015)
Artificial organ design	• Creativity • Innovativeness • Critical thinking • Complex problem-solving skills	Labarre, S. (2016)
Avatar programming and design for virtual spaces	• Creativity • Affinity for design • IT skills	Labarre, S. (2016)

New/changed fields	Skills required	Sources
Drone service experience design	• Management skills • Understanding of human nature • Emotional intelligence • Customer service skills • Affinity for design • Innovativeness	Labarre, S. (2016)
Creativity tutor for algorithms	• Creativity • Art • Communication skills • Social skills • Emotional intelligence	Labarre, S. (2016)
Embodied interaction design (development of virtual forms and objects for virtual and augmented reality)	• Creativity • Art • Skills in the field of the Internet of Things, virtual and augmented reality	Labarre, S. (2016)
Design and implementation of appropriate, business-specific machine-learning algorithms	• Innovativeness • Critical thinking • Complex problem-solving skills • Systems thinking • Creativity	Labarre, S. (2016)
Nanomedical treatment and advice	• Social skills (emotional intelligence, strong communication skills)	CBC (2015)
Bringing together and managing virtual project teams	• Recruitment • Social skills (networking, emotional intelligence) • Management skills (leadership culture) • Moderation skills • Organisational skills • Understanding of human nature • Support, coaching • ICT, Enterprise 2.0 skills	Murphy, D. (2016) Expert survey*
Workplace design	• Knowledge in the field of ergonomics • Entrepreneurial skills • Personal organisation • Knowledge in the field of motivation, productivity, happiness • Knowledge of IC technologies (from smartphones to virtual reality glasses) and applications	Hutt, R. (2016)

New/changed fields	Skills required	Sources
Installation of service robots	• Social skills (emotional intelligence, strong communication skills) • Commercial expertise	Țărmure, S. (2016)
Maintenance of electronic implants (neural laces)	• Surgical expertise • Nursing • IT skills • Knowledge in the field of augmented reality	Z_punkt*
Adjustment and implantation of electronic implants	• Surgical expertise • Nursing • IT skills (programming) • Critical thinking • Knowledge in the field of augmented reality	Z_punkt*
Sale and adjustment of smart contact lenses (new opticians)	• Optometric skills • Knowledge in the field of augmented reality	Z_punkt*
Internet of Things interior architecture and connectivity	• IT skills • Expertise in the field of network technology, sensors, etc. • Systems thinking • Social skills	Z_punkt*
Virtual property tours	• Sales skills • Personal organisation, entrepreneurial skills • Social skills • Knowledge in the field of augmented and virtual reality	Z_punkt*
Integrating diverse AI services (bots) to create service bundles	• Complex problem-solving skills • Critical and innovative thinking • Creativity	Z_punkt*
Servicing of autonomous vehicles	• IT skills (hardware and software) • Systems thinking	Z_punkt*
Augmented media marketing, branding	• Knowledge in the field of augmented reality • Marketing skills • Emotional intelligence	Z_punkt*

New/changed fields	Skills required	Sources
Provision of personalised online continuing education programmes	• ICT skills • Personal organisation • Entrepreneurial skills • Understanding of human nature • Big Data analytics	Z_punkt*
3D printed gastronomy	• 3D printing skills • Molecular gastronomy • Creativity, innovative thinking	Kundu, S. (2016)
Management of virtual reality events	• Knowledge in the field of virtual reality • Personal organisation • Entrepreneurial skills • Social skills	Z_punkt*
Recycling of wearable fashion	• Sustainability • Social engagement • Creativity, innovativeness	Z_punkt*
Augmented reality app development	• Knowledge in the field of augmented reality • Programming skills • Design skills	Z_punkt*
Augmented reality user experience	• Knowledge in the field of augmented reality • Programming skills • Design skills • Emotional intelligence, understanding of human nature	Z_punkt*
Diagnosis of illness based on wearable clothing data	• IT skills • Data analysis • Social skills	Z_punkt*
Drone traffic control	• Expertise in the field of air traffic and air navigation services • Knowledge of drone technology • Critical thinking • Rapid problem-solving	Z_punkt*
Maintenance/servicing of smart infrastructure (sensors, cameras, etc.)	• Systems thinking • Extensive IT skills (hardware, software)	Z_punkt*
Corporate sharing management (implementation of the sharing economy within a company)	• Creativity • Innovative thinking • Leadership skills • Emotional intelligence, social skills	Frey, T. (2015)

New/changed fields	Skills required	Sources
Shareability audits (examining whether products and services can be shared)	• Creativity • Innovative thinking • Emotional intelligence	Frey, T. (2015)
Contextualisation of "quantified self" data	• Critical thinking • Data analysis • Systems thinking, complex problem-solving skills	Frey, T. (2015)
Development and management of drone-based advertising	• Use of and affinity for drones • Creativity • "Digital savviness"	Z_punkt*
Development of 3D-printed materials and combining them in creative ways	• 3D printing expertise • Creativity, innovativeness	Frey, T. (2015)
Maintenance and repair of 3D printers	• 3D printing expertise • Social skills	Frey, T. (2015)
Experience design for autonomous vehicles	• Understanding of human nature • Creativity • Innovativeness • Affinity for design	Frey, T. (2015)
Film development for virtual reality	• Knowledge in the field of virtual reality • Personal organisation • Video editing • Knowledge of 360-degree cameras	Z_punkt*
Conversational commerce (via messaging services, service robots, etc.)	• Understanding of human nature • Sales experience • Social skills	Z_punkt*
Development of IoT interfaces and operating systems / software development (new: major focus on the Internet of Things, connectivity)	• IT skills (hardware and software, i.e. programming) • Affinity for design • Systems thinking • Critical thinking • Operating systems • Knowledge in the field of databases / data analysis	Z_punkt* Expert survey*
App development for service robots	• IT expertise (programming) • Service-oriented thinking • Systems thinking • Affinity for design, innovativeness	Z_punkt*

New/changed fields	Skills required	Sources
Monitoring of and regulation for DAOs (decentralised autonomous organisations)	• IT skills (software, networks, programming) • Complex systems thinking	Z_punkt*
Old age wellness consulting and management	• "Quantified self" skills • Fitness skill	Hancock, T./ Talwar, R. (2010)
Design and development of industrial apps (apps for Industry 4.0)	• Knowledge in the field of manufacturing, production and factory management	Weiner, J. (2016)
Quality control and cybersecurity for Industry 4.0	• Encryption technology • Complex problem-solving	Weiner, J. (2016)
Development of gamification experiences for the workplace (Office and Industry 4.0)	• Augmented reality knowledge • Gamification • Creativity, innovativeness	Annunziata, M. (2016) GE (2015)
3D-printed prototyping of medical instruments	• Knowledge in the field of 3D printing • Affinity for design, creativity	GE (2016)
Carbon dioxide capture and storage by means of geoengineering	• Systems thinking • Understanding of sustainability, resource management • Critical thinking	Farming Futures (n.d.)
Energy farming by agricultural businesses	• Knowledge of smart grid management • Installation and maintenance of solar, wind and biomass systems	Farming Futures (n.d.)
Monitoring livestock using biometric sensors (precision livestock farming)	• Data analysis and monitoring • ICT skills	Z_punkt*
Management of livestock's psychological and physical wellbeing	• IT skills	Farming Futures (n.d.)
Development and growing of genetically modified crops (pharming)	• Innovativeness • Critical thinking • Complex problem-solving skills • Systems thinking • Creativity	Farming Futures (n.d.)
Agricultural entomology / insect farming	• Entomology • Agricultural knowledge	Farming Futures (n.d.)

New/changed fields	Skills required	Sources
Resource management via precision farming	• ICT skills (Internet of Things, sensors); installation and application • Drone use	Guerrini, F. (2015)
Use of drones to spread plant protection products	• Drone use • Technical skills	Proplanta (n.d.)
Monitoring of livestock and plant populations using drones	• Drone use • Technical skills • Data analysis	Proplanta (n.d.)
Installation of home batteries and PV systems	• Social skills • Ability to work independently	Lorenz, D./ Riering, B. (2013) Expert survey*
Installation and maintenance of smart home technologies	• Technical skills (hardware and software): network technology, sensors, but also linking of various technologies and applications • Knowledge of smart home platforms, apps, software • Basic programming skills • Social skills	Lorenz, D./ Riering, B. (2013) Expert survey*
Virtual design, sampling and construction of craft and trade projects	• Use of digital software and technologies • Knowledge in the field of virtual and augmented reality	Runde, C. (2016)
ICT-based monitoring, management and support for crafts- and tradespeople	• Data analysis • Knowledge of IC technologies • Knowledge in the field of augmented reality	Runde, C. (2016)
Virtual teleservices in crafts and trades (crafts- and tradespeople giving instructions to laypersons via augmented reality or other technologies)	• Knowledge in the field of augmented reality • Social skills • Entrepreneurial skills • Personal organisation skills	Runde, C. (2016)
Measuring and dimensioning using 3D mapping	• 3D mapping skills (hardware, software, application)	Z_punkt*
Development of risk profiles on the basis of behavioural data	• Complex problem-solving skills • Critical and innovative thinking • Emotional intelligence	World Economic Forum (ed.) (2015)

New/changed fields	Skills required	Sources
Asset management and lending via alternative platforms (start-up investments and P2P lending)	• Social skills • Innovativeness • Critical thinking	World Economic Forum (ed.) (2015)
Accurate underwriting of risks due to real-time data	• Critical thinking • Systems thinking • Complex problem-solving skills	World Economic Forum (ed.) (2015)
Personalised risk provisions via ICT / digital platforms	• Social skills • ICT skills	World Economic Forum (ed.) (2015)
Development of algorithms and efficient hardware for automated trading	• Complex problem-solving • Critical thinking • Robots	World Economic Forum (ed.) (2015)
Development and use of intelligent algorithms in scientific research	• Critical thinking • Scientific methods	Rotman, D. (2015)
Management of messenger bots in customer service	• Technical skills (usage, basic programming skills) • Social media skills • Affinity with customers • Social skills	Messina, C. (2016)
Personalisation of gastronomic services on the basis of customer data (social media data, genetic data, purchasing behaviour, mobile data, etc.)	• Social skills • Creativity • Emotional intelligence, empathy • Understanding of human nature	Z_punkt*
Support for the development and use of affective service robots (for education, long-term care, therapy)	• Emotional intelligence, understanding of human nature • Knowledge in the field of long-term care, education, therapy • Programming skills	Z_punkt*
Personalised, data-driven fashion design (genetic data, biometric data, smart home data, etc. being used to create relevant materials and designs)	• Creativity • Technical skills (programming, connectivity, mechanics)	Z_punkt*

New/changed fields	Skills required	Sources
Storytelling via digital/robot platforms	• Storytelling • Social skills • Creativity	Z_punkt*
Design of custom prostheses	• Affinity for design • Creativity • Social skills • Medical expertise • Knowledge in the field of 3D printing	Z_punkt*
Programming of DNA molecules	• Critical thinking • Systems thinking • Complex problem-solving skills	MIT Media Lab (2016): Project 104
Student-specific biometric data analysis to adapt lessons and types of teaching via the use of wearables	• Data analysis • ICT skills • Creativity • Social skills (emotional intelligence, strong communication skills, understanding of human nature) • Personal organisation	MIT Media Lab (2016): Project 108
Authentication and verification via behavioural data (biometrics, general digital behaviour and usage)	• Hacking • Creativity • Emotional intelligence, understanding of human nature	MIT Media Lab (2016): Project 227
Printing and integration of biological organisms in material products	• Creativity • Affinity for design • IT skills • Innovativeness • Cross-sectoral knowledge and thinking	Z_punkt*
Design and development of real-time marketing which responds to emotions	• Social skills, emotional intelligence • Creativity • Innovativeness	Choi, C. (2016)
Teaching AI systems human social norms and values	• Emotional intelligence • Extensive expertise in the field of ethics and law • Cross-sectoral knowledge • Complex problem-solving skills • Critical thinking	Hsu, J. (2008) Shah, S. (2016)
Quality control of customer service robots in stores	• Social skills • Technical skills	Buckley, S. (2016)

New/changed fields	Skills required	Sources
Drone-assisted mapping	• Use or knowledge of drones • Drone technology • Data analysis	Mitsui, E. (2013)
Transformation of over-the-counter business into a virtual online business with digital interaction with customers	• Monitoring of algorithms • Big Data-based analysis of customer needs • Virtual online customer interfaces • Virtual interaction with customers • Customer interface / user experience design	Expert survey*
IT data security – increasing complexity of security mechanisms and of the systems to be protected, increase in vulnerabilities	• Encryption technology • IT security • Network technology • Complex problem-solving • Risk analysis • Hacking • Understanding the needs of customer systems (understanding of the sector) • Communication skills to explain problems and solutions • Creativity, emotional intelligence (putting oneself in the shoes of "opponents")	Expert survey*
Data analyst – analysis of ever more data, solution-oriented preparation of data	• Encryption technology • IT security • Network technology • Complex problem-solving • Risk analysis • Hacking • Understanding the needs of customer systems (understanding of the sector) • Communication skills to explain problems and solutions • Creativity, emotional intelligence (putting oneself in the shoes of "opponents")	Expert survey*
Bank strategy – development of new business models based on virtual contacts with customers	• Business model innovation • Creativity • Digital innovations • Customer needs analysis	Expert survey*
Risk analyst at insurance companies – dealing with Big Data and developing new insurance products	• Actuarial mathematics • Business model innovations • Creativity • Assertiveness in the in-house marketing of new ideas	Expert survey*

New/changed fields	Skills required	Sources
Insurance broker – disappearance of bricks-and-mortar insurance offices, shift to the online world	• Analysis of customer needs • User interface design / UX • Risk analysis • Development of new business models • Creativity	Expert survey*
Roofer, using drones to visually examine roofing quality	• Drone use • High-quality image capturing (photo, video) • Analysis of the image data • Communication of the result • Sales advice regarding potential solutions	Expert survey*
Joiner, using CAD technologies in product design	• Advanced design skills • Ability to use CAD programmes and CIM machines • Creativity • Communication and talent for sales	Expert survey*
Orthopaedics, involving increasingly technologically advanced prostheses which are computer-controlled or controlled via nerve signals	• Basic technical and digital skills • Basic understanding of programming • Medical knowledge, especially of neurology and brainwave control • Communication skills in order to explain the application to the customer and to communicate with the technology manufacturer regarding the customisation of the product	Expert survey*
Agriculture with computer- and satellite-controlled agricultural machinery, analysis of satellite and drone images to determine fertiliser and irrigation quantities, harvest yields and the ideal times for these activities	• Basic technical skills • Use of increasingly complex machines • Data analysis and interpretation	Expert survey*
Increasing differentiation in the education services offered in early childhood education	• Broad skills in the field of early childhood education: equality of opportunity, inclusion, language development, and the involvement and activation of parents with regard to language skills • Cooperation between graduate early childhood educators, childcare workers and social assistants (good mix in child daycare centres) • Strong social skills	Expert survey*

* Entries which list *Z_punkt* as their source refer to fields which played a role in foresight processes carried out by Z_punkt in parallel with the present project, but which did not result in a publication. Entries which list *Expert survey* as their source refer to fields which were raised in interviews during the survey of experts.

A.5 Participants in the expert survey

Experts consulted from the member institutions of the Partnership for Skilled Professionals

Marion Binder
Federal Ministry for Family Affairs,
Senior Citizens, Women and Youth
(BMFSFJ)

Karl-Heinz Brandl
United Services Trade Union
(ver.di)

Jan Dannenbring
German Confederation of Skilled
Crafts (ZDH)

Dr Stefan Hardege
Association of German Chambers
of Commerce and Industry (DIHK)

Johannes Jakob
German Trade Union
Confederation (DGB)

Sabrina Klaus-Schelletter
German Trade Union
Confederation (DGB)

Konrad Klingenburg
Metalworkers' Union (IG Metall)

Katrin Locker
Mining, Chemical and Energy
Industrial Union (IG BCE)

Jochen Reinecke
Association of German Chambers
of Commerce and Industry
(DIHK)

Dr Anette Rückert
Federal Ministry for Economic
Affairs and Energy (BMWi)

Oliver Suchy
German Trade Union
Confederation (DGB)

Peter Thiele
Federal Ministry of Education and
Research (BMBF)

Dr Tobias Viering
Federal Ministry for Family Affairs,
Senior Citizens, Women and Youth
(BMFSFJ)

Henrike Werner
Federal Ministry for Family Affairs,
Senior Citizens, Women and Youth
(BMFSFJ)

Judith Wüllerich
Federal Employment Agency
(Bundesagentur für Arbeit)

Jupp Zenzen
Employers' association

Experts consulted from business and academia

Bernd Altgen
VR-Bank Nordeifel eG

Ralf-Christoph Arnoldt
German Association of Cooperative
Banks (BVR)

Junior Professor Melanie Arntz
Centre for European Economic
Research (ZEW)

Jan Balcke
Airbus

Markus Bell
SAP SE

PD Dr Andreas Boes
Institute of Social Science Research
Munich (ISF München)

Professor Gerd Bosch
Institute for Work, Skills and Training
(IAQ Uni Duisburg)

Dr Werner Eichhorst
Institute of Labor Economics (IZA)

Alfred Geissler
STEAG

Benjamin Gruschka
Works council, Ford Deutschland

Mélanie Héroult
Bayer

Dr Stefan Heumann
Stiftung Neue Verantwortung

Dr Josephine Hofmann
Fraunhofer Institute for
Industrial Engineering
(Fraunhofer IAO)

Detlef Hollmann
Bertelsmann Stiftung

Klara Japing
SAP SE

Dr Thomas Lange
acatech

Akiko Maeda
OECD, Health Division

Wolfgang Müller-Pietralla
Volkswagen

Dr Iris Pfeiffer
German Confederation of Skilled
Crafts (ZDH)

Stefan Rehm
Association of Knowledge
Management (GfWM)

André Riemer
Federal Ministry of the Interior
(BMI)

Gerd Telsemeyer
facts and fiction GmbH

Dr Gerd Zika
Institute for Employment
Research (IAB)

Bibliography

Acatech (ed.) (2016): Kompetenzentwicklungsstudie Industrie 4.0 – Erste Ergebnisse und Schlussfolgerungen. Available online: http://www.acatech.de/de/publikationen/stellungnahmen/kooperationen/detail/artikel/kompetenzentwicklungsstudie-industrie-40-erste-ergebnisse-und-schlussfolgerungen.html

Accenture (2016): Fokussierung auf digitale Fähigkeiten und Technologien könnte deutscher Wirtschaft zu Wachstumsschub von 82 Milliarden Euro verhelfen. Pressemitteilung. Available online: https://www.accenture.com/de-de/company-focus-digital-skills-technologies

Accenture (2015): Deutschland droht bei der Digitalisierung den Anschluss zu verpassen. Pressemitteilung. Available online: https://www.accenture.com/de-de/company-newsroom-germany-may-miss-digitization-connection

Acemoglu, D. / Restrepo, P. (2017): Robots and Jobs: Evidence from US Labor Markets. NBER Working Paper No. 23285.

Annunziata, M. (2016): Pokémon Goes To The Office: GE Chief Economist Explains How Gaming And Work Are Merging. Available online: https://gereports.ca/pokemon-goes-office-ge-chief-economist-explains-gaming-work-merging/

Arntz, M. / Gregory, T. / Jansen, S. / Zierahn, U. (2016): Tätigkeitswandel und Weiterbildungsbedarf in der digitalen Transformation. Mannheim.

Arntz, M. / Gregory, T. / Zierahn, U. (2016): The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis. OECD Social, Employment and Migration Working Papers, No. 189. OECD Publishing. Paris.

Arntz, M. / Bonin, H. / Zierahn, U. (2014): Auswirkungen des technologischen Wandels auf den Arbeitsmarkt. ZEW. Mannheim.

Bennett, N. / Lemoine, G.J. (2014): What VUCA Really Means for You. In: Harvard Business Review, January 2014.

Berger, T. / Frey, C.B. (2016a): Digitalization, jobs and convergence in Europe: strategies for closing the skills gap. Available online: http://www.oxfordmartin.ox.ac.uk/downloads/reports/SCALE_Digitalisation_Final.pdf

Berger, T. / Frey, C.B. (2016b): Future Shocks and Shifts: Challenges for the Global Workforce and Skills Development. OECD Education 2030.

Bertelsmann Stiftung (2015a): Arbeits- und Lebensperspektiven in Deutschland – Pfade der Veränderung. Ergebnisse der Arbeit der Expertenkommission Arbeits- und Lebensperspektiven in Deutschland. Gütersloh.

Bertelsmann Stiftung and Prognos (2015b): Nachschulische Bildung 2030. Available online: https://www.bertelsmann-stiftung.de/de/themen/aktuelle-meldungen/2015/oktober/volle-hoersaele-leere-werkbaenke-studium-laeuft-ausbildung-den-rang-ab/

Bertelsmann Stiftung (2013): Berufliche Mobilität - Studienergebnisse einer repräsentativen Bevölkerungsumfrage. Available online: https://www.bertelsmann-stiftung.de/fileadmin/files/user_upload/Studie_NW_Berufliche_Mobilitaet_2013.pdf

Bertschek, I. / Ohnemus, J. / Viete, S. (2015): Befragung zum sozioökonomischen Hintergrund und zu den Motiven von Crowdworkern. ZEW. Mannheim.

Bitkom (2016): Neue Arbeit – wie die Digitalisierung unsere Jobs verändert. Eine Präsentation des Bitkom. Available online: https://www.bitkom.org/NP-Themen/NP-Standort-Deutschland/Bildung-Arbeit/Neue-Arbeit/Bitkom-Charts-PK-Neue-Arbeit-30-06-2016.pdf

Bonin, H. / Gregory, T. / Zierahn, U. (2015): Übertragung der Studie von Frey/Osborne auf Deutschland. ZEW. Mannheim.

Bowles, J. (2014): The computerisation of European jobs. Bruegel Research Institute Blog July 2014. Available online: http://www.bruegel.org/nc/blog/detail/article/1394-the-computerisation-of-european-jobs/

Brenke, K. (2015): Selbstständige Beschäftigung geht zurück. DIW Wochenbericht No. 36, 2015. Available online: https://www.diw.de/documents/publikationen/73/diw_01.c.513229.de/15-36-3.pdf

Buch, T. / Dengler, K. / Matthes, B. (2016): Saarland, Thüringen und Baden-Württemberg haben den größten Anpassungsbedarf. Relevanz der Digitalisierung für die Bundesländer. IAB-Kurzbericht 14/2016. Nuremberg.

Buckley, S. (2016): San Francisco Lowe's stores to get robot workers this fall. Available online: https://www.engadget.com/2016/09/02/san-francisco-lowes-stores-to-get-robot-workers-this-fall/

Caylar, P. / Naik, K. / Noterdaeme, O. (2016): Digital in industry: From buzzword to value creation. Available online: http://www.mckinsey.com/business-functions/digital-mckinsey/our-insights/digital-in-industry-from-buzzword-to-value-creation?cid=digistrat-eml-alt-mip-mck-oth-1608#0

CBC (2015): Generation jobless. 10 Jobs Of The Future. Available online: http://www.cbc.ca/doczone/features/top-jobs

Centre for European Economic Research (ZEW) (2014): Auswirkungen der Digitalisierung auf Arbeitsverhältnisse. Kurzexpertise Nr. 50. ZEW. Mannheim.

Choi, C. (2016): Mood-Detecting Sensor Could Help Machines Respond to Emotions. Available online: http://spectrum.ieee.org/the-human-os/robotics/robotics-hardware/mooddetecting-sensor-could-help-machines-respond-to-emotions

Chui, M. / Manyika, J. / Miremadi, M. (2015): Four fundamentals of workplace automation. McKinsey Quarterly. Available online: http://www.mckinsey.com/business-functions/business-technology/our-insights/four-fundamentals-of-workplace-automation

Cologne Institute for Economic Research (IW Köln) (2016): Wohlstand in der digitalen Welt. Erster IW-Strukturbericht. IW. Cologne.

Cologne Institute for Economic Research (IW Köln) (2015): Industrie 4.0-Readiness. Forschungsvorhaben gefördert von Impuls-Stiftung und VDMA.

Commission of Experts for Research and Innovation (EFI) (2016): Gutachten 2016. Available online: http://www.e-fi.de/fileadmin/Gutachten_2016/EFI_Gutachten_2016.pdf

CST (n.d.): Jobs of 2030. Available online: http://careers2030.cst.org/jobs/

Daheim, C. / Wintermann, O. (2016): 2050: Die Zukunft der Arbeit. Ergebnisse einer internationalen Delphi-Studie des Millennium Project. Available online: https://www.bertelsmann-stiftung.de/fileadmin/files/BSt/Publikationen/GrauePublikationen/BST_Delphi_Studie_2016.pdf

Demary, V. / Engels, B. (2016): Collaborative Business Models and Efficiency. Potential Efficiency Gains in the European Union. Impulse Paper No. 07, European Commission Internal Market, Industry, Entrepreneurship and SMEs Directorate-General. Available online: http://ec.europa.eu/DocsRoom/documents/16954/attachments/1/translations/en/renditions/native

Dengler, K. / Matthes, B. (2015): Folgen der Digitalisierung für die Arbeitswelt. Substituierbarkeitspotenziale von Berufen in Deutschland. IAB. Nuremberg.

Deschermeier, Philipp (2016): Einfluss der Zuwanderung auf die demographische Entwicklung in Deutschland. IW Köln. IW-Trends 2/2016. Available online: http://www.iwkoeln.de/studien/iw-trends/beitrag/philipp-deschermeier-einfluss-der-zuwanderung-auf-die-demografische-entwicklung-in-deutschland-280299

Eichhorst, W. / Tobsch, V. (2014): Flexible Arbeitswelten. IZA Research Report No. 59. IZA. Bonn.

Etventure / GfK (2016): Deutschlandstudie. Available online: http://www.etventure.de/deutschlandstudie/

Eurofound (2016): What do Europeans do at work? A task-based analysis: European Jobs Monitor 2016. Available online: https://www.eurofound.europa.eu/sites/default/files/ef_publication/field_ef_document/ef1617en.pdf

European Commission (2016a): A European agenda for the collaborative economy - supporting analysis. Available online: http://ec.europa.eu/DocsRoom/documents/16881/attachments/3/translations/en/renditions/native

European Commission (2016b): Summary of Policy Recommendations on e-Leadership Skills, Key Enabling Technology (KET) Skills, and e-Skills. Unpublished.

Expert Council of German Foundations on Integration and Migration (SVR) (2015): Drei Jahre Blue Card: In Deutschland ein Erfolg, in Europa ein Flop. Available online: http://www.svr-migration.de/presse/presse-svr/drei-jahre-blue-card-in-deutschland-ein-erfolg-in-europa-ein-flop/

Farming Futures (n.d.): Future Skills. Available online: http://www.farmingfutures.org.uk/future-skills/6-jobs

Federal Agency for Civic Education (bpb) (2014): Fachkräftemangel. Available online: http://www.bpb.de/politik/innenpolitik/arbeitsmarktpolitik/178757/fachkraeftemangel?p=all

Federal Ministry for Economic Affairs and Energy (BMWi) (2016): Monitoring Report Wirtschaft Digital 2016. Available online: http://www.tns-infratest.com/WissensForum/Studien/monitoring-report_digitale_wirtschaft.asp

Federal Ministry of Labour and Social Affairs (BMAS) (2016a): Wertewelten Arbeiten 4.0. Nextpractice GmbH. Bremen.

Federal Ministry of Labour and Social Affairs (BMAS) (2016b): Monitor – Digitalisierung am Arbeitsplatz. Aktuelle Ergebnisse einer Betriebs- und Beschäftigtenbefragung.

Federal Ministry of Labour and Social Affairs (BMAS) (2016c): Weißbuch Arbeiten 4.0. BMAS. Berlin.

Federal Ministry of Labour and Social Affairs (BMAS) (2015a): Monitor Mobiles und entgrenztes Arbeiten. Aktuelle Ergebnisse einer Betriebs- und Beschäftigtenbefragung. Available online: http://www.bmas.de/SharedDocs/Downloads/DE/PDF-Publikationen/a873.pdf?__blob=publicationFile&v=2

Federal Ministry of Labour and Social Affairs (BMAS) (2015b): Gewünschte und erlebte Arbeitsqualität. Freiburg, Bonn, Münster.

Federal Ministry of Labour and Social Affairs (BMAS) (2014): Fortschrittsreport „Altersgerechte Arbeitswelt". Issue 4: Lebenslanges Lernen und betriebliche Weiterbildung.

Federal Office for Migration and Refugees (BAMF) (2016): Asylberechtigte und anerkannte Flüchtlinge in Deutschland Qualifikationsstruktur, Arbeitsmarktbeteiligung und Zukunftsorientierungen. BAMF-Kurzanalyse, issue 01/2016.

Federal Statistical Office (Destatis) (2017): Zahlen und Fakten. Available online: https://www.destatis.de/DE/ZahlenFakten/ZahlenFakten.html

Federation of German Industries (BDI) (ed.) (2012): Deutschland 2030. Zukunftsperspektiven der Wertschöpfung. Berlin. Available online: http://www.zpunkt.de/uploads/default/114/2012_bdi_deutschland_2030_de.pdf

Frey, T. (2015): 162 Future Jobs – The Video. Available online: http://www.futuristspeaker.com/business-trends/162-future-jobs-the-video/

Fuchs, J. / Söhnlein, D. / Weber, B. / Weber, E. (2016): Ein integriertes Modell zur Schätzung von Arbeitskräfteangebot und Bevölkerung. IAB Forschungsbericht 10/2016. Available online: doku.iab.de/forschungsbericht/2016/fb1016.pdf

Fuchs, J. / Kubis, A. / Schneider, L. (2015): Zuwanderungsbedarf aus Drittstaaten in Deutschland bis 2050. Published by the Bertelsmann Stiftung. Available online: http://iab.de/389/section.aspx/Publikation/k150323302

GE (2016): Jobs of The Future: Doctors as Designers. Available online: https://gereports.ca/jobs-future-doctors-designers/

GE (2015): Beyond Gaming. Available online: https://gereports.ca/beyond-gaming/

Gebhardt, B. / Hofmann, J. / Roehl, H. (2015): Zukunftsfähige Führung. Die Gestaltung von Führungskompetenzen und -systemen. Gütersloh.

German Bundestag (Deutscher Bundestag) (2013): Achter Zwischenbericht der Enquete-Kommission „Internet und digitale Gesellschaft". Wirtschaft, Arbeit, Green IT. Berlin.

German Trade Union Confederation (DGB) (2016): DGB-Jugend: Ausbildungsreport 2016. Available online: http://www.dgb.de/themen/++co++b536d92c-6f89-11e6-808e-525400e5a74a

Goos, M. / Konings, J. / Vandeweyer, M. (2015): Employment Growth in Europe: The Roles of Innovation, Local Job Multipliers and Institutions. TKI Discussion Paper 15-10, Utrecht University School of Economics.

Grothaus, M. (2015): The Top Jobs In 10 Years Might Not Be What You Expect. Available online: https://www.fastcompany.com/3046277/the-new-rules-of-work/the-top-jobs-in-10-years-might-not-be-what-you-expect

Guerrini, F. (2015): The Future Of Agriculture? Smart Farming. Available online: http://www.forbes.com/sites/federicoguerrini/2015/02/18/the-future-of-agriculture-smart-farming/#b146214337cb

Hall, P. A., Soskice, D. (eds.) (2001): Varieties of Capitalism. The Institutional Foundations of Comparative Advantage. Oxford: Oxford University Press.

Hammermann, A. / Stettes, O. (2016): Qualifikationsbedarf und Qualifizierung. Anforderungen im Zeichen der Digitalisierung. IW. Cologne.

Hammermann, A. / Schmidt, J. / Stettes, O. (2015): Beschäftigte zwischen Karriereambitionen und Familienorientierung. IW. Cologne.

Hancock, T. / Talwar, R. (2010): The shape of jobs to come. Possible New Careers Emerging from Advances in Science and Technology (2010 – 2030). Available online: http://fastfuture.com/wp-content/uploads/2010/01/FastFuture_Shapeofjobstocome_FullReport1.pdf

Hennige, S. (2015): Die Trends im Arbeitsmarkt 2015: Es bleibt spannend. Available online: https://www.roberthalf.de/blog/die-trends-im-arbeitsmarkt-2015-es-bleibt-spannend

Hollmann, D. / Patscha, C. (2015): Arbeits- und Lebensperspektiven in Deutschland – Pfade der Veränderung. Ergebnisse der Arbeit der Expertenkommission Arbeits- und Lebensperspektiven in Deutschland. Bertelsmann Stiftung. Available online: http://www.bertelsmann-stiftung.de/fileadmin//files/BSt/Publikationen/GrauePublikationen/ArbeitsLebenspersp_final_.pdf

Hosking, R. (2015): The Evolving Role of The Administrative Professional. Available online: http://executivesecretary.com/the-evolving-role-of-the-administrative-professional/

Hsu, J. (2008): Teaching AI to be Sociable. Available online: http://spectrum.ieee.org/computing/software/teaching-ai-to-be-sociable

Hunt, G. (2016): Check out these 10 jobs of the future. Available online: https://www.siliconrepublic.com/jobs/jobs-of-the-future

Hutt, R. (2016): Want a job in 2025? These are the sectors to focus on. Available online: https://www.weforum.org/agenda/2016/09/job-in-2025-skills-sectors-to-focus-on/

ILO (2012): International Standard Classification of Occupations. Structure, group definitions and correspondence tables. Available online: http://www.ilo.org/wcmsp5/groups/public/---dgreports/---dcomm/---publ/documents/publication/wcms_172572.pdf

ING-DiBa (2015): Die Roboter kommen – Folgen der Automatisierung für den deutschen Arbeitsmarkt. Available online: https://www.ing-diba.de/pdf/ueber-uns/presse/publikationen/ing-diba-economic-research-die-roboter-kommen.pdf

Institute for Employment Research (IAB) (2016): Wirtschaft 4.0 und die Folgen für Arbeitsmarkt und Ökonomie. IAB Forschungsbericht 13/2016.

Institute for Employment Research (IAB) (2015): Die Qualifikationsstruktur der Zuwanderer. Aktuelle Daten und Indikatoren. IAB.

Institute for Innovation and Technology (IIT) (2016): Foresight-Studie „Digitale Arbeitswelt" für das Bundesministerium für Arbeit und Soziales. Available online: http://www.iit-berlin.de/de/publikationen/foresight-studie-digitale-arbeitswelt

Ittermann, P. / Niehaus, J. / Hirsch-Kreinsen, H. (2015): Arbeiten in der Industrie 4.0. Trendbestimmungen und arbeitspolitische Handlungsfelder. Available online: http://www.boeckler.de/pdf/p_study_hbs_308.pdf

Kagermann, H./ Anderl, R./ Gausemeier, J./ Schuh, G./ Wahlster, W. (eds.) (2016): Industrie 4.0 im globalen Kontext: Strategien der Zusammenarbeit mit internationalen Partnern (acatech STUDIE). Herbert Utz Verlag. Munich.

Kay, R. / Holz, M. / Kranzusch, P. (2014): Mittelstand im globalen Wettbewerb. Internationalisierung als unternehmerische und wirtschaftspolitische Herausforderung. Friedrich-Ebert-Stiftung. WISO Diskurs.

KfW (2016): KfW-Gründungsmonitor 2016. Arbeitsmarkt trübt Gründungslust deutlich - Innovative Gründer behaupten sich. KfW Research.

Kundu, S. (2016): Pneumatic Bread: It's Food, But Not As We Know It. Available online: http://www.forbes.com/sites/sujatakundu/2016/08/31/pneumatic-bread-its-food-but-not-as-we-know-it/#5d5d0ae61bb1

Kurzmann, S. (2015): Individualität und Flexibilität im Personalmanagement. Die neue Herausforderung durch die Generation Y. Hamburg.

Labarre, S. (2016): The Most Important Design Jobs Of The Future. Available online: https://www.fastcodesign.com/3054433/design-moves/the-most-important-design-jobs-of-the-future

Lobo, S. (2014): Auf dem Weg in die Dumpinghölle. Spiegel-Online. Available online: http://www.spiegel.de/netzwelt/netzpolitik/sascha-lobo-sharing-economy-wie-bei-uber-ist-plattform-kapitalismus-a-989584.html

Lorenz, D. / Riering, B. (2013): Große Studie: Die Zukunft des Handwerks. Available online: http://www.deutsche-handwerks-zeitung.de/grosse-studie-die-zukunft-des-handwerks/150/3096/198966

McKinsey (2015): McKinsey-Studie zu Industrie 4.0: Deutsche Unternehmen trotz wachsender Konkurrenz zuversichtlich. Available online: https://www.mckinsey.de/mckinsey-studie-zu-industrie-40-deutsche-unternehmen-trotz-wachsender-konkurrenz-zuversichtlich

Messina, C. (2016): 2016 will be the year of conversational commerce. Available online: https://medium.com/chris-messina/2016-will-be-the-year-of-conversational-commerce-1586e85e3991#.2kr1rpq0g

Microsoft (n.d.): Futureproof yourself. Available online: http://enterprise.blob.core.windows.net/whitepapers/futureproof_tomorrows_jobs.pdf

Mirza, A. (2010): Neue Tätigkeitsfelder bringen neue Berufschancen – Fundraiser statt Philosoph. Available online: http://www.berliner-zeitung.de/neue-taetigkeitsfelder-bringen-neue-berufschancen-fundraiser-statt-philosoph-14605058

MIT Media Lab (2016): Projects Fall 2016. 227. Beast. Available online: https://www.media.mit.edu/research/?filter=projects

Mitsui, E. (2013): Commercial drones could have 'endless' uses under Canada's laws. Available online: http://www.cbc.ca/news/technology/commercial-drones-could-have-endless-uses-under-canada-s-laws-1.1386300

Moretti, E. (2010). "Local Multipliers." American Economic Review, 100(2): 373-77. DOI: 10.1257/aer.100.2.373.

Morozov, E. (2015): Where Uber and Amazon rule: welcome to the world of the platform. Available online: https://www.theguardian.com/technology/2015/jun/07/facebook-uber-amazon-platform-economy

Murphy, D. (2016): Top 20 Jobs Of The Future. Available online: https://medium.com/@deemurphy/top-20-future-jobs-that-don-t-exist-yet-6ae6c1ef6a46#.bicqg14ng

OECD (2017): Employment Outlook 2017. OECD. Paris.

OECD (2016): An OECD Horizon Scan of Megatrends and Technology Trends in the Context of Future Research Policy. Available online: http://ufm.dk/en/publications/2016/an-oecd-horizon-scan-of-megatrends-and-technology-trends-in-the-context-of-future-research-policy

OECD (2011): Towards an OECD Skills Strategy. Available online: http://www.oecd.org/edu/47769000.pdf

Office of Technology Assessment (TAB) (2016): Brief Nr. 47 Digitaler Wandel der Bildungs- und Arbeitswelten. Available online: http://www.tab-beim-bundestag.de/de/publikationen/tab-brief/index.html

Osborne, M.A. / Frey, C.B. (2013): The Future Of Employment: How Susceptible Are Jobs To Computerisation? Oxford Martin School. Oxford.

Parker, G. / van Alstyne, M.W. / Choudary, S.P. (2016): Platform Revolution: How Networked Markets are Transforming the Economy – and How to Make Them Work for You. Norton & Company. New York City.

Pew Research (2016): Public Predictions for the Future of Workforce Automation. Available online: http://www.pewinternet.org/2016/03/10/public-predictions-for-the-future-of-workforce-automation/

Proplanta (n.d.): Precision Farming: Drohnen in friedlicher Mission. Available online: http://www.proplanta.de/Journal/AgrarStellenmarkt-13/Drohnen-Landwirtschaft_jo1399224616.html

Prümper, J. / Lorenz, C. / Hornung, S. / Becker, M. (2016): „Mobiles Arbeiten" Kompetenzen und Arbeitssysteme entwickeln. DGFP. Mannheim.

PwC (2015): The World in 2050. Will the shift in global economic power continue? Available online: http://www.pwc.com/gx/en/issues/the-economy/assets/world-in-2050-february-2015.pdf

PwC (2014): Fit for the future. Capitalizing on global trends. 17th Annual Global CEO Survey.

Rifkin, J. (2015): The Zero Marginal Cost Society: The Internet of Things, the Collaborative Commons, and the Eclipse of Capitalism. Macmillan. New York City.

Rotman, D. (2015): Who Will Own the Robots? Available online: https://www.technologyreview.com/s/538401/who-will-own-the-robots/

Runde, C. (2016): Virtuelle Techniken im Handwerk. Available online: http://www.vdc-fellbach.de/files/Whitepaper/2016-VDC-Whitepaper-Virtuelle-Techniken-im-Handwerk.pdf

Schaub, S. / Schuppisser, R. (2015): So sehen die Jobs der Zukunft aus. Available online: http://www.aargauerzeitung.ch/leben/leben/so-sehen-die-jobs-der-zukunft-aus-128731427

Schmidt, K. (2015): 13 Berufe mit Zukunft. Available online: http://www.handelsblatt.com/unternehmen/beruf-und-buero/zukunft-der-arbeit/jobs-in-der-digitalbranche-category-manager/11072838-3.html

Shah, S. (2016): Facebook is developing a revolutionary method to teach chatbots common sense. Available online: http://www.digitaltrends.com/social-media/facebook-ai-common-sense/

Statista (2016): Entwicklung der Anzahl der Beschäftigten im deutschen Handwerk von 1998 bis 2015. Available online: https://de.statista.com/statistik/daten/studie/5156/umfrage/entwicklung-der-anzahl-an-beschaeftigten-im-deutschen-handwerk/

Stettes, O. (2016): Arbeitswelt und Arbeitsmarktreform der Zukunft. Welche Schlüsse können aus der vorliegenden empirischen Evidenz bereits geschlossen werden. IW. Cologne.

Stone, P. et al. (2015): Artificial Intelligence And Life In 2030. Available online: https://ai100.stanford.edu/sites/default/files/ai_100_report_0906fnlc_single.pdf

Störmer, E. / Patscha, C. / Prendergast, J. / Daheim, C. / Rhisiart, M. (2014): The Future of Work: Jobs and Skills in 2030. Evidence Report 84. Available online: http://www.z-punkt.de/fileadmin/be_user/D_Publikationen/D_Auftragsstudien/the-future-of-work-evidence-report.pdf

Sundararajan, A. (2016): Sharing Economy: The End of Employment and the Rise of Crowd-Based Capitalism. The MIT Press. Cambridge.

Țărmure, S. (2016): #JobsFrom2050 – Robot Trainers. Available online: https://medium.com/small-academy/jobsfrom2050-robot-trainers-caf85371d93d#.b3oymjaed

UN (2015): Word Population Prospects, the 2015 Revision. Available online: https://esa.un.org/unpd/wpp/DataQuery/

Vogler-Ludwig, K. / Düll, N. / Kriechel, B. / Vetter, T. (2016): Arbeitsmarkt 2030 – Wirtschaft und Arbeitsmarkt im digitalen Zeitalter. Prognose 2016. Szenario beschleunigte Digitalisierung. Economix Research & Consulting. Munich.

WEF (2016): The Future of Jobs. Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution. World Economic Forum – Global Challenge Insight Report. Cologny/Geneva.

Weiner, J. (2016): How The Industrial App Economy Will Drive The 4th Industrial Revolution. Available online: https://gereports.ca/industrial-app-economy-will-drive-4th-industrial-revolution/#

World Economic Forum (ed.) (2015): The Future of Financial Services. How disruptive innovations are reshaping the way financial services are structured, provisioned and consumed. Available online: http://www3.weforum.org/docs/WEF_The_future__of_financial_services.pdf

Z_punkt GmbH (2014): Connected Reality 2025. The next wave of digital transformation. Trend Study. Available online: http://www.z-punkt.de/uploads/files/9/connected_reality.pdf

Zika, G. / Maier, T. / Helmrich, R. / Hummel, M. / Kalinowski, M. / Hänisch, C. / Wolter, M.I. / Mönnig, A. (2015): Qualifikations- und Berufs-feldprojektionen bis 2030. Engpässe und Überhänge regional ungleich verteilt. IAB Kurzbericht 9/2015. Available online: http://doku.iab.de/kurzber/2015/kb0915.pdf

Imprint

Citizens helpline:

Monday to Thursday, from 8 am to 8 pm.
We are here to answer your questions.

Pensions:

+49 (0)30 221 911 001

Occupational accident insurance/ voluntary work:

+49 (0)30 221 911 002

Labour market policy and support:

+49 (0)30 221 911 003

Labour law:

+49 (0)30 221 911 004

Part-time work, part-time work for older workers, mini-jobs:

+49 (0)30 221 911 005

Information for people with disabilities:

+49 (0)30 221 911 006

European Social Fund/Social Europe:

+49 (0)30 221 911 007

Employee equity participation:

+49 (0)30 221 911 008

Information on the educational package:

+49 (0)30 221 911 009

Information on the minimum wage:

+49 (0)30 6028 0028

Service for the deaf and hearing-impaired:

Email: info.gehoerlos@bmas.bund.de
Fax: +49 (0)30 221 911 017
Sign language telephone: gebaerdentelefon@ sip.bmas.buergerservice-bund.de