International Labour Organization

Digitalization and the Future of Work in the Chemical Industry in Germany

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Preface

The International Labour Organization (ILO) is the United Nations specialized agency dedicated to promoting opportunities for women and men to obtain decent and productive work in conditions of freedom, equity, security and human dignity. The ILO Sectoral Policies Department promotes decent work by helping the Organization's tripartite constituents, namely governments, employers and workers, to create opportunities and address challenges in 22 different economic and social sectors at the global, regional and national levels.

The digitalization of societies, economies and sectors promises to bring dividends, spur innovation, generate efficiencies and improve the quality of services as well as people's standards of living. The digital transformation is contributing to innovation not only in production, products and services, but also in processes, working life and organizational arrangements. Digitalization is often disruptive, however. It raises a number of important policy challenges for governments, employers and workers everywhere, in areas such as privacy, security, consumer protection, competition, taxation, job creation and destruction, skills development, working conditions, social protection and the protection of workers' rights. It also brings the risk of worsening inequalities and the digital divide within and across countries.

The Centenary Declaration for the Future of Work (2019) was adopted at the 108th International Labour Conference which marked the 100th anniversary of the ILO. The Declaration advocates a human-centred approach to the future of work which focuses on: 1) strengthening the capacities of all people to benefit from the opportunities of a changing world of work; 2) strengthening the institutions of work to ensure adequate protection for all workers, and reaffirming the continued relevance of the employment relationship as a means of providing certainty and legal protection to workers while recognizing the existing extent of informality and the need to ensure effective action to achieve transition to formality; and 3) promoting sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all.

Prior to the adoption of the Centenary Declaration, in December 2018 the ILO organized the Global Dialogue Forum on Challenges for Decent and Productive Work Arising from Digitalization in the Chemical and Pharmaceutical Industries. The Forum was attended by 71 participants, comprising 33 Government representatives and advisers from 26 member States, eight Worker and eight Employer representatives together with 14 additional members (five from the Employers' group and nine from the Workers' group), and eight observers from intergovernmental organizations (IGOs) and international non-governmental organizations (NGOs).

The Forum unanimously adopted points of consensus including one requesting the ILO to: "...undertake and disseminate research and comparative analysis, develop and share knowledge on trends and developments, lessons learned and good practices [...] in addressing challenges and opportunities arising from digitalization in the industries with the full involvement of the tripartite constituents, including with constituents in other sectors;" (para.18(b)).[1]

1 https://www.ilo.org/sector/activities/sectoral-meetings/WCMS_624029/lang--en/index.htm

The present report is also an important contribution to the growing knowledge base on technological change and digital transitions and the ways in which constituents can shape a future that works for all in the industry.

The report was prepared by an external consultant, Mr. Tim Vetter, of Economix Research and Consulting, under the supervision of Yasuhiko Kamakura, Casper N. Edmonds, Head of the Extractives, Energy and Manufacturing Unit, and Alette van Leur, Director of the Sectoral Policies Department. Mr. Richard Long, an external consultant, proofread and edited the report. Sincere thanks are due to Dr Annette Niederfranke, Jae-Hee Chang, Rafael Peels, as well as officials of the *undesarbeit-geberverband Chemie* (German Federation of Chemical Employers' Associations) and the *Industriegewerkschaft Bergbau*, *Chemie*, *Energie* (Union for the Mining, Chemical and Energy Industries) including Lutz Mühl and Dr Andreas Ogrinz.

Alette van Leur

Director, Sectoral Policies Department

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Abbreviations and acronyms

BAVC	Bundesarbeitgeberverband Chemie (German Federation of Chemical Employers' Associations)
DESTATIS	Statistisches Bundesamt (German Federal Statistical Office)
ICT	Information and Communication Technology
IG BCE	Industriegewerkschaft Bergbau, Chemie, Energie (Union for the Mining, Chemical and Energy Industries)
SME	Small and Medium Sized Enterprises
STEM	Science, Technology, Engineering, Mathematics
ILO	International Labour Organization
VCI	Verband der Chemischen Industrie e.V. (German Chemical Industry Association)
VET	Vocational Education and Training

1.

Executive summary

1. Executive summary

After the automotive and mechanical engineering industries, the chemical industry is one of the most important in the German economy. Next to other important drivers of change, such as globalization or climate change, digitalization is a key issue in the German chemical industry, where digital technologies have the potential to further optimize production processes and business models by building on the existing systems. However, the extent to which these new technologies can and will be applied in the chemical industry is uncertain. The limited availability of fast internet is a key obstacle to digitalization that needs to be addressed by policy makers.

Experts agree that the changes taking place are reshaping the skills needs in the industry, as demand increases for technical as well as soft and transversal skills. Digitalization also leads to greater interdisciplinarity across occupational profiles.

In contrast with other industries, there is consensus among the social partners that the German vocational training system will be flexible enough to adapt to changing skills needs in the chemical industry. This is essential, because more than two thirds of workers in the industry have received vocational training.

Digitalization in the chemical industry will also increase the demand for workers with tertiary education, including highly-skilled ICT specialists. Although this is not a core group, companies in the chemical industry will increasingly have to compete for these workers with those in other industries. Attracting female workers with STEM (science, technology, engineering, mathematics) degrees, as well as promoting immigration, are possible ways to mitigate the impending skilled worker shortages.

Against the background of changing skills needs in the German chemical industry, it will be essential to promote upskilling and reskilling for all workers in order to maintain their employability throughout working life, enable employers to find adequately skilled workers, and help policy makers ensure that the labour market functions properly. It is unclear how many workers in the German chemical industry in atypical employment currently profit from upskilling and reskilling opportunities.

Other challenges and opportunities concern working conditions. Digitalization makes it possible to shift work organization away from rigid hierarchies towards flatter, more decentralized structures. Most workers in the chemical industry in Germany seem open to the changes in work organization offered by digitalization, but surveys indicate that the resulting workload is greater in the chemical industry than in other branches of manufacturing. Flexible working-time arrangements (e.g. mobile work) offer opportunities for the workforce to enjoy greater balance in family and working life, but can also lead to increased stress. These issues imply that the current legislation on working hours needs to be adapted to a more modern world of work. Moreover, the use and misuse of data, including the issue of ensuring protection of personal and corporate data, presents a challenge that is particularly relevant to Germany today.

The social partners in the chemical industry – the IG BCE and the BAVC – are aware of these challenges and cooperate successfully to work on solutions. Examples of best practice in Germany are the WORK@industry4.0 dialogue process, the chemistry qualification campaign and collective agreements that take into consideration the flexibilization of working hours. However, in an increasingly uncertain operating environment, new challenges and opportunities are emerging for workers and employers in Germany. It therefore becomes important to further strengthen social dialogue at all levels in order to find solutions which enable the chemical industry to continue to grow and create decent work opportunities for an increasingly diverse workforce.

2.

Introduction

2. Introduction

Digitalization, together with climate change, demographic shifts and a new era of globalization, affect not only the chemical industry but the whole German economy (Demary/Matthes/Plünnecke/Schaefer 2021). The shift in skills needs expected to result from digitalization has the potential to destroy, transform and create jobs, change the nature of the current training and lifelong learning systems, and alter working conditions in the industry.

This report presents the available data and literature relating to digitalization and the future of work in the German chemical industry. Information was provided by the federal authorities (e.g. federal ministries, the Federal Employment Agency, the Federal National Statistical Office), research organizations, industry associations, and the social partners (the IG BCE, representing workers and the BAVC, representing employers), among others. It builds upon the ILO issues paper produced for the *Global Dialogue Forum on Challenges for Decent and Productive Work Arising from Digitalization in the Chemical and Pharmaceutical Industries* (2018). Consultations were also held with the social partners.

A wide range of data is available on the chemical industry in Germany, but the industry and its relevant occupations are defined in several ways. In many cases, publications do not consider the chemical industry in isolation, but rather the chemical and pharmaceutical industries as a whole. Table 1 provides an overview of industries Nos 20 and 21 in the German classification of industries (*Klassifikation der Wirtschaftszweige 2008*[2]) as well as their corresponding sub-sectors. However, the main focus of this report will be the analysis of industry 20 (Manufacture of chemicals and chemical products).

2 Compared with the international classification of economic activities ISIC Rev. 4, the German classification includes a higher level of detail at the three-digit and four-digit level. These levels can, however, always be assimilated to a corresponding three- or four digit level in the ISIC Rev. 4 classification. For example, WZ 2008 20.11 (Production of industrial gases), 20.12 (Manufacture of dyes and pigments), 20.13 (Manufacture of other inorganic basic materials and chemicals) and 20.14 (Manufacture of other organic raw materials and chemicals) all correspond to ISIC Rev. 4 sector 2011 (Manufacture of basic chemicals) – see DESTATIS (2008), p.85.

▶ Table 1. Sectors and sub-sectors of the chemical and pharmaceutical industry according to the German classification of industries (WZ 2008)

Code	WZ 2008 (English)	WZ 2008 (German)
20	**Manufacture of chemicals and chemical products**	**Herstellung von chemischen Erzeugnissen**
20.1	Manufacture of basic chemicals, fertilizers and nitrogen compounds, plastics and synthetic rubber in primary forms	Herstellung von chemischen Grundstoffen, Düngemitteln und Stickstoffverbindungen, Kunststoffen in Primärformen und synthetischem Kautschuk in Primärformen
20.2	Manufacture of pesticides and other agrochemical products	Herstellung von Schädlingsbekämpfungs-, Pflanzenschutz- und Desinfektionsmitteln
20.3	Manufacture of paints, varnishes and similar coatings, printing ink and mastics	Herstellung von Anstrichmitteln, Druckfarben und Kitten
20.4	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	Herstellung von Seifen, Wasch-, Reinigungs- und Körperpflegemitteln sowie von Duftstoffen
20.5	Manufacture of other chemical products	Herstellung von sonstigen chemischen Erzeugnissen
20.6	Manufacture of man-made fibres	Herstellung von Chemiefasern
21	**Manufacture of basic pharmaceutical products and pharmaceutical preparations**	**Herstellung von pharmazeutischen Erzeugnissen**
20.1	Manufacture of basic pharmaceutical products	Herstellung von pharmazeutischen Grundstoffen
20.2	Manufacture of pharmaceutical preparations	Herstellung von pharmazeutischen Spezialitäten und sonstigen pharmazeutischen Erzeugnissen

Source: DESTATIS 2008a, DESTATIS 2008b.

Occasionally, data on occupations is available disaggregated by requirement level, as in the German Classification of Occupations (KldB 2010). The requirement level describes the complexity of a professional activity and is always typical for a specific occupation, but independent of a person's formal qualification (table 2).

▶ Table 2. Requirement levels according to the German classification of occupations (KldB 2010)

1	Helper (*Helfer*)	Occupations that do not require a formal vocational qualification or a 1-year VET course
2	Skilled worker (*Fachkraft*)	Occupations that require VET training of at least 2 years
3	Specialist (*Spezialist*)	Occupations that require an initial formal VET degree and an additional level of continuing training within the formal VET system (*Meister*); occupations that require a Bachelor's degree
4	Expert (*Experte*)	Occupations that require a Master's degree (or equivalent) or at least 4 years of tertiary education

Source: https://statistik.arbeitsagentur.de/DE/Statischer-Content/Grundlagen/Methodik-Qualitaet/Methodische-Hinweise/uebergreifend-MethHinweise/Anforderungsniveau-Berufe.html.

There are some limitations to this report that call for further research. First, it does not contain company case studies that would give in-depth insights as to how digital technologies and (company-specific) lifelong learning systems are implemented in the German chemical industry. Second, future research would benefit from interviews with a wider range of actors, including political decision-makers, additional industry associations (e.g. the Chemical Industry Association (VCI[3])), company representatives from small and medium-sized enterprises (SMEs) and multinational enterprises (MNEs) based in Germany, as well as individual researchers. Third, as the topic of this report is very specific, some of the in-depth studies used are considered relevant even if they were not always carried out in the very recent past or do not refer to Germany as a whole or exclusively. Two relevant examples are the in-depth surveys on digitalization of the chemical industry in the Federal States of Hesse (IW Köln 2017) and Baden-Württemberg (Fraunhofer IAO 2017).

3 https://www.vci.de/startseite.jsp

3.

Brief overview of the chemical industry

▶ 3. Brief overview of the chemical industry

This section provides a brief overview of the chemical industry in Germany. To give the reader an insight into the relationship between the chemical sector and the pharmaceutical sector, the section will occasionally include data on the latter. Some data are only available for the chemical and pharmaceutical industries combined.

3.1. Overview and structure of the industry

The chemical industry has a long tradition in Germany. The world's largest producer of chemicals, BASF[4], was founded in Germany in 1865. The five German companies with the highest sales in 2020 were all founded between the years 1863 and 1912.[5] However, most enterprises in the German chemical and pharmaceutical industries are SMEs (table 3). Employment and sales are concentrated in the largest companies, namely those with 1,000 and more employees, which comprise 1.8 per cent of all the companies in the two industries.

▶ **Table 3. Size structure of the German chemical-pharmaceutical industry in 2019**

Persons employed	% share of all companies	% share of all persons employed	% share of sales
1 to 9	41.7	1.2	0.5
10 to 19	15.8	1.8	0.7
20 to 49	12.1	3.1	2.1
50 to 99	10.8	5.8	4.3
100 to 249	10.4	11.8	9.6
250 to 499	4.9	13.1	10.6
500 to 999	2.6	13.3	11.8
1000 and more	1.8	49.9	60.4

Source: VCI, DESTATIS, Statista (https://de.statista.com/statistik/daten/studie/203587/umfrage/groessenstruktur-der-deutschen-chemisch-pharmazeutischen-industrie/).

4 https://cen.acs.org/business/finance/CENs-Global-Top-50-2021/99/i27

5 BASF SE (1865), Bayer AG (1863), Fresenius SE & Co. KGaA (1912), Boehringer Ingelheim (1885), Henkel AG & Co. KGaA (1876). Data on sales in 2020: https://www.vci.de/ergaenzende-downloads/rangliste-top-20-chemieunternehmen-deutschland-excel-rohdaten.xlsx.

The social partners in the German chemical industry are the trade union IG BCE (*Industriegewerkschaft Bergbau, Chemie, Energie*) and the Federal Chemical Employers' Association BAVC (*Bundesarbeitgeberverband Chemie*). The IG BCE was founded in October 2007 and represents 660,000 members from the mining, chemistry, energy, glass, rubber, ceramics, plastics, leather, paper and renovation industries.[6] The trade union represents all workers in these industries, including production and office workers.[7] The BAVC[8] dates back to an association founded in 1949 and represents 1,900 companies with 580,000 employees in the chemical and pharmaceutical industry as well as large parts of the rubber and the plastics processing industries. Important manufacturers of chemicals, for example BASF SE, Merck, Bayer AG, Henkel AG and Boehringer Ingelheim, are members of the board of the BAVC. Around 80 per cent of BAVC members are SMEs.[9]

The BAVC serves as the secretariat of the International Chemical Employers Labour Relations Committee (LRC), which is collaborating closely with the International Organisation of Employers (IOE). The IG BCE is affiliated with the IndustriALL Global Union and the International Trade Union Confederation (ITUC) via the *Deutscher Gewerkschaftsbund* (DGB).

The German Chemical Industry Association (*Verband der Chemischen Industrie e.V.* – VCI[10]) was founded in 1877. It represents the interests of the chemical industry towards policy makers, state authorities, other industries, science and the media. More than 1,700 companies[11] in the German chemical industry are VCI members.

3.2. Production, sales, trade and productivity

With sales of €160 billion, the German chemical industry ranked third in the world in 2020 (after China with €1,547 billion and the United States with €426 billion).[12]

After the automotive and mechanical engineering industries, the chemical and pharmaceutical industry was the third largest in terms of sales among all manufacturing industries in Germany in 2019.[13] According to data from DESTATS (Federal Statistical Office), sales of both chemical and pharmaceutical products decreased slightly from 2018 to 2020 (figure 1). The domestic market was significantly more important for the chemical industry in the past, but has been decreasing since 2015, while its importance to the pharmaceutical industry has been on the increase since 2018 (figure 2).

6 https://igbce.de/resource/blob/29768/f616a140a38723b6e525a6dee091c201/leistungen-der-ig-bce-englisch--data.pdf, https://igbce.de/igbce/ueber-uns/branchen

7 https://igbce.de/resource/blob/3044/aaf0e665f03d3fef38b29679c5ca2c47/a3-g20-leistungen-data.pdf

8 https://www.bavc.de/

9 https://www.bavc.de/service/daten-fakten

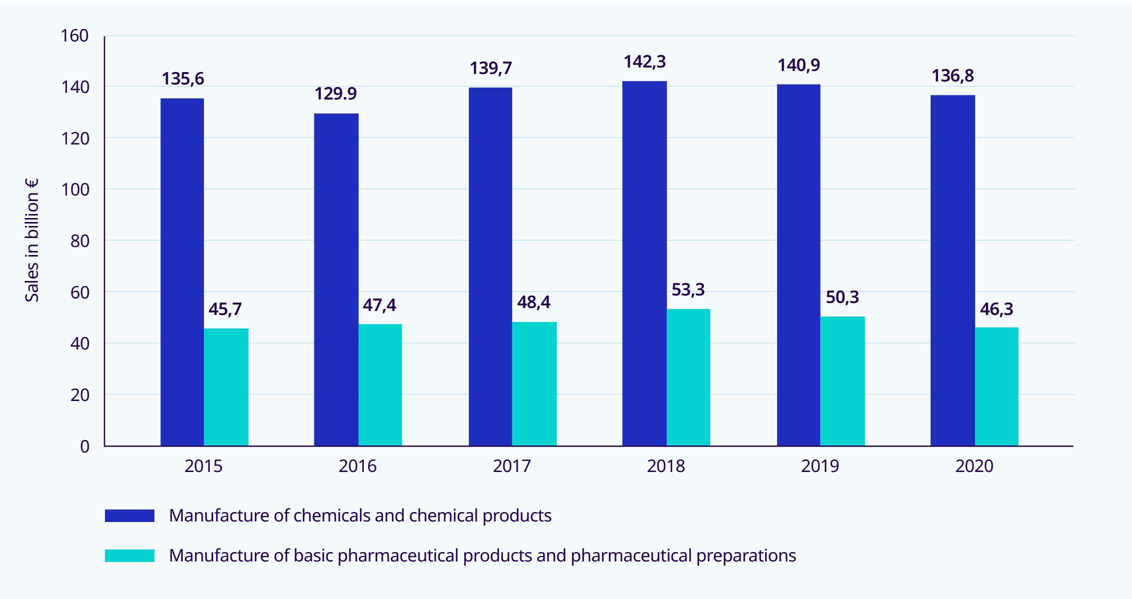
10 https://www.vci.de/ergaenzende-downloads/2021-02-08-vci-kurzportraet-de.pdf

11 According to the VCI, their membership companies represent around 90 per cent of sales across the whole industry.

12 Source: CEFIC (Chemdata International); Statista (https://de.statista.com/statistik/daten/studie/288751/umfrage/laender-mit-dem-hoechsten-umsatz-der-chemieindustrie/)

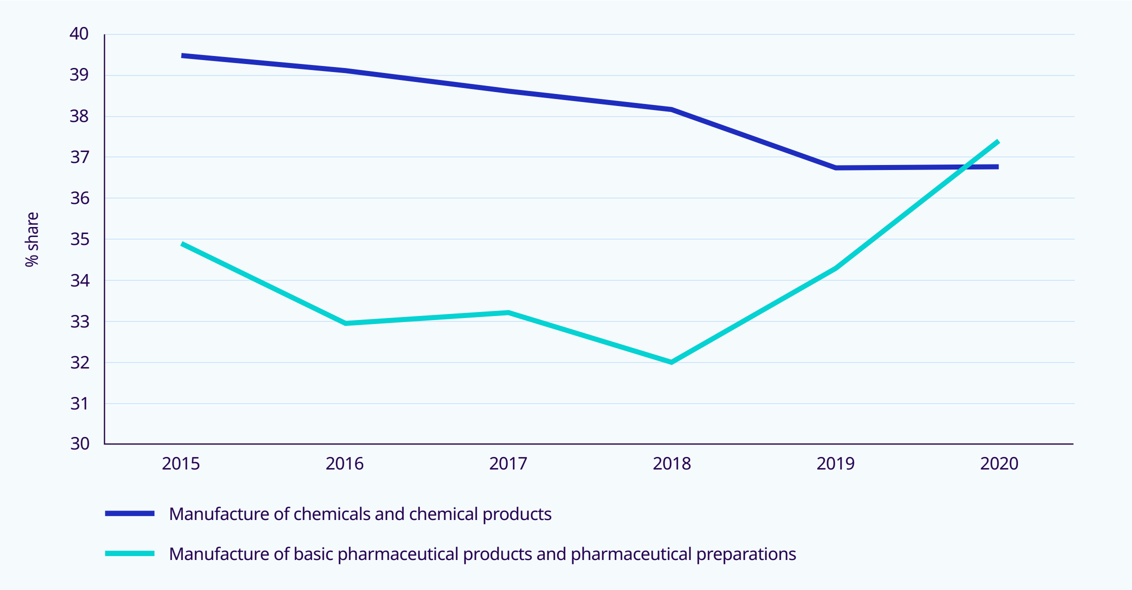
13 Source: DESTATIS, VCI (https://www.vci.de/vci/downloads-vci/publikation/chemische-industrie-auf-einen-blick.pdf)

▶ Figure 1. Sales in billions of Euros



Source: DESTATIS.

▶ Figure 2. Share of domestic sales in total sales



Source: DESTATIS.

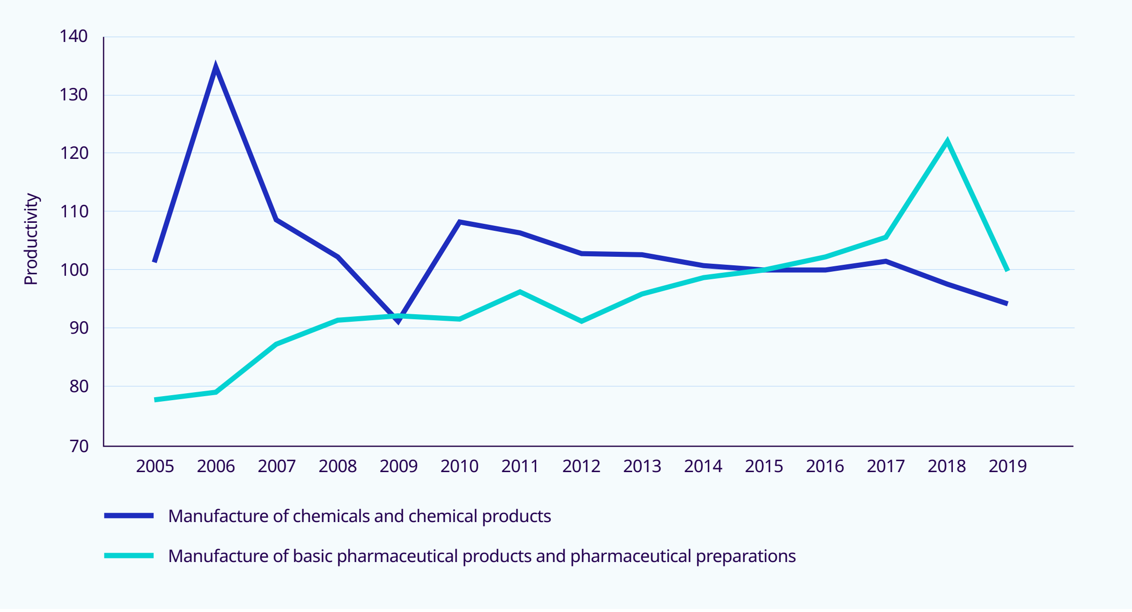
With the exception of the economic crisis in 2009, worldwide exports and imports of German chemical and pharmaceutical products increased continually until 2018 (Exports: €202.71 billion, Imports: €146.57 billion) and have remained at a high level since then (2020: Exports €199.74 billion, Imports: €143.22 billion).[14]

14 Source: DESTATIS, VCI, Statista (https://de.statista.com/statistik/daten/studie/242701/umfrage/im-und-exportwert-der-chemisch-pharmazeutischen-industrie/).

Germany had the highest export value of chemical and pharmaceutical products worldwide in 2020.[15] A total of 49.6 per cent of exports flowed to the EU 27, with 15.5 per cent going to Asia, 13.8 per cent to North America (Canada, Mexico and the United States), 16 per cent to other European countries, 1.7 per cent to Africa, 1.0 per cent to Latin America and 0.8 per cent to Australia/Oceania.[16]

The production value of the German chemical and pharmaceutical industries peaked in 2018 (€153 billion), decreasing in 2019 to €143.9 billion and in 2020 to €138.3 billion.[17] Productivity in the pharmaceutical industry increased significantly until 2018, but fell from 2018 to 2019. By contrast, productivity in the chemical industry has shown a slight downward trend since 2010 (figure 3).

▶ **Figure 3. Productivity index per employee, 2005 – 2019 (2015 = 100)**



Source: DESTATIS.

3.3. Supply chains

According to a survey among employers in the German chemical industry in 2020, the supply chains of their companies will remain global but will be reorganized in the future, and will rely on a balance between cost optimization on the one hand and safety and environmental sustainability on the other.[18]

Disruptive product innovations caused by digitalization have so far had only a limited impact on the structure of the supply chain. It is likely that the impact of digitalization on supply chains will remain limited in the future, provided that products continue to be manufactured and marketed through the existing structures and channels. By contrast, digitalization is likely to lead to disruptive changes in the business

15 Source: VCI, CEFIC (Chemdata International), Statista (https://de.statista.com/statistik/daten/studie/240963/umfrage/weltweit-fuehrende-exportlaender-von-chemisch-pharmazeutischen-produkten).

16 Source: VCI, DESTATIS, Statista (https://de.statista.com/statistik/daten/studie/340014/umfrage/exportverteilung-der-deutschen-chemieindustrie-weltweit-nach-regionen/).

17 Source: Federal Statistical Office, VCI (https://de.statista.com/statistik/daten/studie/242736/umfrage/produktionswert-der-chemisch-pharmazeutischen-industrie-in-deutschland/).

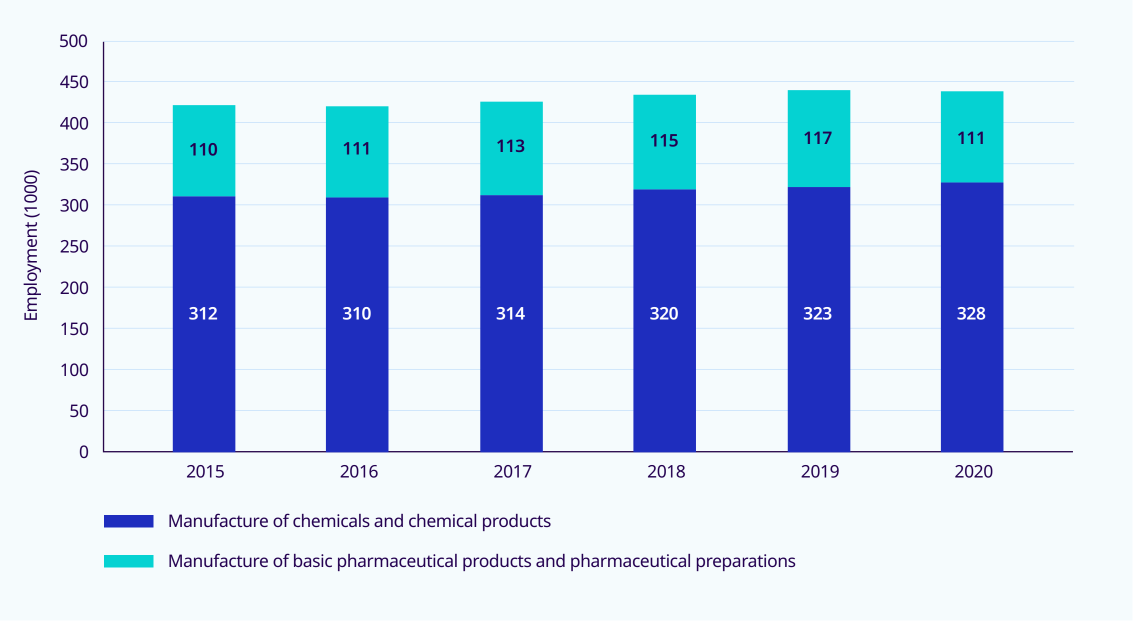
18 https://www.technik-einkauf.de/einkauf/strategien/chemieunternehmen-setzen-weiter-auf-globale-lieferketten-279.html

model, for instance through digital business platforms and value-added networks (see section 4.1). The German chemical industry could be at risk if other, including new, non-chemical competitors build up market power and control the value-added networks (Deloitte 2017).

3.4. Employment

Between 2015 and 2020, employment in the chemical industry increased continually from around 312,000 to around 328,000 (figure 4). In the pharmaceutical industry, employment increased until around 2019, but decreased from 2019 to 2020.

▶ **Figure 4. Employment in the chemical industry in Germany, 2015-2020**



Source: DESTATIS.

Roughly three quarters of all persons employed in the chemical industry (as defined in table 1) are male (table 4). This share remained largely stable between 2017 and 2021. The gender balance in the pharmaceutical industry has been much more even, with women making up 49 per cent of the workforce in April 2021. The share of women fell slightly during those five years, however.

▶ **Table 4. Share of women among employees subject to social security contributions, 03/2017 – 03/2020**

	03/2017	03/2018	03/2019	03/2020	03/2021
Manufacture of chemicals and chemical products	26.4	26.5	26.3	26.3	26.3
Manufacture of basic pharmaceutical products and pharmaceutical preparations	49.5	49.7	49.5	49.3	49.0

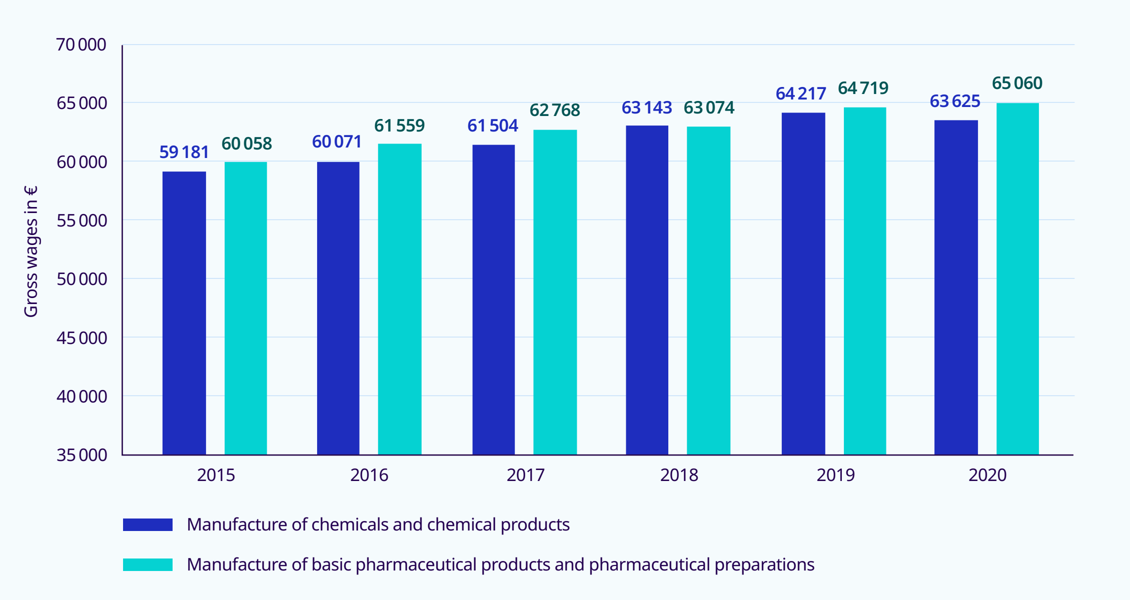
Source: Federal Employment Agency; author’s calculations.

In general, the share of women employed in the chemical industry is strongly dependent on the skills requirement level (table 2) and the job being performed. The vast majority of women are employed as specialists, as pharmaceutical-technical assistants, or in the laboratory (KOFA 2021). In chemistry-related occupations in research and development (R&D), laboratories and production, which are primarily found in the chemical industry, the proportion of female employees is significantly higher than in occupations in the fields of technology and maintenance or ICT and software development.

3.5. Terms and conditions of employment

The annual gross wages of workers in the pharmaceutical industry for the period 2015 to 2020 increased continually from €60,058 to €65,060 (figure 5), which was higher than the average in the whole manufacturing industry in 2020 (around €51,890– DESTATIS data). In the chemical industry, gross wages were on a similar level and also developed positively, with the exception of a slight decrease between 2019 and 2020. In the chemical industry as a whole, collectively agreed wages rose by a total of 12.6 per cent between 2015 and 2020.[19]

▶ **Figure 5. Annual gross wages per employee, 2015 - 2020**

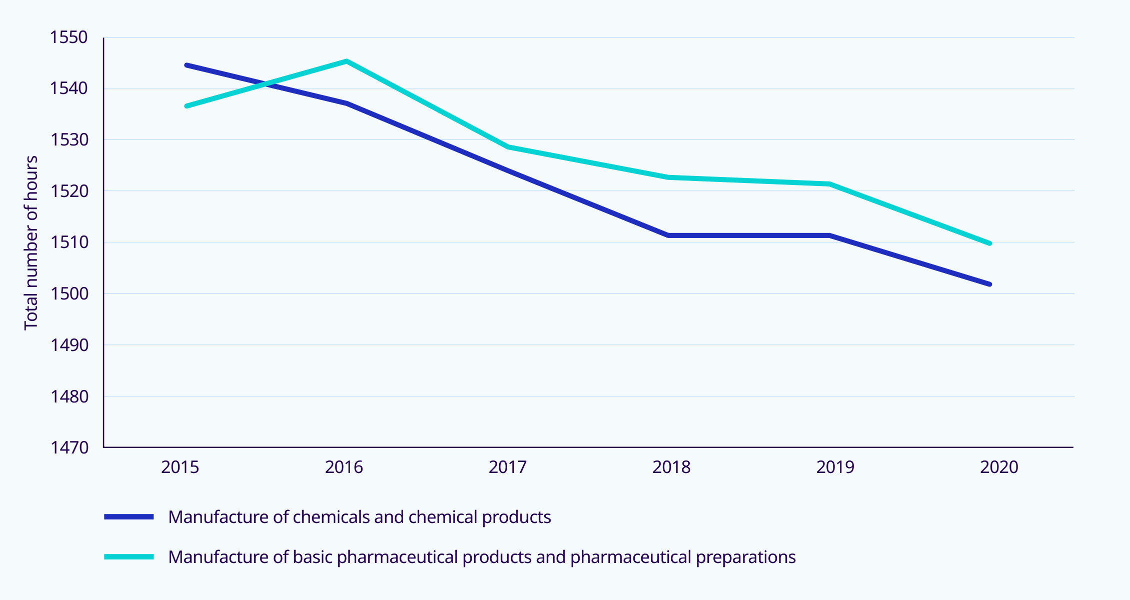


Source: DESTATIS; author's calculations.

Between 2015 and 2020, annual working hours per employee decreased both in the chemical and the pharmaceutical industry (figure 6). However, in 2020 the annual working hours in the chemical (1,502 hours) and pharmaceutical (1,510 hours) industries were above the average in the manufacturing industry as a whole (1,421 hours) (DESTATIS data).

19 https://www.destatis.de/DE/Themen/Arbeit/Verdienste/Tarifverdienste-Tarifbindung/_inhalt.html

▶ **Figure 6. Annual working hours per employee**



Source: DESTATIS; author's calculations.

In the chemical industry, as of February 2021, 69 per cent of companies or 87 per cent of workers in the *Tarifgebiet West* (Western German Federal States) and 34 per cent of companies or 38 per cent of workers in the *Tarifgebiet Ost und Berlin* (Eastern German Federal States and Berlin) were subject to collective agreements (Schulten/Bispinck/Lübker 2021).

3.6. COVID-19 and its impacts on the industry and workers

According to both the BAVC and the IG BCE, the COVID-19 pandemic greatly accelerated digitalization processes in the German chemical industry. Mobile work and working from home were used more frequently and accepted more widely. Moreover, digital technologies were used significantly more often by instructors in the dual vocational training system (Interview with BAVC/IG BCE on 16/11/2021).

A survey conducted by the BAVC shows that in May 2020 around 15 per cent of workers were in short-time work, compared with 3 per cent before the pandemic (March 2020).[20] While this represents a rapid growth in short-time work, it is still at a lower rate than the average in the German manufacturing industry in May 2020 (29.2 per cent[21]). By comparison, enterprises closer to the automotive industries were hit harder by the impact of the crisis and used short-time work schemes more frequently (Interview with BAVC/IG BCE on 16/11/2021). Thus, while short-time work was practised in the chemical industry during the pandemic, the main measures taken to adapt to the crisis were collective agreements on flexible working-time arrangements (see also section 5.3.3) (Interview with BAVC/IG BCE on 16/11/2021).

20 https://www.bavc.de/aktuelles/1985-bavc-umfrage-zu-kurzarbeit-und-beschaeftigung-corona-lagebild-aus-der-chemie
21 https://de.statista.com/statistik/daten/studie/1143144/umfrage/corona-krise-anteil-der-kurzarbeiter-nach-sektoren/

4.

Digitalization and other drivers of change

▶ 4. Digitalization and other drivers of change

This section highlights how digitalization and other new technologies affect the German chemical industry, and then analyzes how they interact with important drivers of change like globalization and de-globalization, demographics and climate change.

4.1. Digitalization and other new technologies and their application in the chemical industry

The Future Skills Report - Chemie[22] identifies 15 technologies relevant to the German chemical and pharmaceutical industries, and provides definitions as well as practical examples for their application. These technologies are categorized under three umbrella terms: digital, those relevant to materials science, and those that improve interaction and business processes;

- Most relevant **digital technologies** (*Digitale Technologien*) involve Big Data (e.g. for developing a database with all types of materials from experimental chemistry and cheminformatics); blockchain (e.g. to track, trace and deliver processed chemicals); cybersecurity (e.g. for protecting valuable information about chemical formulas and customer databases from unauthorized access); data science and analytics (e.g. for analyzing various data sources such as experiments, photos and images used to predict the chemical structure of a material); and machine learning/AI (e.g. for simulating chemical reactions in the development of new materials and reducing development time by reducing the number of laboratory tests required). Big Data also has the potential to support data-driven decisions, for example in the fields of predictive maintenance or sales (Deloitte 2017).
- One promising digitalization technology identified in the field of **materials science** (*Materialtechnologien*) is 3D-printing/additive manufacturing (e.g. for printing broken parts of production plants). Other technologies in this field involve the development of batteries, alternative non-fossil resources, biotechnology (mRNA vaccines) and the development of nanomaterials.
- Finally, relevant digitalization technologies in the area of **interaction and business processes** (*Interaktion und Geschäftsprozesse*) include the Agile Principles (e.g. project management methodology, potential application in chemical product development); automation and robotics (e.g. chemical laboratory technicians supported by robots when conducting dangerous laboratory experiments); digital distribution (e.g. implementation of e-commerce platforms); IoT & connectivity (e.g. sensors that collect data from production systems enabling scalable data analysis leading to optimized and predictive maintenance of machines, cost-savings, increased efficiency and remote monitoring); and virtual and augmented reality (e.g. the training of maintenance technicians).

22 https://future-skills-chemie.de/chemical-trends/#link_1; based on the evaluation of online vacancies of companies in the chemical industry, career pages of companies, patents, statistics, business networks or scientific publications. For details, see chapter 7.

In combination, these technologies can lead to the development of new digital business models and new smart products. For example, more flexible production processes can supply small batches of personalized products (e.g. by using 3D-printing/additive manufacturing technology) and the establishment of additional (digital) services can improve customer benefits, as can the introduction of direct sales (B2B or B2C) on online platforms (Deloitte 2017[23]). These will not replace the existing systems in the chemical industry, but build upon them (ILO 2018). The extent to which these new technologies can and will be applied in the chemical industry is still uncertain. However, some points can be made about the state of application of these technologies in the German chemical industry.

Fragmented skills for chemical digitalization

The implementation of traditional automation and production processes is already very advanced in the German chemical industry, and the collection of production data via sensors is also at a high level (Fraunhofer IAO 2017). This is also evident from data in the Future Skills Report - Chemie[24]. By comparison with the EU, the United States and China, the German chemical industry is leading when it comes to demand for skills in the fields of automation and robotics, 3D-printing and IoT & connectivity (see also table A1). However, the demand for skills related to machine learning and AI is low by international comparison. This indicates that there is still potential in the further interlinking or integration of automated production processes (Fraunhofer IAO 2017), as the possibilities for systematically collecting digital mass data and using algorithms offer a new basis for further such automation (Deloitte 2017).

Uncertainty in the introduction of digitalized technologies

The German chemical industry is aware of new digital business models (Deloitte 2017). In the Federal State of Baden-Württemberg, some chemical companies have indicated that they are digitizing their supply chains (e.g. implementing a digital workflow or real-time controls in production and logistics) and their customer relations (Fraunhofer IAO 2017). In a survey conducted in the Federal State of Hesse (IW Köln 2017), chemical companies indicated that they pay a very high level of attention to digitalization processes in indirect work areas such as personnel and control as well as logistics. However, there are signs of a lack of new products with digital components and of new business models with digital added value in the chemical industry (Fraunhofer IAO 2017). This is also evident from the percentage of all chemical companies in Germany (with at least five employees) offering market innovations, which decreased from 48 per cent in 2010 to 24 per cent in 2019.[25]

There seems to be a generally high level of uncertainty in the German chemical industry as to how to implement new digital business models, even though employers are aware of their benefits. In a survey conducted by EY (2019, see also table A2) among 101 managers in the chemical industry, 35 per cent stated that the main barrier to the implementation of digitalization was unclear business models, with 34 per cent citing a lack of IT know-how. By comparison, 30 per cent stated that investment needs are too high and only 22 per cent felt that the economic benefit of digitalization was unclear. The result of a survey among chemical and pharmaceutical companies in Hesse indicated that the specialist knowledge needed for an accelerated transformation process and the implementation of digitized business models was still lacking (IW Köln 2017). This uncertainty might also limit the demand for workers with the relevant skills. According to the Future Skills Report - Chemie, the demand for skills in Big Data, Data Science & Analytics, and Digital Distribution (see table A1) is very low by international comparison.

23 See also https://www.mckinsey.com/industries/chemicals/our-insights/how-chemical-players-can-win-in-the-transition-to-digital-platforms

24 https://future-skills-chemie.de. For details, see chapter 7.

25 Source: ZEW, Statista (https://de.statista.com/statistik/daten/studie/164949/umfrage/unternehmen-der-deutschen-chemieindustrie-mit-marktneuheiten/).

High level of work digitalization

The degree of work digitalization in the chemical industry is significantly higher than in other industries in Germany (Priesack et al. 2019). In 2019, a survey among 14,007 respondents from 614 German chemical companies whose employees are represented by the IG BCE revealed that the use of digital communication and information systems was very common – for example, 77 per cent of respondents used email communication very often. The use of digitally processed data for end products and work results was less common – for example, Big Data was used very often by 5 per cent of respondents, often by 9 per cent, sometimes by 12 per cent, seldom by 13 per cent, and never by 61 per cent. Moreover, 88 per cent of respondents indicated that they never used AI. Digital production technologies were also rarely used (93 per cent of respondents indicated that they never used 3D-printing), and personal measurement systems only sporadically (6 per cent of respondents used a health tracker very often). Overall, 65 per cent of respondents indicated that they knew of a digitalization strategy in their companies. This share was only 50 per cent in the production field, but 72 per cent in R & D and ICT.

As in other advanced economies, the first wave of digital transformation (digitalization of analogue data and integration of cloud solutions (see Prognos 2019)) has largely been accomplished in the German chemical industry.

4.2. Other drivers of change

The following sections will briefly address other drivers of change and their relationship to digitalization in the German chemical industry.

4.2.1. Globalization

Globalization and digitalization have increased the competition for international workers (Risius/Werner 2018), including those with STEM backgrounds and ICT skills (ILO 2020). Against the background of demographic change and a skilled worker shortage, securing a skilled migrant workforce is particularly important to Germany (see sections 4.2.2 and 5.2.2).

The outbreak of the COVID-19 pandemic, together with Brexit and the trade tensions between the United States and China, have highlighted the vulnerability of many international chemical supply chains, driving a discussion on the "de-globalization" (the heightened need to strengthen local supply channels and manufacturing facilities) of the German chemical industry.[26] This trend could lead to further investment in automation processes, but also to further demand for workers with the required skill set.

4.2.2. Demographics

Recent data provided by the Federal Employment Agency shows that the share of older workers (55 years old and above) increased in the period between March 2017 and March 2021 in the chemical industry (+4.0 percentage points) and in the pharmaceutical industry (+3.3 percentage points) – see table 5.

26 https://www.chemanager-online.com/news/chemieindustrie-ausblick-2021

Not only does the ageing population in Germany imply that an older workforce will need to be replaced, but also the resulting skilled worker shortages will intensify as falling birth rates limit the number of apprentices in the vocational training system (Risius/Werner 2018). The upskilling and reskilling of workers as needs change due to digitalization are therefore essential in Germany (see also section 5.2). The simplification of work processes (e.g. via digital assembly assistance systems) could also increase the employability of older workers and help to mitigate future skills shortages. However, according to the German social partners, digital assembly assistance systems are more relevant to manufacturing (e.g. the automotive industry) than to process industries such as the chemical industry (Interview with BAVC/IG BCE on 16/11/2021).

▶ **Table 5. Age structure of employees subject to social security contributions**

Industry	Age group	Percentage of age group in employment subject to social security contributions				
		03/2017	03/2018	03/2019	03/2020	03/2021
Manufacture of chemicals and chemical products	Under 25	8.0	8.0	8.1	8.1	7.9
	25 -54	70.8	69.8	68.7	67.8	66.9
	55 - 64	20.8	21.8	22.7	23.6	24.6
	65 and older	0.4	0.4	0.5	0.5	0.6
	Total	100	100	100	100	100
Manufacture of basic pharmaceutical products and pharmaceutical preparations	Under 25	6.8	6.6	6.7	6.7	6.7
	25 -54	77.2	76.5	75.7	74.9	74.1
	55 - 64	15.7	16.5	17.3	18.1	18.8
	65 and older	0.2	0.3	0.3	0.4	0.4
	Total	100	100	100	100	100

Source: Federal Employment Agency; author's calculations.

The future demand for chemical products will be influenced by changing demographics (ILO 2018). Big Data analytics and digital business models that allow for customization of products could be of importance to the chemical industry as it seeks to satisfy shifting consumer demand. This would raise the issue of companies' responsibilities for managing data and protecting workers' and consumers' privacy (see sections 5.3.3 and 6.1).

4.2.3. Climate change

Climate change and decarbonization (the process of reducing carbon dioxide emissions) are considered to pose one of the main structural challenges to the chemical industry in Germany (Interview with BAVC/ IG BCE on 16/11/2021).

Production in the German chemical industry increased by 63 per cent between 1990 and 2019, while energy use decreased by 19 per cent and greenhouse gas emissions fell by 54 per cent.[27]

Digitalization has the potential to further contribute to this trend, for example by optimizing production processes in order to make them more environmentally sustainable (Deloitte 2017). External factors that might also speed up digitalization processes and make energy-intensive production more efficient include higher energy costs and the European Emissions Trading Scheme (Prognos 2019). The expected tightening of environmental regulations in the future (Gehrke/Weilage 2018) will offer further potential for efficiency by digitizing the relevant bureaucratic processes.

Closely related to digitalization is the concept of the circular economy[28], in all of whose aspects the analysis and exchange of digital data are essential (Deloitte, 2017), for example in achieving sustainable product design and increasing the resource efficiency of production or recycling systems. One survey of German chemical companies (Deloitte 2017) revealed that 52 per cent already applied this concept in resource-efficient production, 40 per cent in recycling, 40 per cent in cleaning, 34 per cent in renewable raw materials, 27 per cent in (Re)Design, 22 per cent for the recovery of energy, and 13 per cent in take-back and reuse services.

27 Source: DESTATIS, VCI, Umweltbundesamt, Statista (https://de.statista.com/statistik/daten/studie/186496/umfrage/entwicklung-der-chemischen-industrie-in-deutschland/)

28 "The circular economy is a model of production and consumption which involves sharing, leasing, reusing, repairing, refurbishing and recycling existing materials and products as long as possible. In this way, the life cycle of products is extended." – see https://www.europarl.europa.eu/news/en/headlines/economy/20151201STO05603/circular-economy-definition-importance-and-benefits.

5.

Challenges and opportunities for decent and sustainable work

▶ 5. Challenges and opportunities for decent and sustainable work

Digitalization will change the skills needs of the chemical industry. For workers, this could present an opportunity, as new jobs are created or traditional jobs are transformed or upgraded, but also a risk, since some jobs might be automated. Adapting to changing skills needs will be a challenge to the lifelong learning, TVET and tertiary training systems in Germany.

Digital technologies will also affect the working conditions and work organization in the chemical industry. This poses challenges, as workers will need to be protected from the downsides of digital technologies, but will also want to benefit from the opportunities they bring. This section addresses these issues.

5.1. Employment

Digitalization of the economy has two main potential effects on the labour market (Arntz/Gregory/Zierahn 2019; Matthes et al. 2019; Wolter et al. 2019):

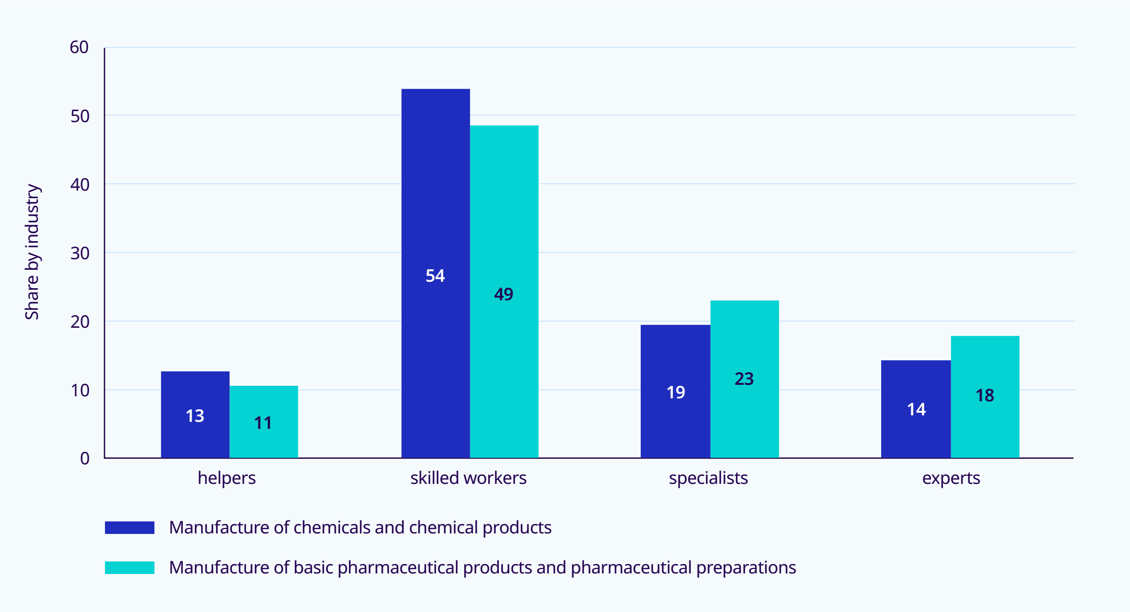
- Job destruction (through the automation of production processes) and job creation (through the development of new products and services or new production processes); and
- Structural changes in the labour market, as some jobs disappear and other job profiles emerge or change.

However, the effects of digitalization in terms of future job losses, job transformation processes, and job creation imply a high level of insecurity.

5.1.1. Job losses

The largest share of workers subject to social security contributions in the chemical and pharmaceutical industry comprises skilled workers whose jobs require VET training of at least 2 years (compare table 2 and figure 7), a requirement level that is considered to be specifically at risk from automation (Dengler/Matthes 2021). The job losses might be limited, however, as low-skilled and medium-skilled jobs in the chemical industry are in general already highly automated (ILO 2018).

▶ Figure 7. Employees subject to social security contributions by requirement level, 03/2021



Source: Federal Employment Agency.

There are differing views as to where job losses caused by digitalization will occur in the German chemical industry. In a survey of the industry conducted in Baden-Württemberg (Fraunhofer IAO 2017), respondents expected the number of low-skilled jobs to decline, particularly in production and logistics. This is partly reflected by recent data on demand for workers. For example, the Future Skills Report - Chemie[29] data shows that from 2018 to 2019, demand for workers in the chemical industry in Germany decreased most markedly in the fields of administration (-18.0 per cent), purchasing (-14.0 per cent), and human resources (-9.1 per cent); however, demand for production workers increased most significantly during this period (+14.8 per cent). A survey of the European chemical industry (Prognos 2019) indicates that the fields at highest risk of workforce reduction in the chemical industry will be administration and accounting. Women with a low level of education working in production might also be at greater risk of losing their jobs, as they are less likely to work with ICT (Bonin et al. 2020).

The IAB QuBe forecast[30] includes a baseline scenario as well as a "digitized world of work" scenario (*Digitale Arbeitswelt*) in which digitalization is enforced across the German economy (for the assumptions, compare table 1 in BMAS 2021). In the Chemistry occupational group[31], the most common in the chemical industry with a 34.2 per cent share of employment in June 2020, demand for workers decreases in the baseline scenario by 13.4 per cent from 2018 to 2030 (owing to demographic trends or lack of skilled workers), but even more strongly under the assumption of enforced digitalization (14.0 per cent). This indicates a negative effect of digitalization on demand for this occupational group (see table A3). Other common occupation groups in the chemical industry where digitalization is forecast to have a negative effect on demand are machine building and operating, warehousing and logistics, postal and other delivery services, cargo handling, and advertising and marketing (see table A3).

29 https://future-skills-chemie.de/global-benchmark/

30 https://www.bibb.de/de/qube_datenportal.php, see also BMAS (2021).

31 *Chemieberufe*, German classification of occupations (KldB 2010 group 413).

5.1.2. Job transformation

Digitalization does not necessarily imply that only the demand for less common professions in the chemical industry, such as ICT specialists, will increase – it is likely that the skills required will also blend into other already existing professions. One publication (BAVC/VCI 2018) indicates that in the chemical industry, data science has already made an impact in data acquisition and processing, data transformation, data calculation and linkage, data modelling, and data visualization and presentation. As these areas become more and more important, demand for data specialists (e.g. data scientists) will increase. To ensure efficient cooperation with these ICT specialists, chemists, chemical engineers, process engineers, bioscientists and other specialists will also increasingly need a certain level of digital literacy and technical digital skills.

It is anticipated that greater importance will be placed on creating a working environment conducive to learning in the chemical and pharmaceutical industries (Priesack et al. 2019). Digitalization will increase the need for self-organization and autonomy (Prognos 2019), and employers could increasingly act as coaches, leaving the way forward largely to the discretion of their workers (Fraunhofer IAO 2017).

Women are likely to be more successful in adapting to this shift in skills needs, as studies indicate that they are on average better equipped with social, interpersonal and creative skills (Bonin et al. 2020). On the other hand, they are less exposed to technological changes, such as the introduction of ICT technology, in their workplace: in 2019, 67 per cent of men in production experienced a technological change, whereas this applied to only 58 per cent of women (Bonin et al. 2020).

5.1.3. Job creation

In the European chemical industry, new job opportunities are expected to be created in sales & marketing, research & development and, particularly, in ICT-related activities, but there are also indications of growth opportunities in production and logistics, which could indicate a structural transformation of occupational profiles in these fields (Prognos 2019). In Germany, this is in part confirmed by Future Skills Report - Chemie[32] data: from 2018 to 2019, demand for workers in the chemical industry increased most strongly in the fields of production (+14.8 per cent), sales (+14.6 per cent), research & development (+9.3 per cent) and marketing (+7.8 per per cent).

With further digitalization and integration of production and business processes, chemical companies will not only need data scientists, but also cyber- security specialists in order to protect their data (Deloitte 2017).

Occupations where demand is generally forecast to be positively affected by digitalization (according to the IAB QuBe forecast, see also section 5.1.1) include some that are common in the chemical industry: the technical occupations in production planning and scheduling, occupations in business organization and strategy and purchasing and sales, those of office clerks and secretaries, and occupations in plastic- and rubber-making and processing, and accounting, control and auditing (see also table A3).

5.2. Skills and lifelong learning

Digitalization creates a need for structured training and upskilling (ILO 2018). Developing the skills required for digital transformation is essential for the labour market to function properly. The future demand for skills will depend on how successfully the German chemical industry can integrate digital technologies, but also on whether new smart products and digital business models can be developed (see also section 4.1).

32 https://future-skills-chemie.de/global-benchmark/

5.2.1. Future demand for skills

Non-routine, non-repetitive work has gained significantly in importance in the German chemical industry, and many routine tasks like paperwork or manual calculation or manual bookkeeping have become less important (IW Köln 2017). This increases the requirement for self-organization and autonomy, as well as self-learning (Prognos 2019). The aforementioned ability to cooperate across occupations will also increasingly call for interdisciplinary, soft, and transversal skills (see also section 5.1.2).

In addition to technical and scientific expertise and problem-solving skills, the core competencies of workers in the chemical industry will increasingly embrace innovative skills, ICT-related user and developer skills, and knowledge of using machines and networked systems (Priesack 2019). These trends are also evident in the comprehensive overview of future skills needs for 16 occupations relevant to the chemical industry provided on the Future Skills Report - Chemie[33] website.

5.2.2. Skills development and lifelong learning

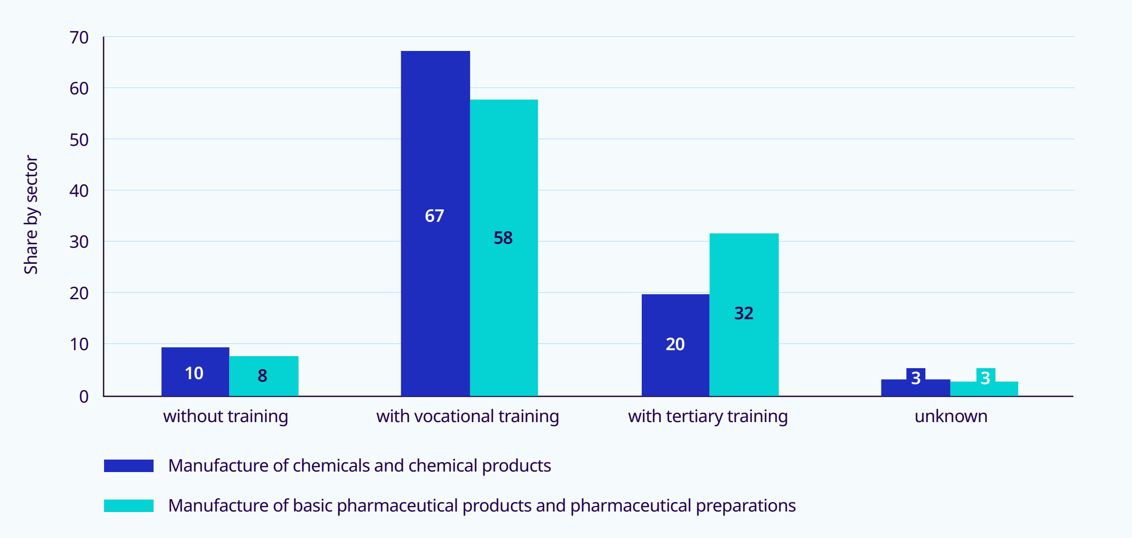
In 2019, 53 per cent of employers in the German chemical industry participating in a survey conducted by EY (see table A2) indicated that the lack of skilled workers is the biggest barrier to the implementation of digitalization. Also, employers in the chemical industry in Baden-Württemberg foresee an impending shortage of well-trained specialists (Fraunhofer IAO 2017).

This underlines the importance of skills development in vocational and tertiary training and lifelong learning in ensuring a successful digital transformation in the chemical industry. Skills shortages can also be mitigated by attracting apprentices, students or skilled workers from abroad.

Vocational training

In March 2021, more than two thirds of workers subject to social security contributions in the German chemical industry had vocational training (figure 8). By comparison, in the pharmaceutical industry, tertiary training is more common and vocational training less common. Nevertheless, the majority of workers in the pharmaceutical industry are vocationally trained.

▶ **Figure 8. Employees subject to social security contributions by education level, 03/2021**



Source: Federal Employment Agency.

33 https://future-skills-chemie.de/wp-content/uploads/2021/03/Zuku%CC%88nftige-Berufsprofile-6.pdf

In the German dual vocational training system, the employers, the employers' organizations including chambers of commerce, the unions, as well as the Federal States and Federal Government representatives, all participate in the preparation of new vocational occupations or the updating of vocational training regulations (*Ausbildungsordnungen*, BiBB 2015). The teaching of digital skills in vocational and academic education and training has been a success factor in supporting digitalization processes in the German economy (Deloitte 2017).

Vocational training regulations are updated frequently. For example, since August 2018, an elective qualification, "Digitalization and networked production",[34] has introduced new digital content into selected vocational training programmes (examples being Chemical technician and Electronics technician for automation technology - Priesack et al. 2019). According to the BAVC, these elective qualifications are more flexible and easier to integrate when compared with direct integration of additional qualifications into the vocational training regulations (Interview with BAVC/IG BCE on 16/11/2021).

A significant part of the dual vocational training system in Germany is the on-the-job training in a company. New technologies could thus become part of the training even if they were not integrated into the vocational training regulations. Both the IG BCE and the BAVC have pointed out that this openness in the vocational training regulations is a success factor that ensures adaptability in the vocational occupational profiles in the chemical industry (Interview with BAVC/IG BCE on 16/11/2021). There is a consensus among the social partners that adapting vocational training to digitalization does not require new job profiles, but rather the addition of digital know-how to existing training programmes (Interview with BAVC/IG BCE on 16/11/2021).

Chemical companies have responded to the existing bottlenecks in ICT by significantly increasing the number of training places in chemistry-related ICT and software development (KOFA 2021). At the same time, there are many more applicants than vacant apprenticeship positions in these professions. KOFA therefore suggests that companies should check whether they can offer additional training positions or dual-study programmes, as the demand for ICT specialists will continue to increase due to digitalization.

Tertiary education

In ICT and software development, the proportion of academically qualified experts with a diploma or Master's degree in the chemical industry is increasing (KOFA 2021).

As demand for these workers grows with advancing digitalization, the chemical industry will increasingly have to compete for ICT specialists with other industries, which might aggravate the skills shortages in the chemical industry (BAVC/VCI 2018).

Attracting female workers with ICT skills might offer a solution to these shortages (see section 5.2.3).

Lifelong learning

Kruppe et al. (2019) point out that initial education will not be sufficient to ensure employability over an entire working life, as the digital transformation of the economy will rapidly and consistently call for changes to skill sets. Training and upskilling throughout working life will therefore also become more relevant for workers in the chemical industry (Prognos 2019; Risius/Werner 2018).

Data from IW Köln[35] shows that participation by chemical and pharmaceutical companies in upskilling and reskilling fell from 93.4 per cent in 2016 to 87.8 per cent in 2019. The most significant decrease, from 91 per cent to 83.8 per cent, was seen in small companies with fewer than 49 employees, while this share decreased from 100 per cent to 98 per cent in medium-sized and large companies.

34 https://www.bibb.de/dienst/berufesuche/de/index_berufesuche.php/profile/apprenticeship/57658

35 https://www.bavc.de/aktuelles/2016-iw-weiterbildungserhebung-2020-chemie-gibt-pole-position-ab

More than 50 per cent of the chemical companies active in upskilling and reskilling state that one of the obstacles to promoting them is lack of interest on the part of the workers. At the same time, 58 per cent of the companies active in continuing education often lack internal planning capacities.

At 15.8 hours per year, the time a worker spends on upskilling and reskilling in a chemical company is below the level of 2016 (22.3 hours) and also lower than the cross-industry average of 18.3 hours. Around half of the companies stated that their upskilling and reskilling offers aim to promote the acquisition of digital skills.

A survey of workers in the chemical industry conducted in 2019 on behalf of the IG BCE (2019) indicated a lack of digitalization-related company training opportunities, especially in the fields of production and technology and in the laboratory. For the BAVC, the reason for decreasing participation in lifelong learning was the difficult economic situation in 2019, which brought falling productivity (see also section 3.2) and rising costs.

Attracting (skilled) workers from abroad

Attracting potential apprentices or students from abroad can compensate for the ageing workforce in Germany (see section 4.2.2). The German chemical industry already attracts an above-average number of workers without German citizenship, especially young people, as technical and scientific experts (Risius/Werner 2018). In the chemical professions, only a third of all skilled workers without German citizenship are older than 45 years.

A qualified immigrant workforce is required in many areas of the labour market, but most importantly in ICT-related occupations where there is already a shortage of skilled workers (KOFA 2021). Experts from abroad will also be needed to meet the increasing demand in the chemical industry in the future (KOFA 2021; ILO 2020). For those seeking to work in Germany, the recognition of formal qualifications is one of the most important barriers to be overcome (ILO 2020).

5.2.3. Gender equality at the heart of skills development

Women are under-represented in the chemical industry (see section 1), whereas the gender balance is much more even in the pharmaceutical industry (see also section 3.4).

The chemical industry’s demand for workers with STEM backgrounds should in principle offer more opportunities for women to find employment. However, according to a 2018 study by the German Federal Employment Agency, while 46 per cent of Germany’s students are female, women account for only 28.9 per cent of students enrolled in STEM-related courses. Concerted efforts will be needed to attract more women and girls to STEM degrees if the chemical industry is to achieve a more meaningful balance of women, men and other gender identities.

There are indications that women could profit from the better transversal/soft skill sets that are increasingly in demand in the industry (section 5.1). However, recent research reveals that women have lower upskilling and reskilling participation rates and lower job mobility (Bonin et al. 2020). Data from the German Linked Personnel Panel (LPP[36]) suggests that women’s lower participation rate in upskilling and reskilling courses is replicated in the continuing education courses intended to expand skills in dealing with new technologies in the workplace (Bonin et al. 2020).

However, a trend towards increasing participation by highly qualified women in the chemical industry may already have taken root (KOFA 2021): the share of women in chemistry-relevant, higher-skilled jobs (requirement level specialist or expert) increased between 2015 and 2020. Among the fields of study most relevant to the chemical and pharmaceutical industries, the share of female students was highest in food

36 https://fdz.iab.de/en/int_bd_pd/linked-personnel-panel-lpp-version-1617-v1-2/

chemistry, pharmacy and biochemistry, but significantly lower in chemistry and chemical engineering/ chemical process engineering (table 6).

▶ Table 6. Numbers of students by selected fields of study, winter term 2020/21

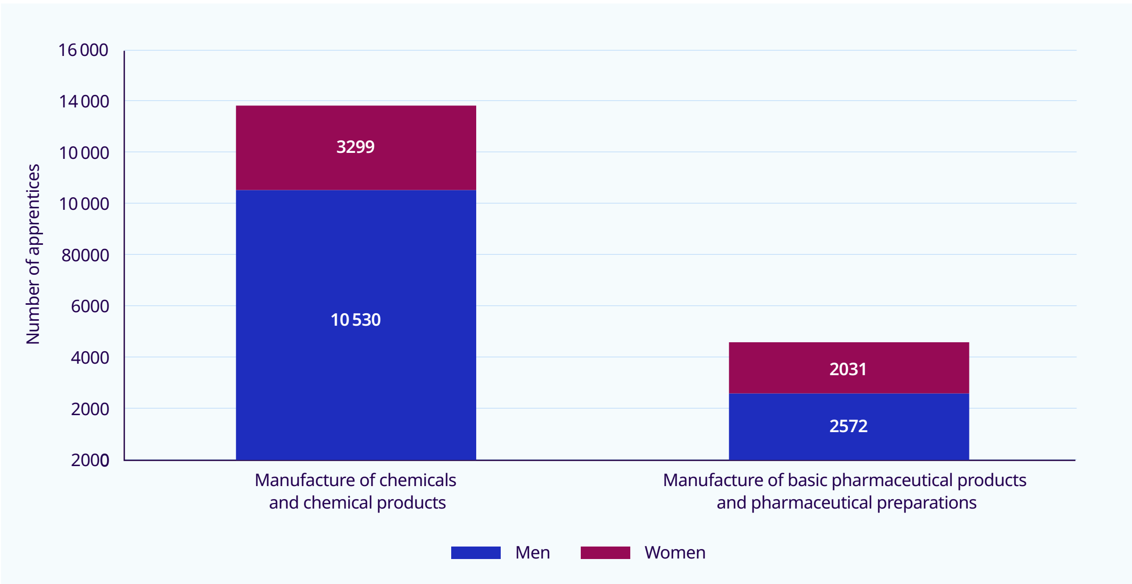
	Student nos., winter term 2020/21			
	male	female	% male	% female
Biochemistry	3 703	5 325	41.0	59.0
Chemistry	25 342	18 484	57.8	42.2
Chemical engineering / chemical process engineering	5 711	3 253	63.7	36.3
Food chemistry	717	1 644	30.4	69.6
Pharmacy	5 179	11 128	31.8	68.2

Source: DESTATIS.

Promoting interdisciplinary courses that combine chemistry with ICT could be a valid strategy both for finding skilled ICT workers and for improving gender equality, as the proportion of women in interdisciplinary ICT courses (e.g. Bioinformatics) is much higher than in traditional ICT courses like computer science (IW Köln 2019; Stifterverband 2018).

Female participation in vocational training in the chemical industry is still very low and could be improved (figure 9). The gender balance among employees is similar to that in vocational training. This calls for urgent measures to formulate and implement a transformative agenda for addressing gender representation in the German chemical industry.

▶ Figure 9. Number of apprentices in dual vocational training by gender, 03/2021



Source: Federal Employment Agency.

5.2.4. Coordinated policies and action for lifelong learning

In general, upskilling and reskilling opportunities are highly company-specific, but can also be subject to works or company agreements between works councils and employers (*Betriebsvereinbarungen*). In addition, the German social partners have implemented several measures to support lifelong learning in the chemical industry. For example, collective agreements allow for upskilling and reskilling periods (see also section 5.3.1 on flexible working-time arrangements).

▶ The chemistry qualification campaign

The chemistry qualification campaign (*Qualifizierungsoffensive Chemie*) is the result of a collective bargaining agreement between the BAVC and the IG BCE concluded in 2019.

The Future Skills Report - Chemie (see section 4) is one of the three elements of the campaign and the first one to be published. It is an AI-based trend analysis of future skills in the chemical and pharmaceutical industry, carried out by HR Forecast between January 2018 and December 2019 and will be updated regularly. The website gives information on the 15 main digitalization technologies in the chemical industry and provides global benchmarking on the implementation of these technologies in the German chemical industry, through comparison with the EU, the United States and China. In addition, it includes a report on changing skills needs (hard and soft) and the level of skills required in 16 occupational profiles relevant to the German chemical industry in the future. The analysis is based on the evaluation of online vacancies at companies in the chemical industry, company career pages, patents, statistics, business networks and scientific publications. The report targets business leaders, human resources departments, works councils and workers in the German chemical industry.

As part of the chemistry qualification campaign, a qualification analysis tool is currently being developed which will be offered free of charge to the member companies of the chemical employers' associations. As a third measure, an upskilling and reskilling advisory programme is currently being tested in cooperation with the Federal Employment Agency. To date, the pilot project has not been successful in finding companies interested in taking part (Interview with BAVC/IG BCE on 16/11/2021).

This campaign is an example of a support framework that is not only relevant to a wide range of interest groups in the chemical industry but also results from a successful collective bargaining process. In specific terms, the Future Skills Report – Chemie aims to monitor skills and tackle uncertainties about the level of implementation of digitalization in the German chemical industry. It does not rely on information provided in worker or company surveys, but on "hard" data gathered from several sources. It also allows the German chemical industry to compare its level of application of technological innovations with other countries and provides easily understandable guidance to workers and employers on which occupations and skill sets are becoming more important due to digitalization. It is too early to assess how successful the other two measures of the qualification campaign chemistry will be.

Several laws have been adopted by the Government in the last two years to promote upskilling and reskilling. The Federal Employment Agency[37] offers general lifelong learning opportunities via its educational voucher programme (*Bildungsgutschein*). The Qualification Opportunities Act (*Qualifizierungschancengesetz*[38]) which came into force in January 2019 promotes upskilling and reskilling opportunities for workers on the basis of this voucher programme. As well as the programme costs, participating workers can also be paid wage subsidies. The above-mentioned Act was followed by the so-called 'Work of tomorrow law' (*Arbeit-von-morgen-Gesetz*[39]) adopted in May 2020, which further increased incentives for upskilling and reskilling, for example by providing increased funding for training courses as well as wage subsidies.

Finally, against the backdrop of the COVID-19 pandemic, the Employment Protection Act (*Beschäftigungssicherungsgesetz*[40]), implemented in December 2020, strengthens the incentive to use the working hours lost during short-time work to undertake further professional training.

5.2.5. Financing lifelong learning

Data from IW Köln shows[41] that more than 90 per cent of upskilling and reskilling activities in the chemical industry take place during working hours, which means that a large part of the investment is borne by employers. Annual investment in upskilling or reskilling measures per worker fell from a peak value of €1,538 in 2016 to €1,209 in 2019.

The bulk of the investment in education and the dual education system in Germany is borne by the Government. The Federal Employment Agency might also be able to bear the costs of lifelong learning courses for workers or to subsidize the wages of workers participating in upskilling and reskilling, under the provisions of the Qualification Opportunities Act (*Qualifizierungschancengesetz*[42], see above).

For the individual dependent worker, expenses related to upskilling and reskilling measures are tax-deductible when declared as professional outlay (*Werbungskosten*).[43] However, this benefits only employees whose expenses are higher than the lump sum for professional outlay, currently €1,000 per year. For the self-employed, upskilling and reskilling costs can be deducted as a business expense (*Betriebsausgabe*).

5.3. Conditions of work

Digitalization, other technological advances and globalization have led to new forms of asymmetric employment relationships and precarious work (Prognos 2019; ILO 2018). Digitalization also changes work organization and offers new possibilities for flexible working-time arrangements, as well as presenting challenges and opportunities for occupational safety and health. As shown in the following paragraphs, the German social partners are aware of these issues.

5.3.1. Atypical employment

No figures on the number of temporary workers in the German chemical industry are available publicly. Out of the five most common occupation groups among the temporary employed in December 2020

37 https://www.arbeitsagentur.de/karriere-und-weiterbildung/foerderung-berufliche-weiterbildung

38 https://www.bgbl.de/xaver/bgbl/start.xav?startbk=Bundesanzeiger_BGBl&jumpTo=bgbl118s2651.pdf#__bgbl__%2F%2F*%5B%40attr_id%3D%27bgbl118s2651.pdf%27%5D__1546505933691

39 https://www.bgbl.de/xaver/bgbl/start.xav?startbk=Bundesanzeiger_BGBl&start=%2F%2F%2A%5B%40attr_id=%27bgbl120s1044.pdf%27%5D#__bgbl__%2F%2F*%5B%40attr_id%3D%27bgbl120s1044.pdf%27%5D__1636452018039

40 https://www.bgbl.de/xaver/bgbl/start.xav?startbk=Bundesanzeiger_BGBl&start=%2F%2F%2A%5B%40attr_id=%27bgbl120s1044.pdf%27%5D#__bgbl__%2F%2F*%5B%40attr_id%3D%27bgbl120s1044.pdf%27%5D__1636452018039

41 https://www.bavc.de/aktuelles/2016-iw-weiterbildungserhebung-2020-chemie-gibt-pole-position-ab

42 https://www.bgbl.de/xaver/bgbl/start.xav?startbk=Bundesanzeiger_BGBl&jumpTo=bgbl118s2651.pdf#__bgbl__%2F%2F*%5B%40attr_id%3D%27bgbl118s2651.pdf%27%5D__1546505933691

43 According to EstG §9 (6), see https://www.gesetze-im-internet.de/estg/__9.html

(Federal Employment Agency data[44]), three (warehousing and logistics, postal and other delivery services and cargo handling; machine-building and -operating; office clerks and secretaries) were also common in the chemical industry (see also table A3). In the areas of logistics, gastronomy, cleaning and industrial services, the IG BCE has concluded collective agreements for workers with temporary employment contracts in the chemical industry (see Vitols 2019). Upskilling and reskilling opportunities differ from company to company and might not be of use if a worker has to switch employers regularly because of temporary contracts (Prognos 2019).

In the chemical industry, part-time work is not widespread among employees subject to social security contributions. Around 89 per cent of workers were full-time in March 2021, compared with 70.9 per cent on average across all industries (Federal Employment Agency data[45]). Minor employment[46] is even more uncommon in the industry: in the same month, only 2,034 persons were in this category, compared with the 137,652 full-time and 23,913 part-time employees subject to social security contributions.

Currently, there is a debate underway as to whether platform work should be regarded as self-employment or dependent employment.[47] For online work platforms, the platform worker has been considered a solo self-employed person, and as such has not been granted any workers rights, such as protection against dismissal or time-related pay. There are no indications that the use of these new recruitment models is widespread in the German chemical industry.

According to the IG BCE (2020), the overall share of the self-employed in the chemical industry is low and not increasing. The union is, however, mindful of the self-employed and their contractual situations and acknowledges that it has to consider these new forms of work and the workers that are subject to them. Without further research (e.g. company interviews, requesting data access from federal authorities), it is difficult to quantify the workers in atypical employment relationships and the extent to which they benefit from the upskilling and reskilling offers of companies.

44 https://statistik.arbeitsagentur.de/Statistikdaten/Detail/202012/iiia6/beschaeftigung-anue-anue/anue-d-0-202012-xlsm.xlsm?__blob=publicationFile&v=3

45 https://statistik.arbeitsagentur.de/Statistikdaten/Detail/202103/iiia6/beschaeftigung-sozbe-wz-heft/wz-heft-d-0-202103-xlsx.xlsx?__blob=publicationFile&v=1

46 Minor employment refers to the so-called Mini-Jobs-scheme. These are small part-time work contracts for which a specific tax and social security contribution scheme applies. They cannot exceed a maximum monthly net income from work of €450 per month or €5,400/year (€520 per month or €6,240/ year from October 2022).

47 https://www.iab-forum.de/arbeit-auf-digitalen-plattformen-selbst-oder-fremdbestimmt/

5.3.2. Flexible working-time arrangements

Digitalization offers the chemical and pharmaceutical industry new potential for flexibility in work organization, in terms of working time and work location sovereignty (Priesack et al. 2019). In research and development, it is assumed that there will be a change in line with a modern, flexible working environment, while in chemical-pharmaceutical shift production there will also be future legal and safety regulations to consider in terms of temporal and spatial flexibility.

Workers see an opportunity to better combine work and private life with the help of digital technology, and senior executives are aware of this growing requirement for flexibility on the workers' part (Fraunhofer IAO 2017). However, a "right to disconnect" is essential to ensure that employment-related stress does not carry over into workers' free time. The German social partners have been actively discussing the best arrangements for enabling long-term flexibilization of working-time (see section 6 and box below).

5.3.3. Changes in work organization

Most workers in the chemical industry in Germany seem open to changes in work organization caused by digitalization and other technologies.

A survey conducted by the IG BCE (2019) showed that workers in ICT, management and administration generally expected digitalization to support and ease their tasks, while technicians and workers in production and the laboratory were more critical. Workers in production, the laboratory and blue-collar activities were less likely to expect a high workload, while the perceived workload was greater for respondents in administrative white-collar jobs such as ICT, management and planning, services, and administration. No gender differences were detected, but older workers said that they anticipated a higher workload while adapting to changes caused by digitalization.

Data evaluations carried out from the point of view of the workers also show that in the course of digitalization the workload has increased more strongly in the chemical industry than in other branches of the manufacturing industry (Priesack et al. 2019).

With increasing digitalization and new possibilities in work organization, worker productivity is likely to be more closely monitored, leading to data protection concerns (ILO 2018). These issues do not seem to be perceived as problematic by workers in the German chemical industry for now. The majority of workers participating in a survey carried out by the IG BCE (2019) indicated that performance control and surveillance by digital technologies was limited. For workers in production and administration, the perceived level of monitoring was slightly higher.

▶ Collective agreements on flexible working-time arrangements

The social partners in the German chemical industry addressed the topic of flexible working-time arrangements very early. In 2008, they concluded a collective agreement in order to improve the flexibility of working-time arrangements throughout working life (*Tarifvertrag Lebensarbeitszeit und Demografie**, BAVC 2021). It included the following regulations:

A demography fund was implemented. By 31 December of the respective calendar year, the employer provides €750 per worker under the collective agreement, which is used to finance one or more instruments for shaping demographic change.

The demography fund can be invested in several instruments, also depending on the number of workers in the company:

- **Long-term accounts (Langzeitkonten):** Workers in the chemical industry can save a credit in a long-term account during their active working life, which is used to finance paid periods of leave (e.g. part-time or parental and care leave) or upskilling/reskilling courses, and individual phases of life.
- **Supplementary occupational disability insurance Chemistry (BUC)**: The BUC offers the company's workers additional protection in the event of occupational disability.
- **The demographic fund** can also be used for collective pension provision (TEA) based on a voluntary company agreement.
- **Life phase-oriented working time organization (RV 80 model):** This scheme enables the agreed working hours to be reduced at certain phases of life without the remuneration being reduced accordingly. As a second variant, this model can also be used to arrange a flexible transition into retirement.
- **Health care:** In addition, the demographic fund can be used for disease prevention measures and proactive health promotion.

A 'demographic corridor' regulation was also implemented. It enables the collective determination of working hours for a limited period within a corridor of 35 to 40 hours per week. Weekly working hours within this corridor can also be agreed with individual workers on the basis of a works agreement.

* This was followed up by collective agreements further concerned with working-time arrangements. According to the social partners, these structures and instruments were also used to increase flexibility of working time during the COVID-19 crisis (Interview with BAVC/IG BCE on 16/11/2021) and will also be helpful in responding to further needs for flexibilization that arise from increasing digitalization in the chemical industry. However, long-term accounts are not used very often for upskilling and reskilling periods, but rather for working time reduction (Interview with BAVC/IG BCE on 16/11/2021).

5.3.4. Occupational safety and health

Germany has a comprehensive national OSH system which follows the Conventions of the International Labour Organization (ILO) and is harmonized with EU OSH directives. The German OSH system has existed for more than a century, and institutional capacities are very strong in both quantity and quality. The implementation and control of compliance with national regulations on OSH are under the individual responsibility of the 16 federal states through their labour inspection authorities.

In this context, the effects of digitalization on occupational safety and health in the chemical industry can be twofold (ILO 2018; Prognos 2019):

- Digitalization could potentially improve worker safety by automating hazardous tasks and enhancing working conditions in general (BAVC/IG BCE 2020c); and
- Technological advances can lead to new hazards caused by new machinery or increased physical and psychosocial risks, owing to the growing complexity of tasks performed. Also, digitalization can increase stress due to changes in work organization and new working-time arrangements.

As part of the WORK@Industry4.0 dialogue process (BAVC/IG BCE 2018), experts suggested that the existing social partner agreement on good and healthy work should be expanded to include aspects related to “Work 4.0”, for example by including general psychological stress factors and by taking into account the growing demand for self-organization and flexibility.[48] It was proposed that at the company level, an app could be introduced to provide relevant target groups (e.g. workers, employers, the HR department, the works council) with simple analyses of the hours actually worked, in order to prevent work overload or better utilize work underload, while also taking data protection into account.

48 In the meantime, a social partner agreement has been published (see BAVC/IG BCE 2020c).

6.

Relevant regulatory or policy frameworks in relation to digitalization and the industry

6. Relevant regulatory or policy frameworks in relation to digitalization and the industry

As shown above, digitalization will change the future world of work. The following paragraphs illustrate how these changes are being addressed by policy makers and social partners in the chemical industry.

6.1. Status of legislation concerning fundamental rights at work

Working-time arrangements

The German Working Hours Act (*Arbeitszeitgesetz*[49]) limits the maximum permissible daily working hours (8 hours per day or 48 hours per week from Monday to Saturday), provides for minimum rest breaks during working hours (at least 30 minutes after 6 working hours, at least 45 minutes after 9 hours), and regulates the rest period between working days (11 hours).

According to statements made by executives and works councils in the chemical industry in Baden-Württemberg (Fraunhofer IAO 2017), the law sometimes does not meet the necessary flexibility requirements for mobile working, for example for work on international projects. While the BAVC is in favour of more flexible working time legislation, the IG BCE has pointed out that the altered regulations should not be less favourable than the current working time law (Interview with BAVC/IG BCE on 16/11/2021). Possible solutions and ideas on how to arrange working time regulations against the background of increasing digitalization were discussed in the WORK@Industry4.0[50] dialogue process (see BAVC/IG BCE 2018).

49 https://www.gesetze-im-internet.de/arbzg/BJNR117100994.html
50 https://work-industry40.de/

▶ The WORK@industry4.0 – dialogue process

The WORK@industry4.0 (BAVC/IG BCE, 2018) process is a good example of "constructive social dialogue and transparent information exchange" (Prognos 2019) between several actors in the German chemical industry. It was initiated by the BAVC and the IG BCE in July 2017. The process aimed to develop:

- a common understanding of digital transformation;
- industry-specific knowledge about its impact on the world of work;
- openness and acceptance to technological change;
- a common political position and recommendations for action;
- and to identify differences in the positions of the social partners.

The steering committee, made up of representatives from employers' associations and trade unions at the federal and regional levels, supervised the entire process. The dialogue took place in thematic workshops focusing on initial training and up- as well as reskilling measures, good and healthy working conditions, flexible working-time arrangements, and leadership and organization. In total, eight workshops, each attended by 30 experts from the German chemical industry, were carried out between September 2017 and February 2018. Workshop participants included, among others, works council members, experts in the fields of human resources, training and production, company physicians, and company representatives.

On 9 May 2018, the steering committee discussed and politically evaluated the catalogue of ideas that had been developed in the expert workshops. In December 2020, the process was concluded formally, but reports are still being published (Interview with BAVC/IG BCE on 16/11/2021).

To date, the dialogue process has seen the publication of several reports relevant to the implementation of digitalization (see Annex).

Data protection

Data protection refers to the protection of company data through increased security measures. In a survey conducted by EY in 2019, 37 per cent of employers in the German chemical industry (see table A2) indicated that security concerns are the biggest barrier to the implementation of digitalization.

Data protection regulations can also be a barrier to the development of digital business models, as machine data must be usable in such a way that innovations in the development of products and services are not hindered (Deloitte 2017). Data protection for workers means that they are shielded from closer surveillance as more data is collected, for example during the production process (see also section 5.3.3).

A recent survey conducted by the ICT industry association, *bitkom*, in 2021[51] found that smaller companies have experienced problems in implementing data protection regulation, nine out of 10 companies have already had to halt innovative projects due to data protection requirements, and some companies have complained about a lack of support from authorities when trying to implement the regulations. At the same time, according to a representative survey conducted in February 2021[52], 66 per cent of Germans would like the government to be more active in preventing misuse of personal data by companies.

Solutions to this conflict between use and fear of misuse of data were also discussed in the WORK@ Industry4.0 dialogue process (BAVC/IG BCE 2018). One suggested way forward was to implement a

51 https://www.bitkom.org/Presse/Presseinformation/Datenschutz-setzt-Unternehmen-unter-Dauerdruck

52 https://www.capital.de/wirtschaft-politik/datenschutz-im-internet-wird-den-deutschen-wichtiger

process of evaluating the data available in a company and classifying this as either sensitive personal data or process-optimizing data. It was argued that this would provide workers and employers with guidance for an objective debate and help to make decision making more effective in the future. The establishment of a social partner agreement for a code of ethics on data protection in the chemical industry was also discussed.

Aside from this, the IG BCE (2020) argues that a Federal Government body is needed to oversee the setting up of a digital strategy, since the ownership and use of data is spread across all ministries.

6.2. Relevant policies and initiatives

Promotion of lifelong learning

Several laws have been adopted since the German upskilling and reskilling strategy (*Nationale Weiterbildungsstrategie*[53]) was decided in June 2019 (see section 5.2.2). In addition, the social partners discussed these matters during the WORK@Industry4.0 dialogue process (see BAVC/IG BCE 2018).

The outcome of those discussions was that, in 2020, the BAVC and the IG BCE published a document setting out ten goals for lifelong learning against the background of digitalization (BAVC/IG BCE 2020d):

- Continued investment in a range of professional and social qualifications for workers through up-to-date training and further education;
- Promotion of a learning and leadership culture 4.0 at all levels, following the principle of employers' and workers' shared responsibility for lifelong learning participation and provision;
- Further development of existing occupational profiles and the development of lifelong learning concepts based on adapted training regulations ("update" of the respective occupational profile) wherever this is necessary in the opinion of both social partners;
- Ensuring that upskilling and reskilling courses are also developed specifically for workers in production;
- Provision of analytical and forecasting tools to determine industry- and company-specific qualification profiles and skills needs;
- Creation of qualification periods in accordance with the principle of shared responsibility between employers and workers;
- Evaluating the feasibility of an industry-specific upskilling and reskilling advisory service for workers and companies;
- Implementing a project to train IG BCE delegates and HR staff as training mentors (see also IG BCE 2020);
- Promotion of qualification measures to up- or reskill workers across companies, with specific focus on those in SMEs;
- Promotion of a new culture of further education in Germany and Europe.

Some of these goals had already been addressed in the context of the chemical qualifications campaign (see box in section 5.2.4). Furthermore, at the initiative of the BAVC and the IG BCE, an elective qualification on Digitalization and networked production[54] was implemented nationwide in August 2018 as part of the vocational training for chemical technicians (see also section 5.2.2).

53 https://www.bmbf.de/bmbf/de/bildung/weiterbildung/nationale-weiterbildungsstrategie/nationale-weiterbildungsstrategie_node.html; https://www.bibb.de/dokumente/pdf/a42_190611_BMAS_Strategiepapier.pdf.

54 https://www.elementare-vielfalt.de/unternehmen/digitalisierung/chemikant.html https://future-skills-chemie.de/

Financing Digitalization in SMEs

SMEs in general have a lower implementation rate when it comes to digitalization as they do not always have an ICT department and perhaps lack the skills to implement and use new technologies or cannot afford to make investments with uncertain returns (Prognos 2019). Also, workers in SMEs tend to participate less in lifelong learning (see also section 5.2.2).

However, implementing digital business models can be a promising strategy for SMEs in the chemical industry, in particular if they are fast and flexible enough and have the support they need (Deloitte 2017).

To promote digitalization in SMEs, the German government has implemented several programmes during the past years that are also relevant to the chemical industry. For example, the "Digital jetzt"[55] [Digital now] programme which was implemented in 2020 by the Federal Ministry for the Economy (BMWi), now the Federal Ministry for Economic Affairs and Climate Action (BMWK), offers financial grants to encourage SMEs (3 to 499 employees) from all industries to invest in digital technologies and in the qualifications of their employees. According to the BAVC, however, these and similar programmes have been ineffective owing to their overly bureaucratic application processes (Interview with BAVC/IG BCE on 16/11/2021).

Investment in digital infrastructure

Inadequate investment in digital infrastructure not only hampers the implementation of digital business models, because fast and stable internet is needed to connect companies, suppliers, customers and workers (Deloitte 2017), but also lifelong learning for workers, as this is increasingly delivered through digital channels (blended learning, webinars and virtual classrooms, Massive Open Online Courses, etc.).

The lack of fast internet connections in Germany is a significant barrier to technological progress in its chemical industry. According to OECD data[56], the percentage of fibre connections in the total fixed broadband provision in Germany in December 2020 was only 5.36 per cent, compared with the OECD average of 30.56 per cent and 84.76 per cent in the Republic of Korea. In a survey conducted by EY (2019, see table A2) 39 per cent of employers in the German chemical industry indicated that technical infrastructure was the biggest barrier to their implementation of digitalization. Consequently, the German Chemical Industry Association (VCI)[57] advocates regularly for the rapid and comprehensive expansion of 4G and 5G fibre connections and mobile communications. Similar requests have been made by the BAVC[58] and the IG BCE[59].

6.3. Status of social dialogue mechanisms

The German social partners initiated the WORK@industry 4.0[60] dialogue process. The chemistry qualification campaign (*Qualifizierungsoffensive Chemie*), which focuses on identifying and monitoring skills needs and on up- and reskilling in the industry, is also a result of social bargaining processes.

In autumn 2014, the then Ministry for the Economy (BMWi) initiated a dialogue with the chemical industry (*Branchendialog chemische Industrie*[61]) the BAVC, the IG BCE and the VCI, among other stakeholders. Within this framework, discussions on the topics of innovation and digitalization have already taken place. The third period of talks concluded with the adoption of joint monitoring in March 2019. The main focus was innovation policy (including digitalization) and energy policy issues.

55 https://www.bmwi.de/Redaktion/DE/FAQ/Digital-Jetzt/faq-digital-jetzt.html
56 https://www.oecd.org/digital/broadband/broadband-statistics/
57 https://www.vci.de/themen/digitalisierung/lokale-5g-netze-wichtige-voraussetzung-fuer-industrie-40.jsp
58 https://www.bavc.de/downloads/impuls/2018/BAVC-Impuls_04_2018.pdf
59 https://igbce.de/resource/blob/172794/d5b606bb427e65be06fd52c252b77ea4/zukunftskommission-digitale-agenda--data.pdf
60 https://work-industry40.de/
61 https://www.bmwi.de/Redaktion/DE/Artikel/Industrie/branchendialog-chemische-industrie.html

For the social partners, digitalization brings new challenges. For example, the IG BCE union (2020) must find ways of using digital and mobile channels to reach workers who are no longer working in the company but at home or on the road. During the WORK@Industry4.0 dialogue process (BAVC/IG BCE, 2018), the suggestion was made to promote workers' participation at company level through digital channels.

7.

Concluding remarks

7. Concluding remarks

Digitalization is a key issue in the German chemical industry.

The implementation of digital technologies has the potential to further optimize production processes and business models. At the same time, these new technologies are changing the skills needs in the industry, and there is increasing demand for technical as well as soft and transversal skills.

Against this background of changing skills needs, it will be essential to promote initial training, upskilling and reskilling in order to ensure workers' employability throughout their working lives, for employers to find adequately skilled workers, and for policy makers to make sure that the labour market functions properly. Other challenges and opportunities concern social protection coverage for workers with atypical employment contracts and conditions of work.

The German social partners are actively seeking solutions to these challenges, being equally aware of the future potential offered by digital technologies. Close cooperation between the BAVC and the IG BCE has resulted in sound measures for addressing digitalization, such as the WORK@Industry 4.0 dialogue process, the chemistry qualification campaign and the collective agreements on flexible working arrangements.

The German example shows that the social partners' involvement in the debate about digitalization and the future of work is essential to ensuring decent and sustainable work in the German chemical industry. This will remain the case, as the industry addresses not only digitalization but also climate change, the return of geopolitics, and other drivers of change in the world of work.

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Annex

Annex

Table A1. Demand for skills related to digitalization megatrends

Megatrend	Technology	Future Skills Report - Chemie Benchmark (01/2018 - 12/2019)	Stage of development in the German chemical industry
Materials technology	Materials sciences (development and discovery of new materials)	5.5	leading
Interaction and business processes	Automation & Robotics	3.5	
Materials technology	3D-Printing (additive manufacturing)	1.0	
Interaction and business processes	Internet of Things & Connectivity	0.2	
Materials technology	Alternative raw materials	0.1	
Interaction and business processes	VR & augmented reality	-0.1	following
Digital technologies	Blockchain	-0.2	
Materials technology	Batteries	-0.8	
Digital technologies	Cybersecurity	-1.0	
Interaction and business processes	Agile principles	-2.4	
Digital technologies	Big Data	-2.4	
Digital technologies	Machine learning & AI	-3.2	
Digital technologies	Data Science & Analytics	-6.8	
Interaction and business processes	Digital distribution	-7.6	
Materials technology	Biotechnology	-9.8	

Source: Federal Employment Agency (https://statistik.arbeitsagentur.de/DE/Navigation/Statistiken/Interaktive-Angebote/Branchen-im-Fokus/Branchen-im-Fokus-Nav.html and https://statistik.arbeitsagentur.de/DE/Navigation/Grundlagen/Klassifikationen/Klassifikation-der-Berufe/KldB2010/Arbeitshilfen/EnglischeKldB2010/KldBEnglischl-Nav.html for the English translation of occupations), QuBe forecast (https://www.bibb.de/de/qube_datenportal.php).

Table 2. What are the three biggest barriers to implementing digitalization?

	Percentage share of respondents
Lack of skilled workers	53
Technical infrastructure	39
Security concerns	37
Unclear business models	35
Lack of ICT know-how	34
Investment needs are too high	30
Lack of standards	29
Economic benefit unclear	22
Other barriers	4

Source: EY (2019).

▶ Table A3. Top ten occupations in industry WZ08 20 (Manufacture of chemicals and chemical products), June 2020

Occupation (KldB, 2010)		Share of employment*	Demand 2018 (base year) - 2030 (QuBe-forecast - baseline)	Demand 2018 (base year) - 2030 (QuBe-forecast - digitalization)	Effect of digitalization
413	**Occupations in chemistry**	34.2	-13.4	-14.0	-0.6
251	**Occupations in machine-building and -operating**	8.1	-10.3	-10.9	-0.6
273	**Technical occupations in production planning and scheduling**	7.7	-9.9	-5.8	4.1
713	**Occupations in business organization and strategy**	7.3	-2.5	1.2	3.7
513	**Occupations in warehousing and logistics, in postal and other delivery services, and in cargo handling**	5.4	-3.5	-7.5	-4.0
611	**Occupations in purchasing and sales**	4.8	-5.5	-1.3	4.2
714	**Office clerks and secretaries**	4.0	-11.4	-5.9	5.4
221	**Occupations in plastic- and rubber-making and -processing**	2.5	-7.2	-5.4	1.8
722	**Occupations in accounting, controlling and auditing**	1.8	-4.9	2.4	7.3
921	**Occupations in advertising and marketing**	1.8	10.7	9.6	-1.0

Source: Federal Employment Agency (https://statistik.arbeitsagentur.de/DE/Navigation/Statistiken/Interaktive-Angebote/Branchen-im-Fokus/Branchen-im-Fokus-Nav.html and https://statistik.arbeitsagentur.de/DE/Navigation/Grundlagen/Klassifikationen/Klassifikation-der-Berufe/KldB2010/Arbeitshilfen/EnglischeKldB2010/KldBEnglischl-Nav.html for the English translation of occupations), QuBe forecast (https://www.bibb.de/de/qube_datenportal.php).

* Subject to social security contributions (30/06/2020) in industry WZ08 20.

▶ **Table A4. Top ten occupations in industry WZ08 21 (Manufacture of basic pharmaceutical products and pharmaceutical preparations), June 2020**

Occupation (KldB, 2010)		Share of employment*	Demand 2018 (base year) - 2030 (QuBe-forecast - baseline)	Demand 2018 (base year) - 2030 (QuBe-forecast - digitalization)	Effect of digitalization
413	Occupations in chemistry	28.9	-13.4	-14.0	-0.6
818	Occupations in pharmacy	9.7	14.4	12.8	-1.6
713	Occupations in business organization and strategy	9.6	-2.5	1.2	3.7
273	Technical occupations in production planning and scheduling	8.1	-9.9	-5.8	4.1
513	Occupations in warehousing and logistics, in postal and other delivery services, and in cargo handling	4.7	-3.5	-7.5	-4.0
251	Occupations in machine-building and -operating	4.6	-10.3	-10.9	-0.6
611	Occupations in purchasing and sales	4.6	-5.5	-1.3	4.2
714	Office clerks and secretaries	4.4	-11.4	-5.9	5.4
412	Occupations in biology	3.3	8.5	21.0	12.5
271	Occupations in technical research and development	2.0	0.3	5.1	4.7

Source: Federal Employment Agency (https://statistik.arbeitsagentur.de/DE/Navigation/Statistiken/Interaktive-Angebote/Branchen-im-Fokus/Branchen-im-Fokus-Nav.html and https://statistik.arbeitsagentur.de/DE/Navigation/Grundlagen/Klassifikationen/Klassifikation-der-Berufe/KldB2010/Arbeitshilfen/EnglischeKldB2010/KldBEnglischl-Nav.html for the English translation of occupations), QuBe forecast (https://www.bibb.de/de/qube_datenportal.php).

WORK@Industry-4.0: Publications

The dialogue process has resulted in several publications relevant to implementing digitalization. They include a report on the results of the dialogue process (BAVC/IG BCE 2018), practical guides targeting companies and containing information about implementing a dialogue process on the digital transformation (BAVC/IG BCE 2021), implementing good and healthy work (BAVC/IG BCE 2020a), and about "Management 4.0" (BAVC/IG BCE 2020b), as well as reports on the corresponding social partner agreements (BAVC/IG BCE 2020c, BAVC/IG BCE 2020d, BAVC/IG BCE 2020e).

* Subject to social security contributions (30/06/2020) in industry WZ08 21.

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