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Research Report

Digital transformation in the workplace of the European Chemicals Sector

A sector-specific study of the European chemical, pharmaceutical, rubber and plastics industry

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Digital transformation in the workplace of the European Chemicals Sector

A sector-specific study of the European chemical, pharmaceutical, rubber and plastics industry

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Short Summary

"Digital transformation in the workplace of the European Chemicals Sector – A sector-specific study on the European chemical, pharmaceutical, rubber and plastics industry" is a study conducted on behalf of the *European Chemical Employers Group (ECEG)* and *industriAll European Trade Union*. The study was tasked to provide answers to the following questions:

- Which are the **sector-specific transformations** through digitalisation and Industry 4.0?
- What are potential **impacts** of the digital transformation on **skills, qualifications, working patterns** and **health and safety**?
- How **digitally mature** is the European chemical, pharmaceutical and rubber & plastics industry?

The study builds upon a **strong empirical basis**, including a comprehensive online-survey with 500 respondents from across the European Member States, more than 20 expert interviews, two conferences and additional steering group discussions, desk research and trend analysis. The research was conducted between March 2018 and December 2018. Based on the extensive research, **six overall conclusions on the digital transformation in the workplace of the European chemicals sector** have been drawn and are explained in more detail below:

Overall conclusions
1. The **1st wave of the digital transformation** (i.e. digitising analogue data and integrating cloud solutions) is successfully accomplished in the European chemicals sector. However, the implementation rate increases with the company size: especially the implementation rate of digital solutions in micro and small enterprises (<50 employees) is lagging.
2. The **2nd wave of the digital transformation** will be driven by the Industrial Internet of Things, Big Data, Artificial Intelligence, automation and augmented reality – and it will come into effect in the near future (within the next 5 years). The transformation around **AI** might cause more drastic implementation gaps between very large enterprises and SMEs.
3. A **shift in skills in the European chemicals sector is clearly visible** – basic digital skills are broadly existing in the sector. However, more advanced digital skills & transversal skills require attention by all stakeholders in the industry. Especially SMEs currently lack dedicated training programmes for digital upskilling and rate their digital skills less positive than larger firms.
4. The **working environment** in the chemicals sector is predominantly changed through mobile working with greater employee autonomy but also an increased level of multi-tasking. Close attention needs to be paid to the level of psychological stress, which is expected to increase significantly due to digitalisation, especially in larger firms.
5. **Collective agreements** need to pay greater attention to the issue of mobile working & working-time arrangements and qualification. Other sensitive issues linked to the digital transformation (data protection, performance monitoring) also need to be addressed with collective agreements or accompanied by other initiatives (e.g. open dialogue processes).

6. **Change management** and the **involvement & support of employees** is currently the biggest challenge in the digital transformation process of the European chemicals sector. It is decisive to address this to allow for a successful transformation. The digital maturity assessment shows little variance across Member States and sectors. Southern and Eastern Europe are more likely to have greater challenges. In these regions the issue of employee participation seems to be addressed less by collective agreements at national, regional or sectoral levels.

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1 Background and Motivation

The **digital transformation** is a driver of significant and profound change in the chemical, pharmaceutical, rubber and plastics industry: from changes of the traditional value chains as we know them today to the creation of dynamic value-added networks that go beyond the individual branch and company. This transformation will impact companies' strategies, their processes, structures and products with inevitable changes to the workplace environment, as new skills will be required from the industry's workforce in the future. While in the early days of this debate, the focus was heavily on the manufacturing industry, it is more obvious today that it will become a critical domain for process industries too – such as the chemical, pharmaceutical, rubber and plastics industry.[1] Advanced technologies relevant to the chemical industry, such as the Internet of Things (IoT), advanced materials, additive manufacturing, advanced analytics, Artificial Intelligence (AI), and robotics, have reached a level of cost and performance that enables widespread applications. Looking at the chemicals sector, digital maturity is also assessed as being 'high' or 'very high' by many top managers. Growth in gross value added in the chemical industry significantly benefits from digitalisation. Between 1996 and 2014 the average annual growth was 1.1% compared to only 0.6% in a scenario without digitalisation.[2]

However, it is still an **open question in how far the digital transformation will further transform the chemical industry**, including the transformation of value chains, the development of new (hybrid) products and, most importantly from the perspective of this project, the **transformation of work**. It is certain that – given the current developments in Industry 4.0 and the digitalisation of the industry – there will be qualitative as well as quantitative impacts on employment. Many of the workers' current skills may become obsolete, and new ones will be needed.

Industrial relations between employers and unions play a crucial role in the negotiation and implementation of strategies and measures to address the nexus between the transformation of work, re- and upskilling as well as occupational health and safety. Hereby, the heterogeneity of industrial relations across EU Member States, e.g. due to varying degrees of sectoral centralisation or organisational density of social partners[3], significantly shapes this process and must therefore be considered in the analysis.

[1] For better readability, we refer to the chemical industry including pharmaceuticals and rubber & plastics, if not otherwise stated.
[2] Figures for Germany, see Prognos AG (2017): Digitalisierung als Rahmenbedingung für Wachstum, on behalf of VBW, Munich; Roland Berger & BDI (2015): The digital transformation of industry, Berlin.
[3] Visser, J. (2009): Industrial relations in Europe 2008 (Employment & social affairs. Industrial relations & industrial change), Luxembourg.

Against this background, a Europe-wide research was conducted with **two major objectives**:

1. Analysis of the **level of awareness and identification of sector-specific challenges** of the chemicals, the pharmaceuticals and the rubber and plastics sectors.
2. Identification and interpretation of evidence of the concrete **impact of digital transformation on three domains: skills, working patterns, health & safety**.

The study is part of a larger European social partners' project by ECEG and industriAll Europe, as briefly described below.

Background - European social partners project on digital transformation of work in the Chemicals Sector
Innovation and digital transformation spread across all sectors and affect competitiveness, growth and the labour market in Europe. This social partner project analyses sectoral challenges and sets the framework for ECEG's and IndustriAll Europe's affiliates to formulate a joint action plan. The full title of the project is: "The impact of innovation and digital transformation in the workplace: a sector-specific study of the European chemical, pharmaceutical, rubber and plastics industry". The results of an EU-wide research study presented in this report will, first of all, analyse the impact of innovation and digital transformation on workers' competences/skills, their working conditions, and on health and safety. Moreover, the study showcases the current level of digital awareness in the sectors that ECEG and industriAll Europe represent. Based on the findings above, social partners will formulate a joint action plan on how to anticipate, prepare and manage change at the workplace as a result of innovation and digital transformation. The action plan will cover the state of play of the European chemicals sector and include a strategy to raise awareness and the exchange of good-practices. Furthermore, it will present concrete measures and recommendations. The project will also foresee the implementation of parts of the current work programme of the European Sectoral Social Dialogue committee in the chemical industry. Given the interdisciplinary nature of the action, the project will allow social partners to jointly address numerous priorities of the European Commission, including employment, social and economic challenges as identified in the discussions on the European Pillar of Social Rights, modernisation of the labour market; anticipation, preparation and management of change; digitalisation of the economy and society, flexsecurity, skills, health and safety at work, and decent work. These EU priorities are further outlined, inter alia, in the Commission Work Programme 2017 and several Commission Communications. For more information, please visit: http://www.ourfutureworkplace.eu/en/

Contents of this report

This report summarises key findings of the research conducted by Prognos AG during 2018, including desk research, an online-survey and interviews.

Following the analysis of key drivers of the digital transformation of work in the chemicals sector, a new Digital Maturity Model is delineated, which allows to characterize the progress of the digital transformation of work in a holistic manner. **Chapter 2** closes with an overview of the state of play, i.e. important findings from earlier studies across the European Member States in the subject area.

Chapter 3 starts with a short presentation of the survey participants and their national, sectoral and company specific backgrounds (Chapter 3.1) and is followed by the presenting of the main empirical results from this study including the findings on the:

- **digital transformation of work** in terms of **skills, working patterns, health & safety** (Chapter 3.2)
- **technological transformations** in the chemicals sector through digitalisation (Chapter 3.3)
- changes in **employer-employee relationships** and collective agreements due to digitalisation (Chapter 3.4), and,
- the level of **digital maturity and awareness** regarding digitalisation in the European chemicals sector (Chapter 3.5).

The main part of the report summarises both survey results and the results from the accompanying interviews and workshops. The different perspectives are presented regarding the transformational plays in the different chemical sectors by company size, type of respondent (manager or employee, union or employer) or from a country comparative perspective.

Finally, **Chapter 4** highlights key findings from the conducted analysis and provides some key conclusions.

2 State of Play: What do we know about the digital transformation in the workplace so far?

2.1 Key drivers and determinants of digital transformation in the workplace

Today, a vast amount of literature already exists about the digital transformation and Industry 4.0. Besides purely technological changes or the influence of digitalisation on existing business models, the changes in the workplace and the impacts on workers also has received greater attention over the years. Most of the existing studies and surveys address the digital transformation on a more general level across industries. However, also the sector-specific changes in the chemical industry are increasingly discussed in the literature.

In order to obtain an overview of the current state of research, almost 100 studies with different thematic foci have been analysed. The largest share of reviewed studies (43) discusses the subject of Industry 4.0 and its implication on the workplace without a sector-specific focus. In addition, 24 studies and position papers that discuss the changing industrial relations in the digital age have been analysed. Finally, almost 30 industry-specific research studies examining the digitalisation in the chemical industry and its sub-sectors have been included in the literature review. Besides the European and globally focused studies, the review includes country specific reports from various EU Member States to identify potential regional differences.

Horizon scanning – global drivers of change in the chemical industry

Before discussing the key drivers of digital transformation in the workplace, several overarching **global drivers of change** are presented. While these drivers do not necessarily have an impact on digital transformation, they do affect the competitive environment of the EU chemical industry.

To this end, a **STEEP-analysis**[4] was performed to identify the most important trends, uncertain developments and weak signals that have an influence on the chemical industry until 2030. Based on the previously described literature review, **55 different influencing global and regional factors and trends were identified**. Not only do they cover economic or technological developments but also cover trends at a political or environmental level. In the following chapters, a summary is presented of the most important global trends for the chemical industry. An overview of all identified trends and influencing factors is provided in Annex 1.

Besides secondary trends, which have a minor influence on the industry's future development, the STEEP-analysis identified **predetermined drivers** and **key uncertainties**. Predetermined drivers (upper left part of Annex 1) represent those trends that are certain in their development and that will have a significant impact on the chemical industry's competitive environment. Key uncertainties (upper right part of Annex 1) are factors with a potentially high impact on the development of the industry. However, their impact and shape cannot yet be completely determined.

[4] STEEP is an acronym for: Social, Technological, Economical, Environmental and Political. The STEEP analysis is used for scanning developments in the external (contextual) macro environment.

The following **predetermined drivers** (mostly macro-economic and social factors) have been identified as being particularly important for the competitive environment of the chemical industry:

- **Increased competition from emerging economies and increasing R&D expenditures in the Asia-Pacific region**: For instance, the "Made in India" strategy or China's "13th Five Year Plan" foresee a move up the value chain from bulk chemicals towards more research-intensive products. The objective of moving up the value chain combined with their more dynamic economic growth will increase the pressure on Europe's position as the leader in chemical innovation and R&D. China increased its share in worldwide chemical and pharmaceutical R&D expenditures from 1.6% in 2000 to 13% in 2017[5] and it is expected that by 2030 China will even reach a share of close to 15%[6]. The largest part of this increase will be at the expense of Japan. Europe and the US will also see their shares shrink[7]. Emerging economies, such as India and China, are also catching up in terms of intellectual property. For instance, China's global share of patents in the chemical and pharmaceutical industry has grown from 1.9% in 2005 to almost 10% in 2016[8].
- **Higher energy costs in Europe driven by European energy and climate policy**: The focus of EU energy policy on renewables occurred alongside with rising energy costs for the sector. In addition, the European Emissions Trading Scheme (ETS) poses an additional challenge to the competitiveness of the energy-intensive sectors of the chemical industry.
- **Low growth in EU-markets vs. growing demand for chemicals in emerging countries**: The low industry growth in the EU and the related lower investment rates reduce the overall demand growth for chemicals in Europe. This is at least partially compensated by the increasing wealth of people in emerging countries, especially in Asia. Therefore, these emerging regions will remain a key driver for global economic expansion and demand for chemical products in the coming years.
- **Demographic challenges in Europe and shortage of labour**: The European countries are facing major demographic changes, driven by an ageing population and low birth rates. This demographic shift increasingly poses a challenge to the labour market and creates a shortage of labour in all branches of the industry. Further, it will have important implications on the workforce, particularly on its composition.

Some examples of **key uncertainties** for the chemical industry's development include:

- **Impact of Artificial Intelligence and robotics on the labour market:** The impact of increasing utilisation of Artificial Intelligence and robotics on labour demand (substitution of repetitive tasks vs. demand for new skills) is still unclear and subject to ongoing discussions.
- **Application of Big Data, cloud computing and global real-time process monitoring:** These new technologies offer great opportunities for new business models and broader product portfolios. Yet, costs and potential revenues ("returns on investments") of the new technologies are still opaque, particularly for SMEs.

[5] Verband der Chemischen Industrie e. V. (2019): Eckdaten der chemisch-pharmazeutischen Industrie zu Forschung, Entwicklung und Bildung. Retrieved from: https://www.vci.de/ergaenzende-downloads/eckdaten-chemisch-pharmazeutische-industrie-forschung-entwicklung-bildung-innovationsstatistik-kurz.pdf, p.13

[6] Prognos AG und Verband der Chemischen Industrie e. V. (2016): Die deutsche chemische Industrie 2030 - Update 2015/2016, Frankfurt, p.36.

[7] Ibid.

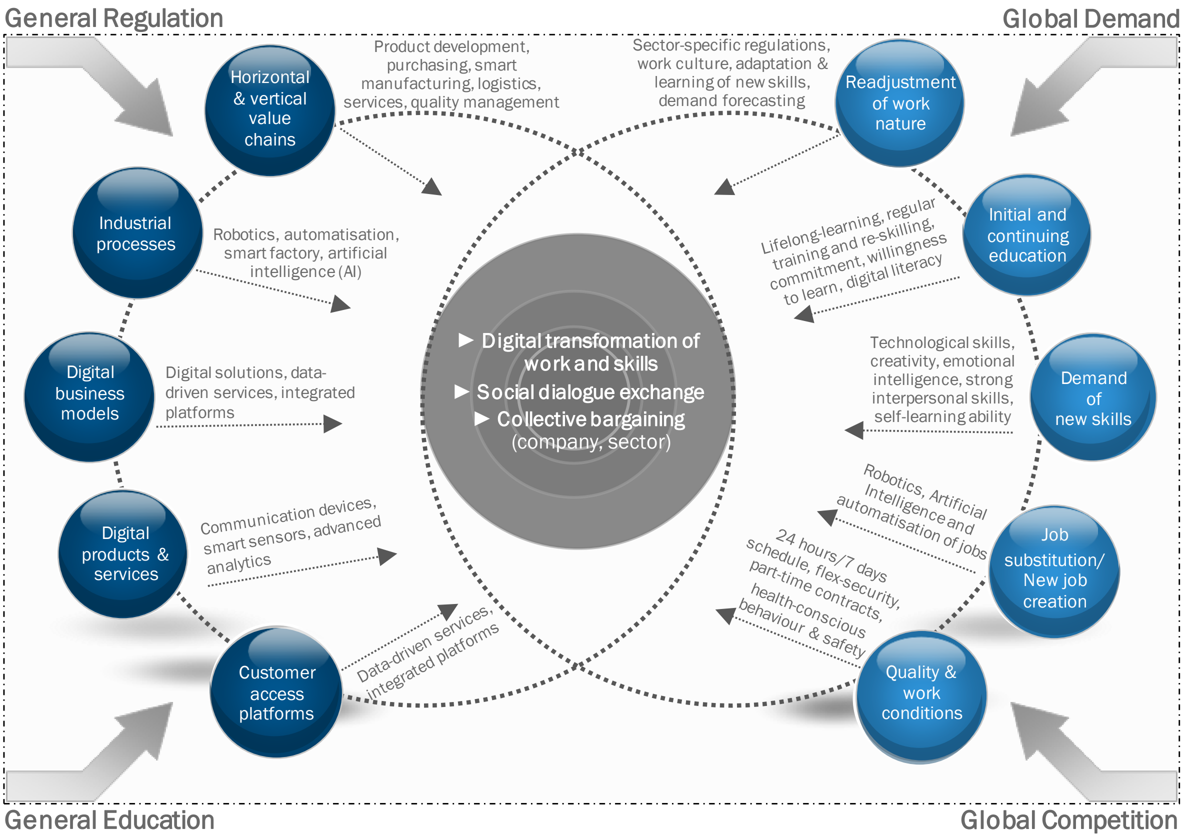
[8] Verband der Chemischen Industrie e. V. (2018): Ausführungen von Thomas Wessel, Vorsitzender des Ausschusses Forschung, Wissenschaft und Bildung im VCI, auf der VCI-Forschungspressekonferenz am 21. August 2018. Retrieved from: https://www.vci.de/presse/mediathek/weitere-downloads/forschung-und-entwicklung-in-der-chemischen-industrie-im-ueberblick-hintergrundmaterial.jsp.

- **Uncertain effects of the Circular Economy on the chemical industry:** The effects of the circular economy are uncertain in terms of new recycling regulations, potential demand reduction, the availability and costs of more sustainable resources, new product designs or the application of new information sharing schemes.
- **New forms and relevance of labour relations in the digital environment:** The active participation of employee representatives and unions in the transformation process, the protection of workers' rights and job reallocation are open questions in many companies, industries and countries (depending on the dominant level of negotiation).
- **Lack of skilled labour in the areas of Science, Technology, Engineering and Mathematics (STEM):** Digitalisation requires new technical skills and digital literacy. However, the demographic challenge in Europe, the proportion of young people actively pursuing a career in STEM-areas and the lack of investment in this type of education might have repercussions on the chemical industry.

Key drivers and determinants of digital transformation in the workplace

Based on the STEEP-analysis, **the key drivers of the digital transformation in the chemicals, pharmaceuticals, rubber & plastics sector** were identified – more precisely, the areas where digitalisation is already having a direct effect or will be leading to a transformation in the industrial processes and the workplace of the chemical industry. Figure 1 shows the main pillars of the digital transformation. On the left side, business related transformations are shown. On the right side, transformations of the working environment are depicted. The centre represents their interaction.

Figure 1: Key pillars of digital transformation in the chemical, pharmaceutical, rubber and plastics industry



Source: Prognos AG (2019), based on own research.

From a technical point of view, digitalisation is already today changing processes along the chemical **value chain**. Digital solutions offer the opportunity to integrate numerous steps of chemical production with technological tools, allowing an uninterrupted and end-to-end communication between employers, machines and products[9], controlling in real time the manufacturing process and contributing to problem-solving. Digital solutions allow to manage and integrate resource databases, logistics and transport systems as well as customer platforms, and encourage user engagement and early planning and communication.

As a result of this digital transformation, value chains and production in the chemical industry could resemble what is known as a **"smart factory"**. The integration of Artificial Intelligence, robotics, additive manufacturing, Big Data analytics, Industrial Internet of Things (IoT) and other more traditional technologies will allow more efficient, digitised and autonomous industrial processes[10]. Robotics, for example, enable new cyber-physical systems that increase productivity

[9] Institute for Plastics Processing (2018): Industry 4.0 in plastics processing. Retrieved from [26.04.2018]: https://www.ikv-aachen.de/en/research/guiding-themes/plastics-industry-40/; McKinsey & Company (2015): Industry 4.0 - How to navigate digitization of the manufacturing sector.
[10] Deloitte University Press (2016): Industry 4.0 and the chemicals industry - Catalyzing transformation through operations improvement and business growth.

and safety, while 3D printing and additive manufacturing offer new options in terms of design and maintenance processes, and contribute to cost savings and resource efficiency in R&D processes[11].

The use of the latest digital technologies and the digital transformation in general may also lead to new opportunities in terms of **digital business models**, characterised mainly by the utilisation of technological platforms, software and Big Data in B2C applications as well as a broader portfolio of products and services offered. Some examples of digital business models include **service-business models**, where chemical companies offer pay-by-use systems for software applications, equipment and machinery. Technology platforms can engender greater connectivity and collaboration between third parties and make real-time engagement with customer demands feasible. Additionally, intellectual property rights may generate revenue for those companies which decide to offer consulting services, licensing and best usage of products, whilst Big Data offers chemical manufacturers the possibility to provide information through crowd-sourced data[12].

These technologies enable chemical companies to **offer new digitised products and services**. They combine the use of data analytics and smart sensors to deliver – with the customer's consent – product information and value-added data services, such as quality assessment, tracking devices and prompt detection of possible product defaults. Chemical companies may thus provide real-time technical recommendations[13].

Moreover, the digital transformation gives chemical companies the possibility to interact and include the **end-consumer** in the decision-making process. Through **interaction platforms**, chemical companies can include all parties involved in the production and distribution processes. By aligning customer requirements with the manufacturing process and offering applications with advanced and **personalised product design and attention**[14], end-users become an integral part of the production process too. These types of networks and platforms improve customer management and service, as companies can offer specified assistance for the implementation of robotics, automation and avatars and, therefore, facilitate the customers' understanding of the new technologies. Further, data collection and analytics can ease the identification of trends, help to predict customer behaviour and improve marketing strategies and price analyses[15]. Hence, digitalisation and the resulting visible **end-to-end connectivity** introduce structural changes to all industrial processes, business models and parties involved.

This is inevitably also influencing the **workplace** and impacts other issues such as the level of employment and quality of employment, wages, skills and the need for continued education, work conditions and social protection. The digital transformation is already changing and influencing the **work environment** in the chemical industry. Digitalisation requires employees to remain up to date with new technologies, causing a continued need to **reskill** to remain competitive on the employment market. **Education and work** are likely to change from the linear pattern of schooling, training, employment and the entitlement to a pension, to a constant switch between

[11] Roland Berger & Siemens (2016): España 4.0 - El reto de la transformacion digital de la economia, Madrid; Deloitte University Press (2016): Industry 4.0 and the chemicals industry - Catalyzing transformation through operations improvement and business growth.
[12] McKinsey & Company (2015): Industry 4.0 - How to navigate digitization of the manufacturing sector; Deloitte & Götz G. Wehberg (2015): Chemicals 4.0 - Industry digitalization from a business.strategic angle, Königswinter.
[13] Smart industry (2016): Dutch industry fit for the future, Zoetermeer.
[14] Roland Berger & Siemens (2016): España 4.0 - El reto de la transformacion digital de la economia, Madrid.
[15] World Economic Forum & Accenture (2017): Digital Transformation Initiative - Chemistry and Advanced Materials Industry, Cologne/Geneva; Institut für Wirtschaftsinformatik, Universität St. Gallen & Crosswalk (2017): Digital Maturity & Transformation Report 2017, St. Gallen.

work, (re-) training and new positions in one's work life. Consequently, life choices, for example relating to family management or retirement, are becoming more complex. This represents also **new challenges for trade unions and works councils**, which need to address the new dynamics relating to work culture, flexsecurity, safety, labour rights and lifelong learning[16].

Lifelong learning is one of the most decisive factors for the digital transformation process. It implies, on the one side, that employees must have the **willingness and self-management to keep learning** during their whole working life. On the other side, it requires companies to provide their employees with adequate **training** strategies and investments in terms of time and money. Lifelong learning thus implies a joint effort by both sides. Moreover, it should be understood as a must-have and not as an available option: for the company – which requires an adequate workforce – and the employee, if they wish to remain employable and reduce their vulnerability to the **risk of automation**[17].

In fact, **automation, Artificial Intelligence** and digital technologies are gaining relevance and perform an increasing number of tasks at the workplace. This opens the space for **newly demanded profiles** with high **technological skills**, such as Internet of Things architects, Big Data analysts and specialists or computing engineers[18], who offer the proper **digital literacy** to work and handle the new technological tools. However, as all steps of the industrial process and business model are being more integrated and connected, digitalisation also requires work profiles **with transversal and social/interpersonal skills**. Transversal and social skills like creativity, negotiating abilities, problem-solving, self-control or emotional intelligence[19] are the type of aptitudes that cannot be replaced by Artificial Intelligence and that complement future digital profiles who will be responsible for leading and managing the digital trends.

The extent of routine and repetitiveness of a task increases the risk of an employee to be replaced by new technologies and automation, as some skills might become obsolete. As machines are becoming more intelligent and autonomous, physical, simple manual and machine-interacting jobs are at higher **risk of being substituted**, such as assemblers, cleaners, and machine and plant operators, to name a few. However, this substitution can also be understood as new **upskilling opportunities** and **labour reallocation** and not as the risk of job-loss[20].

Still, digitalisation will transform the working environment in terms of **quality and work conditions**. Positive effects may be related to the improvement of **physical safety** and **flexible working conditions**. Automation, robotics and Artificial Intelligence can lead to the reduction of hazardous tasks that employees must perform. It also opens the possibility for more autonomous work, greater flexibility in working schedules, mobile work, work-life balance and even greater multilateral and democratic cooperation between parties[21]. However, these aspects may also result in negative effects: work flexibility may imply constant employee availability with blurred time boundaries between work and private life (7 days, 24 hours schedules) and in turn increase

[16] European Commission (2016): The future of work, skills, and resilience for a world of change, Brussels; CCOO Industria (2017b): Encuentros sobre digitalización e industria 4.0 - principales conclusions, Madrid.
[17] BAVC - Die Chemie Arbeitgeber (2017): Positionspaper zum Weißbuch „Arbeiten 4.0" des Bundesministeriums für Arbeit und Soziales (BMAS), Wiesbaden; Bundesministerium für Arbeit und Soziales (2017): Weiterlernen für die Arbeitswelt 4.0, Berlin.
[18] European Commission (2016): The future of work, skills, and resilience for a world of change, Brussels.
[19] Ibid.
[20] OECD (2018): Automation, skills use and training, OECD Social, Employment and Migration Working Papers, No. 202, OECD Publishing, Paris. Retrieved from [17.01.2019]: https://doi.org/10.1787/2e2f4eea-en; European Commission (2016): The future of work, skills, and resilience for a world of change, Brussels.
[21] CCOO Industria (2017b): Encuentros sobre digitalización e industria 4.0 - principales conclusions, Madrid; IndustriAll Europe Trade Union (2015): Position Paper 2015-02 Digitalisation for equality, participation and cooperation in industry - More and better industrial jobs in the digital age, Brussels

psychological stress and anxiety. Furthermore, the dynamics of full-time employment – as they are known today – are challenged. Several studies emphasize that due to the digital transformation new forms of **asymmetric relationships** and **precarious work with individualised** terms could emerge in many industrial sectors (e.g. freelancers, false/bogus self-employment[22] or crowd-sourcing[23]). Potential consequences could be inadequate welfare protection and wages, lack of skilling opportunities due to part-time contracts, or outsourcing of activities to temporary employment agencies with more insecure working conditions[24].

These are challenges that most industrial sectors may be facing now and, in the future, – including the chemical sectors – and why subjects such as flexsecurity are gaining more relevance. The European Commission, for instance, has been working with a variety of actors such as governments, social partners and academic institutions to create a strategy that aligns the demands of the industry and the workers. The strategy should be implemented through reliable contract agreements, fair lifelong learning strategies, as well as sustainable social protection and labour market policies[25].

It is, therefore, important that all parties involved – companies, trade unions and works councils – consider the possible future scenarios and **anticipate the changes** that the digital transformation entails in the workplace. It is very likely that employees feel threatened by the digital transformation and are skeptical about the benefits associated with it. Thus, these issues and concerns must be addressed from an **early stage** through communication, **constructive social dialogue** and **transparent information exchange**, so that the interests of all parties are considered, and **co-determination rights** are promoted[26].

Companies and their employees can commonly agree on the design of appropriate measures to increase the workforce's **level of acceptance** of and participation in the digital transformation at the workplace. This should allow to get the most out of the possibilities of the digitalisation, whilst ensuring that associated risks are minimised[27]. For instance, **health-conscious behaviour** and **work-life balance** can reduce physical and psychological stress and promote a responsible lifestyle among employees, when well addressed[28].

However, **collective bargaining** and **social dialogue exchange** should not be seen as means to block technological innovation, but rather be applied to ensure that all parties can benefit from it: further digitalisation does not necessarily imply workplace deterioration[29].

[22] False or bogus self-employment refers to a situation where "[…] people work as independents but on a sub-contract basis to a single company and essentially do the same job as an employee but on less favourable terms, with relatively low earnings and often without social protection." (European Commission (2015): Recent changes in self-employment and entrepreneurship across the EÚ. Research note no. 6/2015, p. 3-4.)

[23] Crowd-sourcing or crowd employment can be defined "[…] as paid work organised through online labour exchanges. This encompasses a range of forms of work, which can be differentiated along several dimensions including: their professional status[…]; whether they are carried out online or offline […]; the location of work […]; the employment status of the workers (employee or self-employed); and whether the work is carried out for a company or a private client." (European Agency for Safety and Health at Work (2015): The future of work: crowdsourcing. Retrieved from [01.02.2019]: https://osha.europa.eu/sites/default/files/publications/documents/EN-Crowdsourcing_dicussion_paper.pdf, p.1.

[24] European Commission (2016): The future of work, skills, and resilience for a world of change, Brussels; industriAll Europe Trade Union (2015): Position Paper 2015-02 Digitalisation for equality, participation and cooperation in industry - More and better industrial jobs in the digital age, Brussels; CCOO Industria (2017b): Encuentros sobre digitalización e industria 4.0 - principales conclusions, Madrid.

[25] European Commission (2019): Employment, Social Affairs & Inclusion – Flexsecurity. Retrieved from [28.01.2019]: https://ec.europa.eu/social/main.jsp?langId=en&catId=102.

[26] Hans-Böckler-Stiftung (2018): ARBEITEN 4.0 - Diskurs und Praxis in Betriebsvereinbarungen - Teil II, Düsseldorf.

[27] Ibid.

[28] Gesamtmetall (2015): Work 4.0 – Opportunities for the Future World of Work; BAVC - Die Chemie Arbeitgeber (2017): Positionspapier: zum Weißbuch „Arbeiten 4.0" des Bundesministeriums für Arbeit und Soziales (BMAS), Wiesbaden.

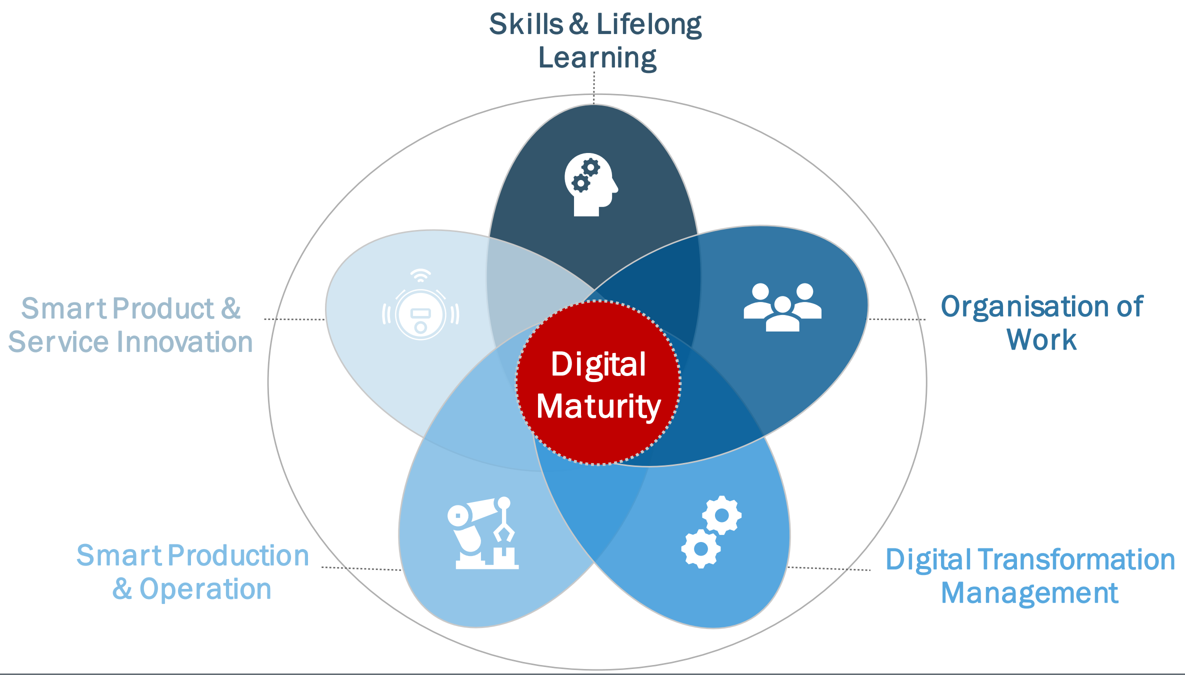
[29] BAVC - Die Chemie Arbeitgeber (2017): Positionspapier: zum Weißbuch „Arbeiten 4.0" des Bundesministeriums für Arbeit und Soziales (BMAS), Wiesbaden; CCOO Industria (2017c): La digitalización y la industria 4.0 - Impacto industrial y laboral, Madrid.

2.2 Digital maturity model for the European chemicals sector

Based on the previous research on the key drivers and determinants of the digital transformation in the workplace, a concept and corresponding parameters have been developed to measure the "digital matureness" of the chemical industry and its different sectors. In addition, different research studies[30] and scientific papers[31] concerning models for assessing Industry 4.0 readiness or digital transformation in various sectors have been consulted to develop the final methodology, which is described in more detail in Chapter 3.

The digital maturity model is based on **five dimensions**, each represents a critical aspect of the digital transformation of the industry and the corresponding changes in the workplace (see Figure 2). Behind these dimensions, a set of **20 related indicators** define in more detail the important issues that need to be considered when assessing the digital matureness of a company or the whole industry.

Figure 2: Digital maturity model for the European chemicals sector



Source: Prognos AG (2019), based on own research. Icons: Copyright Flaticon.

This conceptualisation represented an important input for designing the European-wide online survey across chemical industry stakeholders. The results of the online survey at same time are the main source for determining the digital maturity of the European chemical industry and its different sub-sectors.

The following Table 1 gives an overview of the used indicators and their correspondence to one of the five maturity dimensions:

[30] University of St. Gallen & Crosswalk (2017): Digital Maturity & Transformation Report 2017.
[31] Schumacher, A., Erol, S. & Sihn, W. (2016): A maturity model for assessing Industry 4.0 readiness and maturity of manufacturing enterprises, in Procedia CIRP, 52(2016), p. 161-166.

Table 1: Dimensions and Indicators of the Digital Maturity Model

		Skills & Lifelong Learning
1.1	Availability of digital skills	Measures the degree to which the **necessary skills** adapted to digital technologies are **available** within the industry and can easily be found on the job market.
1.2	Openness to new digital technologies	Measures to which degree employees and management within the industry **are familiar with** (their own) new **digital technologies** and how open they are to use them.
1.3	Development of digital expertise	Measures the extent to which companies within the industry are implementing **strategies to reskill their workforce** and provide adequate training measures to their employees.
1.4	Role of social dialogue	Measures the degree to which **strategies to retain and adapt the needed skills** (e.g. occupational training and lifelong learning) are being sufficiently **discussed between management and employees** and their representatives.
		Organisation of Work
2.1	Flexibilisation of work: Flexible time-management	Measures to which extent **flexible working arrangements are put in place** to manage concurrent changing Industry 4.0 conditions and new expectations for work-life balance.
2.2	Flexibilisation of work: Availability of infrastructure	Measures to which extent the **infrastructure enabling flexible working arrangements** is **available** within the industry.
2.3	Interdisciplinary collaboration	Measures to which extent interdisciplinary and interdepartmental **collaboration** is encouraged, facilitated and **improved by new digital collaboration platforms**.
2.4	Social dialogue: Consideration of experience	Measures whether the **experience and concerns of employees** are **being sufficiently addressed** through the discussions between management and employees.
2.5	Social dialogue: Improvement of acceptance	Measures the extent to which the **outcomes of discussions** between management and employees or their representatives have **improved the level of acceptance** of new working patterns and technologies among the workforce.
2.6	Social dialogue: Competitiveness	Measures the degree to which the **outcomes of discussions** between management and employees or their representatives have **improved the company's competitiveness**.
		Digital Transformation Management
3.1	Digital transformation strategy	Measures the degree to which **digitalisation** within the industry is planned, coordinated and implemented in a **target-oriented manner** (e.g. presence of a roadmap or a clear strategy as a basis for clear communication and reduction of uncertainty).
3.2	Transformation management	Measures to which extent the **digital change** process in the company and the promotion of personal responsibility and initiative taking are actively **promoted** and adequately **supported**.
3.3	Innovation culture	Measures the degree to which the **framework conditions**, necessary for enabling digital **innovations**, exist within the industry (i.e. by providing financial and human resources, temporal space for experimentation and risk-taking attitude).
		Smart Production & Operations
4.1	Smart Production & Maintenance: Degree of automation	Measures the degree to which the industry uses the latest digital possibilities to **automate routine processes** for more efficient **production and maintenance** (e.g. CPPS or IoT).
4.2	Smart Production & Maintenance: Degree of flexibility	Measures to which degree the **flexibility of production tools** allow to meet the growing demands for customisation and adaptability of production (e.g. flexible production-lines allowing production planning to be adapted to real-time demands).
4.3	Horizontal process integration	Measures the degree of horizontal **integration along the value-added network** over production processes, integrating customers, supply chain and data recording.
4.4	Vertical process integration	Measures the degree of the **vertical integration of all relevant** business, production and automation **processes**.
		Smart Product & Service Innovation
5.1	Smart products & services	Measures to which extent companies in the industry are already utilising **digital technologies** (IoT, Big Data, etc.) to **add intelligence and value added for customers**.
5.2	Smart business models	Measures the extent to which companies in the industry are **aware of potential new digital business models** and are using them to expand the companies' existing offerings.
5.3	Smart innovation management	Measures if companies within the industry use new **digital technologies to analyse and integrate customers or suppliers** in the development of new digital innovations.

Source: Prognos AG (2019), based on own research.

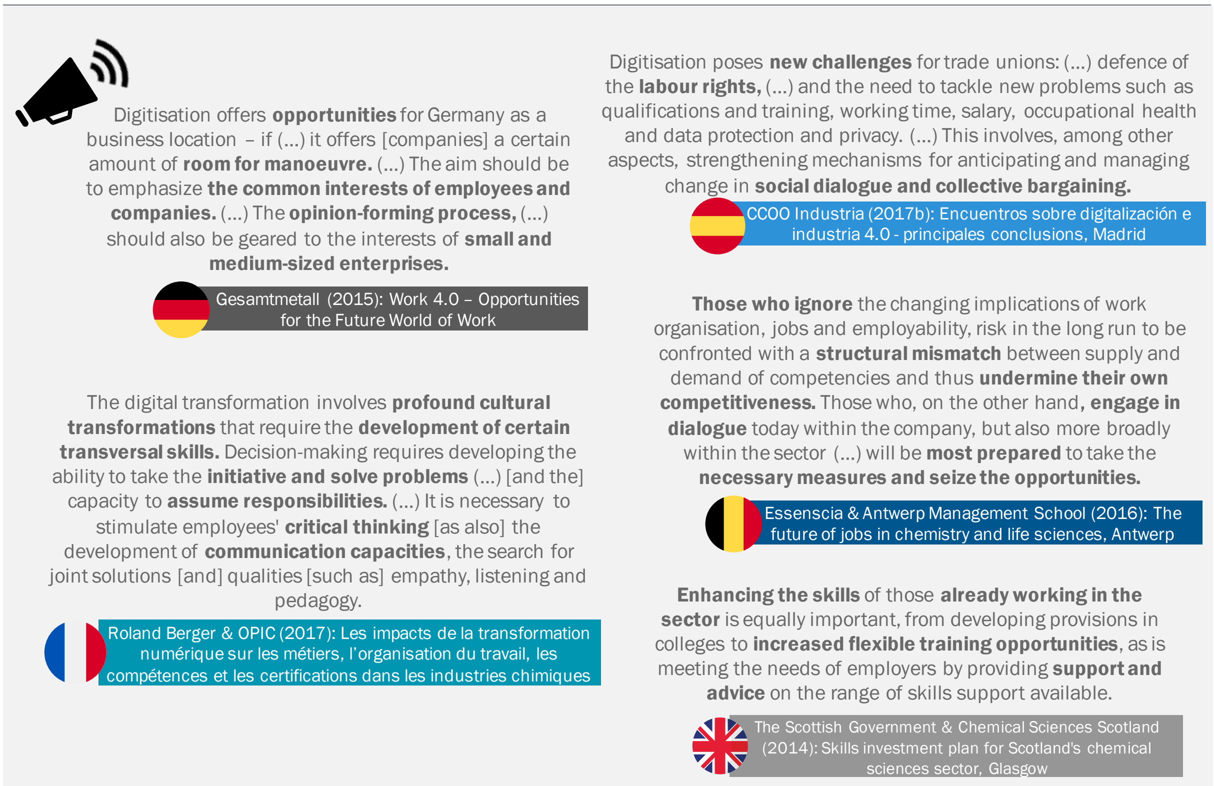
These conceptual findings form an important basis for this study and will be further explored in the empirical analysis presented in Chapter 3.

2.3 Current state of play in the European discussions around digital transformation of the chemical industry

As described in Chapter 2.1, the consulted literature comprises 96 studies and scientific papers addressing all subjects concerning digitalisation and Industry 4.0.

The following Figure 3 and Table 2 provide an overview of the current **state of play in the European discussions around digital transformation in the chemical workplace**. The summary depicts which subjects were mainly addressed, provides some key findings, and shows the priorities that each country has set to address and prepare the digital transformation.

Figure 3: Key insights from European studies



Source: Prognos AG (2019), based on own research. Icons: Copyright Flaticon.

Table 2: Current state of play and key messages from other European studies

Country	Current state of play - Key messages
Germany 	■ Digitalisation requires much more flexibility and **less state regulation** in order to be successful in the chemical industry. ■ **Further training** should not be a legal entitlement for companies, but instead be a **fair balancing of costs and responsibilities between employers and employees.** ■ The chemical industry should promote a healthy workplace, especially in terms of **mental health**, however, all company initiatives must be supported by **health-conscious behaviour** and responsible lifestyles on the part of employees[32].
Spain 	■ **State's role is decisive** in promoting digitalisation since it must be responsible for bringing together companies, political parties, trade unions and educational institutions. ■ It must also prevent – through the **regulation and coordination** of actions – that the digital transformation does not imply the increase of inequalities, lower wages, the limitation of workers' rights or the deterioration of their working conditions[33]. ■ It is necessary that the industry works together with educational centres and the government to improve university programs and **vocational training**, especially in the areas of **Science, Technology, Engineering and Mathematics (STEM)**[34].
France 	■ French chemical companies – especially **SMEs** – are having **difficulties to recognise the opportunities** of digitalisation and to stablish strategic plans and methods on how to initiate this transformation. ■ One of the main challenges of digitalisation concerns the **demand of new and much broader profiles** that stand out for their **technical, transversal and behavioural skills**[35].
Italy 	■ The biggest transformation of the chemical industry makes evident the demand of **new emerging skills** and the competences that will be required **depending on the job position.** ■ Managers, for instance, are expected to have also **social skills** to motivate employees to keep up with new technological tools and to **ease their adaptation** in the new market dynamic, as well as multicultural sensitivity and communication in foreign languages to accompany offshoring and outsourcing business.

[32] BAVC - Die Chemie Arbeitgeber (2017): Positionspapier zum Weißbuch „Arbeiten 4.0“ des Bundesministeriums für Arbeit und Soziales (BMAS), Wiesbaden.
[33] CCOO Industria (2016): Industria 4.0 - una apuesta colectiva, Madrid; CCOO Industria (2017b): Encuentros sobre digitalización e industria 4.0 - principales conclusions, Madrid.
[34] CCOO Industria (2017): El futuro del trabajo que queremos, Madrid; CCOO Industria (2017c): La digitalización y la industria 4.0 - Impacto industrial y laboral, Madrid.
[35] Roland Berger & OPIC (2017): Les impacts de la transformation numérique sur les métiers, l'organisation du travail, les compétences et les certifications dans les industries chimiques.

	■ Production operators are expected to acquire updated **technical knowledge** of the production process, **higher flexibility**, strong decision-making skills and the ability to adapt to work in different contexts[36].
Scotland 	■ Scotland's "skills investment plan" not only focuses on improving the technical skills of the Scottish workforce, but also on enhancing their **soft skills,** with the objective to improve the workforces' overall job skills. The requirements are rapidly changing as automation advances in the chemical industry. ■ It is also important to attract new **young entrants** and **experienced staff** with sector-specific knowledge to maximize opportunities from digitalisation in the chemical industry[37].
Belgium 	■ The chemical industry should encourage a **two-way knowledge transfer between generations,** where experienced employees can pass on their in-depth process' knowledge to the younger generations, while the latter in turn can assist them with their **digital literacy** to adapt and implement the new technology tools in their daily tasks. ■ In this way, digitalisation would lead mostly to **qualitative job changes**, where technology and workforce complement each other, rather than **big quantitative transformations** and massive job substitution[38].

Source: Prognos AG (2019), based on own research. Icons: Copyright Flaticon

The contribution made by these studies to Work 4.0, Industry 4.0 and Chemistry 4.0 is recognizable, as well as their contribution to identifying national priorities to approach the digital transformation in the most successful way. The **surveys** made by Roland Berger & OPIC (2017)[39] for France or Fraunhofer & IAO (2017)[40] for Baden-Württemberg, Germany, are likewise useful guidelines regarding digitalisation in the chemical industry.

Overall, however, **evidence at the cross-European level is still lacking**. There is still too little knowledge about the digital transformation in the European chemicals sector from a holistic perspective. To our knowledge, there exists no European study that addresses at the same time the sector's technological transformation, the impacts on the workplace and the digital maturity of the chemical industry. Therefore, this study represents a first of its kind attempt at filling the current research gap by providing a cross-European analysis of the digital maturity of the chemicals sectors.

[36] SOGES S.p.A. e Ares 2.0 (2014): Anticipazione dei fabbisogni professionali per il settore chimico e farmaceutico.
[37] The Scottish Government & Chemical Sciences Scotland (2014): Skills investment plan for Scotland's chemical sciences sector, Glasgow.
[38] Essenscia & Antwerp Management School (2016): The future of jobs in chemistry and life sciences, Antwerp.
[39] Roland Berger & OPIC (2017): Les impacts de la transformation numérique sur les métiers, l'organisation du travail, les compétences et les certifications dans les industries chimiques.
[40] Fraunhofer & Organisation IAO (2017): Digitalisierung und Arbeitswelt in Chemie und Pharma Baden-Württemberg, Stuttgart.

3 The Research Findings: Cross-European evidence of the digital transformation in the European chemical, pharmaceutical, rubber and plastics industry

3.1 Design of the survey and the survey participants

The main source of evidence for this study is a large-scale, Europe-wide online-survey which aimed at generating a deeper understanding of the digital transformation in the workplace of the European Chemicals Sector. The survey conducted is the first of its kind, as it combines the perspectives of employers and employees (including their interaction) as a pan-European sector study. Furthermore, the study has been supported, in a joint effort, by the social partners.

The survey was launched as a **multilingual online survey**[41] and was conducted between July and October 2018. It addressed **three different target groups**:

- representatives at company level (managers and employees),
- representatives from employers or industry associations and
- representatives from trade unions.

For these target groups, three different questionnaires were developed. While the questionnaires for trade union representatives and employers or industry association representatives were similar, the questionnaire for company level workers' representatives, including both management and blue-collar workers, was specifically designed for this target group.

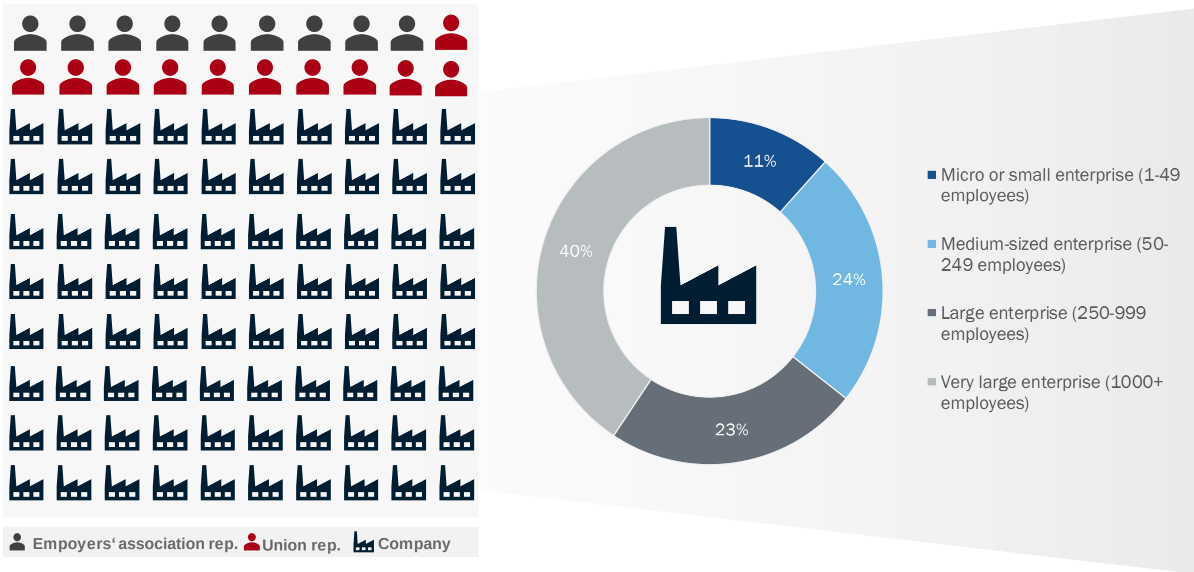
The survey questionnaires were developed in spring 2018 in close cooperation with ECEG and industriAll Europe involving a steering group consisting of representatives of both trade union and employers' associations. It was launched at the beginning of July 2018 and disseminated to all ECEG and IndustriAll Europe affiliates at national level and online/social media platforms. The survey was conducted for around four months and promoted during a stakeholder conference in mid-October in Tallinn, Estonia[42]. The survey was closed at the end of October 2018.

In total, **around 500 industry representatives participated in the European wide chemical industry stakeholder survey**, which showcases representative results at EU-level[43]. A structural representativeness of the survey was achieved through the sectoral composition, size-composition and job position/role played within the business. This provides a sound basis for differentiated answers.

[41] The online survey was available in 6 languages: English, German, French, Italian, Spanish and Polish. In addition, a Dutch translation, in form of a PDF-document, was made available.
[42] Our Future Workplace (2018): Stakeholder Conference 2018: European social partners discuss digital transformation in the European chemical industry. Retrieved from [28.01.2019]: http://www.ourfutureworkplace.eu/en/events/stakeholder-conference-2018/.
[43] The representativeness of a survey depends on its sample size and composition (the structure should be as similar as possible to that of the population). For the current survey, the population represents the number of companies and/or employees in the European Chemicals, Pharmaceuticals and Rubber & Plastics sector. Against this background, a sample size of 360-380 complete answers is considered to be sufficient to make statements at EU industry level (assuming 3.3 Million employees or approx. 6,300 companies, a confidence level of 95%, and an error margin of 5%). By accepting an error margin of 10%, about 100 complete answers are sufficient.

Figure 4 provides an **overview of the survey participants**. 80% of all survey responses (401) were from company participants, which were likewise categorised according to their size. Very large enterprises showed the greatest participation rate (40%), most of them from Germany, the Netherlands and Italy (see Annex 2). They are followed by medium-sized enterprises (24%) and large (23%) and micro or small enterprises (11%) (see Figure 4). Belgium and Spain are among the countries with the highest participation rate in the latter three groups of companies (see Annex 2). Nearly 60 trade unions/employees' associations and 43 industry organisations and employer's federations participated in the survey – both groups are mostly concentrated in Western Europe (see Annex 3).

Figure 4: Participants by type of organisation and by company size

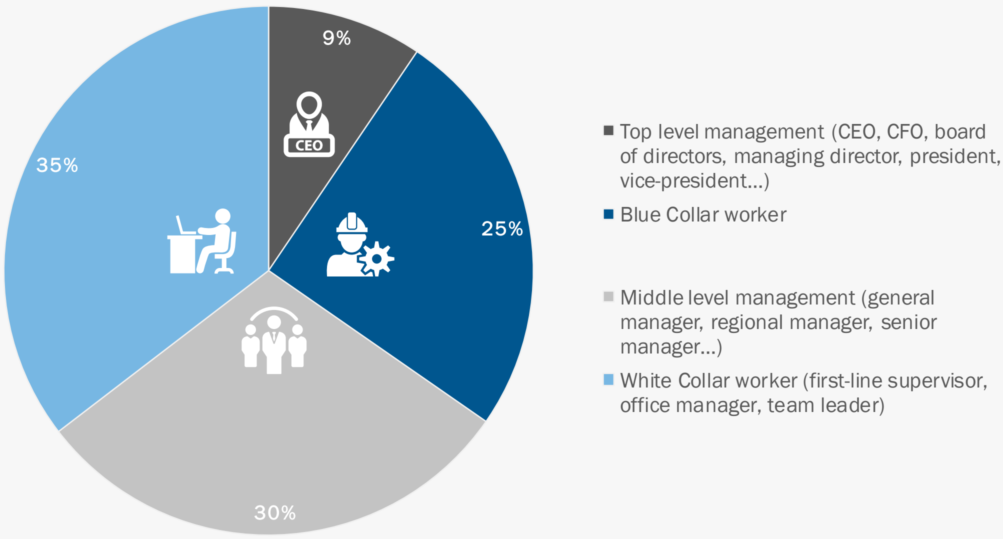


Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018), n=501.

In terms of the **position of company participants**, white collar workers and middle level management had, with respectively 35% and 30%, the highest participation rates in the survey. They are followed by blue collar workers (25%) and top-level management (9%) (see Figure 5).

The overall **participation rate across all chemical sectors** was homogeneous with 23% by the pharmaceutical industry, 22% by the specialty chemical and 20% both by the rubber & plastics and the basic chemical industry (see Figure 6). While most pharmaceutical and specialty chemicals companies are located in Southern Europe, rubber & plastics and basic chemicals companies are in Western Europe.

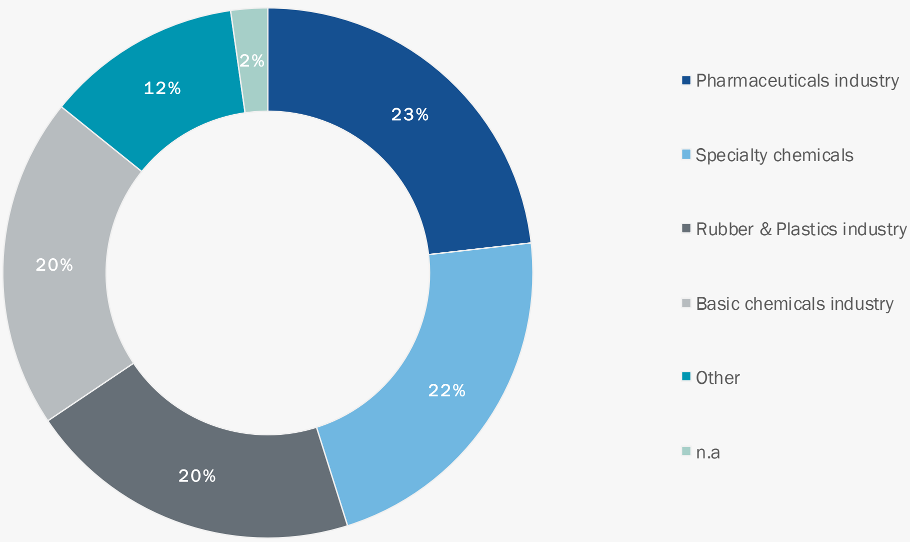
Figure 5: Participants by type of position in the company



Note: This question was only addressed to company representatives.

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018), n=401.

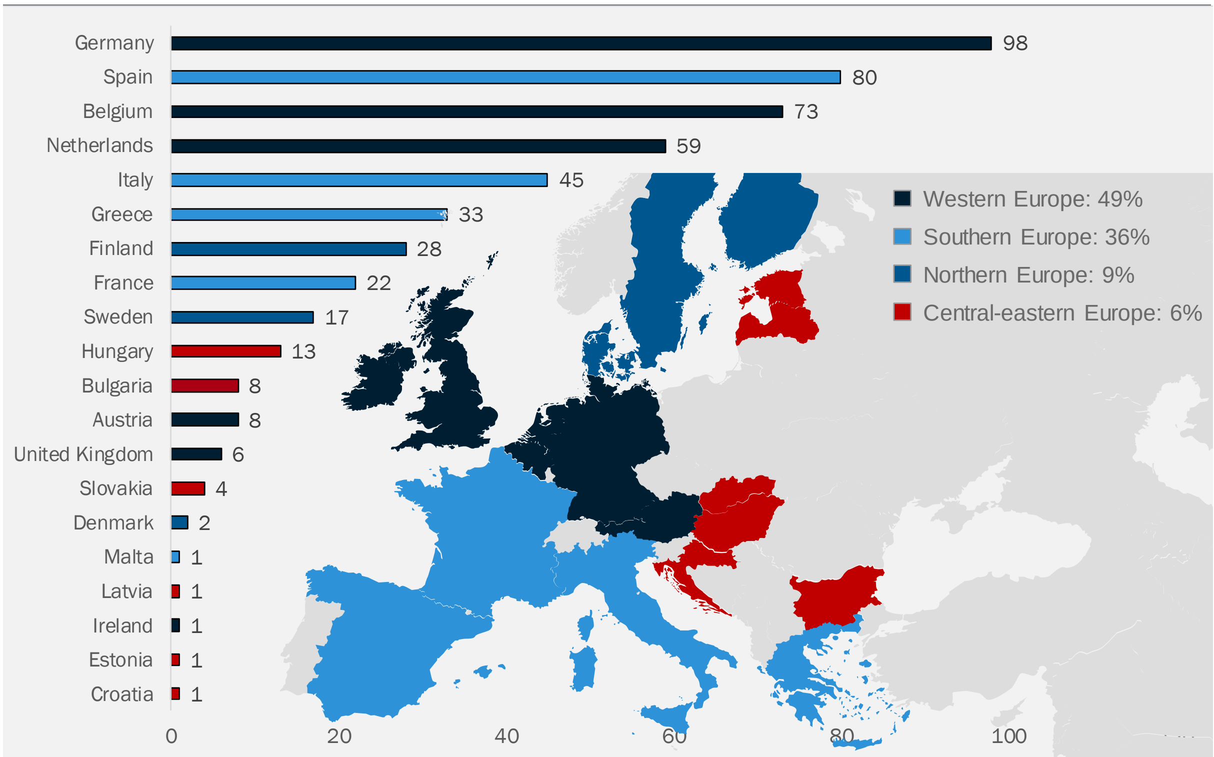
Figure 6: Participants by type of sector



Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018), n=401.

Participants from 20 EU Member States took part in the survey. However, some countries stood out and especially chemical industry stakeholders from Western Europe took part in the survey. The most responses were received from Germany, Spain and Belgium. In Southern Europe, Italy and Greece showed the highest participation rates of about 22%. Likewise, Finland (28%) and Hungary (13%) showed both the highest participation rate in their respective regions. Compared to these results, response rates in other countries were much lower, with ten countries having a participants' number of less than ten. Therefore, 93% of all responses are linked to 10 countries, namely the seven mentioned above, the Netherlands, France, and Sweden (see Figure 7).

Figure 7: Regional distribution of the survey participants



Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018), n=501.

To complement the survey results, **more than 20 expert interviews** were conducted with the same target groups, including company representatives, representatives from unions or employer associations. The interviewees were spread across 11 EU Member States. The interview guideline was structured in a similar way as the online survey and allowed to validate the existing results as well as to deepen their understanding.

3.2 Digital transformation of work: skills, working patterns, health & safety

KEY FINDINGS

- In the chemicals, pharmaceuticals and the rubber & plastics sector, a **skills shift is clearly visible**. Overall, the chemical job of the future will require less manual and basic cognitive skills but more advanced digital and complex transversal digital skills that necessitate at least some basic technical and digital knowledge.
- In addition, the analysis of skills across company sizes shows that there exists a digital **skills gap** between SMEs and large enterprises. Respondents from SMEs consistently assessed their technical and transversal competencies worse than large companies. **Training and upskilling** will gain further relevance against the backdrop of the digital as well as the demographic transformation Europe is facing.
- Regarding the **working environment, mobile working,** collaboration in heterogeneous and interdisciplinary teams and multitasking will increase the most due to the digital transformation.
- The assessment of **health and safety** in the digital workplace shows that hazardous tasks will decrease, while psychological stress is expected to increase. Overall, the assessment of the general health is balanced.
- Most jobs in the European chemical industry will change with new technologies as they become more available, which will require updated skills-sets. Thus, digitalisation bears **a risk of job losses for some profiles**, but also brings many **new opportunities** in the chemical, pharmaceutical and rubber & plastics industry.

Progressing digitalisation is inducing structural changes in all spheres of society and, therefore, it is changing business models, industrial processes and the workplace itself, as outlined in Chapter 2. **Competing in an era of digital technology requires a digitally skilled workforce, not only in terms of technical skills** (e.g. programming skills) **but also in terms of social and transversal skills as enablers**. As the division of labour between employees and digital technology is being redefined by digitalisation, it has implications for the working environment, safety and health, and, beyond that, may create new job opportunities, as more activities will be performed by digitally driven technology.

3.2.1 Skills & training in the digital age

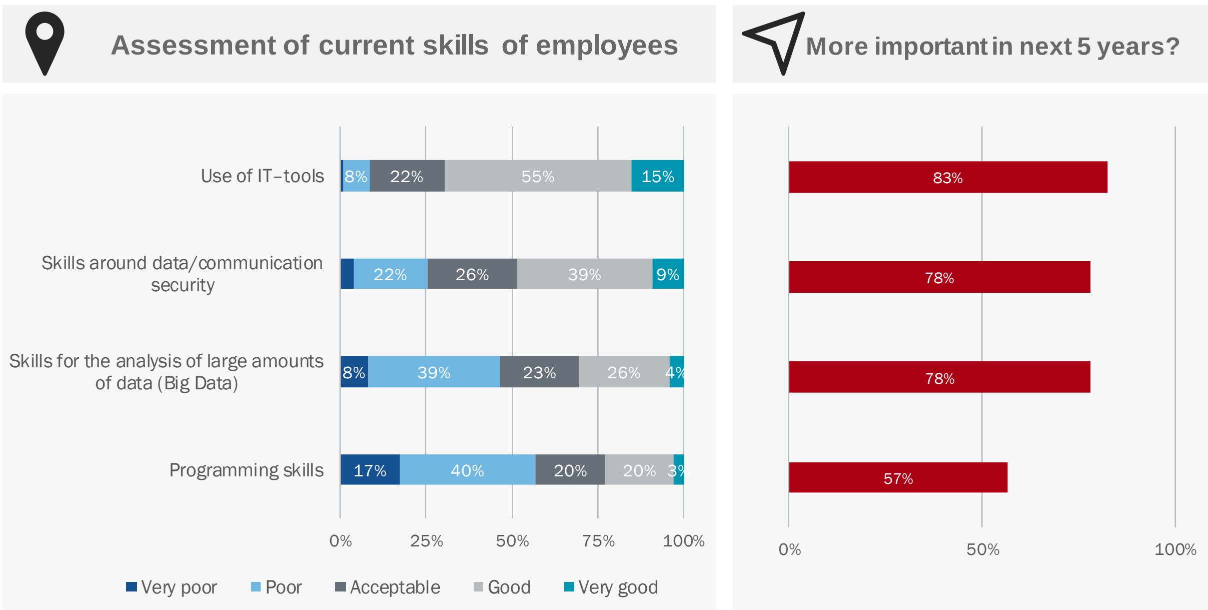
The skills assessed by the survey participants were broken down to a general level (e.g. "Use of IT Tools" or "Programming skills") to make them compatible with differing needs and requirements of companies of different sizes and sectors. In this way, it was ensured that the broad variety of the chemical industry was covered. To operationalise the skills requirements for an assessment of current digital skills of the chemical workforce, and the relevance of these digital skills in the next five years, three distinct types of skills-sets related to digitalisation were extracted from the literature and subject to the survey: technical, social and transversal skills. In sum, these different skills are mutually beneficial and can

> "Digitalisation means a **cultural and a mindset change**. We need more ICT skilled workers in every area. Blue collar workers need to be able to understand the digital tools, have analytical skills and multitasking abilities."
> (HR-Manager, Finland)

be regarded as an approximation to what is sometimes referred to as "digital mindset"[44]. Participants were asked to assess these skills in two dimensions: Firstly, current skills were evaluated on a scale from very good to very poor, showing the status-quo in the European chemical industry. Secondly, participants estimated the skill's future importance at a relative basis.

Technical skills are needed to directly apply digital tools. Looking at the survey results in Figure 8, **basic technical skills for the digital transformation are already widely established** across the chemical workforce. 70% of respondents assess the skills of using basic IT-tools (e.g. software to process and store information) as good or very good. However, more **advanced digital skills**, like programming (e.g. development and application of digital assistance systems or machine learning), or **IT-skills for the complex analysis** of large data sets **require more attention**. On the one hand, programming skills and skills for Big Data analysis are assessed to be poor to very poor by 57% and 47% of the participants, respectively. On the other hand, these advanced digital skills will become more important for employability in the coming five years, thus indicating a potential lack of skills in the industry.

Figure 8: Assessment of technical skills of employees /industry in the context of digitalisation



Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018), n=360-400 and n=412-440.

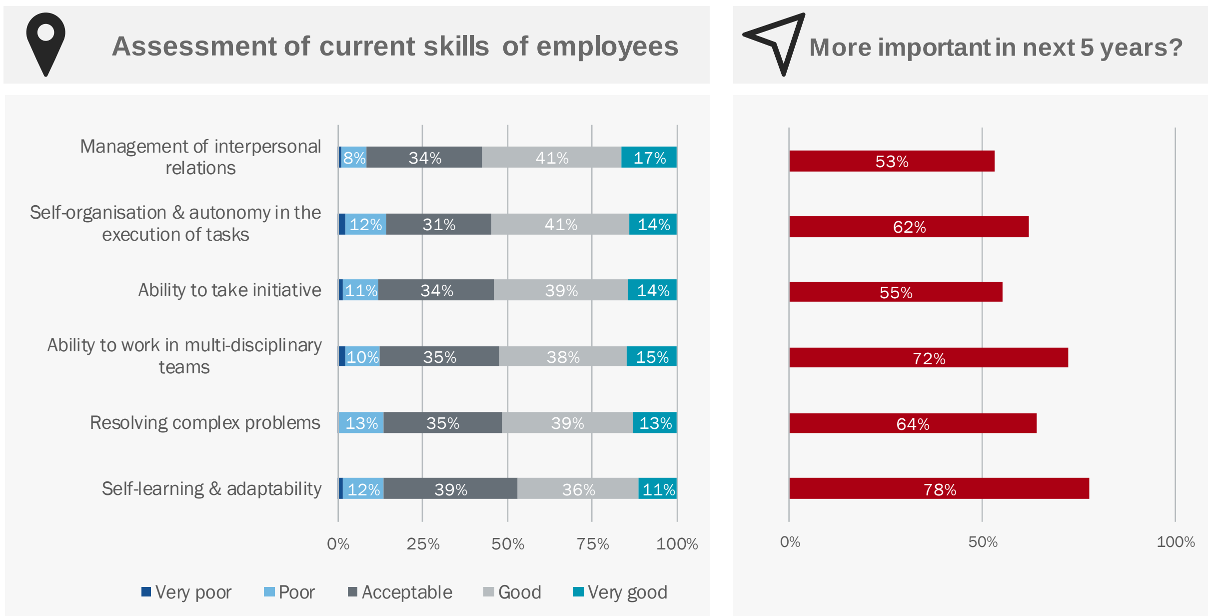
[44] The key skills surveyed in this report are for example referred to as "essentials we are looking for" by ceemet (2018), Digitalisation and the world of skills an education, p.5. Retrieved from https://www.ceemet.org/sites/default/files/ceemet_digitalisation_and_skills_report_spreads.pdf, [23.01.2019].

> "Our company is increasingly looking for the profile of "**bridge builders**". The ability to work effectively together in teams to find solutions and to connect well with people and different cultures is becoming more important."
>
> (Works Council Representative, Belgium)

Beyond technological competences, analytical abilities and the capacity to communicate and cooperate within and across teams, organisations and cultures are key to solving problems collaboratively. Moreover, self-organisation and autonomy, as well as self-learning are pivotal skills in order to adapt to a changing working environment. These **social skills** are not specific to occupations or sectors, but rather enable and enforce technical or other skills.

A broad set of **social skills was assessed by the respondents**. The results for the European chemical industry are overall **positive**. For the skills surveyed, incl. managing interpersonal relations, self-organisation or initiative-taking, at least 85% of the respondents gave an acceptable or good assessment. In the coming 5 years, particularly **self-learning and multi-disciplinary work** will **gain importance** according to almost 80% of the respondents, which is in line with the results on the changing work environment and training needs (see below).

Figure 9: Assessment of social skills of employees/industry in the context of digitalisation



Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018), n=448-461 and n=411-426.

In addition to social skills, which can be regarded as general enablers, **transversal digital skills**[45] are a complementary concept more closely linked to digital technology. For example, business communication, which includes internal communication with colleagues as well as external communication with customers, partners and suppliers, is already being delivered by digital tools through multiple channels (i.e. Email, Skype, WhatsApp, Slack, etc.). In this context, successful

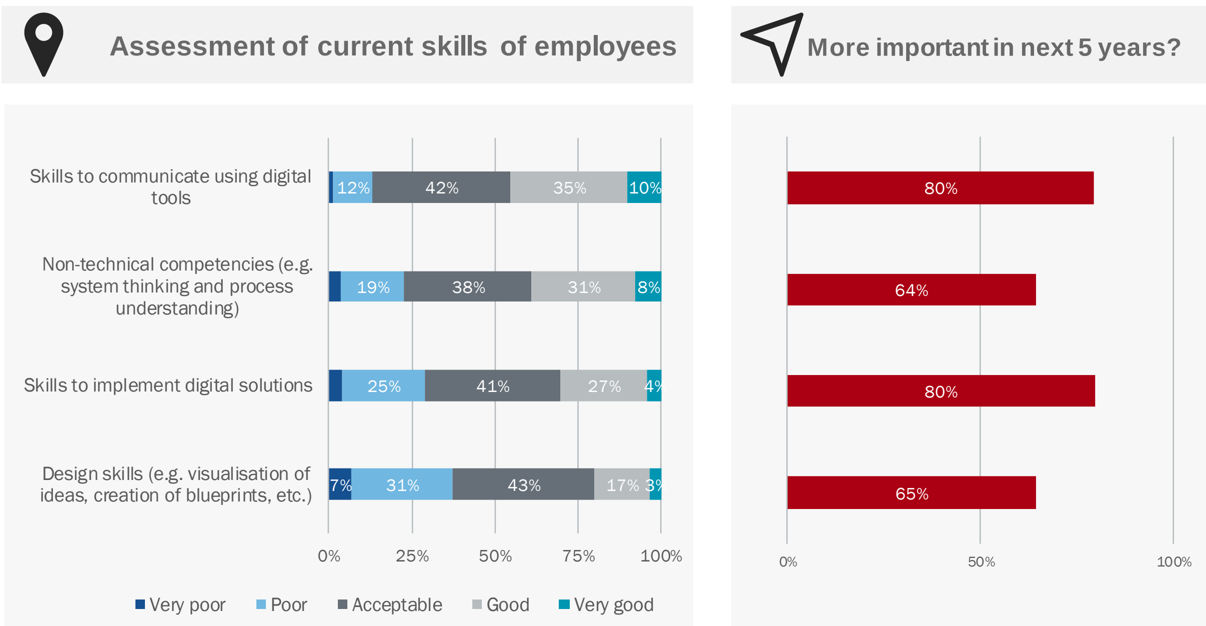
[45] Transversal skills are skills that are typically considered as not specifically related to a particular job, task, academic discipline or area of knowledge and that can be used in a wide variety of situations and work settings (e.g. critical and innovative thinking).

interpersonal communication depends on the ability to use these tools adequately as well as to manage and prioritise multi-channel communication.

The overall assessment indicates that **requirements will be increasingly focused on transversal digital skills**. Digital communication skills are widely established in the chemical industry, with approximately 87% of the survey participants assessing current competencies as acceptable or better (45% as being good or very good, see Figure 10). Within a mobile working environment, where spatial and temporal ties between team members are changing, these skills will become progressively more important. This fact is supported by the survey participants. Around 80% see an increase in importance for digital communication skills in the next five years (see Figure 10). Likewise, **skills to implement digital solutions** are rated to become more important in the next five years (80%). These refer to the ability to understand and exploit the added value that new digital tools provide to improve current (production) processes. For example, whilst chemical process engineers' might have previously optimised production processes on their own, today they tend to cooperate with computer scientists and data analysts and have to be able to comprehend their working methods or digital tools. Currently, however, skills to implement digital solutions are considered to be poor to very poor by nearly 30% of respondents, suggesting a future **need for these skills**. In a similar manner, this applies to more creative and analytical skills categories, like design skills or non-technical competencies (e.g. system thinking or process understanding).

"It is evident that **technical skills** and an understanding of digitalisation will be needed. But **social skills, communication and creativity** are going to be very important. These are the kind of abilities that can't be replaced by any machine and that will be **necessary to drive these new trends**."
(Industry Representative, Spain)

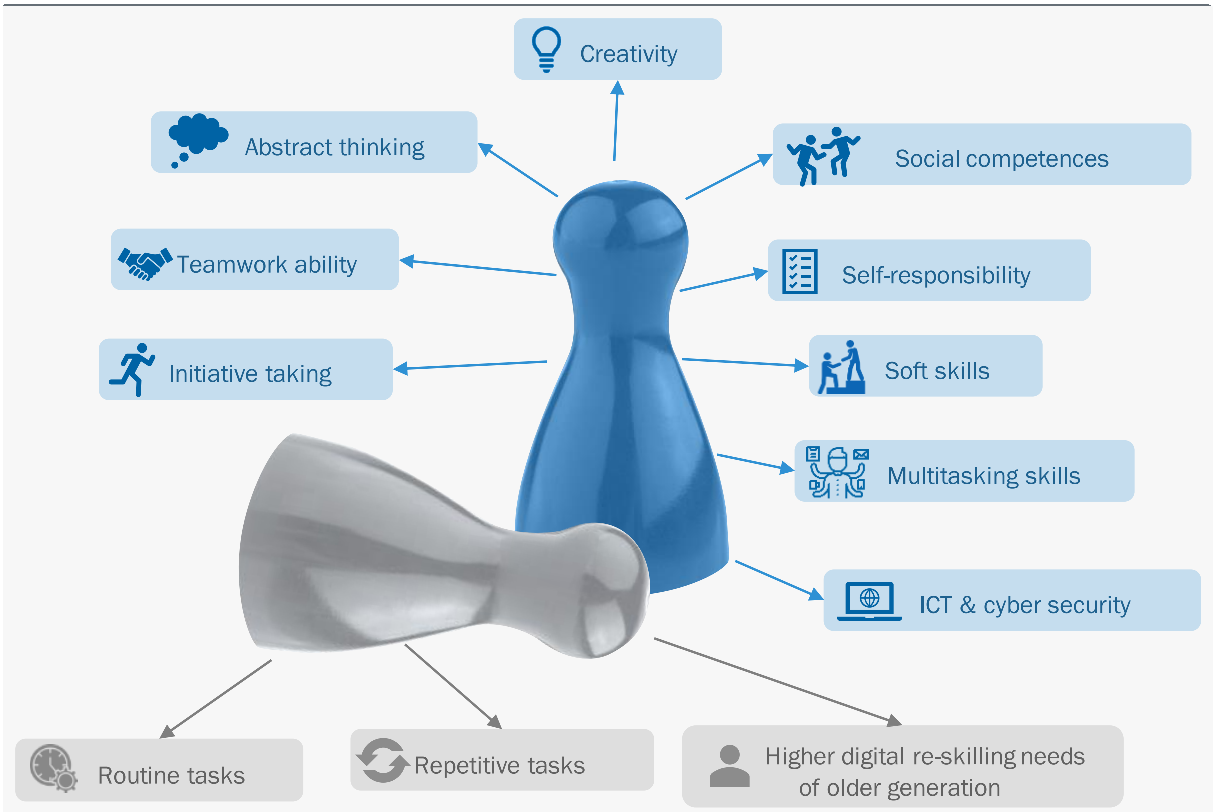
Figure 10: Assessment of digital transversal skills of employees/industry in the context of digitalisation



Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018), n=440-459 and n=404-426.

In sum, a **skills shift is clearly visible**. Generally, the chemical job of the future will require less manual and basic cognitive skills, and more advanced digital and complex transversal digital skills that require at least some basic technical and digital knowledge. In the upshot, the industry should not only focus on basic and advanced digital competencies, they also need to consider social competencies when it comes to skills development in an always more digitalised working environment.

Figure 11: Findings from the interviews regarding skill needs and skill development



Source: Prognos (2019) based on expert interviews with chemical industry stakeholders. Icons: Copyright Flaticon.

Training and upskilling will gain further relevance against the backdrop of both the digital as well as the demographic transformation that are taking place in Europe. The survey results show that most employees already participate in **training measures for digital up-skilling at least once or twice a year,** but only a minor share rates the availability and the quality as sufficient.

i

Fostering digital R&D, competences and education at Covestro

Covestro is currently seizing the opportunities of the digital transformation and is introducing digital technologies for R&D in its operative business through a comprehensive programme. As described on the Covestro website, a central element are investments in the expansion of the company's computing capacity in Leverkusen (Germany). The planned hardware expansion will significantly increase computing power through high-performance computing and will digitally support worldwide R&D activities. To this end, Covestro not only cooperates with established companies from the IT-sector but also with the RWTH Aachen University.

To take full advantage of the new technological opportunities, Covestro is investing also in the skills of its workforce, such that their comprehensive expertise also covers the core fields of data science and computational chemistry. In addition, they promote the education of young university graduates and advertise positions throughout Europe for master, doctoral and post-doctoral programmes[46].

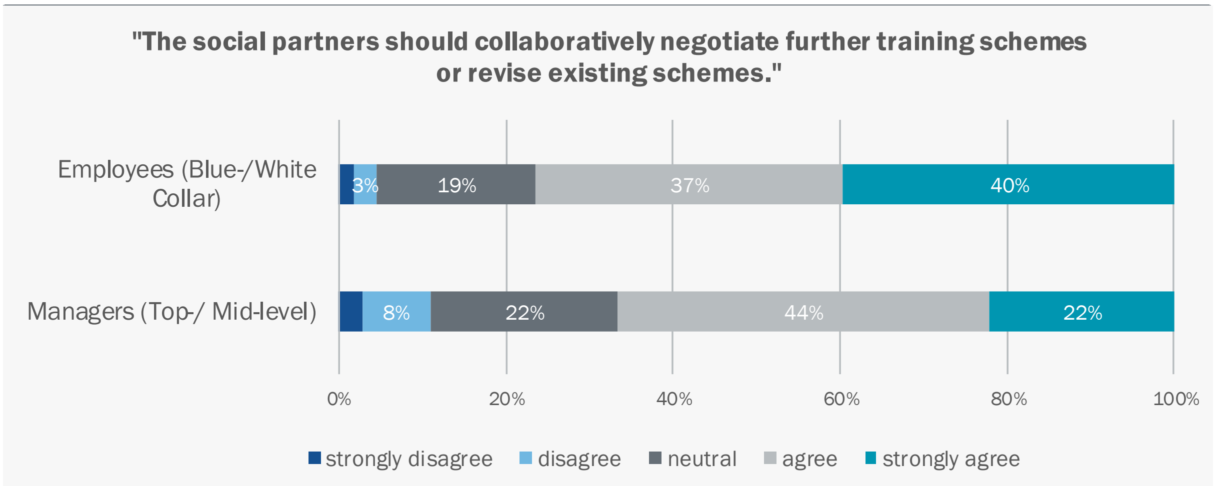
The **sharing of responsibilities** between public and private actors and between companies and employees on the distribution of costs and the definition of content are central issues in the **field of training**. The analysis shows that both managers and employees recognise their responsibility to invest time and/or financial means for digital up-skilling. Around 50% of the participating managers strongly agree that companies should invest in training programmes to keep their employees' digital skills up to date (see Annex 4) and 58% of employees agree that they need to invest in digital training themselves too (see Annex 5). In this context, the social partners play a crucial role in raising the awareness of employees of all levels for the need to actively participate in training measures.

"In the chemical industry, we have agreed on a **collective agreement** that includes further **training rules** in order to address the new requirements of digitalisation."
(Trade Union Representative, Germany)

Furthermore, managers as well as employees find that the **government and other public institutions** can play an important role in securing digital skills – for instance, by providing incentives (~75% agree, see Annex 7) or investments for training programmes (75-80% agree, see Annex 6). Both groups of respondents recognize the important role of social partner cooperation within this process. Over three-quarters of the surveyed employees and two-thirds of managers agree that social partners should negotiate new and/or revise existing training schemes (see Figure 12). As discussed above, there is still potential for **improving quantity and quality of existing training schemes**. Company and union representatives emphasised in the interviews, that training never is an end in itself, but training programmes should always be driven by the needs that companies and social partners recognise.

[46] Covestro (2018): Covestro fosters digital research and development. Covestro Press Release. Retrieved from: https://press.covestro.com/news.nsf/id/covestro-fosters-digital-research-and-development, [31.01.2019].

Figure 12: Assessment of the role of social partners in the negotiation of training schemes



Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018), n=440-459 and n=404-426.

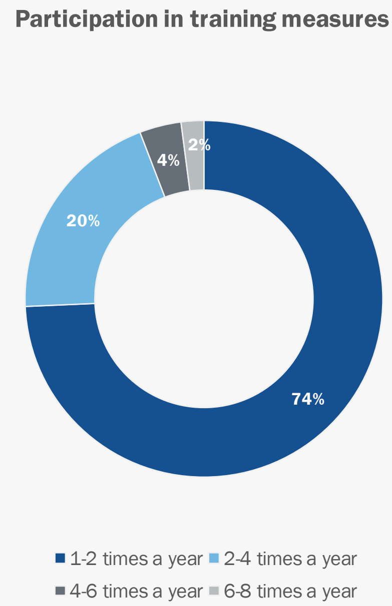
Specific findings on skills and training related to company size

SMEs face different skills base challenges than large enterprises in the digital transformation. Generally, large enterprises can draw on a larger pool of resources, whether they be monetary resources or human capital. This is also confirmed by the analysis of skills across company sizes, which shows a **digital skills gap between SMEs and large enterprises**. Respondents from SMEs consistently assessed the technical and transversal competencies of their employees as worse than large (>250 employees) or very large enterprises (>1000 employees). For example, while 81 percent of respondents from large enterprises assessed the use of IT-tools good or very good, only 74 percent from large and 65 percent from SMEs did.

This **pattern resembles the assessment of the future importance of the different skills**: participants from SMEs attribute a lower importance to the future technical (e.g. Big Data analysis), social (e.g. the ability to work in multi-disciplinary teams) and transversal digital skills (e.g. abilities to communicate using digital tools). While this might not necessarily be related to lacking awareness, it indicates that the implementation of new technology and the related changes in skills requirements will probably take place more slowly in SMEs.

Examining **training measures** reveals another gap: for respondents working in SMEs, up to 43% indicate that the training offer is not appropriate to their needs or does not exist at all. If this trend continues, the digital skills gap between SMEs and large enterprises might deepen. In contrast, one third of respondents working in large or very large companies reveal that, currently, the offer of training measures is insufficient and can lack in quality. This result highlights the need to continuously improve existing programmes.

Figure 13: Participation and quality of training measures by company size



In **43 % of SMEs,** training measures **do not exist** or do **not adress the needs** at all.

In about **one third** of **large to very large companies,** the **quantity** and **quality** of training measures are **insufficient.**

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018), n=396.

3.2.2 Job substitution & job opportunities in the digital workplace

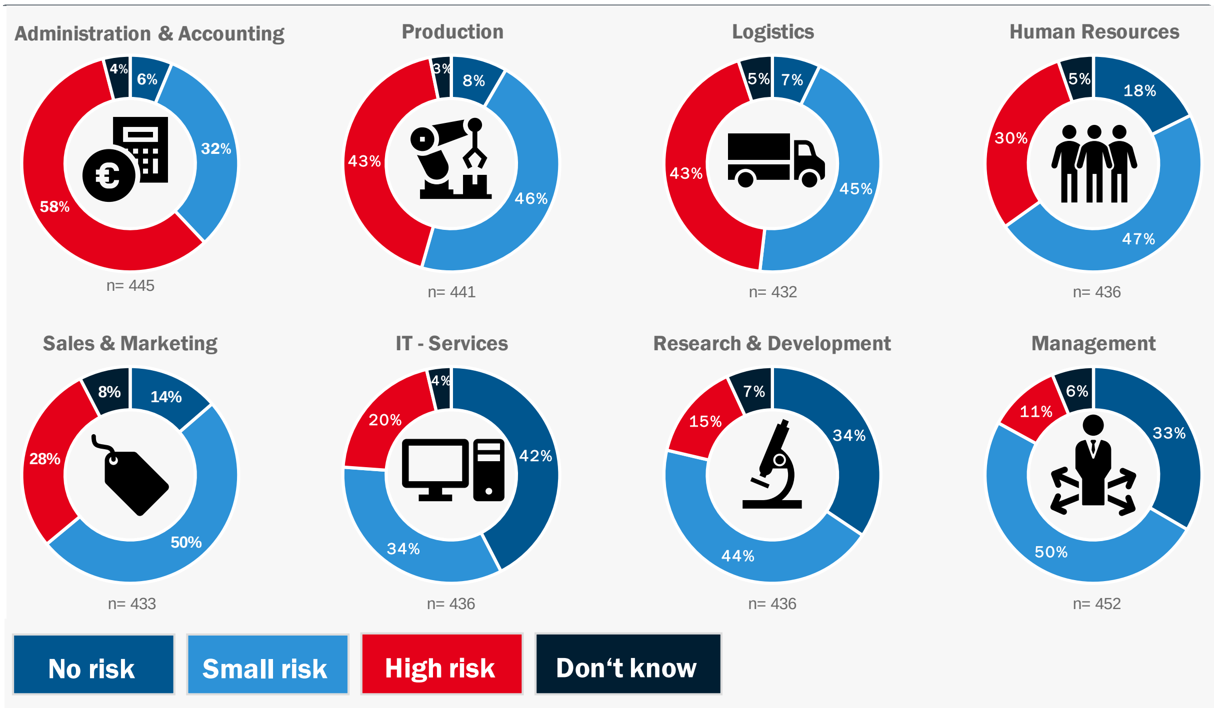
Regarding the **risk of workforce reduction, digitalisation bears (high) risks for some job profiles, but also brings many new opportunities**, as most job profiles will not become fully obsolete or redundant. Technology will take over several routine tasks and complement existing tasks by providing additional information when it comes to analysis and decision making. Thus, most jobs in the European chemical industry will change with new technologies as they become available, which will require an updated skillset as discussed above.

According to the survey respondents, the **risk of a total workforce reduction by 2023[47] is the highest** in **administration & accounting,** then followed by production, and logistics (see Figure 14). On the contrary, the lowest risks are seen for the management, R&D and IT-services. This is in line with the findings that an expected decrease of repetitive tasks, which can be more easily automated, and with the insights gained from the interviews with experts from the European chemical industry, showing that this process is already gaining pace. These general results match recent research findings from international studies conducted by the OECD[48] or the World Economic Forum[49].

> "**Job substitution** is already happening, not merely due to digitalisation. The industry **needs other types of skills:** self-determination, results-orientation, creativity, self and long-learning capacity, to have different mindsets."
> (HR-Manager, Finland)

[47] The survey was conducted in 2018. Risks and opportunities were evaluated by respondents for the next 5 years.
[48] OECD (2018): Automation, skills use and training, OECD Social, Employment and Migration Working Papers, No. 202, OECD Publishing, Paris. Retrieved from [17.01.2019]: https://www.oecd-ilibrary.org/employment/automation-skills-use-and-training_2e2f4eea-en.
[49] World Economic Forum (2016): The future of jobs. Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution.

Figure 14: Risk of reduction of the workforce in the following company divisions in the next 5 years



Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). Icons: Copyright Flaticon.

For administration and accounting, 90% consider employment at least at some risk of being reduced of which 58% assess the risk as high and 32% as low. In production and logistics, almost 90% also see an overall risk of workforce reduction, although a smaller share of respondents sees high risks (43%).

New job opportunities are expected to be created in sales & marketing, research & development and, **particularly, in IT related activities**. Importantly, the results show that also around one fifth see many opportunities in the “threatened” departments of **production and logistics**. This can be a strong indication of a **structural transformation of profiles** in these departments. For IT related activities, 86% of respondents expect at least some opportunities in the chemical industry of which 61% see many opportunities. For the department of research & development, close to 80% of survey respondents see new opportunities (44% see many opportunities).

Figure 15: New job opportunities in the following company divisions in the next 5 years

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). Icons: Copyright Flaticon.

The respondents' evaluation of sales & marketing illustrates that risks and opportunities can be two parts of the same coin: 78% see a low to high risk for substitution, whilst around three quarters of respondents think there are opportunities for new jobs. A case in point for that is predictive marketing in B2B markets, which is based on Artificial Intelligence and Big Data analysis of customer profiles in combination with other signals (business expansion, job vacancies, etc.). By exploiting data, marketers are increasingly able to prioritise their actions or better tailor them to expected customer needs[50]. In this way, AI driven data analysis has the potential to increase productivity in a people driven business, where interpersonal relations are still a key factor for success.

[50] MARTECH (2016): B2B Predictive Marketing Analytics Platforms: A Marketer's Guide. Retrieved from: https://marketingland.com/buyers-guides/b2b-predictive-marketing-analytics-platforms-marketers-guide, [28.01.2019].

Specific findings on job substitution & opportunities related to company size and position in the company

Overall, some differences exist between the surveyed groups. **Participants from larger enterprises evaluate both risks of job reduction and opportunities for new jobs higher among all departments** than participants from smaller firms. This leads to two interpretations: Firstly, opportunities to implement digital technology are higher in larger enterprises due to the related economies of scale. Secondly, chances and risks for new jobs go hand in hand.

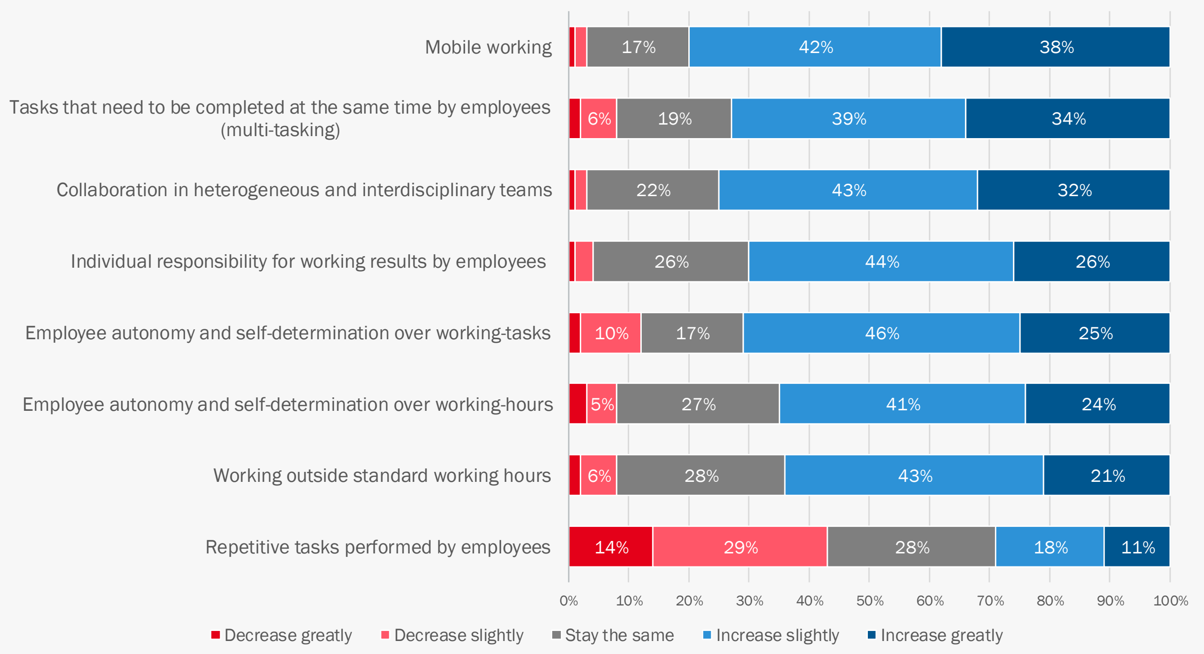
Irrespective of company sizes, managers see more opportunities with digitalisation, whereas employees emphasize risks. This shows the importance of sound communication strategies between management and employees on the profound changes that occur with the digital transformation: it calls for a clear communication about actual risks by clarifying how a company and its workforce can embrace the transformation and reduce existing uncertainties.

3.2.3 The digital working environment and its health & safety implications

The digital transformation contributes to the evolution of the **working environment** and changes the way activities are performed by both managers and employees. With different intensity across company departments, **one of the predominant changes is related to mobile working** (see Figure 16), a trend which has also been confirmed in the expert interviews. Overall, 80% of respondents expect an increase in remote working opportunities. This trend will have an important impact on the organisation of work, since spatial and temporal ties between workers are changing. On the one hand, the possibility of working outside the company can contribute to a better reconciliation of work and private life or to enhance productivity during travel times. On the other hand, mobile working not only raises new challenges regarding the safety of data and ergonomics of work. It also requires a fundamental trust between employers and employees and comes with an increasing responsibility of and autonomy for employees how they handle their working tasks, working hours and working results.

As an increasing share of tasks will potentially be carried out by digital tools and technologies, 43% of respondents expect that their **share of day-to-day simple and repetitive tasks will further decline**. At the same time, new technologies enable workers to carry out a greater number of more diversified activities: 73% of respondents see an increase (of which 34% a strong increase) in multi-tasking and, potentially, in the complexity of their work. **The increase of collaboration in heterogeneous and interdisciplinary teams**, which has been affirmed by three-quarters of the respondents, is further evidence for greater work environment complexity in all chemical sectors. One example is the situation mentioned in Chapter 3.2.1 where chemical process engineers need to cooperate with computer scientists and data analysts to improve current production processes. To implement a Big Data application that allows a faster analysis of large amounts of data on production levels and external factors (energy prices, order level, etc.), chemical process knowledge of engineers needs to be combined with the IT-/coding-knowledge of computer scientist. In such a setting, requirements must be communicated clearly and comprehensibly by both sides for a well-functioning and performing tool. In this context, the ability to cooperate across disciplines and occupations is a central skill to find optimal solutions for complex issues, as discussed above.

Figure 16: Assessment of the impact of digitalisation on the working environment



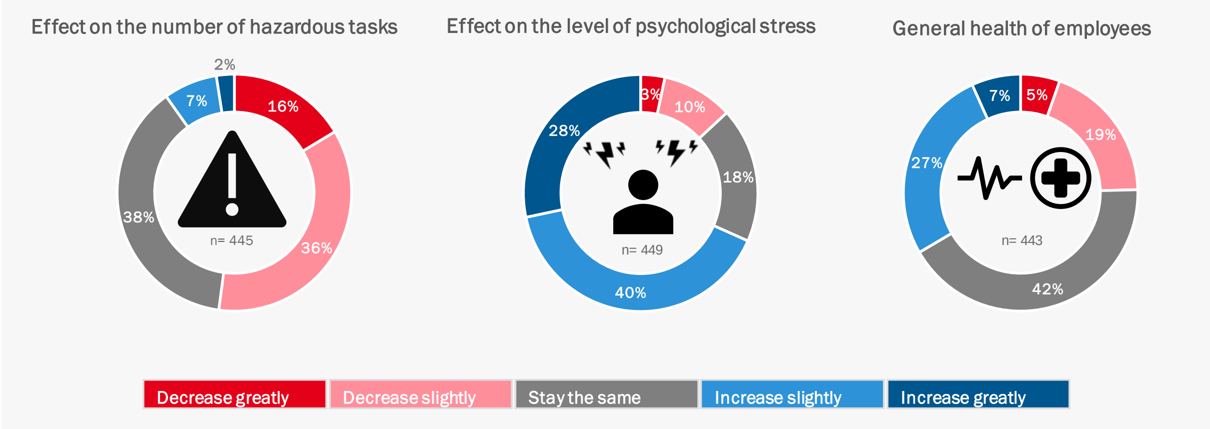
Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018), n=443-449.

These changes in the working environment also have an impact on health issues. Through developments in automation and new technical assistance systems, digitalisation will help to decrease the number of hazardous tasks, thereby **reducing the risk of working accidents and physical injuries** in the sector, according to around half of the respondents.

However, increased demands for self-autonomy, multi-tasking and multi-channel communication make employees, managers and other industry representatives expect a **significant increase in psychological stress at work** (see Figure 17). This was also confirmed by expert interviews, which indicated that unions and companies are recognising the need for clear agreements and supporting employee resilience.

Overall, there is a balanced and rather positive assessment of the impact on the **general health of the workforce**. Around 34% of respondents expect an increase in general health of the workforce, compared to 24% that expect an overall decrease. Most respondents (42%), however, see no major overall changes.

Figure 17: Decrease of hazardous tasks and increase of psychological stress due to digital technology



Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018), n=443-449.

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"Smart Tooling" - Facilitating inspections in high-risk environments with drones (Netherlands)

The cross-border research project "Smart Tooling" is financed by the EU Interreg programme Flanders-Netherlands and develops technological innovations for maintenance in the process industry[51]. Next to universities, the Dutch knowledge and innovation centre for maintenance and process industries (KicMPi) cooperates with important players from the basic chemical industry like Dow Chemical or BASF.

One of the researched topics within "Smart Tooling" is the use of "unmanned aerial vehicles" (UAS) (i.e. drones) to make the inspection of chemical installations safer and more reliable. The main purpose is to check the integrity of installations visually, using video or thermal cameras fixed on the drone. In combination with experienced workers who interpret the visual information gained, this approach is already successfully applied in the oil & gas industry to inspect large scale facilities, where it is reducing time, costs and dangerous tasks to be directly performed by workers[52]. There is further potential in the application of drones to detect hazards: e.g. by utilising sensor technology to detect gas leaks in installations (e.g. due to corrosion) or to carry out repair operations in dangerous situations using an articulated arm.

[51] Infochimie (2017): Les drones préparent leur entrée dans les sites chimiques. Retrieved from: https://www.info-chimie.fr/les-drones-preparent-leur-entree-dans-les-sites-chimiques,81912, [31.01.2019].
[52] The Chemical Engineer (2018): Drones: The End of the Rope? Retrieved from: https://www.thechemicalengineer.com/features/drones-the-end-of-the-rope/, [31.01.2019].

Specific findings on the digital working environment related to company size and sector

Changes in the working environment of European chemical companies can be observed in all sectors and across all enterprises of different sizes, while the **magnitude of the expected impacts of some aspects vary**. Concerning the working environment, working outside standard hours, mobile working and collaboration in heterogeneous teams are expected to increase more strongly in larger firms. Regarding collaboration, 69% expect a slight to strong increase for SMEs (1-249 employees), 75% for large enterprises (>249 employees), and 83% for very large enterprises (>999 employees). Branches of very large enterprises tend to be located in several regions or countries and exhibit a higher organisational division of responsibilities. In this context, it becomes clear, that the progression of digital technology is tapping the potential to intensify communication and cooperation across places and areas.

Different **magnitudes of change in the working environment may also imply a different impact on health issues, such as psychological stress**: 74% of participants from very large enterprises expect an increase (slight or great increase), whereas only 52% of participants from SMEs expect this.[53]

Regarding **hazardous tasks**, there are no remarkable differences by company size, while sector participants especially from the rubber- and plastics as well as the specialty chemicals sector expect hazardous tasks to decrease (slightly or greatly).

[53] At the same time however, there are no significant differences between SMEs and larger companies when it comes to the assessment of the impact of digital technology on the number of hazardous tasks or the general health.

3.3 Technological transformation through digitalisation in the European chemical, pharmaceutical, rubber & plastics industry

KEY FINDINGS

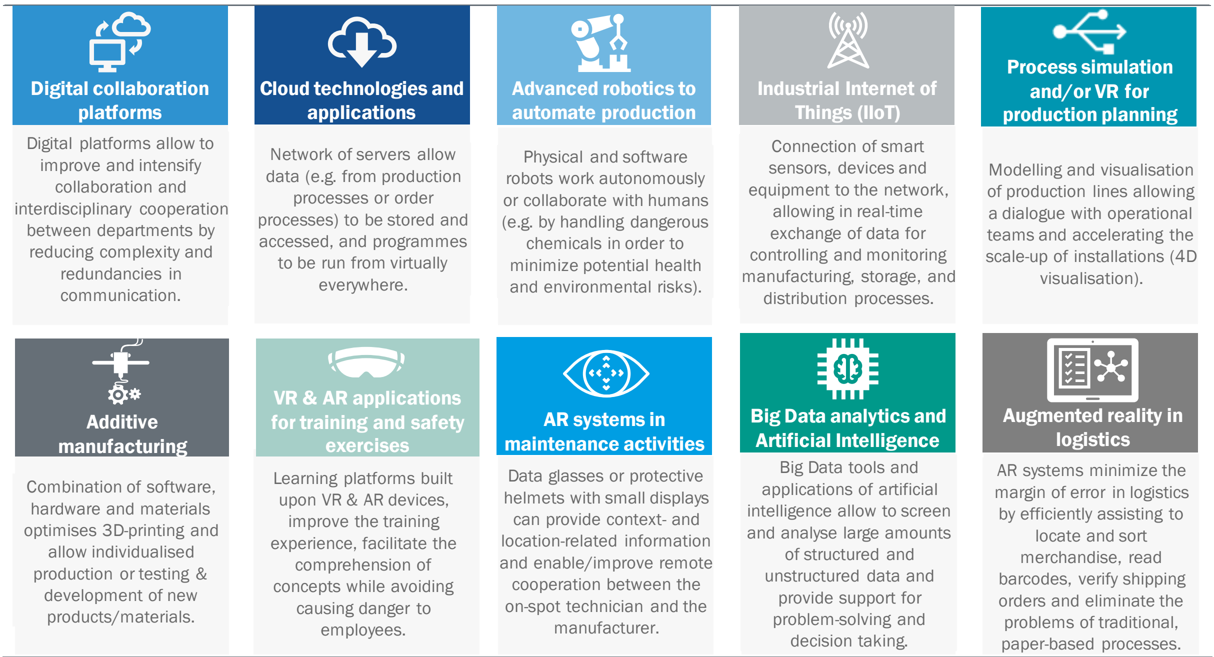
- The **1st wave of digital transformation** in the European chemicals sector, i.e. digitising analogue data and integrating cloud solutions in business processes, is widely accomplished.
- **No significant differences were found across the different sub-sectors** studied. But the **implementation rate** of such digital technologies **increases by company size.** Especially the implementation rate for micro and small enterprises (<50 employees) is lagging.
- The **2nd wave of digital transformation** will be driven by the Industrial Internet of Things (IIoT), Big Data, Artificial Intelligence (AI), automation and augmented reality – and it will come into effect shortly (in the next five years).
- The **pharmaceutical industry is a frontrunner**, especially with respect to testing and using advanced robotics, Big Data, AI and IIoT.
- The findings indicate a **considerable implementation gap by company size** with very large enterprises being better prepared than small to mid-sized companies.

As the digital transformation is progressing, companies in the chemicals sector are seeking to take advantage of the potential of new and emerging technologies in order to reach higher levels of efficiency of production and to expand into new markets. The new **technological advancements will create some challenges** with respect to their implementation, their compatibility with existing business models or their acceptance by the current workforce. **At the same time**, many of these technologies are set to become **primary drivers of opportunities for new growth**, not only in the chemical industry[54].

Therefore, the following chapter takes a closer look at the **transformations through digitalisation** and analyses their importance within the chemical, pharmaceutical and rubber & plastics industry. To this end, the survey respondents were asked to indicate the implementation rate of a given set of technologies (see Figure 18 below). The possible options were “currently used”, “currently tested” and “in the future”. In addition, survey participants could indicate “not important”, if the technology in question is, from their perspective, not relevant for the company or industry they work in. Following, they were asked to estimate the timeframe for the utilisation of those technologies they had indicated as being currently tested or being implemented in the future.

[54] World Economic Forum (2018): The future of Jobs Report 2018. Retrieved from: http://www3.weforum.org/docs/WEF_Future_of_Jobs_2018.pdf, [11.01.2019].

Figure 18: Digital Technologies relevant to the chemical, pharmaceutical and rubber & plastics industry



Note: VR: Virtual Reality; AR: Augmented Reality

Source: Prognos AG (2019), based on own research. Icons: Copyright Flaticon.

Overall assessment of the technological transformation through digitalisation within the chemicals sector

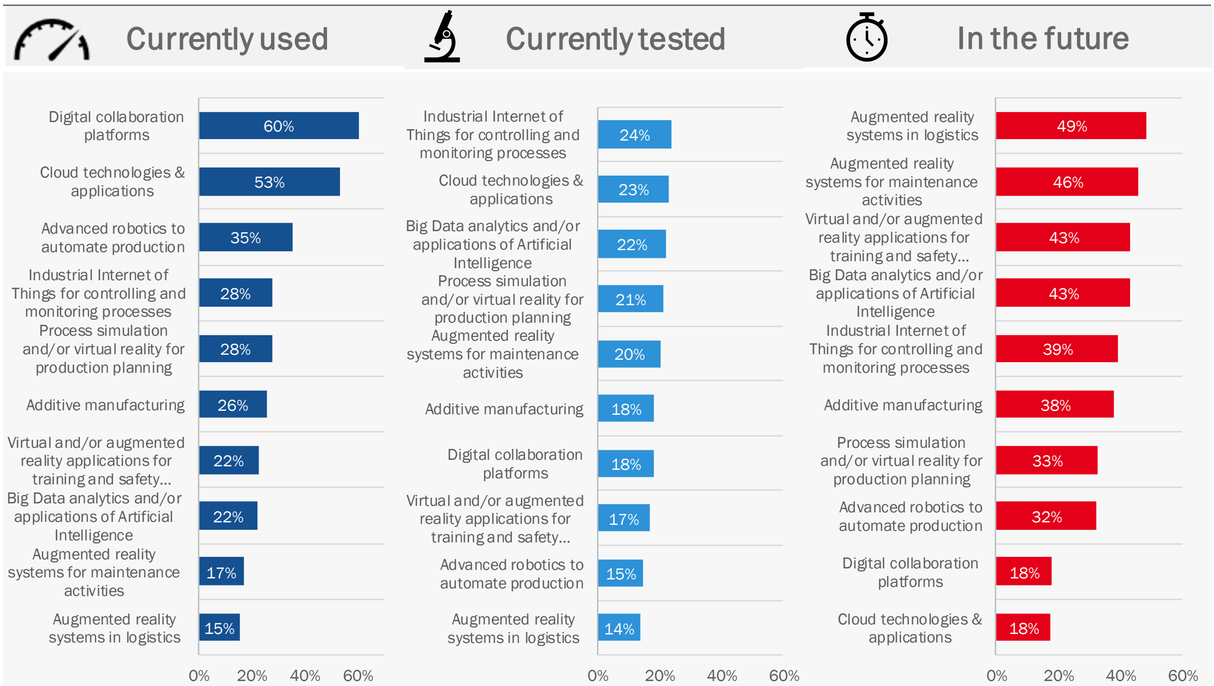
Figure 19 shows that the most widely implemented digital technologies within the chemical, pharmaceutical and rubber & plastics industry are **digital collaboration platforms** for internal communication and cooperation. 60% of surveyed participants indicate that their company or the companies in the industry are currently using them. Including those companies that are currently testing the use of digital collaboration platforms, the survey points to an adoption rate of close to 80% in the chemical industry. **Cloud technologies** are widely implemented as well. 76% of survey participants indicate that their company is currently at least testing the use of cloud technologies, with a majority (53%) mentioning a current use. Looking more closely at companies where an implementation of the two previously mentioned technologies is being tested or envisaged in the future, the survey shows that the company-wide roll-out will be completed in the near future (see Figure 21). 73% indicate that they will use digital collaboration platforms this year or in the next two years (i.e. until 2020), if not already the case. With 77% for cloud technologies and applications, the share is markedly higher.

> "Currently, flexibility in working time and location via **cloud technologies** is the greatest and **most noticeable result**, especially for our administration."

The results suggest that the **1st wave of digital transformation**, i.e. improving connectivity and digitising analogue data, is **widely accomplished** across companies within the European chemical industry.

Figure 19: Application of digital technologies in the chemical industry

Which of the following digital technologies are already used in your company/industry or are planned to be implemented in the future?



Note: The share of respondents indicating "not important" is not included in the figure. It ranges from 4-22%.

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018), n=290-376.

The application of the other technologies can be considered as the **2nd wave of digital transformation** and their **current deployment rate is rather low.** The considered technologies can be categorised into two different levers that drive the 2nd wave of digital transformation. First, the lever of **automation** gives rise to systems that work autonomously and organise themselves, rendering current manufacturing processes more efficient (e.g. by reducing error rates, cutting costs or increasing production speed). This evolution will be driven by technologies such as advanced robotics or additive manufacturing[55]. Second, the collection and processing of **digital data** has a potentially substantial effect on all company areas. For instance, it enables better predictions and decision taking. This lever will be driven by the Industrial Internet of Things (IIoT), Artificial Intelligence (AI), Big Data analytics or new kinds of wearables displaying information[56].

The research shows that **advanced robotics to further automate production** is, after digital collaboration platforms and cloud technologies, the most widely used digital technology. 35% of survey respondents indicate a current use and another 15% state that they are testing its application. The use of **additive manufacturing** is considerably lower (26% current use and 18% current testing).

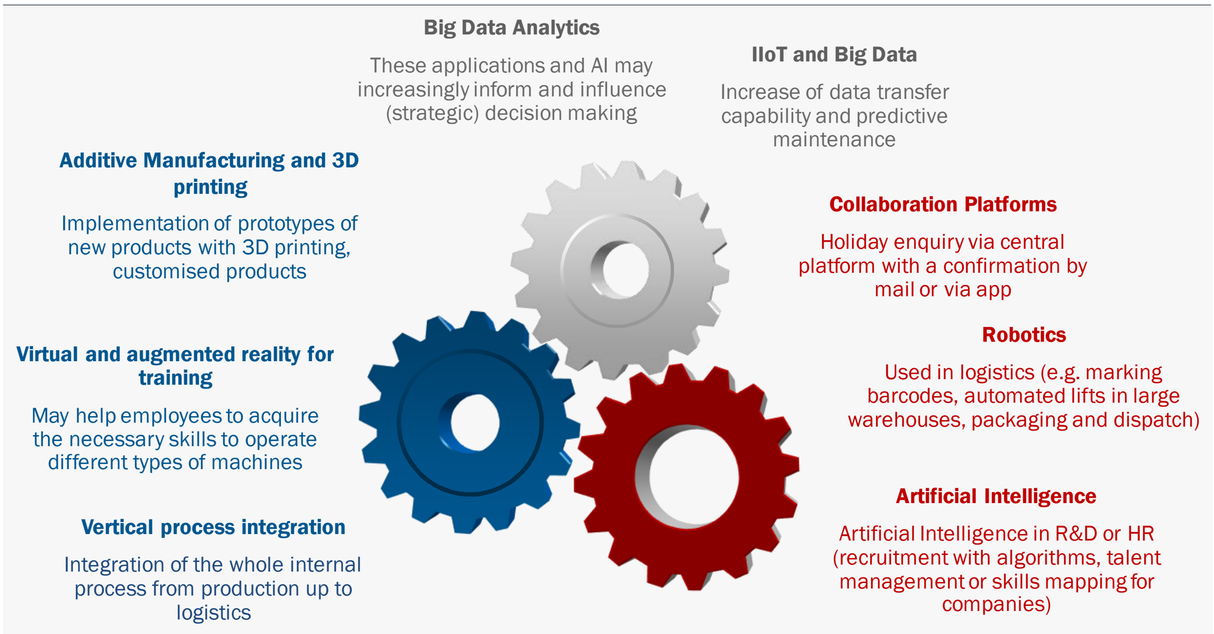
[55] Roland Berger & BDI (2015): The Digital Transformation of Industry. Retrieved from: https://bdi.eu/media/user_upload/Digitale_Transformation.pdf, [21.01.2019].
[56] Ibid.

> "**Strategic decision making** will increasingly be influenced by the analysis of large amounts of data. I expect here a quite **profound change due to Artificial Intelligence.**"

Concerning technologies that allow the collection and processing of data, the survey shows that the use of the Industrial Internet of Things within the chemical industry is markedly lower than for advanced robotics. Only **28%** of survey participants mention that their company (or companies within the industry) is **currently using IIoT-systems** in order to better monitor/control their different processes (i.e. supply chain and manufacturing processes or maintenance operations). At the same time, around 25% of surveyed stakeholders indicate that they are testing possible applications. As new data sources become available through the Internet of Things, they create significant potential for more detailed data analysis. In this regard, **Big Data analytics and applications of Artificial Intelligence (AI)** are important to take advantage of this increasing amount of digital data. The research shows, however, that these applications are not yet widespread in the chemical industry. Only **22% of the survey participants indicate a current use** of Big Data analytics or application of AI. Another 22% are aware of a current testing phase. Yet, most of the industry stakeholders (43%) only expect concrete applications in the future. The increasing availability of digital data and larger computing power capacities also allow improved **process simulations or the use of virtual reality for production planning**. But, with 28%, the share of respondents indicating a current use is rather low. Most of the industry stakeholders state that it is currently being tested (21%) or will be implemented in the future (33%).

> "In the case of acutely occurring problems in systems, **troubleshooting** can be handled more quickly from home with **virtual reality glasses**."
> (Company Representative, Spain)

Figure 20: Examples from the interviews regarding technological transformation through digitalisation and Industry 4.0

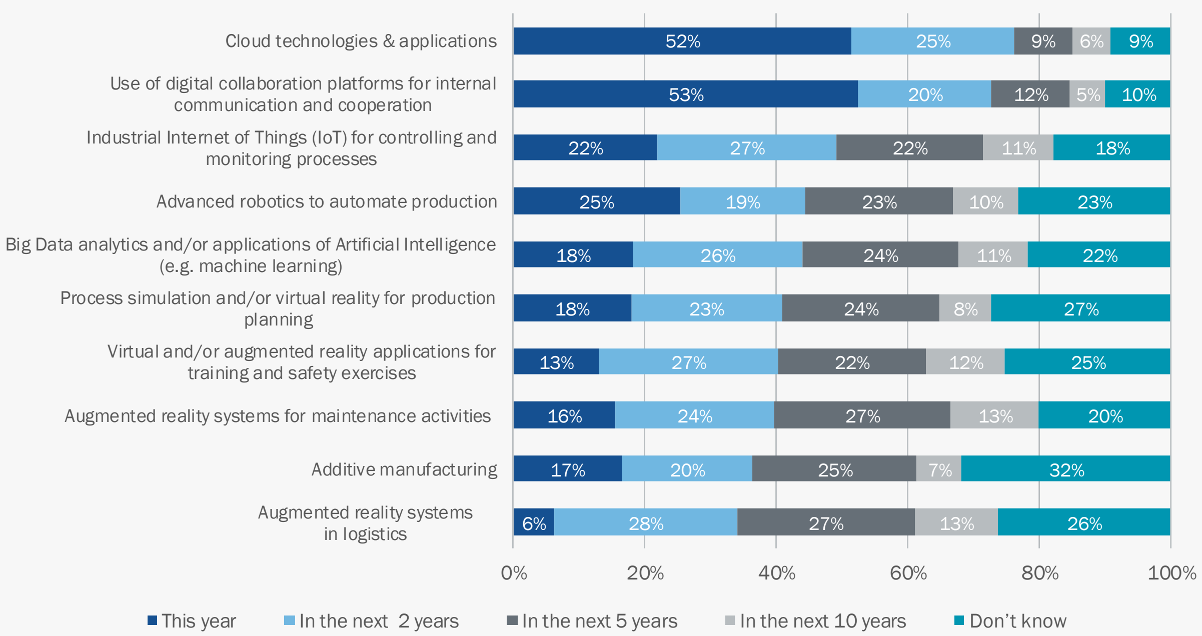


Source: Prognos (2019) based on expert interviews with chemical industry stakeholders. Icons: Copyright Flaticon

Overall, **virtual or augmented reality applications** have the **lowest application rate** of all technologies under consideration. Applications of virtual reality (VR) or augmented reality (AR) for training and safety exercises seem to be used somewhat more than similar applications for logistics activities or maintenance activities (e.g. remote maintenance assistance). 22% of surveyed stakeholders mention that they are aware of the current use of VR/AR for training and safety exercises. This share is with 15% to 17% considerably lower for the use of AR systems supporting the workforce in logistics or maintenance activities. Nevertheless, all three technologies will become more relevant. Between 43% and 49% of surveyed chemical industry stakeholders expect that VR and AR applications will be used in the future.

Figure 21: Timeframe for the utilisation of digital technologies

Please indicate the timeframe for the utilisation of the previously mentioned digital technologies



Note: This question was only asked when the survey participant previously answered: "currently tested" or "in the future" for at least one of the listed technologies.

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018), n=236-298.

"**Big data will certainly affect us**. For example, it will enable preventive maintenance and, in this way, optimise the production processes. We already have some applications, but they are not yet at the level they should be. **It will still take a couple of years**."

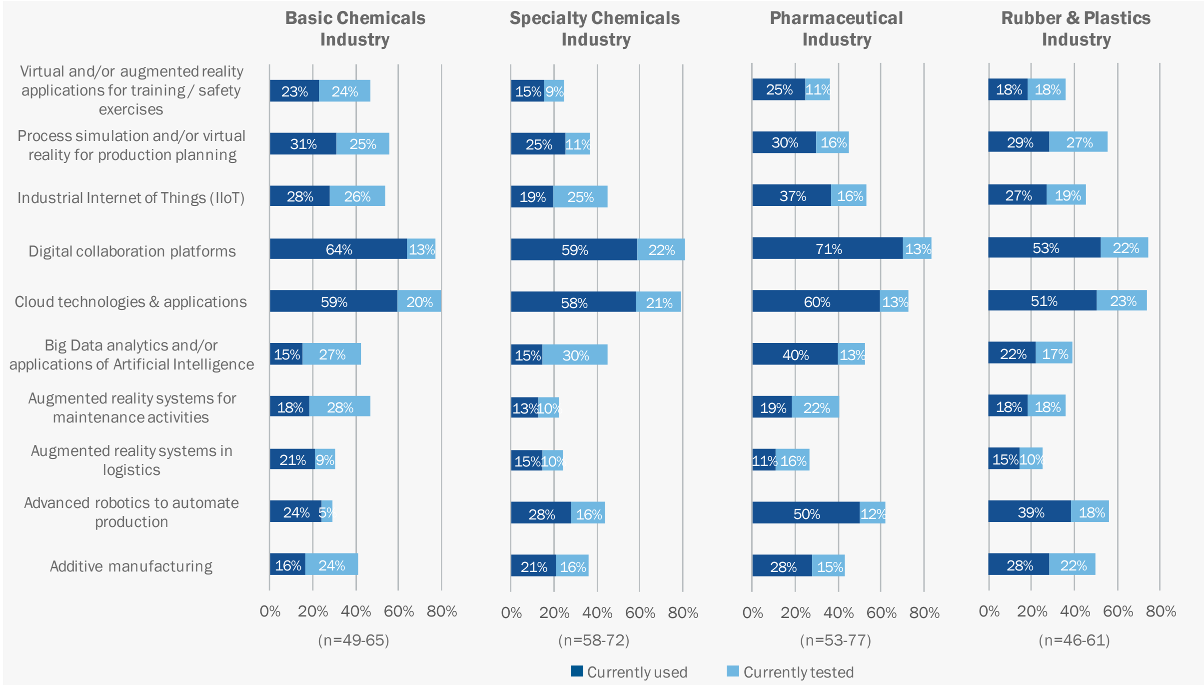
(HR- & Production Manager, Finland)

Regarding the time frame for the utilisation of "2nd wave" technologies (see Figure 21), the research shows that IIoT for controlling and monitoring processes will be implemented most rapidly in the chemical industry. Around 50% of survey respondents assume that IIoT will be implemented in their company or industry within the next two years (i.e. until 2020). This is followed by advanced robotics and Big Data analytics or applications of AI (44% indicate this year or in the next 2 years). Concerning process simulation and VR/AR for training and safety exercises or maintenance activities there are somewhat fewer surveyed stakeholders, who expect an implementation in the coming two years (around 40%). With respect to other technologies, the implementation of additive manufacturing and AR systems to support the workforce in logistics activities seem to lag behind. 37% of respondents indicate that their company or industry will use additive manufacturing this year or in the next two years. For AR systems in logistics, the share is even lower at 34%. However, the research shows that, for all technologies of the 2nd wave, at least 60% of survey respondents expect that the above-mentioned applications will be used in the next five years (i.e. until 2023). This highlights the fact that the **2nd wave of digital transformation will come into effect shortly**.

Sector-specific technological transformation through digitalisation

Given that the covered chemical sectors are heterogeneous in the way they produce and are organised, it is necessary to look more closely at sector-specific differences. To this end, Figure 22 shows the currently used and tested technologies within the four sub-sectors of the chemical industry.

Figure 22: Currently used or tested technologies within the chemical sub-sectors
Which of the following digital technologies are already used in your company/industry or are planned to be implemented in the future?



Note: The sector-specific analysis includes only responses from company representatives (managers & employees).

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018).

Again, the most widely used and/or currently tested technologies in all four sectors are cloud technologies and applications (73-79% of sector-specific respondents) as well as digital collaboration platforms (75-83% of sector-specific respondents). Only the **pharmaceuticals sector** seems to be **more advanced regarding the use of digital collaboration platforms**, especially compared to the rubber & plastics industry. Around 71% of survey respondents working in the pharmaceutical industry indicate that they are using digital platforms compared to 53% of respondents from the rubber & plastics sector. Further, there appears to be **no significant difference regarding the time frame for utilisation across the four sectors**. For digital collaboration platforms, between 69% and 76% of survey respondents from the four sectors assume that their company will utilise them until 2020 (i.e. this year or in the next two years). Similar shares (71% to 82%) exist for the utilisation of cloud technologies and applications (see Annex 12 to Annex 15). Hence, it can be concluded that the **1st wave of digital transformation is widely accomplished across all chemical sectors**.

> "The last two years, I already noticed some changes but for the next three years much more is to come. Our company is currently **reviewing the production process** and they want to **produce up to five times faster**. Mainly by installing new machines and **automating** the current processes."
> (Employee in Rubber & Plastics Sector, Belgium)

With respect to the technologies of the 2nd wave (i.e. automation and processing digital data), the research points to larger differences between the chemical sectors (see Figure 22). The first striking difference is in **advanced robotics to automate production**. The research shows that it is **most widely implemented and tested** within the **pharmaceutical industry (62%)** and the **rubber and plastics industry (57%)**, whereas a large share (45%) of respondents working in the basic chemical industry expect their application in the future (see Annex 8 to Annex 11). At the same time, respondents from the basic chemical industry consider this technology as being significantly less important as opposed to respondents from the other sectors. Around 26% indicate that advanced robotics is of no importance for their company, whereas this share lies between 15-19% for the remaining sectors (see Annex 8 to Annex 11). In addition, the deployment of advanced robotics seems to happen faster in the specialty chemicals, pharmaceuticals and rubber & plastics sector. Whereas 42-55% of the respondents working in these three industries expect its use latest in the next two years, the share is considerably lower for the basic chemical industry with 28%.

Another difference exists in the use of **Big Data and applications of Artificial Intelligence**. Here, the **pharmaceutical industry is also a frontrunner**. More than half of respondents working in this sector either indicate that they are currently working with Big Data and AI (40%) or are aware of current tests with them (13%). For the other three sectors, only a minority of survey respondents (15-22%) mention a current use (see Figure 22). They rather expect such applications in the years to come (see Annex 8 to Annex 11).

Regarding the time frame for implementation, however, the survey results show that especially the **specialty chemical and rubber & plastics industry might catch up**. Respectively, 45% and 52% of respondents in these two sectors expect that they will implement Big Data and/or AI applications latest by 2020 (see Annex 13 & Annex 15). **Respondents from the basic chemical industry appear more sceptical**. Only 36% think that Big Data and AI will be implemented in their company until 2020 (see Annex 12). This is also apparent with regards to the deployment of these technologies: 29% of respondents from the basic chemicals sector answered "don't know" as opposed to 17-23% in the other sectors when asked to indicate the concrete time frame of utilisation (see Annex 12 to Annex 14), indicating some uncertainty.

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Big Data from Lab to Patient at Janssen Pharmaceutica (Belgium)

As a pharmaceutical division from Johnson & Johnson, Janssen Pharmaceutica has been implementing a unique software application since 2017 that maps in a clear and structured way information that is spread across different collaborators, procedures and systems.

It has been designed in such a way, that engineers and scientist no longer need to have specific Big-Data- or IT-skills to manage and analyse the various information sources. Large amounts of data can be shown, and complex processes displayed with just a few clicks. Furthermore, the system allows to compare data from different processes in a more efficient way since all departments are connected through the same software.

Thanks to this, employees' work performance has been improved. For instance, by facilitating the exchange between departments such as R&D and commercial production. The results are quicker, more robust and more cost-efficient operating processes.

The software is being further updated so that the pilot project can be implemented in nearly 60 production sites worldwide. Such a large-scale Big Data application makes it one of the first of its kind in the pharmaceutical industry[57].

Regarding **IIoT**, the companies of the **pharmaceutical industry seem to be slightly ahead of the other three sectors**. 37% of respondents from the pharmaceuticals sector indicate that they are currently using IIoT compared to 28% in the basic chemicals, 27% in the rubber & plastics, and 19% in the specialty chemicals sector. By including the respondents who mention a current testing phase of IIoT, the differences, however, are lower (see Figure 22). Between 44% and 53% of respondents in all sectors indicate that they are currently using or testing the IIoT. Regarding the **timeframe of deployment** of this technology (if not yet used), the research shows that it **will be fastest in the basic chemicals sector**. 64% expect an implementation latest by 2020 (Annex 12). For the other sectors this share lies between 42% and 45% (see Annex 13 to Annex 15).

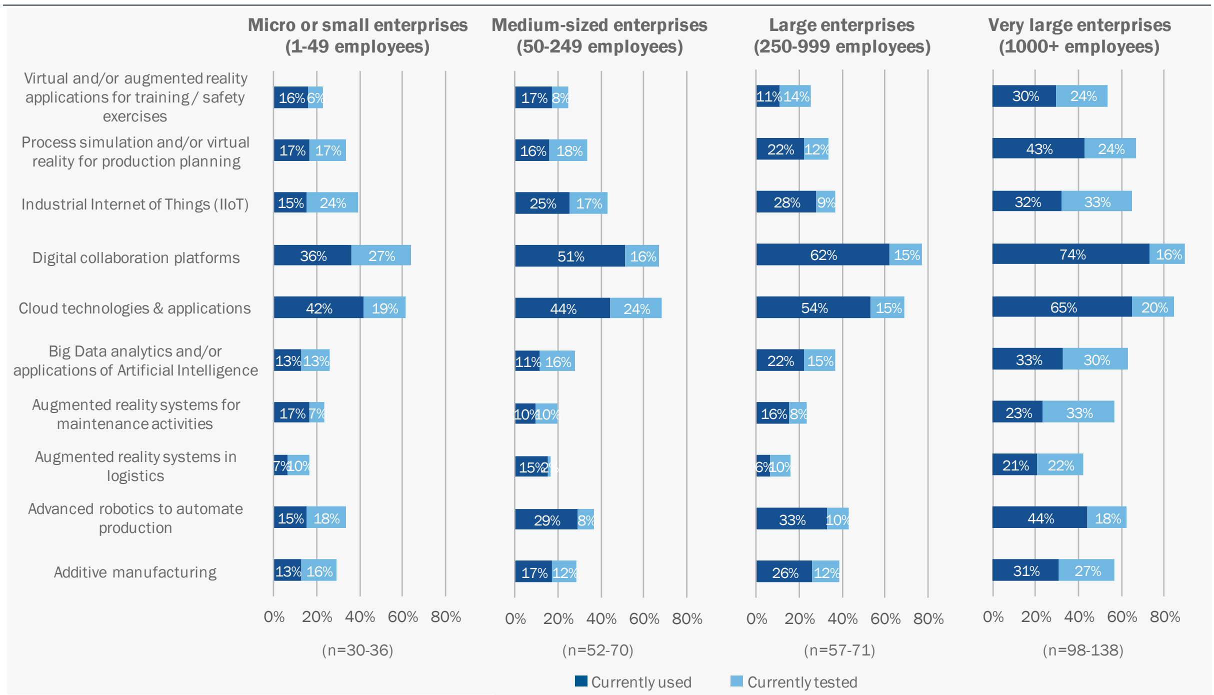
[57] Essenscia (2017): Janssen Pharmaceutica - Big data from lab to patient (English subtitles) [Video File]. Retrieved from: https://www.youtube.com/watch?v=RTw91oOMcUg, [29.02.2019].

Company-specific technological transformation through digitalisation

In addition to sector-specific differences, the study points out strong variations in the use and implementation of the different digital technologies across **company size** (Figure 23).

Figure 23: Currently used or tested technologies across company sizes

Which of the following digital technologies are already used in your company/industry or are planned to be implemented in the future?



Note: The analysis across company sizes includes only responses from company representatives (managers & employees).

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018), n=30-138.

Digital collaboration platforms for internal communication and cooperation as well as **cloud technologies** are, yet again, the most intensively used digital technolgies across all company sizes. Furthermore, the research shows that **their implementation consistently increases with company size**. Whereas 74% of survey respondents working in very large enterprises (+1000 employees) state that they are currently working with digital collaboration platforms, only 38% of respondents from micro or small enterprises do (see Figure 23). The survey further indicates that many micro and small enterprises are still testing its use (27%) or expect an implementation in the future (33%, see Annex 16). Concerning cloud technologies and applications, the differences between company sizes are less pronounced.

> "**Big Data analytics** is a matter that is **mostly discussed within big companies** in the sector. Here the **pharmaceuticals sector is once again ahead**. In Sweden, there is a lot of knowledge in this matter, but **we don't use it yet**."
> (Manager Trade Union Representative, Sweden)

The survey results further indicate that the **transformations surrounding the other reviewed technologies might cause quite drastic implementation gaps** between very large enterprises and SMEs. Even large enterpises (250-999 employees) do not seem to be able to keep up (see Figure 23). For instance, 34 to 43% of respondents from micro or small, medium-sized or large enterprises are aware of current applications or testing phases for advanced robotics within their company. This share is about 62% for very large enterprises, indicating an implementation gap of between 19 to 28 percentage points (pp.). A similar gap exists for the use of the Industrial Internet of Things for monitoring and controlling processes. An even larger implementation gaps exist for process simulations, AR systems for maintenance activities and Big Data analytics or application of AI. For example, only **26% to 27%** of respondents from **micro and small or medium sized enterprises currently use or test applications of Big Data analytics or AI compared to 63%** of respondents from **very large enterprises**. This represents an implementation gap of 36 to 37 pp. Even for large enterprises the gap is around 25 pp.

The research also shows that **very large companies** are **much faster in managing the digital transformation, at least in terms of adoption of new digital technologies**. For all reviewed technologies, at least 70% of survey participants working in very large companies expect that these will be implemented in the next five years (i.e. until 2023) (see Annex 19). For small, medium-sized or large enterprises this share is considerably lower and lies between 40% and 53% (see Annex 20 to Annex 22).

Several reasons can explain the lower implementation rate and speed in SMEs and, to a certain extend, in large enterprises with less than 1000 employees. Before investing in new kinds of technologies, business leaders need to know their technical maturity and economic potential. In **small to mid-sized companies**, however, they do **not always have a specific IT- department**, let alone a department with a Chief Digital Officer (CDO), which could support such decisions. Furthermore, planned investments are often aimed at concrete and predictable success. This is especially the case for small or medium-sized companies, even more so than for large or very large companies, since they **cannot afford to make any misjudgements or wrong investments**, or it might lead to financial ruin[58]. Large or very large companies, on the other hand, can rely on their much broader portfolio of activities and larger financial resources[59]. In addition, the results in Chapter 3.2 show that the **necessary skills** for implementing and using new digital technologies seem to be **less available within SMEs** as compared to large or very large enterprises. Other research[60] also indicates that a majority of **SMEs might be more in a wait-and-see position**, aimed at benefiting from initiatives led by large companies and ensuring to catch up on the adoption and exploitation of new digital technologies (automation, ERP-Systems[61], etc.) once fully functional and stable.

[58] Icks, A. & Schröder, C. (2018): Chancen und Herausforderungen der Digitalisierung für kleinere und mittlere Unternehmen in AWV-Informationen 2/2018, IfM Bonn.
[59] Roland Berger & OPIC (2017): Les impacts de la transformation numérique sur les métiers, l'organisation du travail, les compétences et les certifications dans les industries chimiques.
[60] Ibid.
[61] ERP: Enterprise-Resource-Planning-Systems.

3.4 Employer-employee relationship and collective agreements

KEY FINDINGS

- From all considered aspects, **working hours are most adequately addressed** by current collective agreements.
- A large share of respondents (between 45-60%) are of the opinion that **collective agreements cover (at least moderately) important issues** like working time flexibility, occupational training, the compatibility of work and private interests and mobile working.
- Between 14-17% of industry stakeholders, however, indicate that occupational training, the compatibility of work and private interests, and mobile working are currently not addressed at all, showing a **gap in collective agreements** in some places.
- **Mobile working**, **working-time flexibility**, **work-life balance**, **occupational training** and employee data protection are expected to have the **most significant increase in importance** for collective agreements in the next 5 years.

The previous chapters highlighted how the digital transformation has and will continue to have a considerable impact on the chemical industry and its sub-sectors – not only from a technological point of view, but also concerning the working environment. Many consequences and challenges (e.g. regarding skills adaption, new forms of collaborations or changing working tasks) are expected by all industry stakeholders.

This chapter has the objective to determine the extent to which the **impacts of digitalisation on the workplace currently feature on the agenda of collective agreements** in Europe. Furthermore, the chapter indicates which aspects will become particularly important for future discussion and negotiations. In order to take account of the different national and regional legislations and industrial relations, the survey questions around collective agreements were set quite broadly. Therefore, survey participants' answers not only refer to national collective agreements but can also be related to regional, sector or company specific collective agreements.

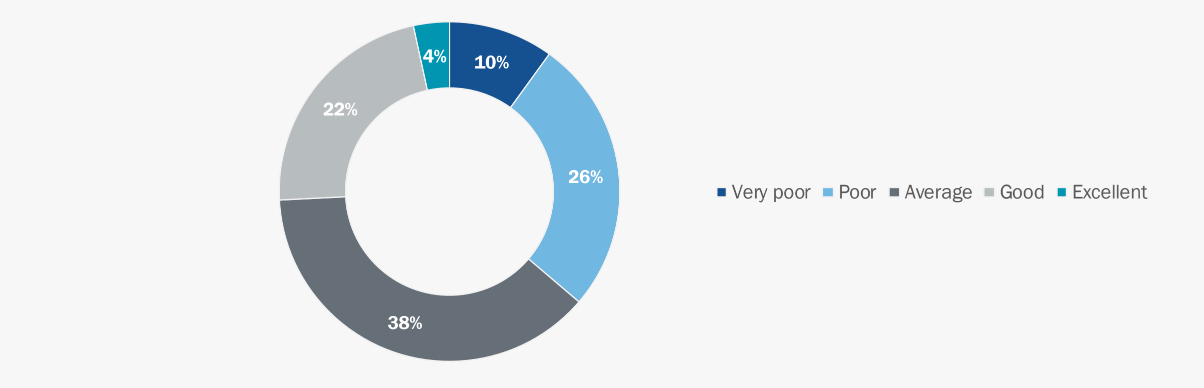
Overall assessment of the employer-employee relationship and collective agreements

The survey first asked participants to provide a general assessment of the suitability of the current collective agreement concerning the digital transformation. Figure 24 shows that only 26% of survey respondents asses the current framework conditions as being good or excellent. With 38% the majority rate them as being average, while 36% rate them as being poor to very poor.

Figure 25 gives a more detailed overview of specific issues which are related to the digital transformation in the workplace and shows how these are currently being addressed by collective agreements. In addition, it indicates to which extent these issues will become more important in the future. Overall, the analysis indicates that **current agreements cover (with varying intensity) most of the given aspects**.

Figure 24: General assessment of the framework conditions set by collective agreements in Europe

How would you generally assess the framework conditions set by collective agreements in your country concerning the digital transformation of the chemical industry?

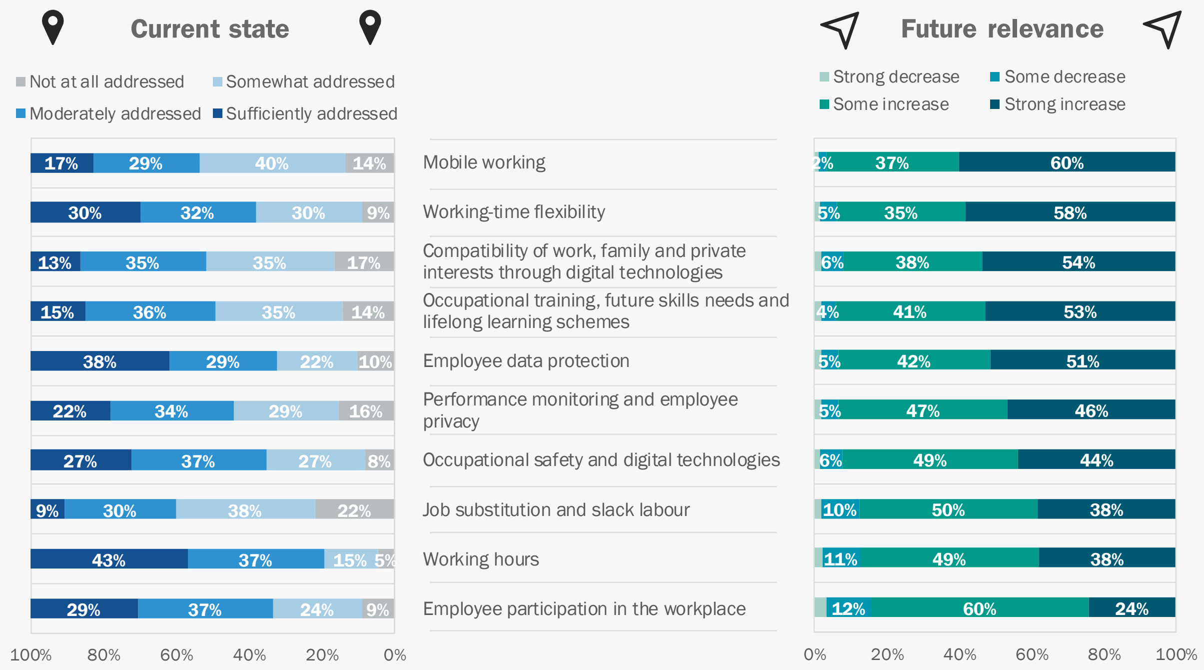


Note: Survey respondents were asked to rate the framework conditions on a scale from "Very poor" to "Excellent".

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018), n= 411.

Figure 25: Assessment of current collective agreements

What aspects of the digital transformation are sufficiently addressed by collective agreements in your country & what will be their relevance in the next 5 years?



Note: Survey respondents were first asked to indicate whether the given aspect is sufficiently addressed on a scale from "not addressed at all" to "sufficiently addressed". This was followed by an assessment of the aspect's future relevance on a scale from "strong decrease" to "strong increase".

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018), n= 307-392.

At least 78% of survey respondents indicate that the mentioned issues are addressed to a certain degree by the collective agreements in place (see Figure 25). From all topics, "**working hours**" is **most sufficiently addressed.** Around 80% of survey respondents indicate that this issue is moderately or sufficiently addressed. This aspect is followed by employee data protection, working-time flexibility, occupational safety, digital technologies and employee participation in the workplace. More than 60% of industry stakeholders agree that these aspects are at least moderately addressed.

Furthermore, Figure 25 shows that those aspects which are currently covered best are not necessarily those that will increase most in relevance in the coming years. For the following aspects **more than half of the survey participants indicate** that there will be **a strong increase in relevance in the next 5 years**:

- Arrangements around **mobile working**;
- Agreements concerning **working-time flexibility**;
- Improved **compatibility of work, family and private interests** through new digital means;
- Frameworks for **occupational training and lifelong learning** against the backdrop of future skill needs;
- Discussions around **employee data protection**.

This reflects the developments analysed in Chapter 3.2 around the increased need for (advanced) digital skills, more complex working environments or greater working flexibility and mobility with, at the same time, blurred lines between work and private life.

> "We have signed a **collective agreement** on the right to disconnect and there also exists a framework for mobile working. Such **frameworks are important and need to be fixed in the context of the digital transformation**."
> (Human Resource Manager, France)

As mentioned above, the issue of employee data protection and working time flexibility are already well addressed. The other important aspects for the future, i.e. **occupational training, work-life balance and mobile working** are, however, **covered** to a **lesser degree.** For occupational training around 50% of survey respondents indicate that it is at least moderately covered. For work-life balance and mobile working, these shares are of 46% and 45%, respectively. However, **between 14-17% of the industry stakeholders indicate that these three issues are currently not addressed at all**. Other, less addressed issues, which will become more relevant in the next five years, are performance monitoring, employee privacy and job substitution due to new digital technologies. Especially the latter aspect seems to be critical, since only 9% of survey respondents think that it is sufficiently addressed (the lowest share across all mentioned issues).

Interview partners emphasised that besides collective and legally binding agreements, other possibilities to address and shape the digital transformation in the workplace and its challenges need to be used as well. For instance, **open dialogue processes** between social partners in the chemical industry, such as the "WORK@industry4.0" initiative in Germany, offer plenty of opportunities to develop recommendations and to establish a clear communication around this topic (see info box below). In addition, some interview partners mentioned that collective agreements should not be defined too narrowly to allow companies a certain flexibility to adapt to changing situations.

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WORK@industry4.0: A new form of social dialogue around the digital transformation

In October 2016, the German chemical employers' association, BAVC and industry trade union, IG BCE decided to start the social partner dialogue "WORK@industry4.0" in order to discuss the challenges and opportunities of the digital transformation in the chemicals and pharmaceuticals sectors. The objective of the dialogue was to develop a common understanding of the topic beyond established roles within the collective bargaining process. On this basis, the opportunities offered by new technologies should be seized and make future working conditions in the sector attractive. The social dialogue especially focussed on the following four topics: occupational training, flexible working conditions (temporally and locally), healthy work, leadership and organisation.

For this dialogue, a new format was developed. For each of the four topics, coordination teams were set up to prepare and pre-structure the discussions. Further, a steering group was established. It was composed of an equal representation of employer and union representatives at the regional and national level. The steering group's role was to monitor the overall process. The actual discussions, however, took place during the workshops around the four main topics. The participants in these workshops were experts from different areas (works councils, human resources, company doctors, production, etc.) and from companies of all sizes.

The dialogue was carried out in two stages. At the first stage, the central topics of the digital transformation in the chemical industry were identified. At the second stage, those topics were selected, which currently promise to be of great value added to the industry. In addition, potential solutions and approaches were developed. At the end of the second stage, in May 2018, the steering group discussed and evaluated the outcomes of the previous discussions. This finally led to a report on the overall process and the definition of six concrete thematic fields for which social partners projects should be envisaged by the members of the Boards of IG BCE and BAVC[62].

Assessment of the employer-employee relationship and collective agreements by position in the company

Regarding the status-quo assessment of the suitability of collective agreements for the digital transformation, the analysis by **company position** reveals that employees[63] and managers[64] indicate the **same five aspects** as currently being addressed best (see Figure 26):

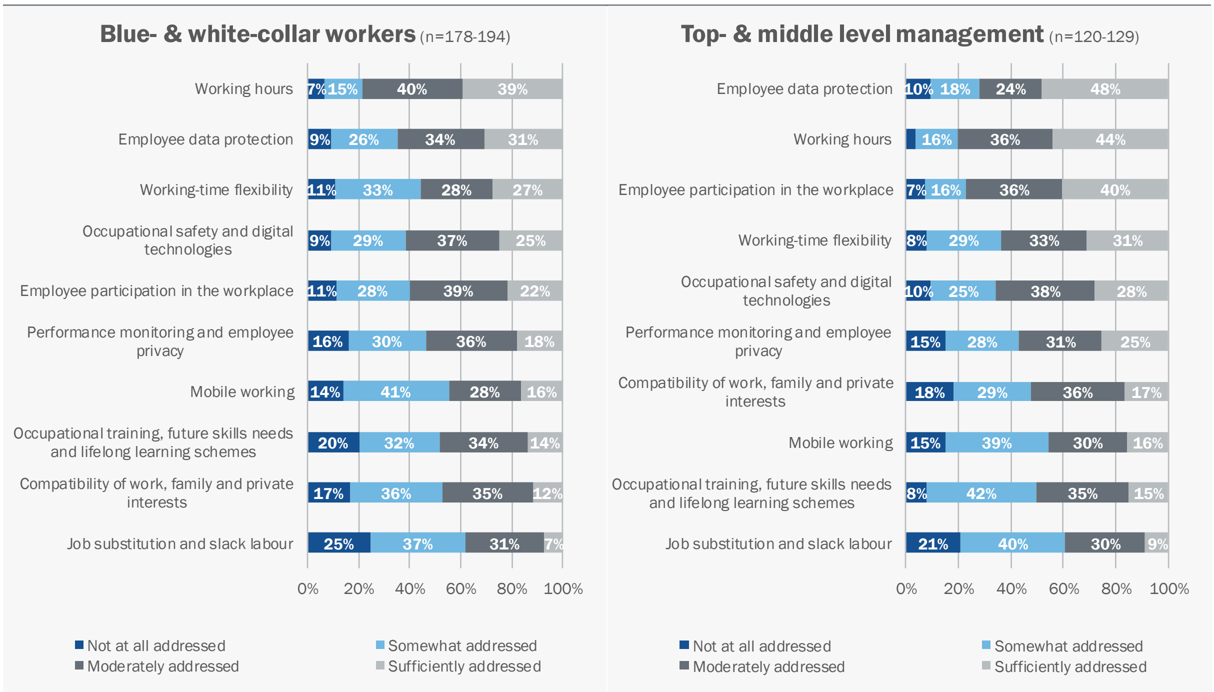
- Agreements around **working hours**;
- Discussions around **employee data protection**;
- Agreements concerning **working-time flexibility**;
- **Occupational safety** and digital technologies;

[62] Work @ Industry 4.0 (2018): Gemeinsamer Bericht über den Dialogprozess WORK@INDUSTRY 4.0 der Chemie-Sozialpartner. Retrieved from: https://work-industry40.de/fileadmin/docs/WAI_gemeinsamer_Bericht_ueber_den_Dialogprozess_WORK%40INDUSTRY_4.0_November_2018.pdf , [31.01.2019].
[63] Blue- and white-collar workers.
[64] Middle and top-level management.

- Arrangements regarding **employee participation** in the workplace.

However, the management is more convinced than employees that the above-mentioned issues are sufficiently addressed in current agreements.

Figure 26: Status-quo assessment of collective agreements by company position



Note: Survey respondents were first asked to indicate whether the given aspect is sufficiently addressed on a scale from "not addressed at all" to "sufficiently addressed".

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018), n=120-194.

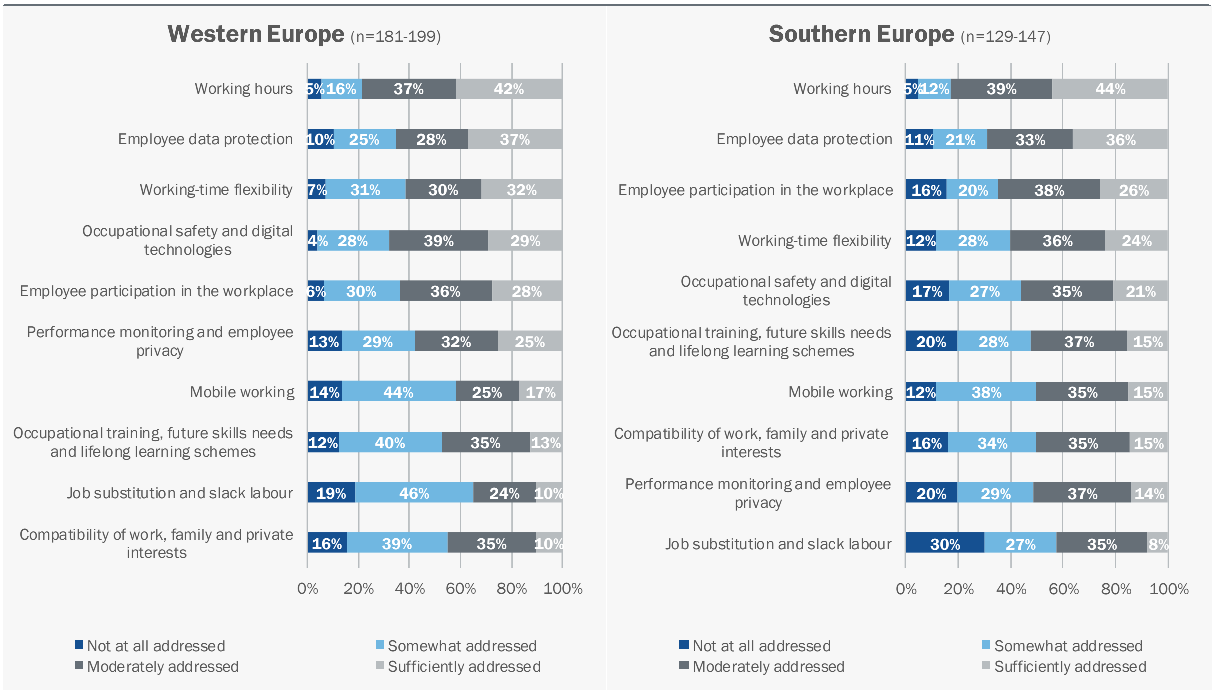
Looking at the assessment of the issues' future relevance for collective agreements, top- and mid-level **managers** in the European chemical industry **find for most of these subjects a stronger increase in importance**, compared to blue- and white-collar workers (see Annex 24). According to both groups, mobile working will become the most important aspect for future discussion: 67% and 60% of surveyed managers and employees, respectively, expect a strong increase in importance. **Assessments differ** more strongly regarding the **future importance** of **compatibility of work and private interests** through digital technologies (65% of managers see a strong increase as opposed to 49% of employees), **working-time flexibility** (66% compared to 53%, respectively) and **occupational training and lifelong learning** (60% compared to 49%, respectively). Compared to managers, employees emphasize more the importance of issues like performance monitoring (51% of employees see a strong increase as opposed to 45% for management) and employee data protection (53% compared to 45%, respectively).

Assessment of the employer-employee relationship and collective agreements across Europe (by country cluster)

Due to the insufficient number of respondents for the questions around collective agreements from Northern European countries (n=22-31) and Central and Eastern European countries (n=16-19), the following analysis only focusses on the Western and Southern European countries for which the analysis can draw on a robust database.

Figure 27 shows that for both country clusters, **West and South, the top 5 of the currently best-addressed issues** in collective agreements **are equivalent** and correspond to the top 5 of the overall assessment (working hours, employee data protection, working-time flexibility, occupational safety and employee participation in the workplace).

Figure 27: Status-quo assessment of collective agreements by a country cluster



Note: Survey respondents were asked to rate whether the given aspect is sufficiently addressed by collective agreements in their country on a scale from "not addressed at all" to "sufficiently addressed".

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018), n=129-199.

The **most striking difference** between both regions exists regarding the issues of **occupational safety** and **job substitution and surplus labour**. 30% of respondents from Southern European countries indicate that job substitution is not addressed in their collective agreements, compared to 18% in Western European countries. For occupational safety and digital technologies, the gap is more pronounced. 17% of survey participants from Southern Europe state that this aspect is not adressed, compared to only 4% in Western Europe. Further, the issue of **employee**

participation in the workplace seems to be adressed more extensively in Western European countries than in Southern ones.

Concerning the future relevance of the different aspects, the analysis shows that mobile working, working-time flexibility, work-life balance and employee data protection are amongst the top 5 in both regions (see Annex 25). However, there are some noteworthy differences between Western and Southern European survey participants. **Western European respondents** see **occupational training and lifelong learning** as becoming more important than their colleagues from the Southern European countries. Around 65% of Western European stakeholders expect that this topic will strongly increase in importance as compared to 45% in Southern Europe. Another **more pronounced difference exists for the future importance of working hours**. Whereas in Western Europe around 45% respondents indicate a strong increase in importance, only 28% of respondents from Southern Europe are of the same opinion. Approximately 20% of the survey participants from Southern Europe indicate a decrease in importance, compared to 5% in Western Europe.

3.5 Level of digital maturity and awareness regarding digitalisation in the European chemicals sector

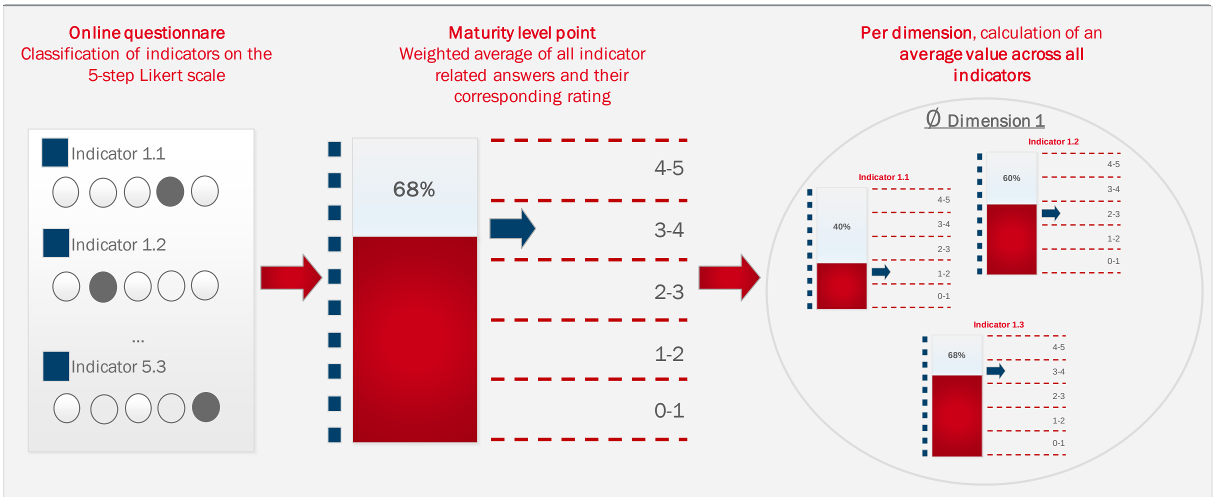
KEY FINDINGS

- The chemical industry receives an **overall maturity rating of 3.07 out of 5** across all important digitalisation dimensions.
- There are **no large differences** in the overall maturity level **across the different sectors**, even though the basic chemical industry shows a somewhat higher degree of digital maturity. There are also **no large differences** in the maturity levels **across the different dimensions.**
- The most striking differences can be found across the 20 different maturity indicators. Their analysis reveals that **change management** and the **involvement & support of employees** receive the lowest scores across the different chemical sectors and, therefore, represent some of the **big challenges** concerning the overall digital transformation process. At the same time, **dialogue between management and employees** is ought to be one of the industry's **strengths,** since it improved the companies' competitiveness.

As explained in Chapter 2.2, the maturity model is composed of 5 dimensions and 20 corresponding indicators, which have been used for the conceptualisation of the European wide online survey. For each dimension, a group of situations/statements, analogous to the indicators, were formulated for which survey participants were asked to indicate their agreement on a five-step Likert scale from "does not apply at all" to "fully applies". Each statement was formulated in such a way that it represented a situation where the company or industry of the survey participant would have the highest possible digitalisation level[65]. In addition, all statements were adapted to the position of the survey participant (e.g. manager, employee, union representative, etc.). In order to assign a maturity level and to make results comparable across all dimensions and indicators, a scoring procedure was applied (see Figure 28).

65 See Table 1 for a description of the different indicators for which a corresponding statement was formulated.

Figure 28: Conception of the assessment model for the digital matureness in the online survey



Source: Prognos AG (2019), own representation.

Every answer given to a statement, related to one of the indicators, was translated into an ordinal scaling system from 1 (if answer = “does not apply at all”) to 5 (if answer = “fully applies”)[66]. Next, a maturity rating for each indicator was calculated by taking a weighted average of all related answers and their corresponding rating (1-5). This was done by adding up the share of persons within a certain answer category (i.e. “does not apply at all”; “does not apply much”, etc.) multiplied by their corresponding ordinal scale (i.e. multiplied by 1 if “does not apply at all” or by 5 if “fully applies”). Finally, for calculating the maturity index of a specific dimension, the average of the corresponding indicators’ maturity ratings was taken.

The survey section with the questions regarding the overall degree of digital transformation of the respondent’s company or industry (i.e. the digital maturity) represented the last section of questions for the survey participants. Therefore, the objective of this part was to obtain not only a maturity index but also a final and comprehensive assessment of the digital transformation in the chemical industry. For this reason, this section shares many similarities to the previous parts of the report.

Assessment of the digital maturity of the chemical industry across the different dimensions

Table 3 reveals a **maturity rating of 3.07** out of 5 for the chemicals sector, based on the answers of all survey respondents (including employers, industry and trade union representatives). This means that on **average** the described situations apply partially to the reality within the companies of the European chemical industry. It should be noted, however, that this index represents an average calculated across all respondents and that there can exist considerable variances in the respondents’ maturity ratings.

[66] 1 = “does not apply at all”, 2 = “does not apply much”, 3 = “uncertain”, 4 = “largely applies”, 5 = “fully applies”.

Table 3: Digital maturity across the chemical sub-sectors and dimensions

Digital Maturity Index					
Dimension	**Basic Chemicals Industry**	**Specialty Chemicals Ind.**	**Pharmaceutical Industry**	**Rubber & Plastics Industry**	**All survey respondents**
Skills & Lifelong Learning	3.26	3.14	3.04	2.96	3.04
Organisation of Work	3.18	3.22	3.12	3.01	3.10
Digital Transformation Management	3.22	3.04	2.90	2.93	2.97
Smart Production & Operations	3.18	2.93	3.03	3.11	3.05
Smart Product & Service Innovation	3.08	3.07	3.05	2.99	3.07
Overall assessment	**3,18**	**3,08**	**3,03**	**3,00**	**3,04**

Note: Basic Chemicals: n=61-68; Specialty Chemicals: n=63-66; Pharmaceutical: n=67-79; Rubber & Plastics: n=63-67. The sector-specific ratings only include answers from company representatives from the respective sectors. Therefore, the ratings for "All survey respondents" do not equal the average across the sector-specific ratings, since they include as well responses from employers, industry and trade union representatives.

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). All survey respondents: n= 344-384. Icons: Copyright Flaticon.

The analysis shows that, for the **overall maturity level,** there is **no large difference across the different chemical sub-sectors**, with ratings ranging from 3.00 to 3.18. However, the **basic chemicals sector** seems to be ahead of the others. For 4 of the 5 existing dimensions, it received the highest digital maturity rating. The basic chemicals sector seems to cope especially well with skills adaption and transformation management (see Table 3), which might be due to the higher share of very large enterprises in this sub-sector. The **differences in ratings across the different maturity dimensions** are quite **low as well**. They range from 2.97 (= digital transformation management) to 3.10 (= organisation of work). However, more striking differences can be found across the 20 maturity indicators.

Assessment of the digital maturity within the dimension "Skills & Lifelong Learning"

Across all survey respondents and sectors, the analysis of the skills and lifelong learning dimension shows that the indicators **"availability of skills"**[67] and the **"role of social dialogue"**[68] received the **lowest maturity rankings**. This is in line with the previous findings regarding missing advanced digital and complex transversal digital skills (see Chapter 3.2) and the increasing importance of occupational training and lifelong learning for collective agreements (see Chapter 3.4).

Regarding the **availability of digital skills** to adopt new digital technologies within the company, the maturity analysis shows that the **basic chemical industry is best positioned** (see Table 4). For the rubber & plastics and the specialty chemicals sector, there is a larger share of

[67] The degree to which the necessary skills to adopt digital technologies are available within the industry.
[68] The degree to which strategies to retain and adapt the needed skills are being sufficiently discussed between management and employees.

respondents indicating that the necessary skills are missing and/or difficult to find on the labour market, which explains their lower rating in this regard.

Table 4: Digital maturity within the dimension of "Skills & Lifelong Learning"

Digital Maturity Index					
Dimension	BC	SC	PH	RP	All. resp
Skills & Lifelong Learning	3.26	3.14	3.04	2.96	3.04
Organisation of Work	3.18	3.22	3.12	3.01	3.10
Digital Transformation Management	3.22	3.04	2.90	2.93	2.97
Smart Production & Operations	3.18	2.93	3.03	3.11	3.05
Smart Product & Service Innovation	3.08	3.07	3.05	2.99	3.07
Overall assessment	**3.08**	**3.07**	**3.05**	**2.99**	**3.07**

Indicator	BC	SC	PH	RP	All. resp
Availability of digital skills	● (yellow)	● (orange)	● (yellow)	● (orange)	● (orange)
Openness to new digital technologies	● (yellow)	● (yellow)	● (yellow)	● (orange)	● (yellow)
Development of digital expertise	● (yellow)	● (yellow)	● (yellow)	● (orange)	● (yellow)
Role of social dialogue	● (yellow)	● (orange)	● (red)	● (red)	● (orange)

● (red) < 2,85 ● (orange) 2,85 - 3,10 ● (yellow) 3,10 - 3,35 ● (green) >= 3,35

Note: Basic Chemicals: n=62-68; Specialty Chemicals: n=65-66; Pharmaceutical: n=76-79; Rubber & Plastics: n=64-66.

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). All survey respondents: n= 344-384. Icons: Copyright Flaticon.

Concerning the **role of social dialogue**, the analysis shows that the **basic chemical industry** receives the **highest rating** across the four chemical sub-sectors, followed by the specialty chemicals sector. Respondents from the **pharmaceuticals** and **rubber & plastics sector**, on the other hand, are **more critical**.

The **openness to new digital technologies** and the **development of digital expertise** (i.e. implementation of strategies to reskill the workforce) receive somewhat better ratings. For these indicators, no large differences exist across the four chemical sub-sectors, despite the indicator' score being slightly lower for the rubber and plastics industry.

Assessment of the digital maturity within the dimension of "Organisation of Work" and "Digital Transformation Management"

The dimension "organisation of work" overall received the highest rating. This is due to the **high scores given to interdisciplinary collaboration**[69] and the **availability of infrastructure** for **flexible working arrangements** (see Table 5). These results can be directly related to the previously mentioned accomplishments of the 1st wave of digitalisation in the chemical industry, which is visible across all sectors. Interestingly, the assessment of flexible time-management does not comply with the positive assessment concerning the availability of infrastructure allowing such flexible working arrangements.

[69] The improvement of interdisciplinary and interdepartmental collaboration by digital collaboration platforms.

Table 5: Digital maturity within the dimension of "Organisation of Work"

Digital Maturity Index – Dimension	BC	SC	PH	RP	All. resp
Skills & Lifelong Learning	3.26	3.14	3.04	2.96	3.04
Organisation of Work	3.18	3.22	3.12	3.01	3.10
Digital Transformation Management	3.22	3.04	2.90	2.93	2.97
Smart Production & Operations	3.18	2.93	3.03	3.11	3.05
Smart Product & Service Innovation	3.08	3.07	3.05	2.99	3.07
Overall assessment	**3.08**	**3.07**	**3.05**	**2.99**	**3.07**

Indicator	BC	SC	PH	RP	All. resp
Flexibilisation of work - Flexible time-management	orange	yellow	orange	red	orange
Flexibilisation of work - Availability of infrastructure	yellow	green	green	orange	yellow
Interdisciplinary collaboration	green	green	green	green	green
Social dialogue– Consideration of experience	orange	red	red	red	red
Social dialogue – Improvement of acceptance	orange	yellow	orange	orange	orange
Social dialogue – Competitiveness	green	green	yellow	yellow	yellow

red: < 2,85; orange: 2,85 - 3,10; yellow: 3,10 - 3,35; green: >= 3,35

Note: Basic Chemicals: n=64-68; Specialty Chemicals: n=63-66; Pharmaceutical: n=72-78; Rubber & Plastics: n=65-67.

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). All survey respondents: n= 344-384. Icons: Copyright Flaticon.

> "Having a strong **participation of the workforce** in **decision making** has helped to **increase the acceptance** of the digital transformation. Good levels of **communication** are **fundamental** to share with the employees the new possibilities of digitalisation."

The indicators related to the **consideration of experience** and concerns of employees and the **improvement of acceptance** by common discussions between employer and employees received **some of the lowest scores.** This applies not only to the dimension "Organisation of Work" but also across all indicators (Annex 26). In addition, Table 6 shows that "Digital Transformation Management"[70] and "Innovation Culture"[71] receive overall poor scores. The results emphasize the fact that **change management** and the **involvement and support of employees** are **some of the biggest challenges** in the digital transformation process. Regarding the different chemical sectors, the maturity analysis indicates that the basic chemical industry, once again, seems to cope better with these aspects.

[70] The extent to which the digital change process in the industry is adequately promoted and supported.
[71] The degree to which the framework conditions enabling digital innovations, like financial and human resources or risk-taking attitudes, exist within the industry.

Table 6: Digital maturity within the dimension of "Digital Transformation Management"

Digital Maturity Index					
Dimension	**BC**	**SC**	**PH**	**RP**	**All. resp**
Skills & Lifelong Learning	3.26	3.14	3.04	2.96	3.04
Organisation of Work	3.18	3.22	3.12	3.01	3.10
Digital Transformation Management	3.22	3.04	2.90	2.93	2.97
Smart Production & Operations	3.18	2.93	3.03	3.11	3.05
Smart Product & Service Innovation	3.08	3.07	3.05	2.99	3.07
Overall assessment	**3.08**	**3.07**	**3.05**	**2.99**	**3.07**

Indicator	BC	SC	PH	RP	All. resp
Digital Transformation Strategy	● (green)	● (yellow)	● (yellow)	● (orange)	● (yellow)
Transformation Management	● (yellow)	● (orange)	● (red)	● (orange)	● (orange)
Innovation Culture	● (yellow)	● (orange)	● (red)	● (orange)	● (orange)

● (red) < 2,85 ● (orange) 2,85 - 3,10 ● (yellow) 3,10 - 3,35 ● (green) >= 3,35

Note: Basic Chemicals: n=68; Specialty Chemicals: n=64-65; Pharmaceutical: n=73-74; Rubber & Plastics: n=65-66.

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). All survey respondents: n= 344-384. Icons: Copyright Flaticon.

At the same time, Table 5 (see page above) shows that survey respondents agree that the outcomes of discussions between management and employees in the chemical industry help improve the industry's and company's competitiveness (Indicator: "Social dialogue – Competitiveness"). Thus, according to the survey participants, the **dialogue** is **one of the industry's strengths,** even more so in the basic and specialty chemicals sector.

"It is necessary to **involve employees** in this transformation process and make them participants. To make them **aware** that this is not a risk but **an opportunity and a transformation of work** and to understand that it **does not necessarily** lead to the **destruction** of jobs."

In conclusion, the analysis of the dimensions "Organisation of Work" and "Digital Transformation Management" highlights that **change management and constructive dialogue** between employers and employees **will be key to a successful digital transformation** in the chemical industry.

Assessment of the digital maturity within the dimension "Smart Production & Operation" and "Smart Product & Service Innovation"

As explained in Chapter 2.1 and 3.3, the companies of the chemical industry will become increasingly what is called "smart factories". By combining new digital technologies like Big Data analytics, Artificial Intelligence, advanced robotics or additive manufacturing with existing technologies, smart factories enable more efficient and flexible industrial processes. Amongst others, this allows to meet the growing demands for customisation and adaptability of production or enables predictive maintenance. This evolution is further supported by the increasing vertical and horizontal integration of every step of the industrial production process, potentially allowing an uninterrupted and end-to-end communication from suppliers to customers and the integration of all relevant business units (e.g. sales, logistics, etc.).

> "We flirted with virtual reality applications but there have been no concrete actions until now. At the moment we are **focusing much more on 'front-end' innovations** to **improve the experience of our customers**."
> (Employee & Works Council Member, Belgium)

Table 7 gives an indication of how "smart" the chemical industry currently is regarding their production and operational processes. Considering all survey respondents, the analysis shows that the indicators measuring the degree of automation and flexibility of current production and maintenance processes receive lower scores compared to other indicators within this dimension. Across all chemical sectors, **automation is at its highest level within the basic chemicals sector**.

The indicators for **horizontal and vertical integration** of existing business processes receive somewhat **better ratings**. As for the previous two indicators, respondents from the specialty chemicals sector assess the aspect of horizontal and vertical integration more poorly than respondents from the other three sectors.

Table 7: Digital maturity within the dimension of "Smart Production & Operations"

Digital Maturity Index

Dimension	BC	SC	PH	RP	All. resp
Skills & Lifelong Learning	3.26	3.14	3.04	2.96	3.04
Organisation of Work	3.18	3.22	3.12	3.01	3.10
Digital Transformation Management	3.22	3.04	2.90	2.93	2.97
Smart Production & Operations	3.18	2.93	3.03	3.11	3.05
Smart Product & Service Innovation	3.08	3.07	3.05	2.99	3.07
Overall assessment	**3.08**	**3.07**	**3.05**	**2.99**	**3.07**

Indicator	BC	SC	PH	RP	All. resp
Degree of automation	● (yellow)	● (red)	● (orange)	● (orange)	● (orange)
Degree of flexibility	● (orange)	● (orange)	● (orange)	● (orange)	● (orange)
Horizontal process integration	● (yellow)	● (orange)	● (yellow)	● (yellow)	● (yellow)
Vertical process integration	● (yellow)	● (orange)	● (yellow)	● (yellow)	● (yellow)

● (red) < 2,85 ● (orange) 2,85 - 3,10 ● (yellow) 3,10 - 3,35 ● (green) >= 3,35

Note: Basic Chemicals: n=61-63; Specialty Chemicals: n=64-66; Pharmaceutical: n=67-70; Rubber & Plastics: n=63-66

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). All survey respondents: n= 344-384. Icons: Copyright Flaticon.

Other important drivers of the digital transformation in the chemical industry are related to the rise of opportunities in terms of new business models (e.g. pay-by-use systems for software applications, equipment and machinery) or new digitised products and services (e.g. real-time technical recommendations to customers). Table 8 shows that, in this regard, the chemical industry seems to be **further advanced in the development of new digital business models than in the development of "smart" products and services**. This, however, is less true for the rubber & plastics sector (see Annex 26).

Further, the previously described horizontal integration with customers and/or suppliers can be used to analyse and involve the latter more closely in the development of new innovative products (i.e. "Smart Innovation Management"). Again, the four chemical sectors seem to be less advanced in smart innovation management as compared to the development of new business models.

Table 8: Digital maturity within the dimension of "Smart Product & Service Innovation"

Digital Maturity Index					
Dimension	**BC**	**SC**	**PH**	**RP**	**All. resp**
Skills & Lifelong Learning	3.26	3.14	3.04	2.96	3.04
Organisation of Work	3.18	3.22	3.12	3.01	3.10
Digital Transformation Management	3.22	3.04	2.90	2.93	2.97
Smart Production & Operations	3.18	2.93	3.03	3.11	3.05
Smart Product & Service Innovation	3.08	3.07	3.05	2.99	3.07
Overall assessment	**3.08**	**3.07**	**3.05**	**2.99**	**3.07**

Indicator	**BC**	**SC**	**PH**	**RP**	**All. resp**
Smart products & services	orange	orange	orange	orange	orange
Smart business models	yellow	yellow	yellow	orange	yellow
Smart innovation management	yellow	orange	orange	orange	orange

red: < 2,85; orange: 2,85 - 3,10; yellow: 3,10 - 3,35; green: >= 3,35

Note: Basic Chemicals: n=62-63; Specialty Chemicals: n=63; Pharmaceutical: n=76; Rubber & Plastics: n=63-65

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). All survey respondents: n= 344-384. Icons: Copyright Flaticon.

4 Conclusions and Outlook

The objective of the study was to provide answers on the level of digital maturity of the sector, to identify sector-specific challenges and, most importantly, to determine the potential impacts of digital transformation on skills, qualifications, working patterns and health and safety. The research findings show that the European chemical industry has made **visible progress in the digital transformation**, both in terms of technology and in the "new world of work". At the same time, **numerous challenges** lie ahead which need to be carefully and rapidly addressed.

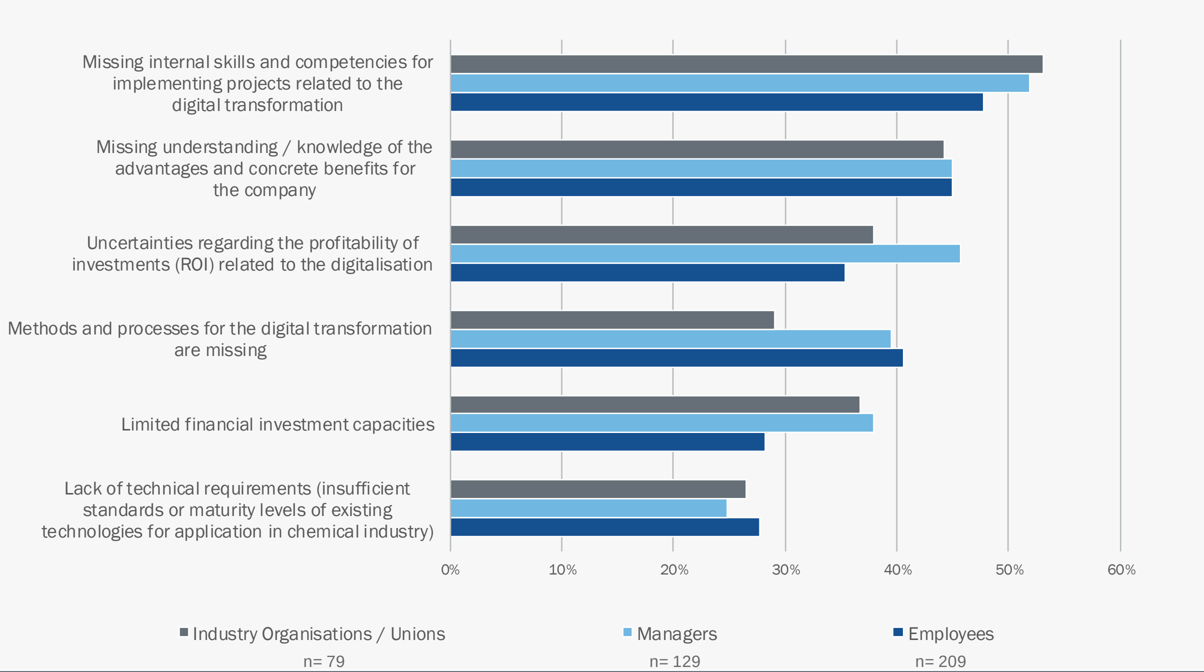
Based on the comprehensive empirical basis, including a large online-survey with 500 respondents from across the EU Member States, more than 20 interviews, two conferences and additional steering group discussions and desk research, **six overall conclusions on the digital transformation in the workplace of the European chemicals sector** have been drawn:

Overall conclusions
7. The **1st wave of the digital transformation** (i.e. digitising analogue data and integrating cloud solutions) is successfully accomplished in the European chemicals sector. However, the implementation rate increases with the company size: especially the implementation rate of digital solutions in micro and small enterprises (<50 employees) is lagging.
8. The **2nd wave of the digital transformation** will be driven by the Industrial Internet of Things, Big Data, Artificial Intelligence, automation and augmented reality – and it will come into effect in the near future (within the next 5 years). The transformation around **AI** might cause more drastic implementation gaps between very large enterprises and SMEs.
9. A **shift in skills in the European chemicals sector is clearly visible** – basic digital skills are broadly existing in the sector. However, more advanced digital skills & transversal skills require attention by all stakeholders in the industry. Especially SMEs currently lack dedicated training programmes for digital upskilling and rate their digital skills less positive than larger firms.
10. The **working environment** in the chemicals sector is predominantly changed through mobile working with greater employee autonomy but also an increased level of multi-tasking. Close attention needs to be paid to the level of psychological stress, which is expected to increase significantly due to digitalisation, especially in larger firms.
11. Collective agreements need to pay greater attention to the issue of mobile working & working-time arrangements and qualification. Other sensitive issues linked to the digital transformation (data protection, performance monitoring) also need to be addressed with collective agreements or accompanied by other initiatives (e.g. open dialogue processes).
12. Change management and the **involvement & support of employees** is currently the biggest challenge in the digital transformation process of the European chemicals sector. It is decisive to address this to allow for a successful transformation. The digital maturity assessment shows little variance across Member States and sectors. Southern and Eastern Europe are more likely to have greater challenges. In these regions the issue of employee participation seems to be addressed less by collective agreements at national, regional or sectoral level.

Transformation processes, especially those with far-reaching implications such as digitalisation, are always accompanied by uncertainty. Figure 29 presents a summary of the **greatest challenges perceived by employees, managers and industry organisations and unions.**

Figure 29: Biggest challenges for a successful digital transformation

In conclusion, what are the biggest challenges for a successful digital transformation of your company?



Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018), n=79-209.

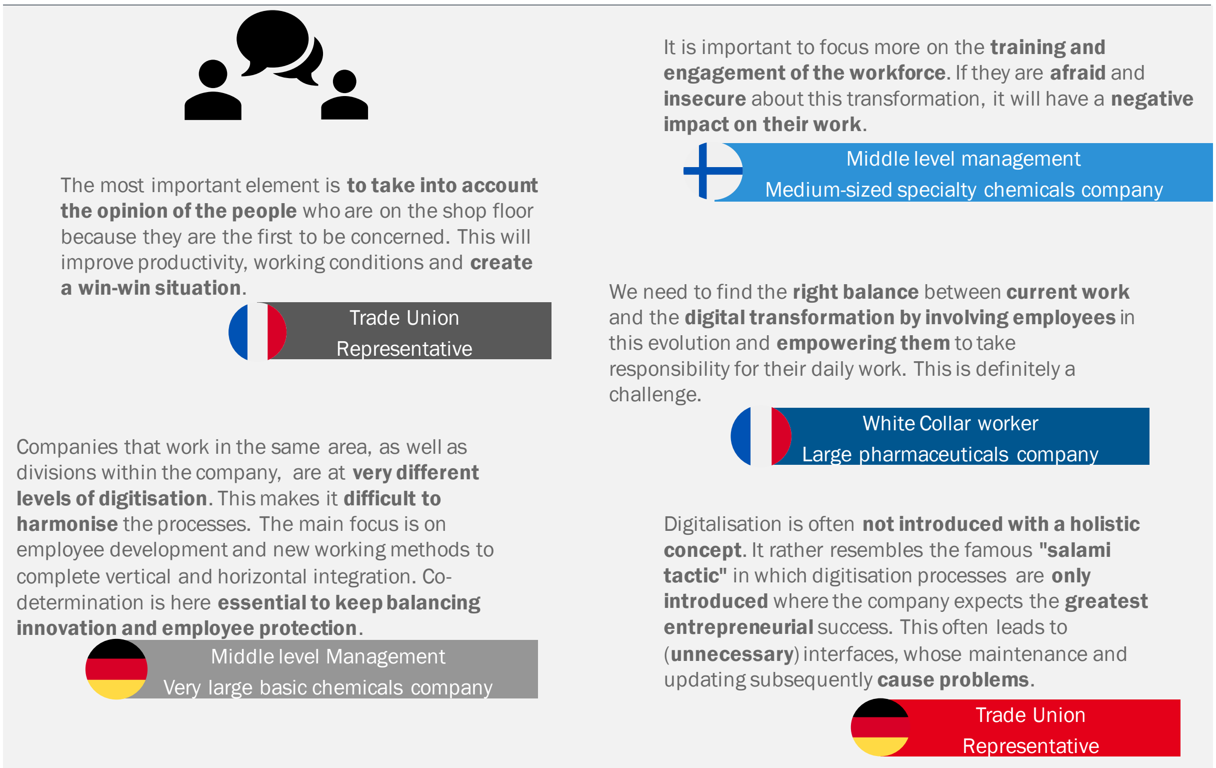
Besides the challenging issue of **missing advanced digital skills** in the industry, which has been discussed in detail in Chapter 3.2 and the conclusion in this section, three additional **key challenges** require the special attention of decision makers in the chemical industry and of the social partners:

1. **Lack of understanding about the advantages of digitalisation:** across the board, managers, employees and industry organisations as well as union representatives report a lack of understanding or knowledge about the specific benefits of digitalisation for companies in the different chemical sectors. This indicates that a more differentiated discussion about digital transformation in the sector is needed which prioritises thinking about the customer needs, business model and employee competencies and, in a second step, asks in how far digital solutions can be supportive.
2. **Uncertain returns from digital investments:** aligned with the above, especially managers in the chemicals sector are not fully confident in the returns of digital investments. Almost 50% of the survey respondents confirm this uncertainty. Besides technological complexities and ongoing R&D for many digital solutions, this finding underlines the need for a clear perspective on the purpose of digitalisation in any company's business model.
3. **Lack of methods and processes for the digital transformation:** for 40% of the 200 company representatives in the online survey, the "how" of digital transformation in terms of methods

and processes is unclear. This finding shows that transformation management competencies, alongside of a clear understanding of the desired digital transformation path (strategy), is crucial and will become even more so in the next few years given the technological progress on digital solutions. This goes hand in hand with the need for internal skills for implementing projects related to the digital transformation.

Several **survey participants mentioned additional challenges** linked to the digital transformation in the workplace of the chemicals sectors, as illustrated in the quotes below:

Figure 30: Specific challenges seen by survey participants associated with the digital transformation of the European chemicals sector



Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). Icons: Copyright Flaticon.

Overall, the analysis of this study underlines that **digital transformation** in the European chemicals sector needs to be addressed with a **holistic approach** as presented in the “Digital Maturity Model” of this study. It needs to be driven by a clear understanding of

- the **customer needs** (Do digitalisation plans meet customer needs better?),
- the **company’s business model** (Is digitalisation improving the business model?) and
- the **internal experiences and competencies of people** (Do we have the necessary skills? How can we develop them internally?).

Knowledge is getting increasingly easier to access (online) and cheaper while digital tools are more and more powerful. **Qualifications and creativity of the workforce** remain both the key differentiator and a competitive advantage of the sector. Investments in employees become ever more important. At the same time, it needs to be ensured that the right strategies for education and training are in place at company, government and stakeholder level to master the vast skills shift. Further, it must be made sure that working conditions, co-determination and health & safety are equally addressed in a social dialogue that characterises and strengthens the European social market economy.

Finally, we need to remind ourselves that this **digital transformation is not a technological but also a cultural and social transformation** and that it is not happening in a vacuum but in the context of **global competition**. China is among the top three regions in the world for venture-capital investment in key digital technologies for the chemicals sectors, including virtual reality, robotics, drones, and Artificial Intelligence[72], alongside enormous investments by the government under the "Made in China 2025" strategy. Likewise, the US chemicals sector is transforming itself through major investments that were made or are planned in order to build more efficient (digital) and larger plants[73]. At the same time, the resource-intensive US base chemicals sector – a core of the European chemical industry as well – profits from low energy and feedstock costs as result of the US shale gas revolution.

The social partners and all relevant stakeholders of the European chemical, pharmaceutical, rubber and plastics industry need to find joint answers to accompany the transformation of the sector into the digital age. Actions need to be made with care and speed at the same time.

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[73] Prognos AG & Verband der Chemischen Industrie e. V. (2016): Die deutsche chemische Industrie 2030 - Update 2015/2016, Frankfurt.

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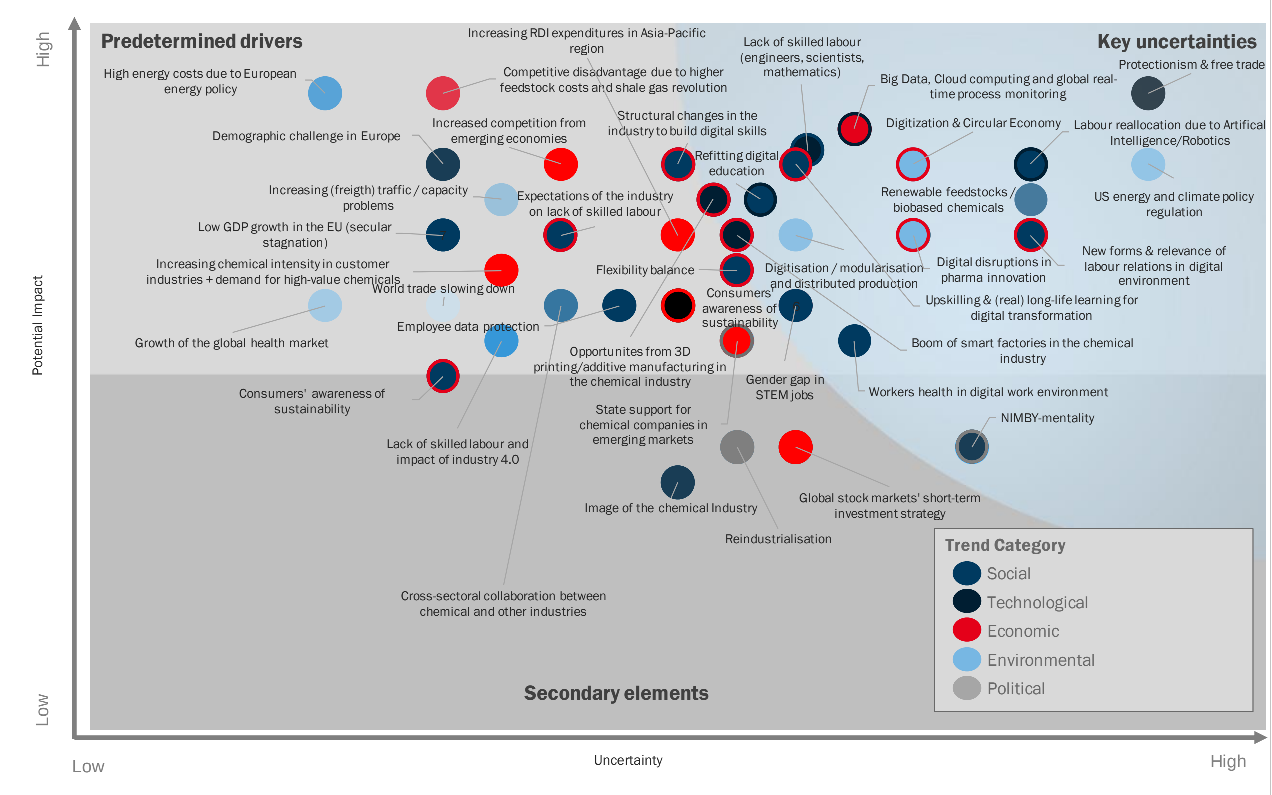
6 Annex

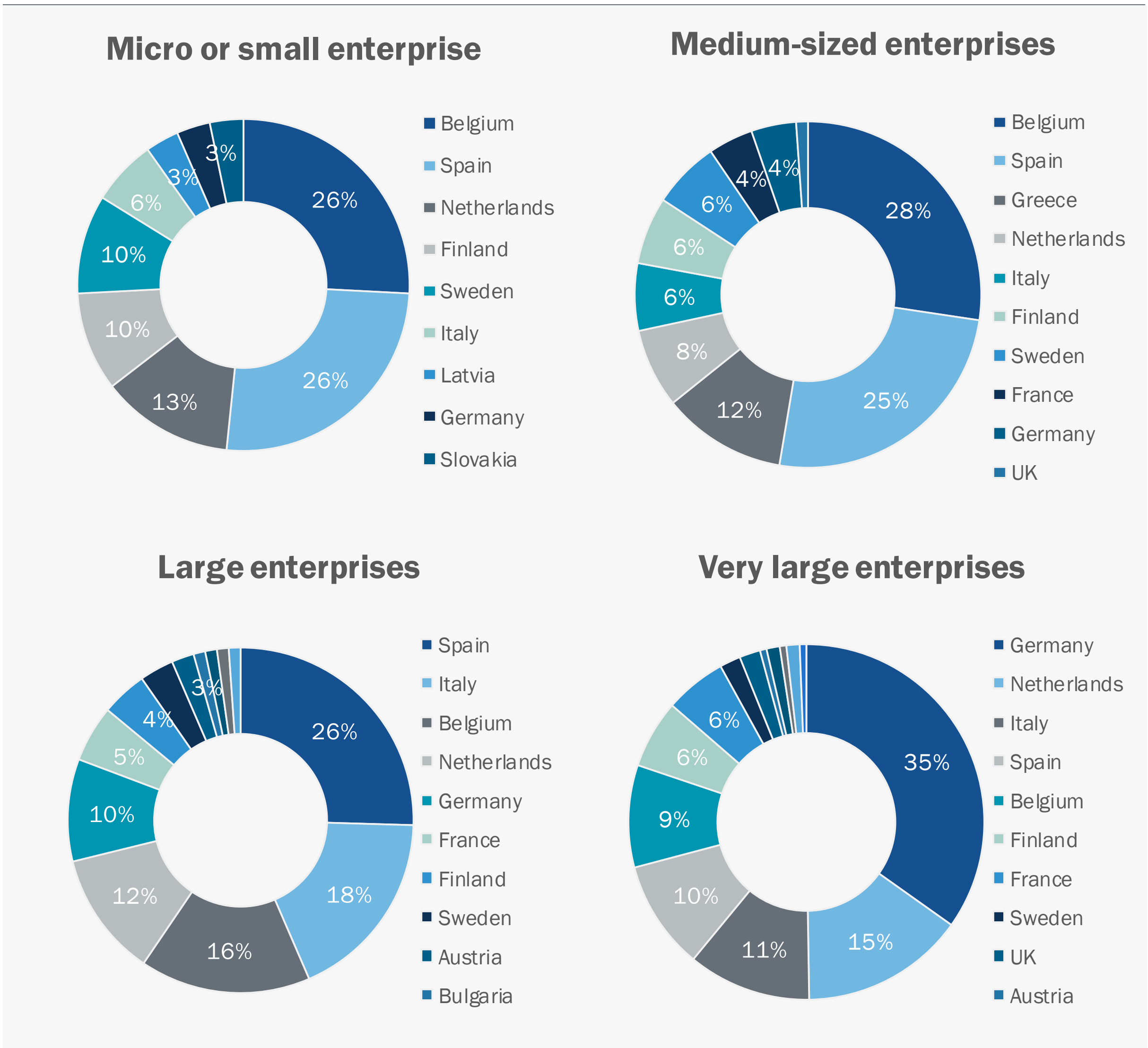
Annex 1: STEEP Analysis - potential influencing trends, uncertain developments and weak signals in the chemical industry up to 2030



Predetermined drivers: (upper left part) are predictable factors with high impact on a successful future development.
Key uncertainties: (upper right part) are factors whose development is uncertain but with possible high impact.
Secondary elements: (bottom part) Have a certain impact on the chemical industry, however, are less relevant for the future

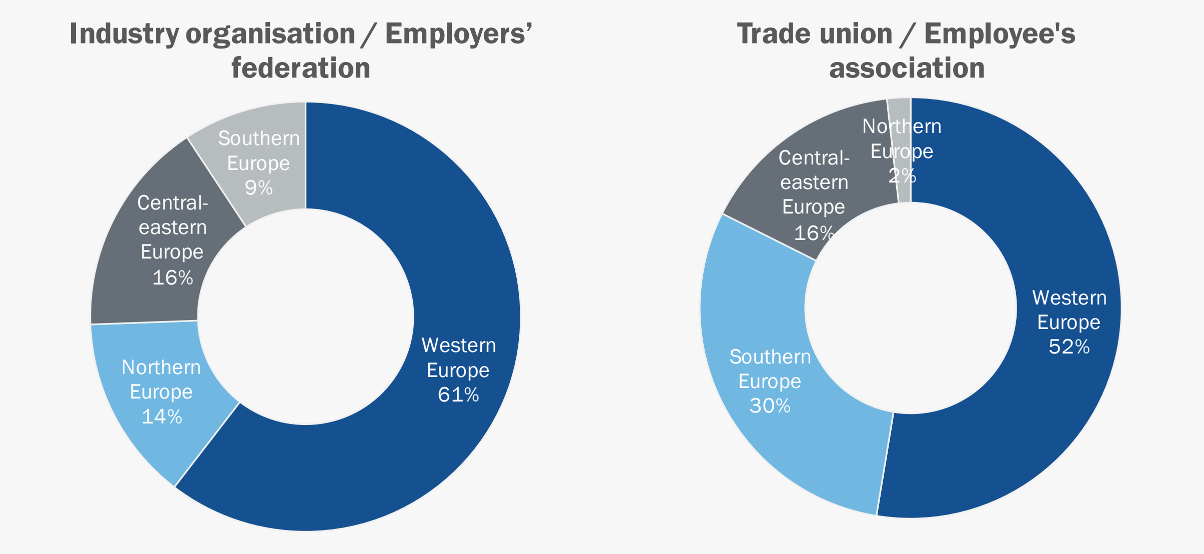
Source: Prognos AG (2019), based on desk research and interviews. **Note:** The depicted trends and uncertainties were analysed, rated and validated by means of desk research and assigned to one of the five interdependent trend areas: social, technological, economic, environmental and political.

Annex 2: Companies' participation across countries



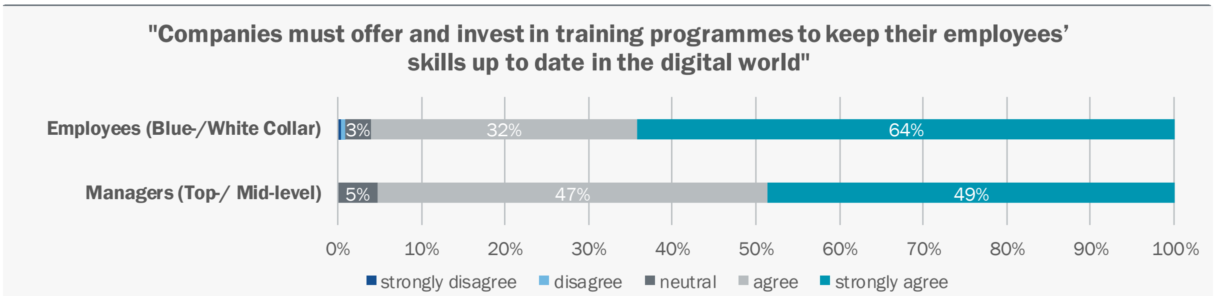
Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). Micro or small enterprise n=46; Medium-sized enterprises n=95; Large enterprises n=94; Very large enterprises n=161.

Annex 3: Industry organisations' and trade unions' participation across country cluster



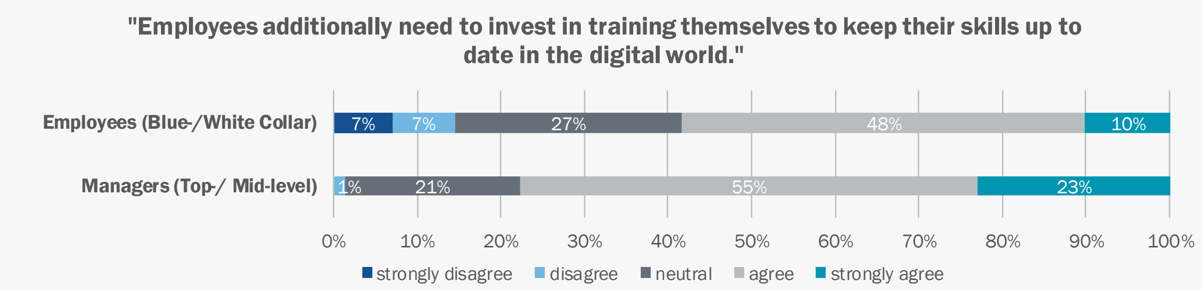
Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). n=43-57.

Annex 4: Assessment of the role of companies for providing training programmes to keep their employees' skills up to date



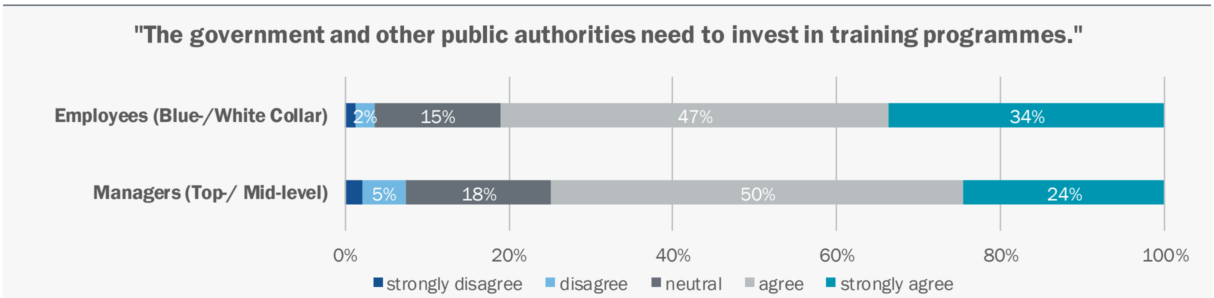
Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). n=148-229.

Annex 5: Assessment of the role of employees to keep their skills up to date



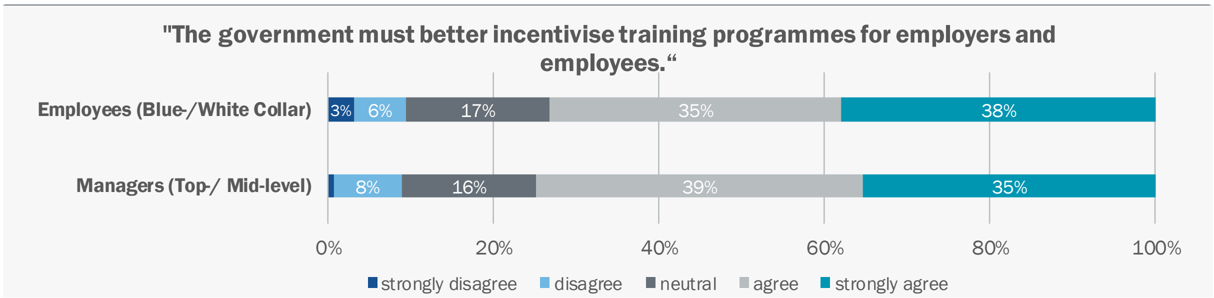
Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). n=148-228.

Annex 6: Assessment of the role of public authorities for investments in training programmes



Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). n=147-226.

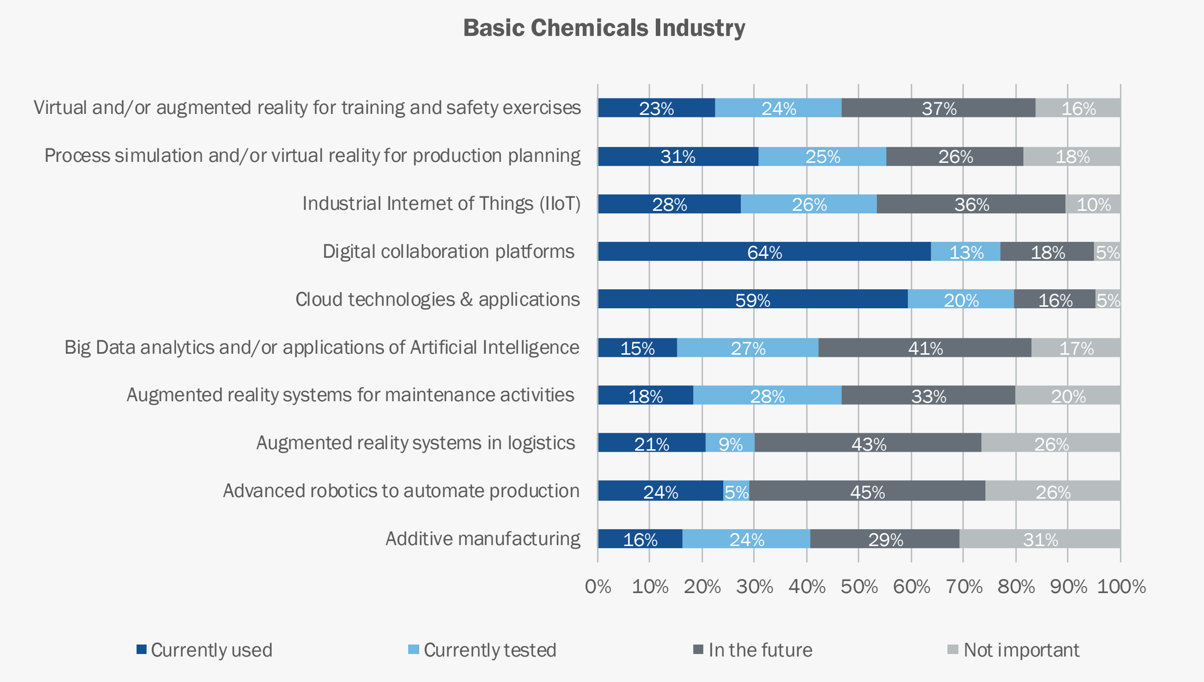
Annex 7: Assessment of the role of governments for incentivising investments in training programmes



Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). n=147-224.

Annex 8: Application of digital technologies in the basic chemical industry

Which of the following digital technologies are already used in your company/industry or are planned to be implemented in the future?

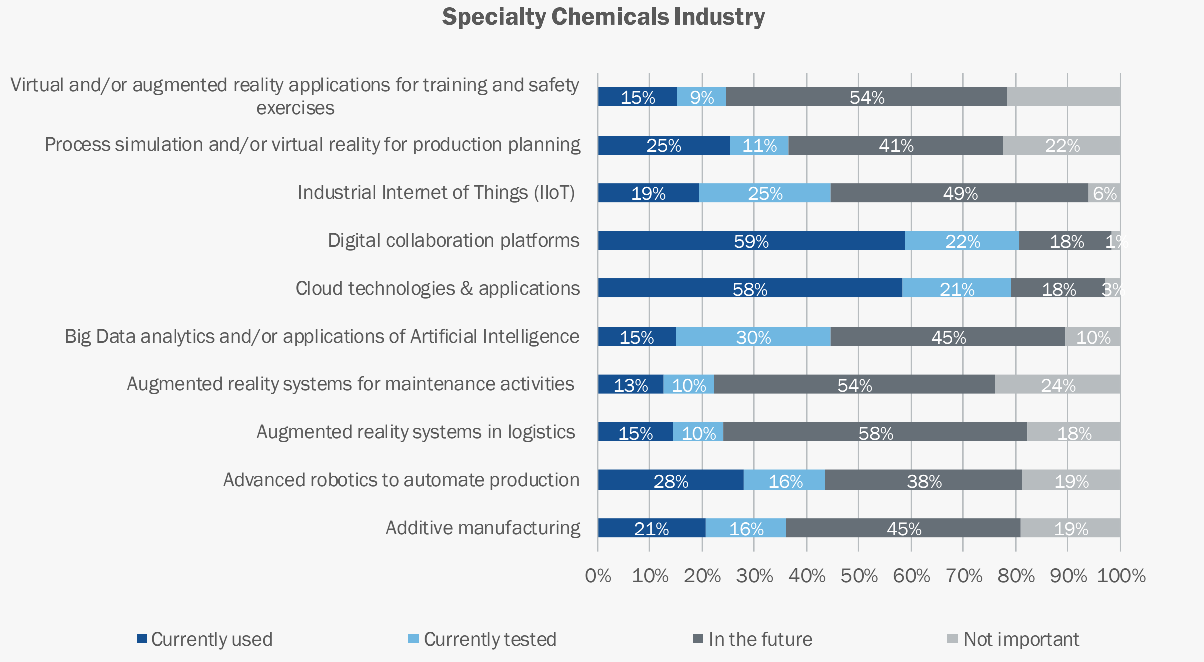


Note: The sector-specific analysis includes only responses from company representatives (managers & employees).

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). n=49-65.

Annex 9: Application of digital technologies in the specialty chemical industry

Which of the following digital technologies are already used in your company/industry or are planned to be implemented in the future?

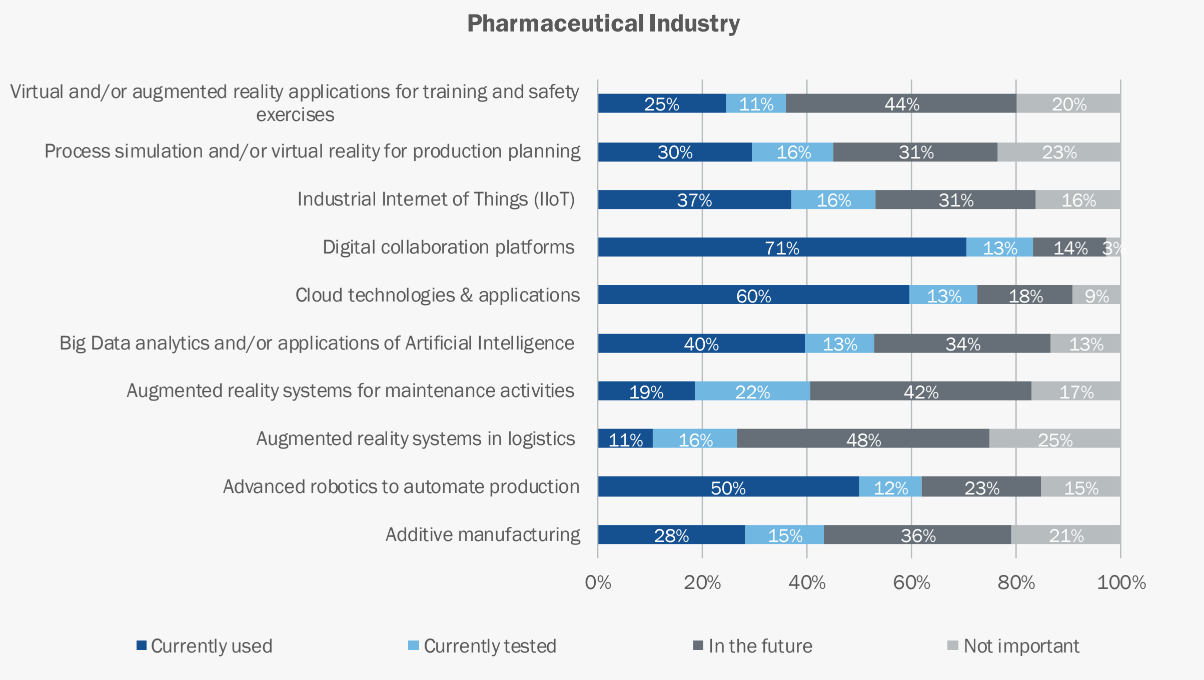


Note: The sector-specific analysis includes only responses from company representatives (managers & employees).

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). n=58-72.

Annex 10: Application of digital technologies in the pharmaceutical industry

Which of the following digital technologies are already used in your company/industry or are planned to be implemented in the future?

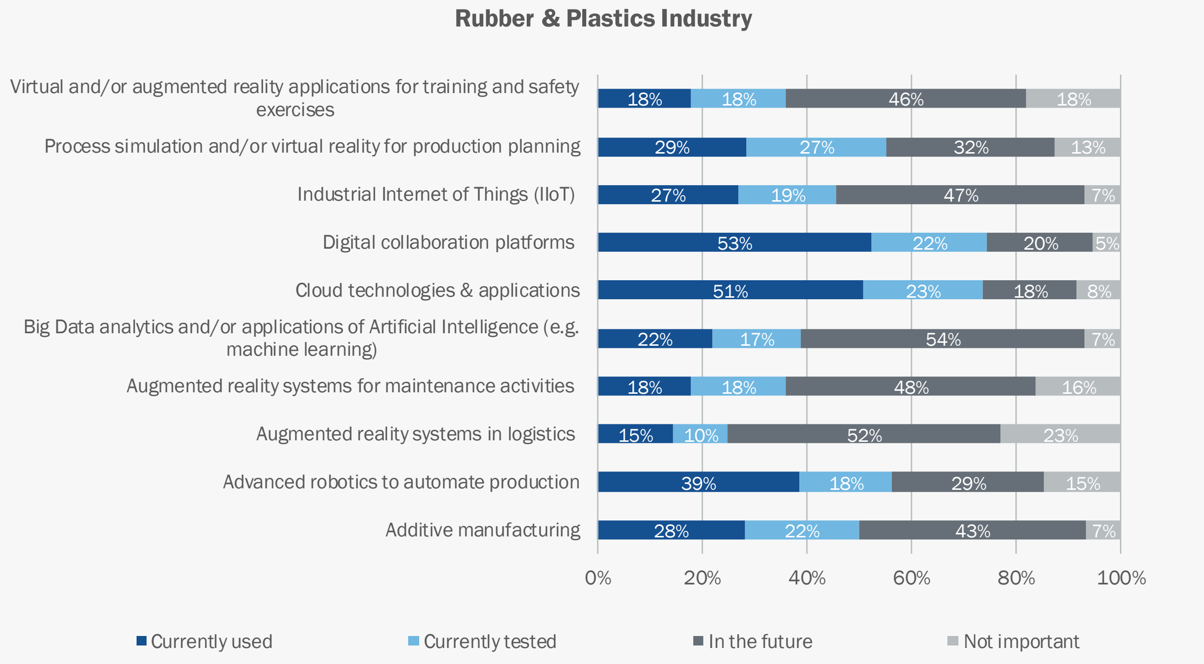


Note: The sector-specific analysis includes only responses from company representatives (managers & employees).

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). n=53-77.

Annex 11: Application of digital technologies in the rubber & plastics industry

Which of the following digital technologies are already used in your company/industry or are planned to be implemented in the future?

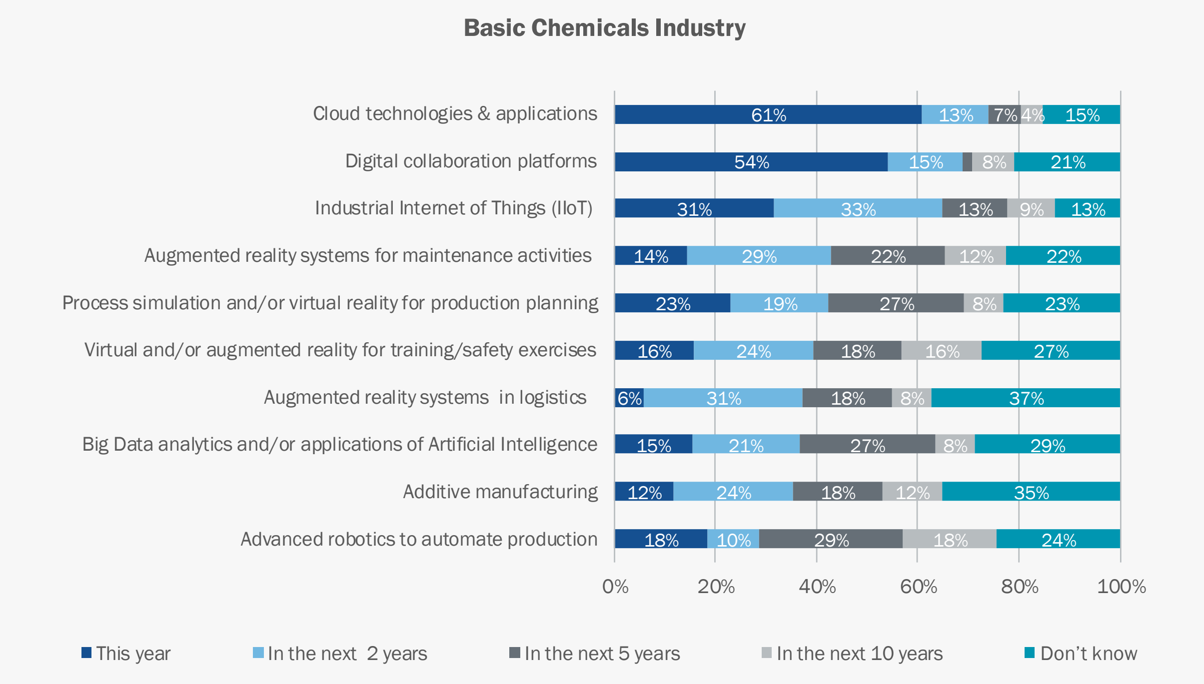


Note: The sector-specific analysis includes only responses from company representatives (managers & employees).

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). n=46-61

Annex 12: Timeframe for the utilisation of digital technologies in the basic chemical industry

Please indicate the timeframe for the utilisation of the previously mentioned digital technologies

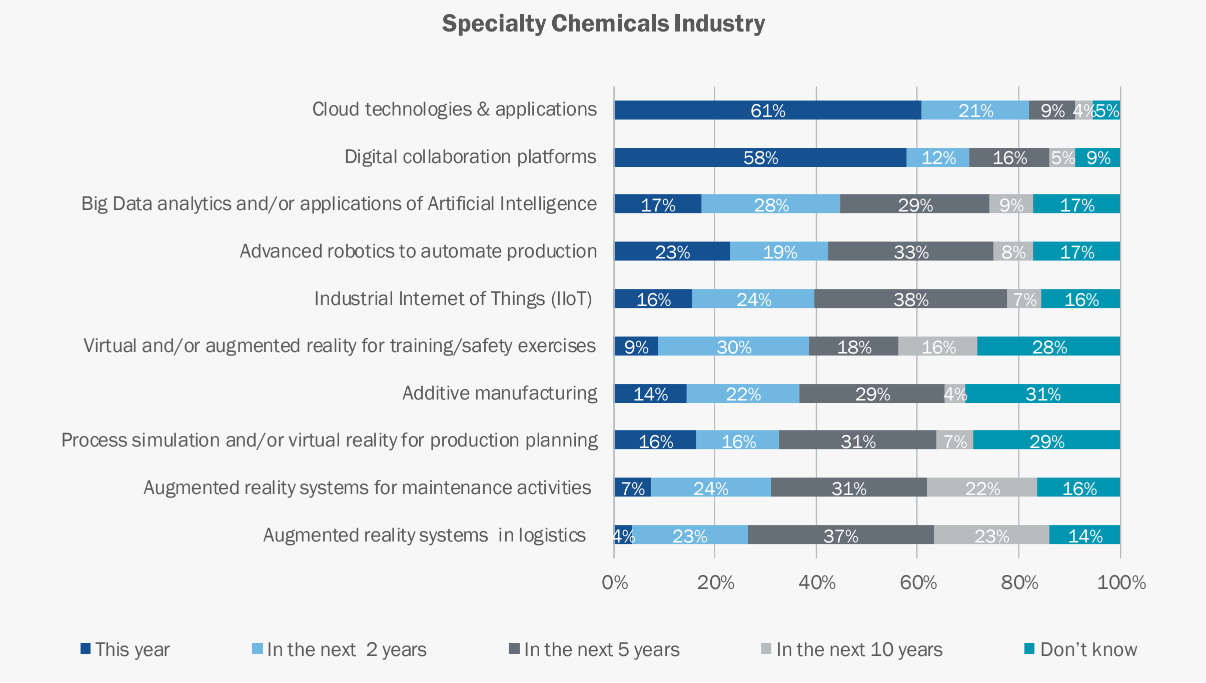


Note: This question was only asked when the survey participant previously answered: "currently tested" or "in the future" for at least one of the listed technologies. The sector-specific analysis includes only responses from company representatives (managers & employees).

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). n=34-54.

Annex 13: Timeframe for the utilisation of digital technologies in the specialty chemical industry

Please indicate the timeframe for the utilisation of the previously mentioned digital technologies

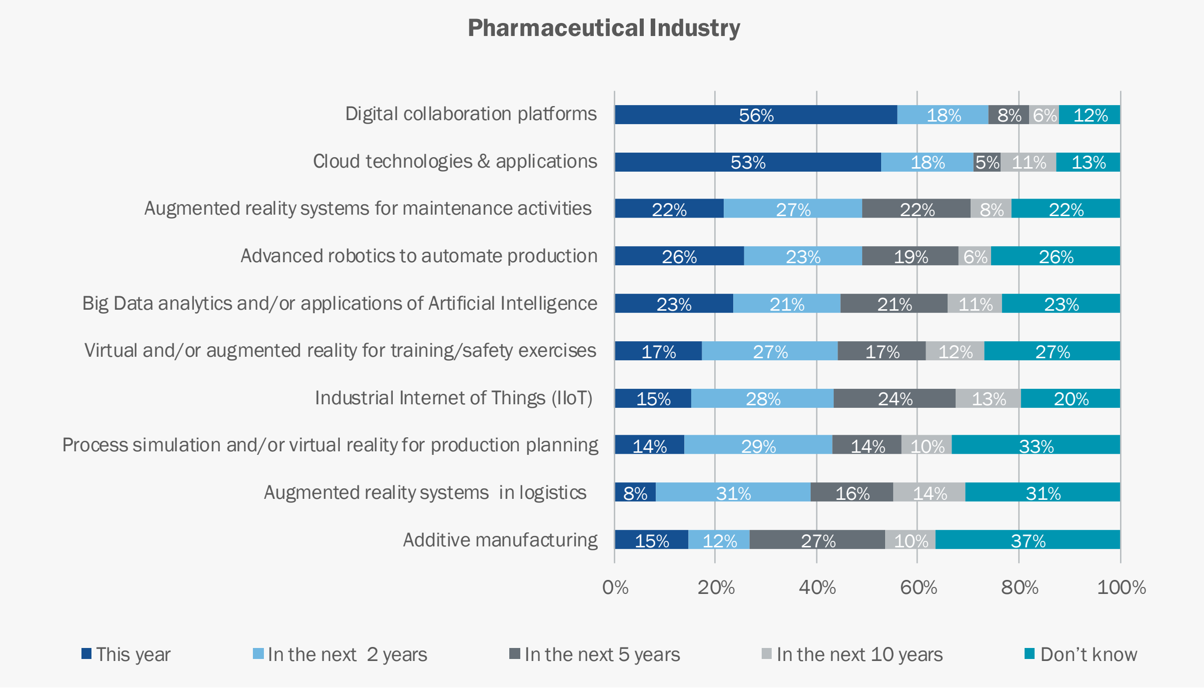


Note: This question was only asked when the survey participant previously answered: "currently tested" or "in the future" for at least one of the listed technologies. The sector-specific analysis includes only responses from company representatives (managers & employees).

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). n=49-58.

Annex 14: Timeframe for the utilisation of digital technologies in the pharmaceutical industry

Please indicate the timeframe for the utilisation of the previously mentioned digital technologies

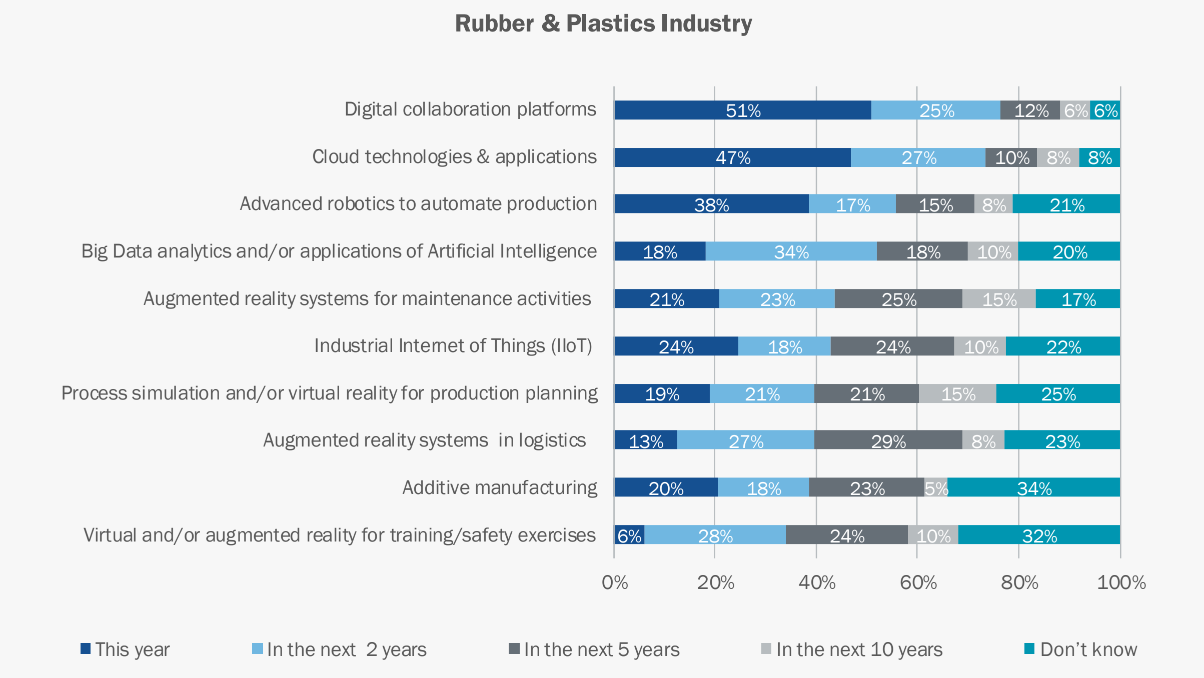


Note: This question was only asked when the survey participant previously answered: "currently tested" or "in the future" for at least one of the listed technologies. The sector-specific analysis includes only responses from company representatives (managers & employees).

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). n=41-55.

Annex 15: Timeframe for the utilisation of digital technologies in the rubber & plastics industry

Please indicate the timeframe for the utilisation of the previously mentioned digital technologies

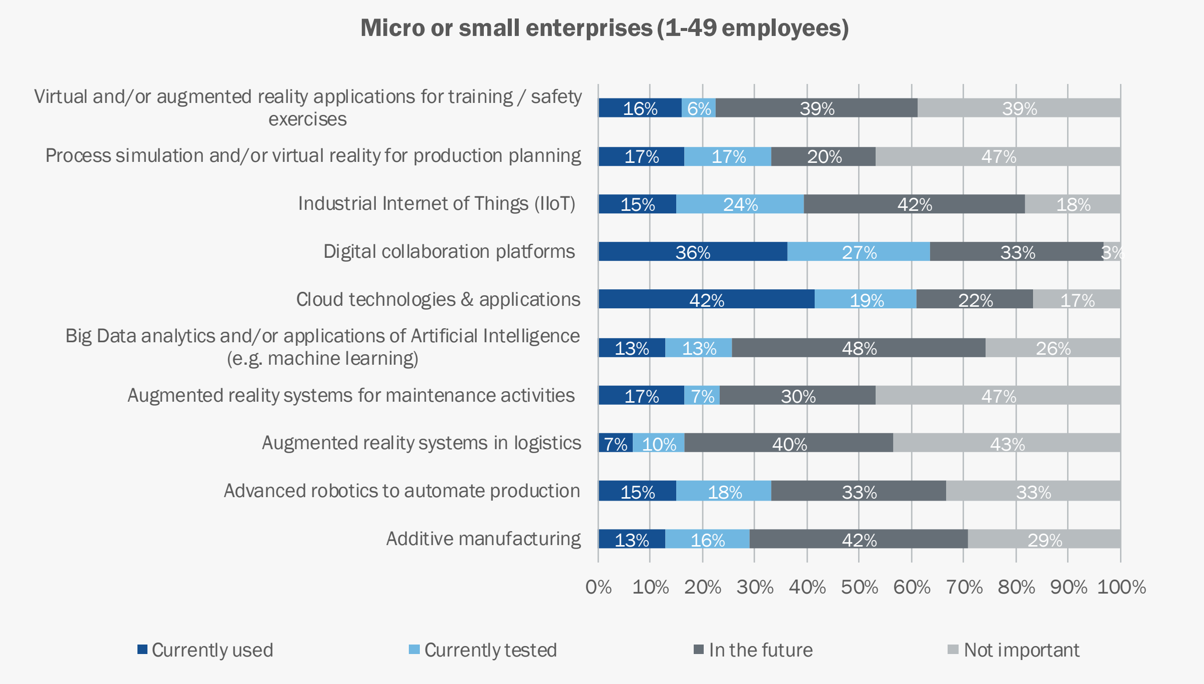


Note: This question was only asked when the survey participant previously answered: “currently tested” or “in the future” for at least one of the listed technologies. The sector-specific analysis includes only responses from company representatives (managers & employees).

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). n=44-53.

Annex 16: Application of digital technologies in micro or small enterprises

Which of the following digital technologies are already used in your company/industry or are planned to be implemented in the future?

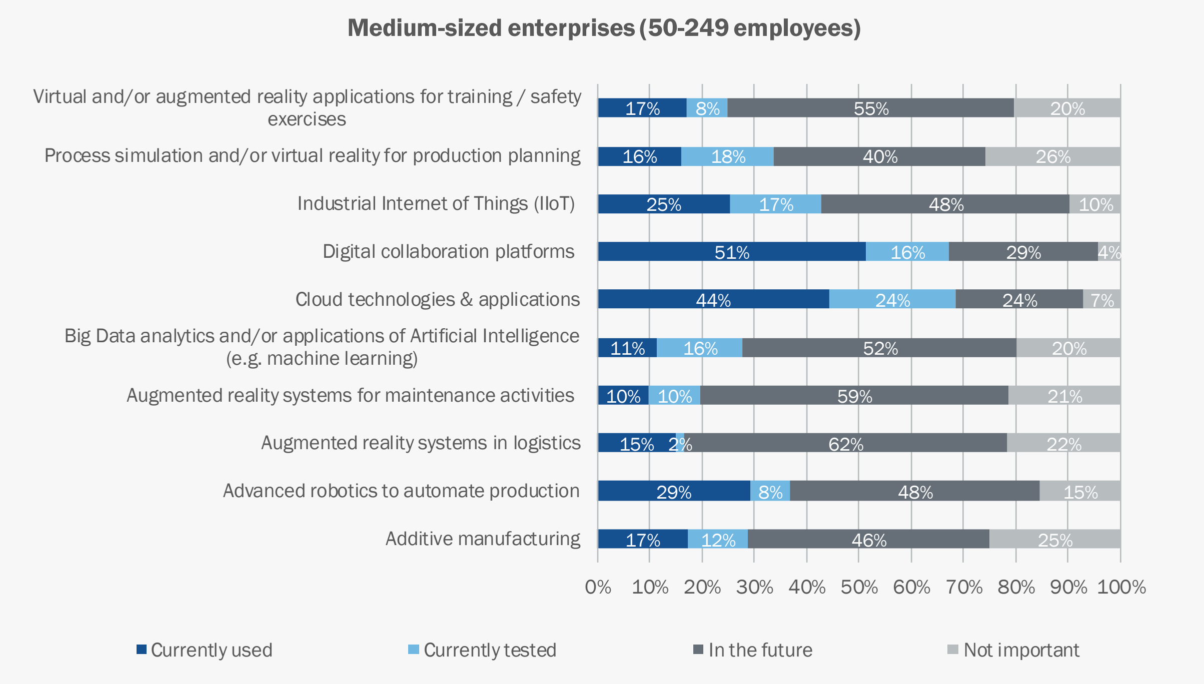


Note: The analysis across company sizes includes only responses from company representatives (managers & employees).

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). n=30-36.

Annex 17: Application of digital technologies in medium-sized enterprises

Which of the following digital technologies are already used in your company/industry or are planned to be implemented in the future?

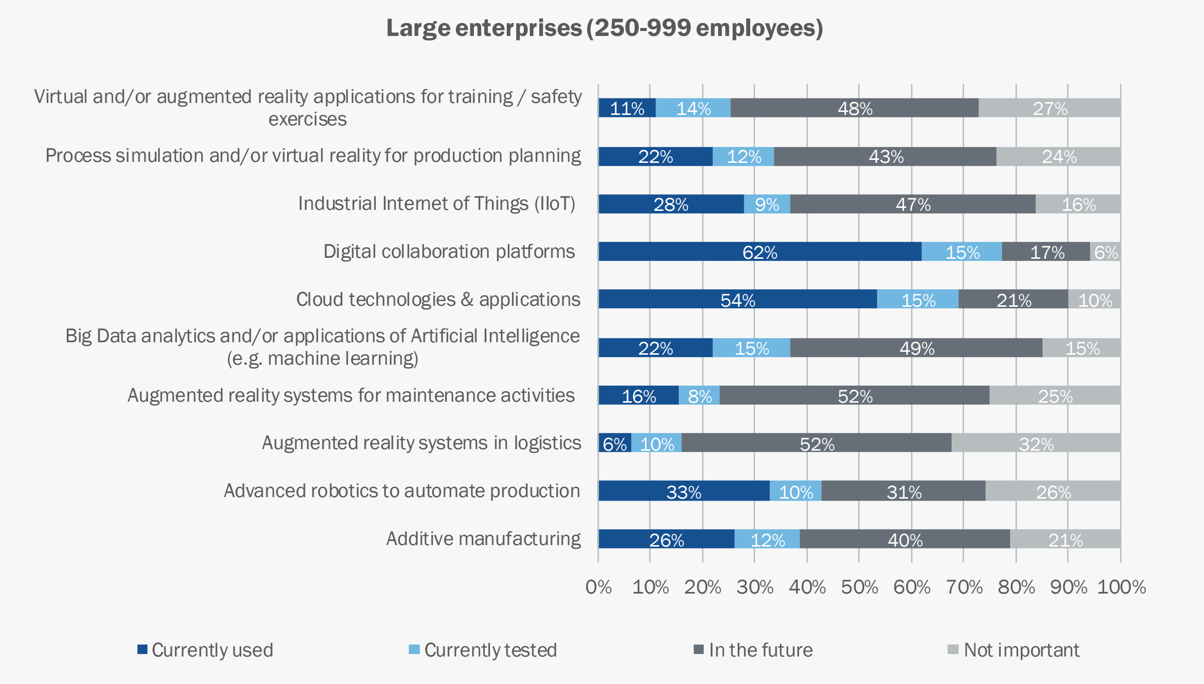


Note: The analysis across company sizes includes only responses from company representatives (managers & employees).

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). n=52-70.

Annex 18: Application of digital technologies in large enterprises

Which of the following digital technologies are already used in your company/industry or are planned to be implemented in the future?

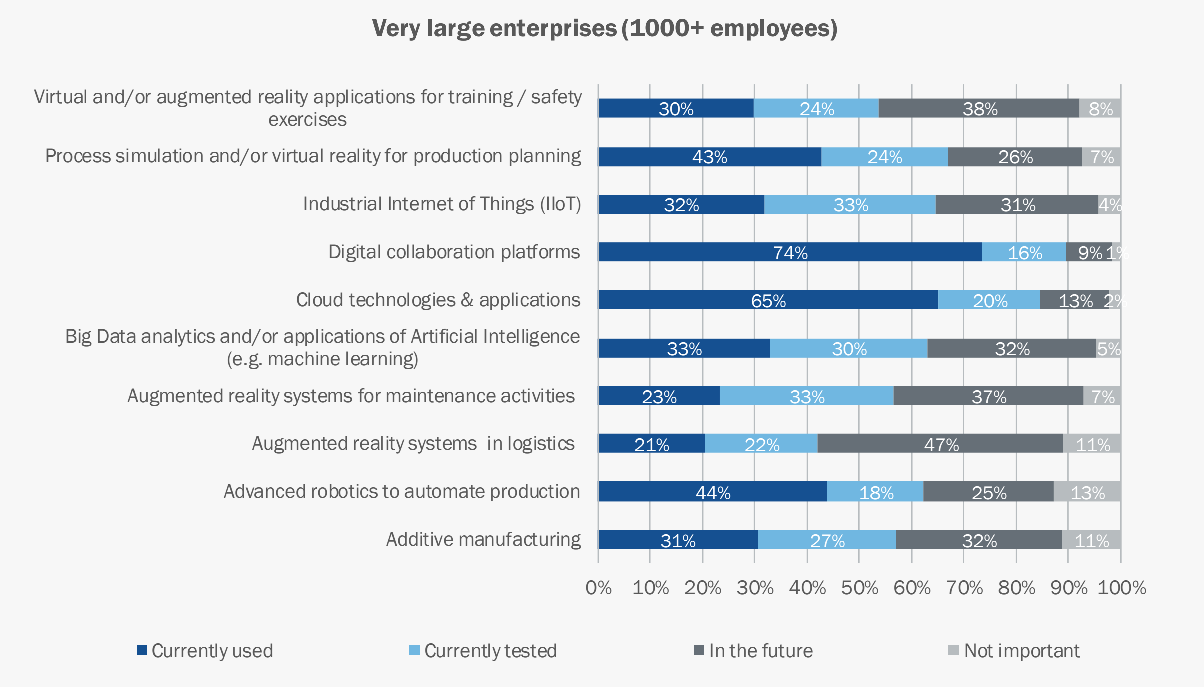


Note: The analysis across company sizes includes only responses from company representatives (managers & employees).

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). n=57-71.

Annex 19: Application of digital technologies in very large enterprises

Which of the following digital technologies are already used in your company/industry or are planned to be implemented in the future?

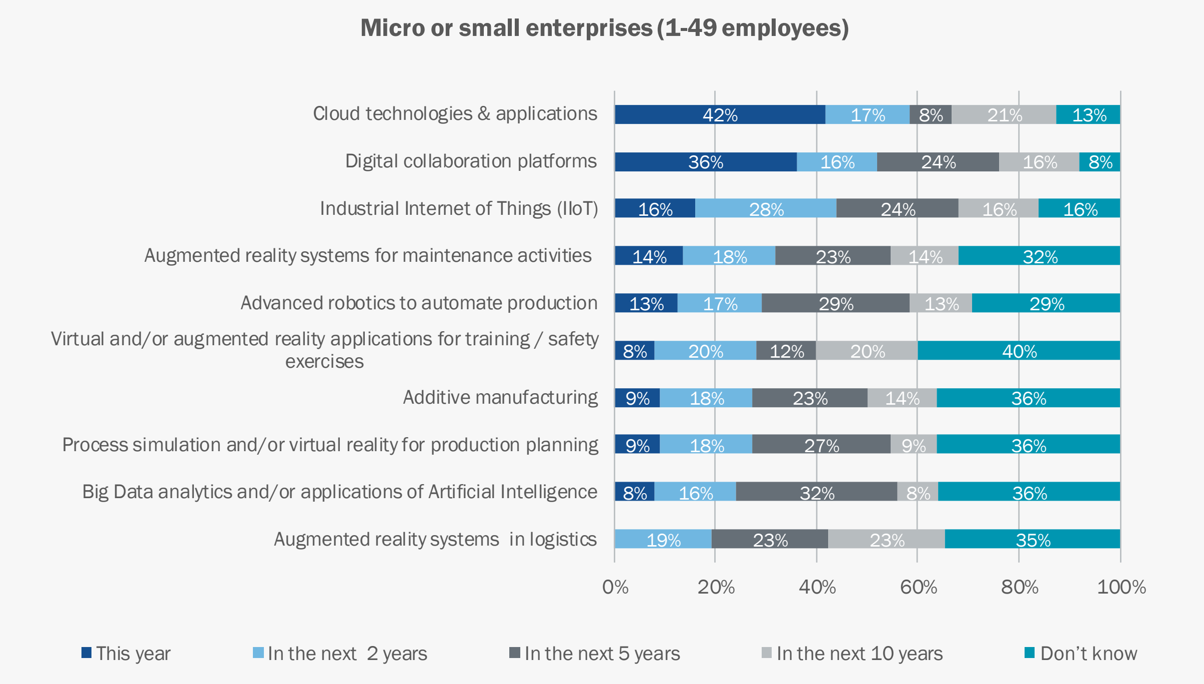


Note: The analysis across company sizes includes only responses from company representatives (managers & employees).

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). n=98-138.

Annex 20: Timeframe for the utilisation of digital technologies in micro or small enterprises

Please indicate the timeframe for the utilisation of the previously mentioned digital technologies

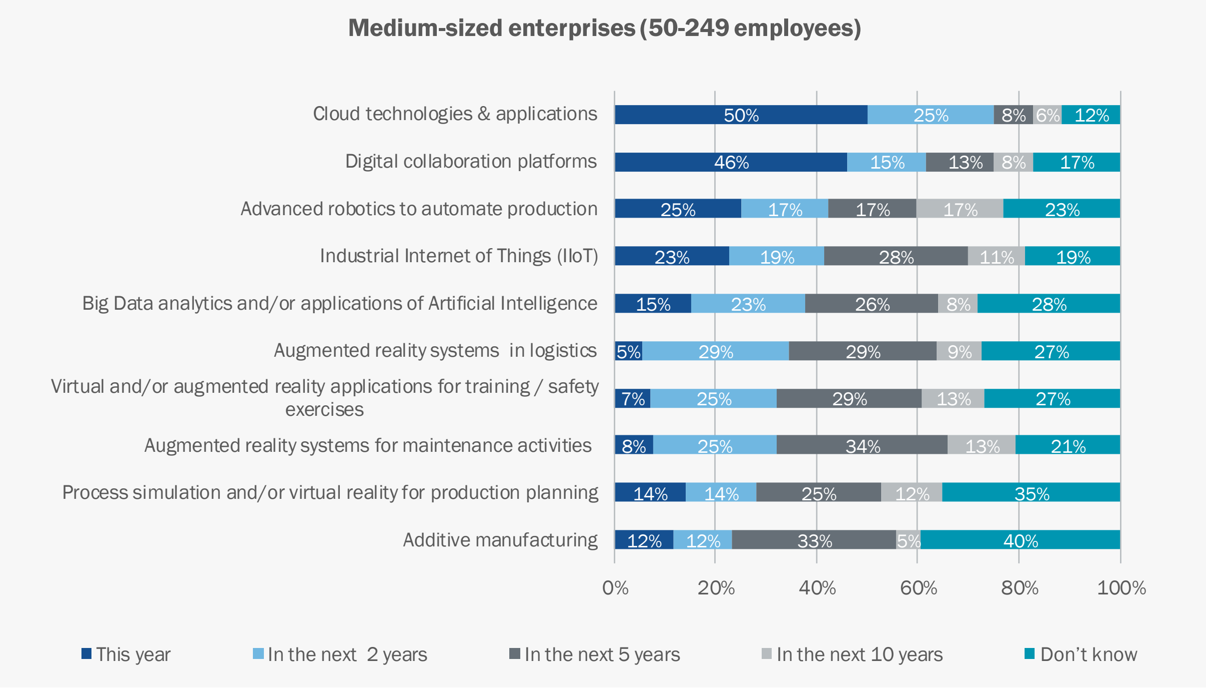


Note: This question was only asked when the survey participant previously answered: "currently tested" or "in the future" for at least one of the listed technologies. The analysis across company sizes includes only responses from company representatives (managers & employees).

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). n=22-26.

Annex 21: Timeframe for the utilisation of digital technologies in medium-sized enterprises

Please indicate the timeframe for the utilisation of the previously mentioned digital technologies

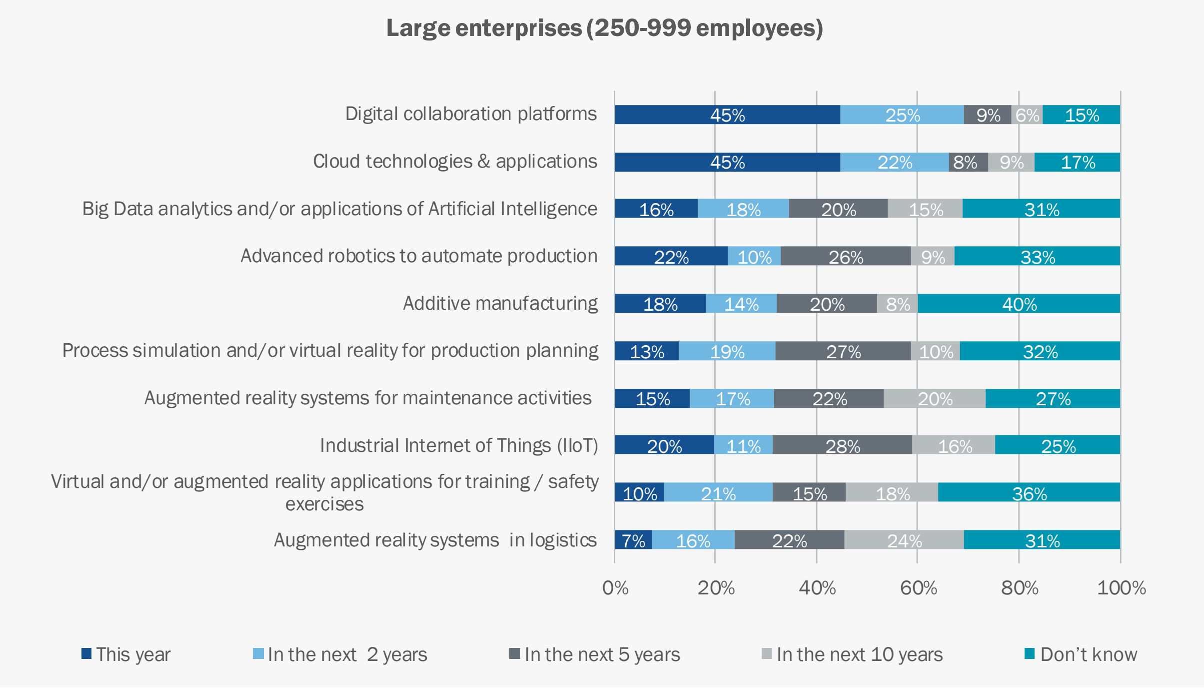


Note: This question was only asked when the survey participant previously answered: "currently tested" or "in the future" for at least one of the listed technologies. The analysis across company sizes includes only responses from company representatives (managers & employees).

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). n=43-57.

Annex 22: Timeframe for the utilisation of digital technologies in large enterprises

Please indicate the timeframe for the utilisation of the previously mentioned digital technologies

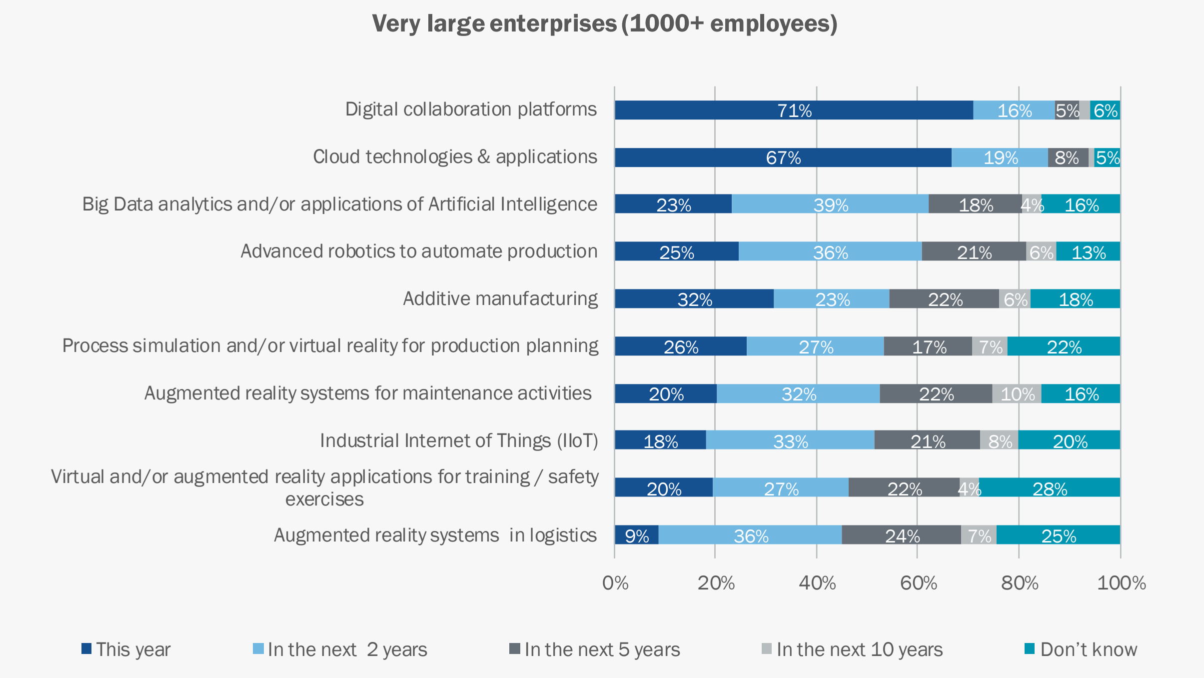


Note: This question was only asked when the survey participant previously answered: "currently tested" or "in the future" for at least one of the listed technologies. The analysis across company sizes includes only responses from company representatives (managers & employees).

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). n=50-65.

Annex 23: Timeframe for the utilisation of digital technologies in very large enterprises

Please indicate the timeframe for the utilisation of the previously mentioned digital technologies

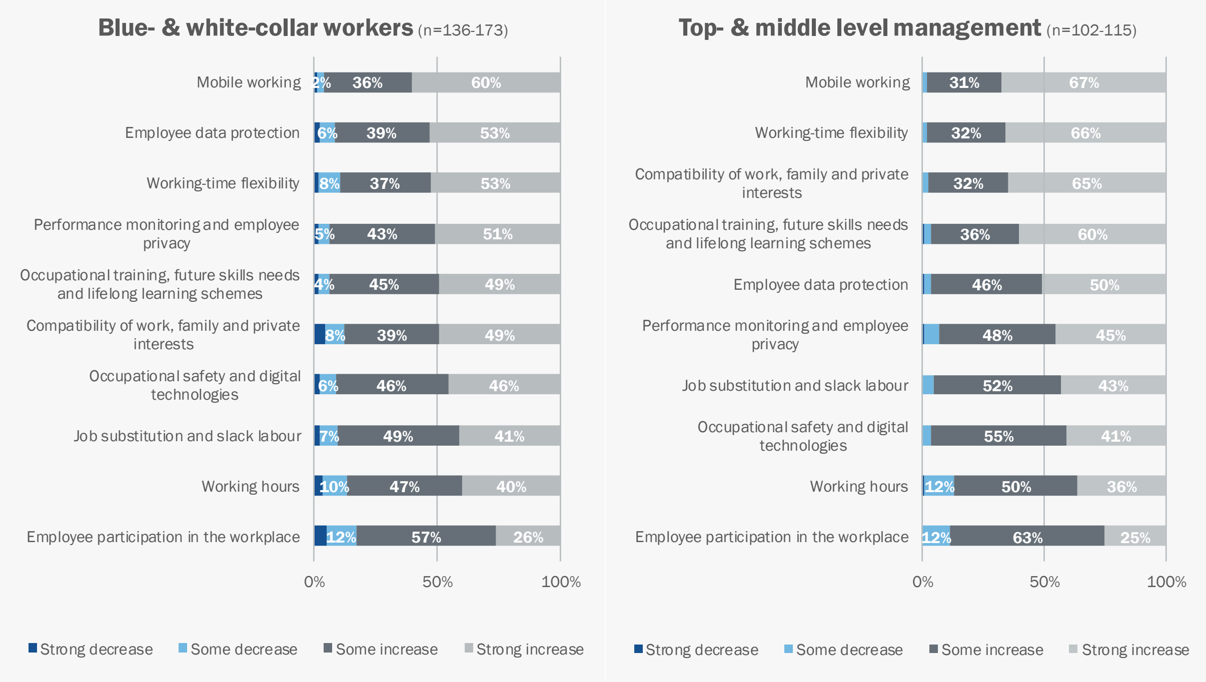


Note: This question was only asked when the survey participant previously answered: “currently tested” or “in the future” for at least one of the listed technologies. The analysis across company sizes includes only responses from company representatives (managers & employees).

Source: Prognos AG (2019), European wide chemical industry stakeholder survey (2018). n=82-103.

Annex 24: Future relevance of addressed aspects by company position

What aspects of the digital transformation are sufficiently addressed by collective agreements in your country & what will be their relevance in the next 5 years?

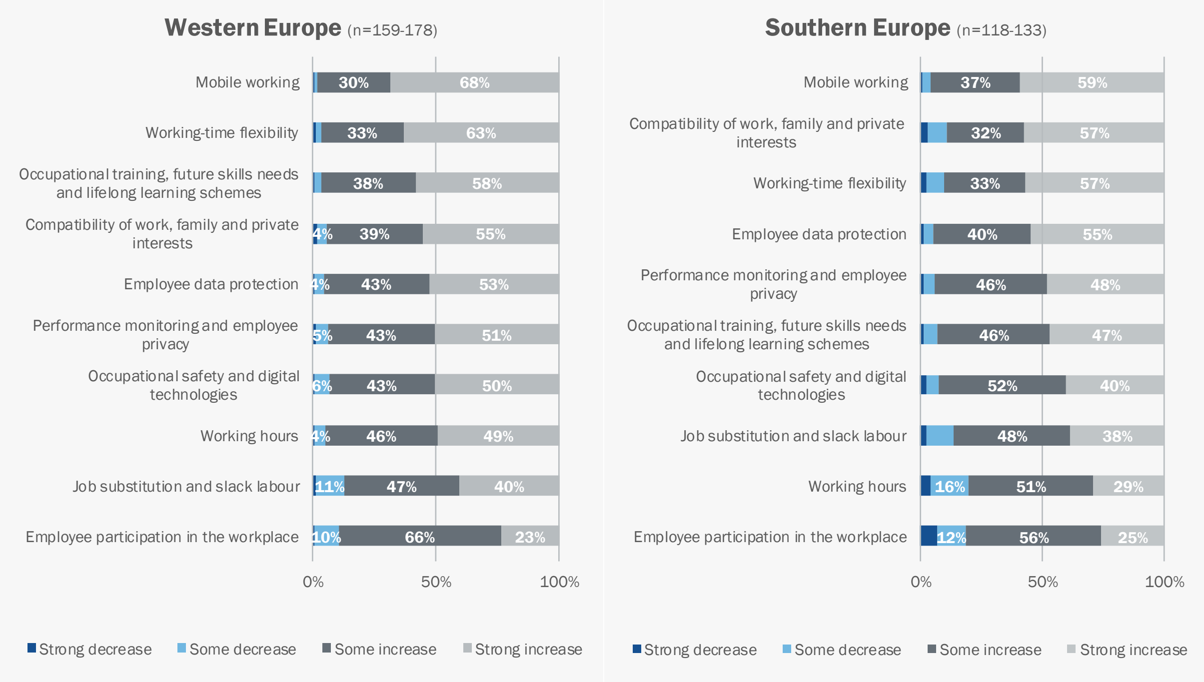


Note: Survey respondents were first asked to indicate whether the given aspect is sufficiently addressed on a scale from "not addressed at all" to "sufficiently addressed". This was followed by an assessment of the aspect's future relevance on a scale from "strong decrease" to "strong increase". The current figure only represents the indications on the aspect's future relevance.

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). n=102-173.

Annex 25: Future relevance of addressed aspects by country cluster

What aspects of the digital transformation are sufficiently addressed by collective agreements in your country & what will be their relevance in the next 5 years?



Note: Survey respondents were first asked to indicate whether the given aspect is sufficiently addressed on a scale from "not addressed at all" to "sufficiently addressed". This was followed by an assessment of the aspect's future relevance on a scale from "strong decrease" to "strong increase". The current figure only represents the indications on the aspect's future relevance.

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). n=118-178.

Annex 26: Maturity level indicators for all sectors and dimensions

	Dimension	Sector				
		BC	SC	PH	RP	All Resp.
1	**Skills & Lifelong Learning**	**3,26**	**3,14**	**3,04**	**2,96**	**3,04**
1.1	Availability of digital skills	3,32	3,07	3,12	3,02	3,01
1.2	Openness to new digital technologies	3,28	3,22	3,19	3,06	3,12
1.3	Development of digital expertise	3,32	3,28	3,16	2,90	3,13
1.4	Role of social dialogue	3,14	2,98	2,68	2,83	**2,88**
2	**Organisation of Work**	**3,18**	**3,22**	**3,12**	**3,01**	**3,10**
2.1	Flexibilisation of work: Flexible time-management	2,98	3,13	3,07	2,81	3,01
2.2	Flexibilisation of work: Availability of infrastructure	3,32	3,35	3,41	2,89	**3,19**
2.3	Interdisciplinary collaboration	3,44	3,39	3,68	3,35	**3,45**
2.4	Social dialogue: Consideration of experience	2,92	2,83	2,59	2,78	**2,71**
2.5	Social dialogue: Improvement of acceptance	3,05	3,20	2,86	2,95	2,97
2.6	Social dialogue: Competitiveness	3,35	3,44	3,14	3,30	**3,29**
3	**Digital Transformation Management**	**3,22**	**3,04**	**2,90**	**2,93**	**2,97**
3.1	Digital transformation strategy	3,35	3,19	3,14	3,02	3,14
3.2	Transformation management	3,16	3,03	2,80	2,90	2,91
3.3	Innovation culture	3,15	2,89	2,75	2,86	**2,87**
4	**Smart Production & Operations**	**3,18**	**2,93**	**3,03**	**3,11**	**3,05**
4.1	Smart Production & Maintenance: Degree of automation	3,12	2,75	2,87	2,98	2,92
4.2	Smart Production & Maintenance: Degree of flexibility	3,07	3,00	2,85	2,98	2,98
4.3	Horizontal process integration	3,22	2,98	3,25	3,22	3,14
4.4	Vertical process integration	3,30	3,00	3,14	3,23	3,16
5	**Smart Product & Service Innovation**	**3,08**	**3,07**	**3,05**	**2,99**	**3,07**
5.1	Smart products & services	2,93	2,89	2,99	2,95	3,01
5.2	Smart business models	3,18	3,31	3,17	3,03	3,17
5.3	Smart innovation management	3,12	3,00	2,98	3,00	3,05
	Total	**3,18**	**3,08**	**3,03**	**3,00**	**3,04**

Note: Basic Chemicals (BC): n=61-68; Specialty Chemicals (SC): n=63-66; Pharmaceutical (PH): n=67-79; Rubber & Plastics (RP): n=63-67. The sector-specific ratings only include answers from company representatives from the respective sectors. Therefore, the ratings for "All survey respondents" (All resp.) do not equal the average across the sector-specific ratings, since they include as well responses from employers, industry and trade union representatives.

Source: Prognos AG (2019), based on European wide chemical industry stakeholder survey (2018). All survey respondents: n= 344-384.

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Imprint

Digital transformation in the workplace of the European Chemicals Sector

A sector-specific study of the European chemical,
pharmaceutical, rubber and plastics industry

On behalf of

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