FAKULTA STROJNÍ ČVUT V PRAZE

ÚSTAV ŘÍZENÍ A EKONOMIKY PODNIKU

Study of Possible Changes in the Workforce during Digitization and Robotics

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Introduction

We are in a period of the Fourth Industrial Revolution. Many people discuss this topic. Many people do not like it because, allegedly, it is not a revolution. Many people do not like it because it is too politicized, profaned, constantly and ceaselessly discussed.

The ongoing Fourth Industrial Revolution is based on the Third Industrial Revolution, and we are only at the beginning of it. We can expect it to last at least another 10-20 years. However, we will only be able to understand its significance, and how we have succeeded towards other states in its course, or how we have used it to our advantage and for the benefit of humanity in hindsight. The Fourth Industrial Revolution does not bring (at least so far) any fundamentally new technologies, and it is true that it is not a revolution in this respect. Robots, unmanned aircraft, artificial intelligence, neural networks, autonomous vehicles and other technologies are really nothing new.

Nevertheless, we think that this is a revolution, the fourth in a row. According to some experts, the fact that the boundaries of the physical, digital and organic world are fading away in the deployment of cyber-physical systems is fundamental and revolutionary. Gradually, these three worlds are more and more interconnected. The Internet, augmented reality, additive technologies or nanotechnologies will be used to a significant extent and on a large scale. Machinery and equipment will take over the work of people or work closely with them. Machine perception will be used to control machines or production units, there will be autoconfiguration and self-diagnostics. No doubt we would find other reasons. [1]

The reasons for the revolution were also summarized by Klaus Schwab, the founder and president of the World Economic Forum. There are three reasons - speed, extent and systemic impact [1]:

1. The speed of change is unparalleled. The current revolution is showing exponential, not linear, growth.
2. The nature of the revolution is global, affecting the entire planet and all industries.
3. There is a transformation of production systems, their administration and management.

As the Fourth Industrial Revolution brings the above-mentioned fundamental changes to our personal and professional lives, it deserves sufficient attention and it is necessary to pay attention to this topic and the changes associated with it. In this context, the study presented here aims to present the possible effects on the labour force and the labour market.

The first chapter of the study focuses on the presentation of selected trends that currently affect employment and the need for skills. These are mainly trends in business management, technological trends or demographic change. The second chapter deals with the expected effects on the labour market due to the introduction of modern technologies. Specifically, the chapter discusses how many jobs can be affected by automation, whether and in what volume jobs will be lost or newly created, how professions and skills required for them will change, whether forms of employment will change or whether, for example, there will be enough university graduates. The third chapter presents the possible effects on the labour market with a focus on selected groups of the population - young people, people over 55, people with low qualifications or women.

Note: The information contained in this study is based on developments prior to the global COVID-19 pandemic, which will undoubtedly affect further developments in terms of the introduction of modern technologies (and thus the labour market). The resulting impacts may take various forms and are difficult to predict. One of the development options is that the pandemic will speed up the implementation of some technologies to ensure the operation of some companies even in these demanding conditions. However, an option that is also possible and certainly not the last may be the fact that the implementation of modern technologies will weaken as a result of negative economic developments. It can be difficult for companies to finance these large investments, always associated with a certain risk.

1 Trends affecting employment rate and need for skills

The development of future employment rate is affected by a number of factors and trends that can interact with each other. These factors can generally include political, economic (e.g. demand for products), social factors (e.g. demographic change, immigration, number of graduates) or technological factors.

However, the factors associated with technological development will have a significant effect in the coming years, and therefore they are given significantly more attention. However, we should also not forget the trends in the field of business management, which actually rely to a large extent on these technological trends and thus in fact indicate their direction. We should also not forget demographic change. Therefore, the following chapters focus mainly on these trends.

1.1 Trends in business management

We could find more trends in the field of business management. However, we could include a change in customer behaviour, which largely shapes other trends (e.g. in modern technologies) among the most visible, as well as trends in internal business management and integration within supply chains.

1.1.1 Trends in relation to customers

In the beginning there is a customer, it is key to all businesses and therefore significantly affects their management. We are at a time when lifestyle and consumer behaviour are gradually changing. The requirements and real needs of customers are not the same and are changing, among other things, under the pressure of new opportunities offered by the market and modern technology. The possibility of individual configuration and, compared to the past, not only functionality and quality are beginning to play a crucial role in purchasing. Product must also evoke positive emotions (Fig. 1). The customer is generally impatient, wants to have all information available and up-to-date, requires quick (sometimes instant) reactions and delivery from the product supplier/manufacturer. At the same time, it is characterized by high mobility, so it wants to solve as many things as possible (obtaining information, communication, orders) remotely via mobile devices.

To remain competitive, businesses need to adapt and respond appropriately. In this context, it is necessary to constantly identify and monitor changes not only in the customers themselves, but also in terms of the introduction of new technologies, approaches or tools that will help businesses succeed. New ways to collect a wide range of data can help gain a deeper understanding and improve relationship with customers. Information can support direct sales of products (from manufacturer to customer without a mediator), improve marketing strategies and enable companies to better target after-sales support and strengthen customer loyalty to the company.

The entire process from the selection of goods to the purchase and subsequent maintenance will change its character under the effect of digitization. The importance of e-commerce will grow and manufacturers will need to further develop digital tools and content that will allow customers to gain as much information and experience from the Internet as possible.

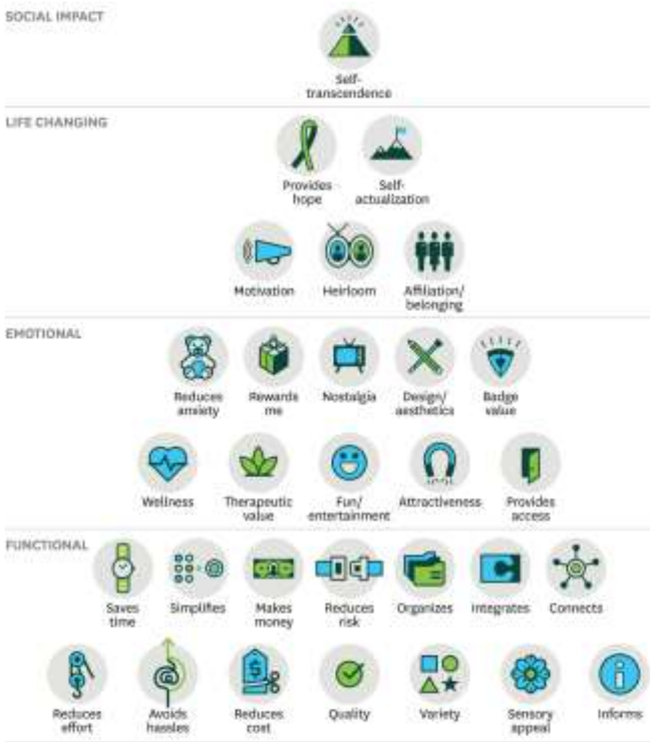


Fig. 1: Key elements of value for the customer [3]

Also important is, for example, system integration, the use of modern software for production planning, scheduling and control or automation and robotics for the fast and efficient passage of products through production to the customer. However, manufacturers will no longer focus only on production and product, but also on after-sales services, which may eventually become more important to them than production itself. [4]

After-sales service, such as remote digital service, updates of software and applications embedded in products, will play a greater role in relation to customers, not only to bring new possibilities to customers, but to ensure their safety, etc. New applications can help diagnose wear and potential problems with the use of products, both current problems and their likely future occurrence, and direct necessary maintenance or repairs.

1.1.2 Trends in internal business management

Trends in the internal business management are largely indicated by the effort to meet the requirements, needs and wishes of customers. Businesses are reorienting themselves to process management, which emphasizes the responsible employee and the resulting customer. The aim is to remove the barriers created by the original organizational structure and thus create an effectively functioning and efficient organization (or effectively functioning communication and transfer of work). In this context, emphasis is placed on the introduction of new information systems, a unified and interconnected database and their mutual integration in order to ensure effective process management. Emphasis is also placed on the preparation of integration within the supply chain (see below) and preparation for automation, robotics and the introduction of other modern technologies.

On the part of manufacturers that are part of multinational groups, in order to ensure compatibility, business applications used throughout the group or systems operated in multinational shared services centres are being implemented relatively quickly. On the part of small suppliers, due to the financial demands of the introduction of new information systems and technologies in general, integration may take place under the 'wings' of larger companies-customers/suppliers.

1.1.3 Integration within the supply chain

In an effort to ensure the most efficient passage of the product (order) from the customer's order to delivery and in an effort to ensure the efficient operation of companies, companies are integrated into the supply chain. The aim is to automate purchasing processes, record material, trace its flow through production and predict its needs with the help of modern technologies and digitization. The Internet of Things, the application of which is gradually expanding, will further advance these possibilities so that the state of production and stocks as well as market demand could be monitored in real time. This will be the basis for communication with suppliers, who will have an overview of the required deliveries in the exact quantity, in the required deadlines and locations. Thus, factories will not need large stocks of material without being exposed to the risk of interrupting the production process due to the failure of subcontracting. However, it is necessary for suppliers, manufacturers, logistics and warehousing service providers and customers to be digitally connected in order to be able to monitor the status of subcontracting, update the delivery date, etc. in real time. [2,5]

The use of blockchain technology is gradually becoming an important trend in integration. It is a database in which mutual transactions are recorded, with it being impossible to change the data already recorded to ensure their security and reliability. Thanks to a blockchain, there would be no dispute over transactions between the individual entities in the supply chain. The customer can also track the entire path from the first supplier to the final product at the end of the chain and has a guarantee of the origin of the product. [6]

Supply chains can also be affected by additive manufacturing, as some parts, especially spare parts in small series, will be able to be produced efficiently by companies directly at their own workplace. However, this will naturally require investment in appropriate additive technologies, will increase the need for operation and maintenance of additive equipment, but will save some costs such as transport or storage.

These trends in supplier relationships can be expected to reduce costs, save some employees in purchasing administration, stock management and administration, possibly directly in warehouses, speed up production, and thus speed up the response of production to market demand. But, for example, the need for workers able to work with information systems and evaluate information will increase. [2]

1.2 Trends in technology

As mentioned in the introduction to this study, we are in the period of the Fourth Industrial Revolution, bringing fundamental changes to our personal and professional lives. It is no longer just automation or the introduction of robots. These are significant complex changes, within which smart companies should gradually emerge based, in addition to robotics and automation, on the use and interconnection of new information and technology elements such as the Internet of Things, cloud computing, BigData or modern business software.

Cyber-physical systems will be created, where elements of the production environment will communicate with each other, perform self-diagnostics and autoconfiguration or auto-optimization. Machines and equipment will take over the work of people or work closely with them to achieve higher productivity and efficiency of the production process. Thanks to cooperation with machines, people will be less burdened with routine tasks and will have space for creativity and self-development. Factories will be supplemented with additive manufacturing technologies to achieve greater flexibility and the ability to adapt the final product to customer requirements.

E-commerce will be used to a large extent and the entire process of ordering and delivering the product will take place significantly faster and more efficiently from the comfort of home, from holiday, from anywhere. The ever-closer integration of entities within the supply chain will play an important role here. Services offered for the products sold, which will offer great added value thanks to new technologies, will also play an important role in the future.

Finally, it turns out that companies that have adapted to digital technologies, automation, robotics and other trends operate more efficiently and have higher workforce productivity. The following subchapters deal with individual technological trends in more detail.

1.2.1 Internet of Things

In addition to the term Internet of Things (IoT), we can come across a relatively large number of similar terms. It can be, for example, Industrial Internet of Things, Internet of Things and Services (Bosch), Internet of Everything (Cisco), Internet of Things & People (Harbor Research), Internets of Things (Forrester Research), etc. These terms differ primarily in which company or organization covers them and what is the specific application in practice, but the principle of perception and functioning of technology remains basically the same.

The Internet of Things is a network of physical objects or ‘things’ that are, simply put, equipped with sensors that monitor status/stimuli such as location, pressure, temperature, humidity, pH, motion, vibration, degree of illumination, etc. Nowadays, physical objects or things can be almost anything like a machine, a handling element (e.g. pallets), a finished product, a car park, clothes, a field or food (in the future even a human being, although it may still seem like sci-fi to many people). In addition to sensors, an object is naturally equipped with other elements such as a communication interface for data transmission (various types of wired or wireless networks), processor, platform, software. Physical objects or ‘things’ embedded in this way are then able to collect data and detect events and changes in their surroundings, communicate with other objects and things by sending a signal, integrate into systems and they may be able to perform decentralized analytics and decision-making for real-time response (simulation, self-optimization) as needed and according to specific applications.

The IoT is used in various areas of human activity, from the engineering industry to agriculture, from machines to smart home products or wearable electronics. Thanks to the IoT in production, we can, for example, monitor production workplaces and transmit data on their operation for the purpose of simulation and subsequent optimization of the production process, for the purpose of fault notification or, for example, predictive maintenance. Thanks to the IoT in logistics, we can, for example, communicate with suppliers for the purpose of timely delivery of stocks, or monitor the movement of items and their condition (e.g. temperature changes in medicines and food). Thanks to the IoT in agriculture, we can, for example, irrigate crops in the field in good time and optimally, or precisely guide and control agricultural machinery (John Deer). In the field of construction, the IoT helps, for example, to optimize the movement of cranes on construction sites so that they do not collide. In transport, it helps control traffic at the intersections based on traffic level on adjacent roads or to occupy car parks. In retail, for a change, it helps monitor customers and determine their preferences. For consumers, for example, it can help effectively manage a smart home or monitor daily activity (smart bracelets, etc.).

The IoT is often perceived as a modern technology that contributes to the replacement of jobs (e.g. remotely controlled machines and equipment) or at least their reduction (e.g. more efficient maintenance requiring fewer workers). However, few people are aware without further reflection that the IoT also creates jobs, both in terms of their development or ensuring their security, and, for example, by creating new business opportunities associated with the use of the IoT. An example is the American company John Deer engaged in the production of agricultural machinery, the business activities of which are currently significantly focused on providing additional services related to the use of the IoT (e.g. monitoring the use and state of technology, the condition of fields and their yield, etc.). Providing these services brings new jobs.

Many organizations have already started the IoT revolution. Everything that can be automated in the production process will be automated. It is only a matter of time before individual industrial companies do this. Fig. 2 on the left shows that the degree of IoT acquisition in individual industrial areas in 2017 did not reach more than 25%. At the same time, many companies from various spheres of the economy confirmed the importance of this technology in 2018 (see Fig. 2, right).

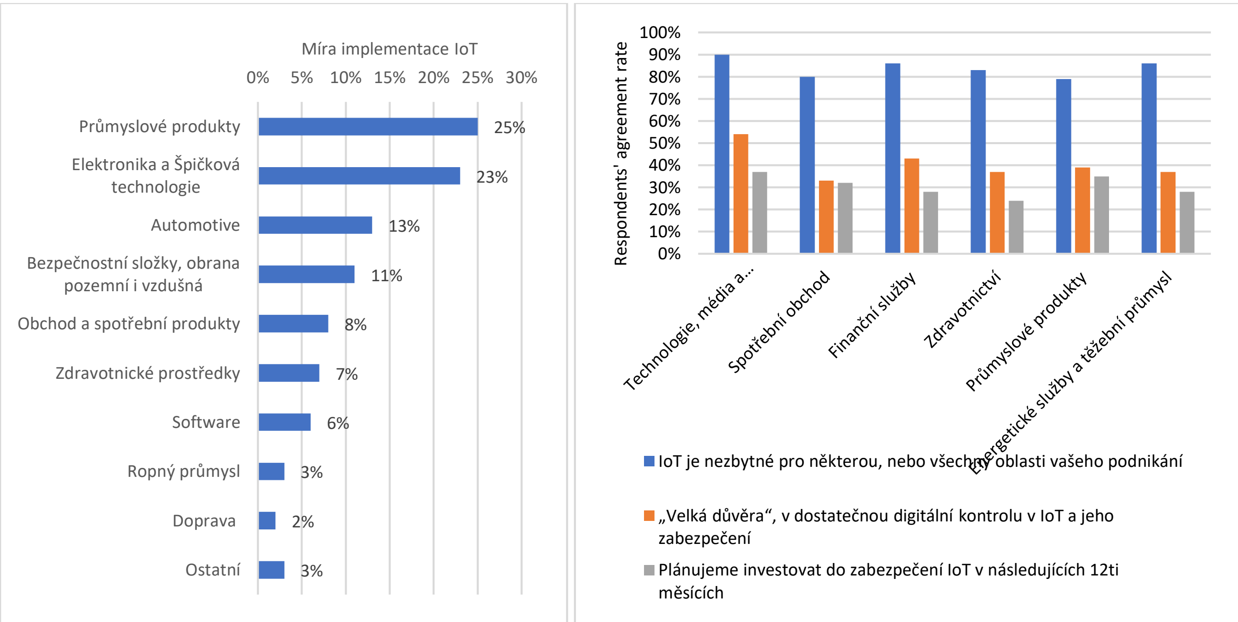


Fig. 2: (left) Industrial implementation of IoT in 2017, by industry; (right) Relevance, confidence in, and investment planning for IoT in organizations worldwide in 2018, by industry [7,8]

IoT implementation rate
Industrial products
Electronics and top-class technology
Automotive
Security services, land and air forces
Trade and consumer products
Medical devices
Software
Oil industry
Transport
Other

Technology, media and…
Consumer trade
Financial services
Health care
Industrial products
Energy services and mining industry
IoT is necessary for some or all areas of your business
High confidence in sufficient digital control in IoT and its security
We plan to invest in IoT security in the following 12 months

In the long run, of course, further growth in the use of the IoT, which is an important element for automation, is expected. The assumption of further growth can be expected even during the global COVID-19 pandemic because automation is proving to be important for not stopping the operation of companies. Further development can then be expected, among other things, with the development of other technologies, such as modern communication networks. Fig. 3 on the left shows that the number of installed bases in many areas is growing and it is expected that the number of globally connected devices could reach up to 50 billion by 2030, which would be more than double the connected devices in 2018 (Fig. 3, right).

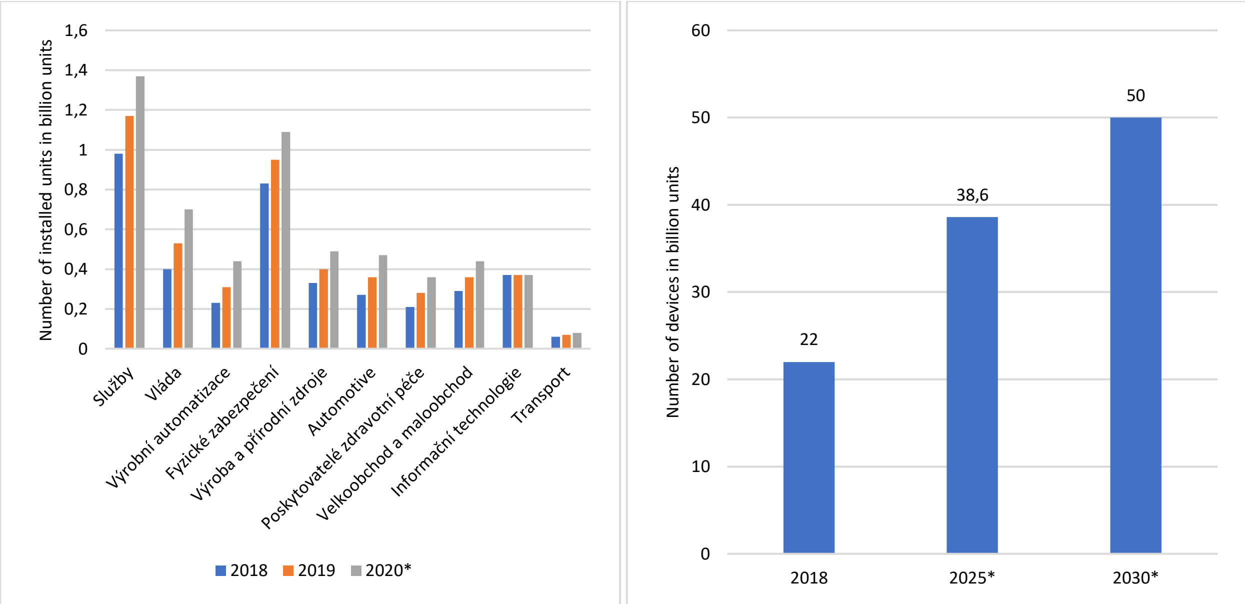


Fig. 3: (left) Target market for IoT installation in companies and automotive, worldwide, from 2018 to 2020, by segment (in billion units); (right) Number of globally connected IoT devices in 2018, 2025 and 2030 (in billion units) [9,10]

Services
Government
Production automation
Physical security
Production and natural sources
Automotive
Healthcare providers
Wholesale and retail
Information technology
Transport

The growth of the entire IoT sector is then confirmed by forecasts of expenditure growth and market size growth (Fig. 4).

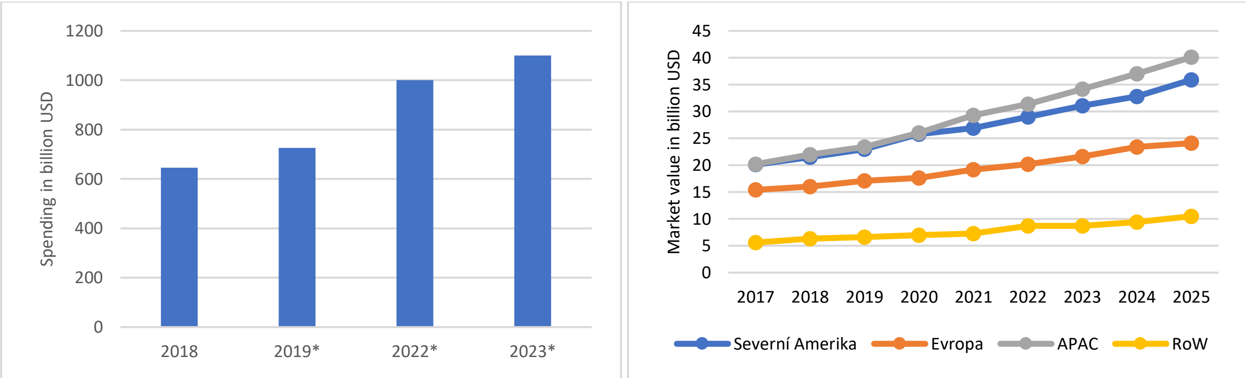


Fig. 4: (left) Forecast of global IoT expenditure from 2018 to 2023 (in billion USD); (right) Value of the industrial IoT market worldwide from 2017 to 2025, by region (in billion USD) [11,12]

North America , Europe, APAC, RoW

1.2.2 Communication technology

Simultaneously with other technological trends, there is also a development of communication technologies, especially modern data transmission networks, which is an important prerequisite for the further development of the IoT. Capacitive data networks will allow multiple IoT devices to be connected at the same time and will also allow them to transfer larger data volumes and at higher speed, allowing them to increase in quality when needed.

Fig. 5 on the left shows that a significant increase in the connection of IoT devices is expected using the new NB-IoT and LTE-M communication technologies. These two technologies bring especially higher speeds and transmission capacity. Thanks to this, it will be possible to connect more devices in the future (see the statistics above) and to increase the transmitted data volumes. They are expected to increase from 13.6 ZB in 2018 to 79.4 ZB by 2025 (Fig. 5, right).

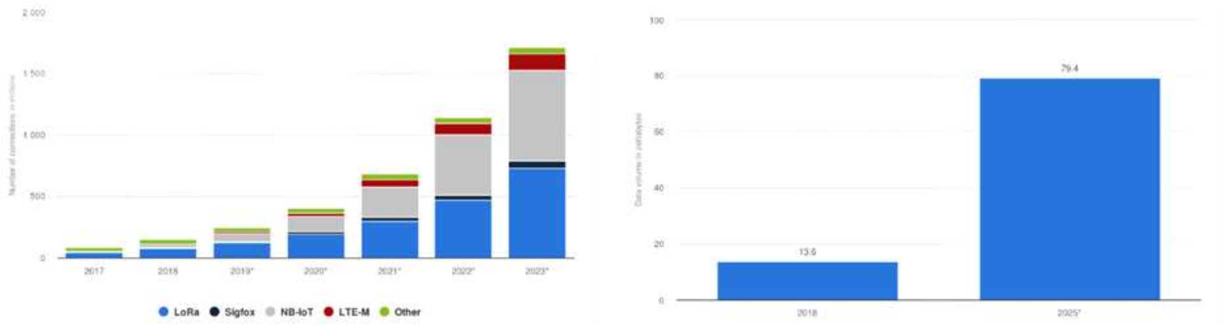


Fig. 5: (left) Number of LPWAN connections by technology 2017-2023 (in million USD); (right) Number of transferred IoT data in 2018 and 2025 in ZB [13,14]

Development of data networks and communication technologies (e.g. 5G) is also important with regard to the further possible development of e-commerce. It is necessary to ensure the smooth running of purchases for customers and sufficient capacity of networks for communication of companies in the supply chain. The effect of new sales tools, which are increasingly being promoted, such as augmented and virtual reality, is also important. These resources help sell products efficiently, but again require more network throughput due to larger data flows.

The inevitability of further development of modern communication networks is, for example, also shown by statistics from Germany, where long-term growth of mobile devices connected to the network (Fig. 6, left) and long-term growth of monthly volume of transferred data per one contract with a mobile operator can be seen (Fig. 6, right).

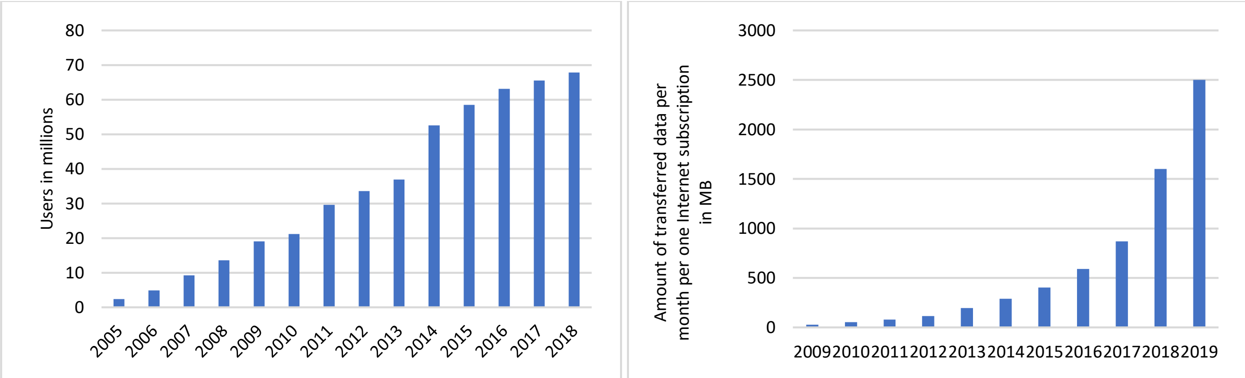


Fig. 6: (left) Number of standard UMTS and LTE users in Germany in 2005-2018 (in millions); (right) Average amount of data transferred per month per mobile subscription in Germany between 2009 and 2019 (in megabytes) [15,16]

In the long run, the volume of data transferred using the Internet through a regular line - VDSL, cable, etc. - is also growing (Fig. 7, left). The development and importance of the e-commerce trend is shown by statistics from France, where these revenues are growing by about €10 billion a year annually (Fig. 7, right).

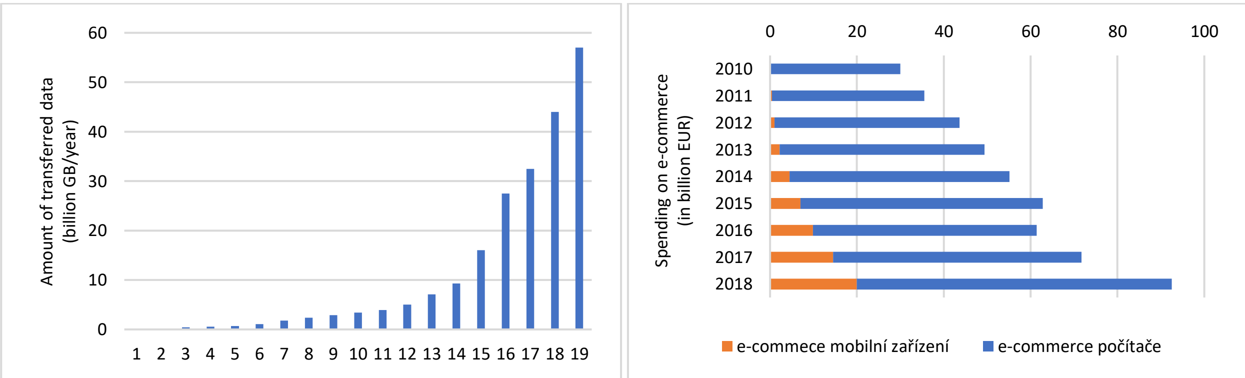


Fig. 7: (left) Development of the amount of data transmission through terrestrial network in Germany between 2001 and 2019 (in billion gigabytes per year); (right) Revenues from e-commerce in France between 2010 and 2018, by device [17]

e-commerce mobile devices
e-commerce computers

Last but not least, the development of means of communication is desirable in connection with the global COVID-19 pandemic and the expanding working from home. Many people working from home felt the Internet overloaded - slow speeds - at peak times.

1.2.3 Data, BigData, SmartData

The data have always been, are and will be here. They support decision-making at all levels of business management. Proper evaluation of the collected data can significantly help increase efficiency, save costs, simply do things meaningfully. Their storage and analysis in real time thus becomes one of the important competitive advantages.

However, their significance has been growing rapidly in recent years compared to the past. This fact is mainly associated with the trend of large data sets (BigData). These are large data sets, e.g. from transport systems, on customer movement and behaviour, or data from the IoT, which meet certain characteristics such as exponential increase in volume, diversity (structured and unstructured data, various formats), uncertain reliability or the need for fast processing. At the same time, capturing, processing and managing these data is impossible with normal hardware/software in real (reasonable) time, and for this Cloud Computing is often used.

However, BigData itself is insignificant without follow-up activities. There is a need for their further processing and analysis in order to become SmartData. Simply put, data that have some meaning, benefit, some informative value. The importance of data is not only growing thanks to BigData itself, but there are many more reasons. E.g. that the means for their more efficient storage and processing in real time are becoming available, we can interconnect various data sources (from business and production systems, from customer systems, etc.) or, for example, that we know how to proceed in their analysis and use the data effectively and be able to interpret them.

Data analysis (and their correct use and interpretation) then helps, for example, identify profitable markets and customers, select new markets (regions) for business expansion, analyse/predict their needs and behaviour, optimize processes in production, logistics, trade or human resources or, for example, predict equipment failures.

As Fig. 8 shows, the global volume of stored data is likely to reach approximately 175 ZB by 2020 (of which only about 10-20% of structured data). (Just to give an idea, an aircraft engine and its sensors produce up to 20 TB of data per hour of flight.) The largest volumes of data are then stored by the manufacturing industry, around 3.5 ZB, followed by retail/wholesale with 2.2 ZB and the financial sector with 2.1 ZB (Fig. 9).

Fig. 8: Total annual worldwide volume of data [18]

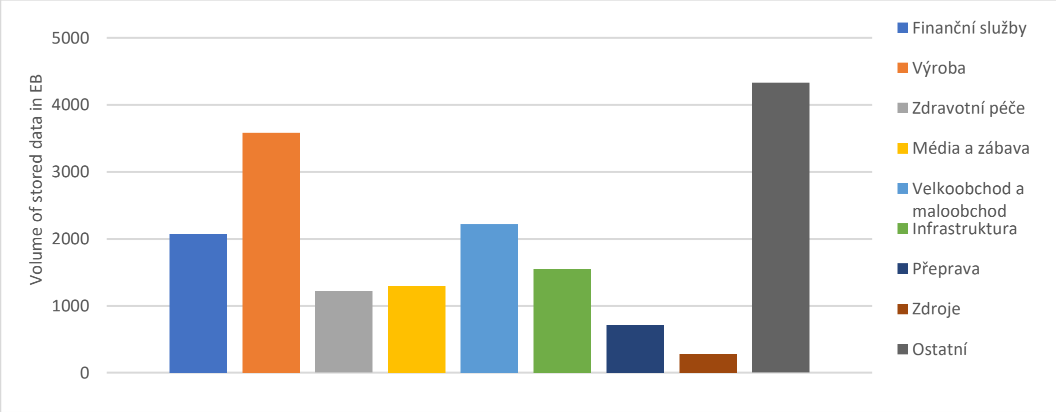
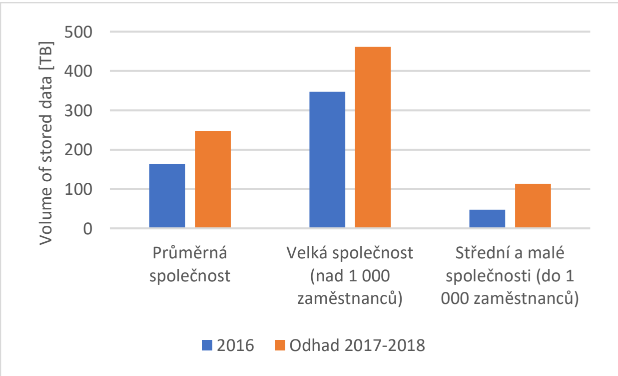


Fig. 9: Volume of data in individual sectors of the economy [19]

Financial services
Production
Health care
Media and entertainment
Wholesale and retail
Infrastructure
Transport
Sources
Other

An average company stored approximately 150 TB in 2016 and today it will be even more (Fig. 10, left). However, many companies report that a large part of the data is black data (Fig. 10, right), which are stored but no longer used, for example, due to missing analysis or processing tools or because the company uses only structured data. Thus, large volumes of data remain, still waiting for their analysis.



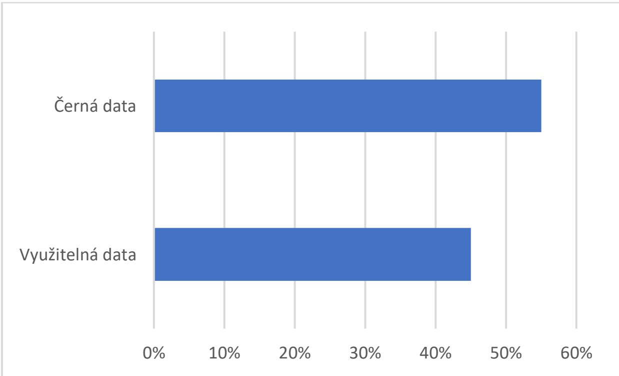


Fig. 10: (left) The amount of data stored depending on company size; (right) Usable and black data - average percentage volume [20]

Average company
Large company (over 1,000 employees)
Small and medium-sized companies (to 1,000 employees)
2016
2017–2018 estimate

Black data
Usable data

1.2.4 Artificial intelligence, machine learning

In connection with data processing and analysis or, for example, in connection with automation (robotics) of business processes, the importance of technologies such as Artificial Intelligence and Machine Learning is also growing significantly. Artificial Intelligence is actually a machine/computer that can imitate human behaviour, thinking, and decision-making. Artificial Intelligence can then be specialized (programmed for specific tasks - e.g. virtual assistants, chatbots, etc.) or general (it does not exist yet, deployment in an average company is expected in more than 10 years - Fig. 11). [22,23]

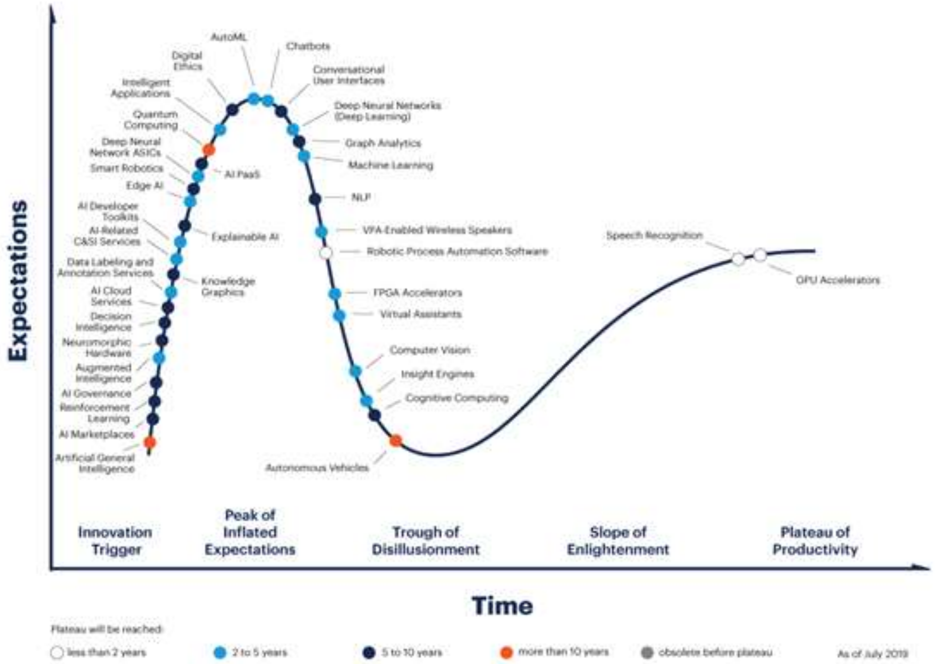
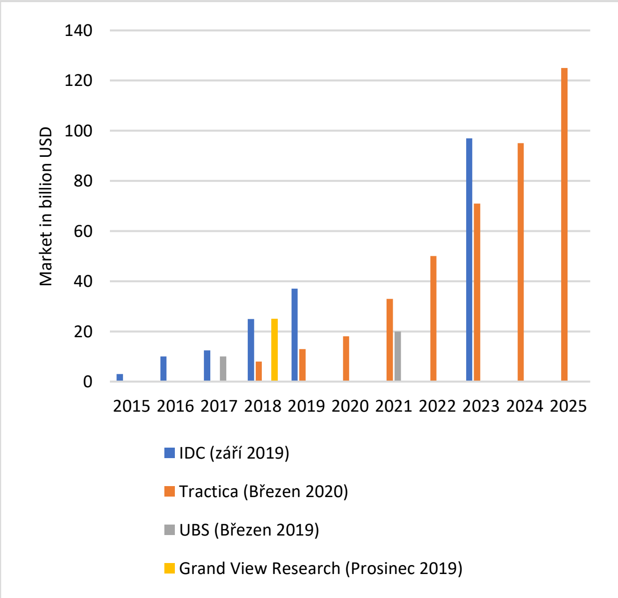


Fig. 11: Hype Cycle – artificial intelligence 2019 [21]

The current Artificial Intelligence ecosystem consists of machine learning, robotics and artificial neural networks. Machine Learning is based on specialized algorithms (e.g. neural networks), which with the help of input data expose the assumption of the resulting situation, which is constantly changing. Thus, Machine Learning represents a dynamic adaptation to new situations based on available data (or even on already gained experience). Large data sets - BigData - are needed to make data-based learning truly functional and usable. [22,23]

As mentioned in part above, artificial intelligence finds use, for example, in analysing data and making various predictions, such as determining why some people die from diseases based on biological data, pricing products based on customer interest, or predictive maintenance. When automating business processes, a specific example can be, for example, advertisements appearing on websites based on our own activity, what we are looking for or buying. Other uses can be, for example, in CallCentres or in warehouse management.

Spending on Artificial Intelligence technology has been rising again for a long time, and research does not completely agree on its specific level (Fig. 12, , left). However, it is estimated that it could be in the range of about $15-40 billion in 2018-2019 and the outlook for 2023 was around $70-100 billion, depending on a specific study. The largest cumulative market revenues are expected for the 2016-2025 period in the areas focused on accident prevention, video output recognition or patient data processing (Fig. 12, right).



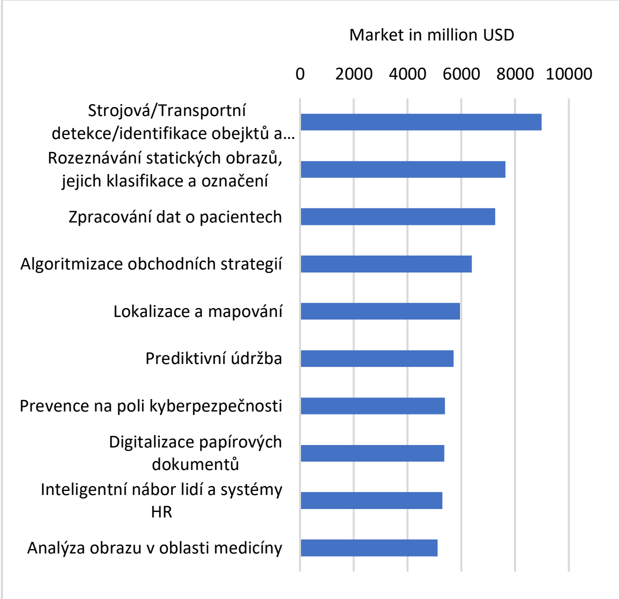
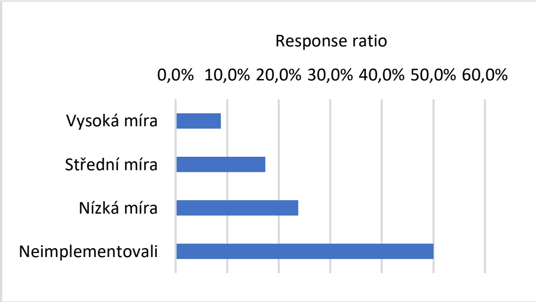


Fig. 12: (left) Market size and comparison of global artificial intelligence revenues between 2015 and 2025 (in billion USD); (right) Cumulative revenue in the top 10 artificial intelligence (AI) segments, worldwide, between 2016 and 2025 (in million USD) [24,25]

IDC (September 2019)
Tractica (March 2020)
UBS (March 2019)
Grand View Research (December 2019)

Machine/Transport detection/identification and…
Static image recognition, their classification and designation
Patient data processing
Trade strategy algorithmizing
Localisation and mapping
Predictive maintenance
Prevention in cybersecurity
Paper document digitization
Intelligent HR recruitment and HR systems
Image analysis in medicine

As for the specific use of artificial intelligence in practice, we can look at the very recent statistics from Italy from 2019, which show that about 50% of companies use artificial intelligence, although about half of them only to a small extent (Fig. 13, left). Most companies have been using it for less than 3 years (about 40%), 34% of companies plan to use it and 21% of companies do not plan to do so yet (Fig. 13, right).



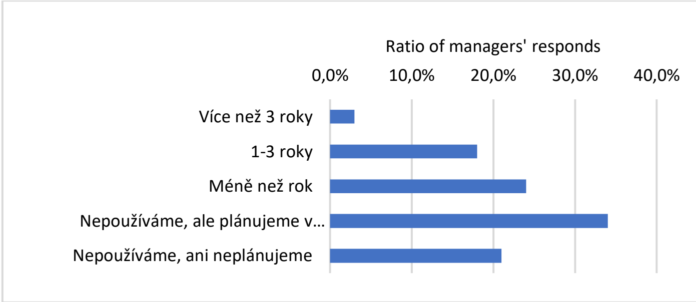


Fig. 13: (left) To what extent have you implemented artificial intelligence as part of the digital transformation in your company?; (right) How long have you been using artificial intelligence in your business? [26,27]

High rate
Medium rate
Low rate
Not implemented

More than 3 years
1–3 years
Less than a year
We do not use it, but plan to…
We do not use it and do not plan to

1.2.5 Predictive maintenance

It is possible to include predictive maintenance among the important technological trends, which is of course significantly based on the use of other technologies such as IoT, BigData, Artificial Intelligence and Machine Learning, or e.g. Cloud Computing.

The importance of the role of predictive maintenance lies in the fact that its principle is based on the analysis of collected data to predict the development of equipment and machinery to detect a potential future failure in good time or well in advance. Subsequently, it is possible to carry out repairs in time to prevent stopping the operation, damage or even accidents. The actual putting out of operation for maintenance is thus planned in advance and it is possible to prepare for it without significant unplanned costs and investments. Predictive maintenance is not only associated with production equipment, for example, but also applies to final products such as cars. Its introduction and use can therefore significantly affect the purchase of new products or, where appropriate, the potential necessary numbers of maintenance staff. [28]

Below you can see the expected development in the predictive maintenance market from 2018 (Fig. 14). This year, the size of the market was approximately $3.3 billion and it is expected to increase to $23.5 billion by 2024.

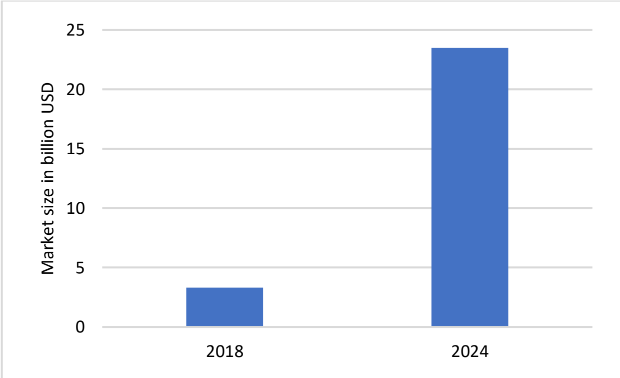


Fig. 14: Projected size of the global predictive maintenance market in 2018 and 2024 (in billion USD) [29]

1.2.6 Cloud computing

In general, we can come across a number of different definitions of the term Cloud Computing (CC). Let's start, for our needs, with the definition of NIST (National Institute of Standards and Technology [13]), which is recognized by most of the world's experts. Thus, CC represents a model of providing computer services, where the service provider leases to the customer access to (resources), which are the cloud infrastructure (hardware: servers, data storages, networks and their transmission capacity, etc.) and software (SW). User accesses these technologies remotely via an extensive network, most often the Internet. Since all operations are performed by software and hardware in the cloud, the user only needs to access hardware-undemanding devices designed primarily for display. The user does not know and does not need to know the specific technology solutions, such as the type of servers used. The user is only interested in whether the service is provided in the appropriate quality. Cloud Computing is talked about because clouds exist in different forms and we do not know what is behind them. In addition, a cloud represents an imaginary interface between the area cared for by the provider and by the customer. [89]

Depending on how the service is operated in relation to the customer (user) and where the infrastructure is located, there are 4 types of clouds referred to as deployment models. These are Public Cloud, Private Cloud, Community Cloud (used e.g. for businesses in the supply chain), and Hybrid cloud (a combination of 2 or more of the previous types – used for safety or performance reasons).

According to the NIST standard, the services offered in the CC area are divided into the following 3 categories (IaaS, PaaS, SaaS), which are referred to as service models or distribution models. In addition to these 3 categories, we can also meet with another two categories that try to complement the portfolio of services offered (DaaS, BPaaS). [89]

- IaaS – Infrastructure as a Service is a model where the customer leases infrastructure (computing power, storage, etc.) or access to it from the service provider.
- PaaS – Platform as a Service is a model where the provider allows the customer to use a web platform (operating system and application environment) for application development for a certain fee.
- SaaS – Software as a Service is a model where the provider undertakes to provide the customer with the use of software for a certain fee. The offered SW should be divided into three groups: ordinary office, business (ERP, CRM, etc.) and specialized (e.g. CAD, simulation or analytical SW).

- DaaS – Data as a Service is a model where the provider provides the customer, in addition to software (SaaS model), also with data/database (e.g. on the behaviour of Internet users, social media, various applications or retail customers, payment card users, etc.).
- BPaaS – Business Process as a Service is a model where the provider provides the customer with the entire process in order to eliminate routine work. For example, the customer receives already processed and evaluated data in the form of required information (e.g. market analysis).

Finally, we can look at the use of Cloud Computing from various perspectives, it representing:

1. An alternative to traditional business IT solutions.
2. A technology providing normally unavailable (or only at an inadequate price) software tools and computing power.
3. A technology that is closely related to several other technologies and largely integrates them together – IoT, BigData, Machine Learning and Artificial Intelligence. (With the growing volume of data, among other things, there is an increasing need for data storage and analysis, which requires more data storage and higher computing power).
4. A technology supporting close interconnection of entities in the supply chain.

The use of CC in businesses has been growing for a long time and, given the possibilities of using CC and its prevailing benefits, it can be expected that the use in businesses will continue to grow. This trend is also confirmed by many statistics, for example, from Eurostat from 2018 (Fig. 15), which show that CC was used on average in 25% of businesses in the EU and this value increased by approximately 7% since 2014. CC is mostly used by companies in the Nordic countries, there were between 55 and 65% of them in 2018, it was approximately 26.5% in the Czech Republic in the same year. There was an increase by about 10–20% of points in all these countries compared to 2014. Naturally, there is a difference between individual companies in their dependence on CC, companies with a high degree of dependence on CC represent an estimated 2/3. However, in view of the global COVID-19 pandemic in 2020, the importance of CC can be expected to grow even more than before.

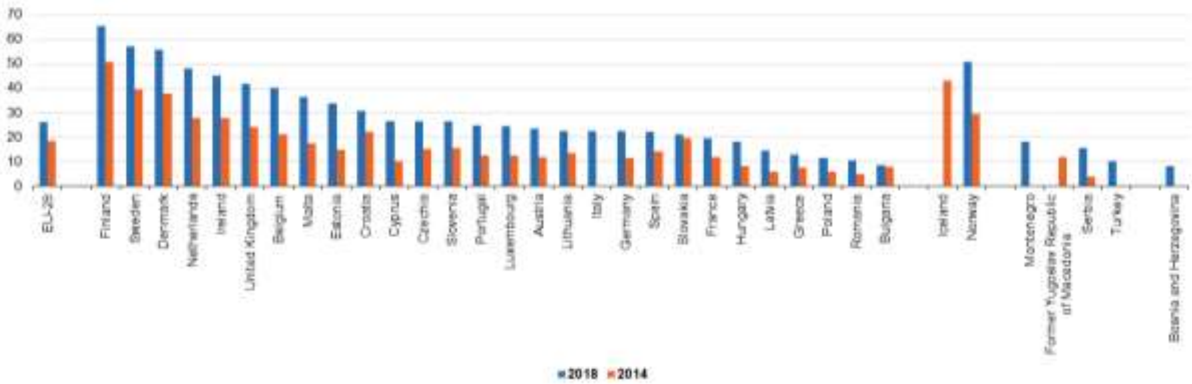


Fig. 15: Use of CC in 2014 and 2018 in Europe in % of companies [30]

Logically, CC is mostly used by companies in information and communication technologies, where it was about 65% of companies in 2018 and, compared to 2014, there was an increase of about 20% of points (Fig. 16). CC is used the least in production, construction and logistics, where it was about 22.5% of companies and the increase compared to 2014 was about 5–7.5% of points.

Fig. 16: Use of CC by economic sectors in 2014 and 2018 in Europe in % of companies [30]

As for the specific purpose of the use of CC, it lies mainly in the use of email services, file storage, and the use of office software has been growing significantly recently (Fig. 17).

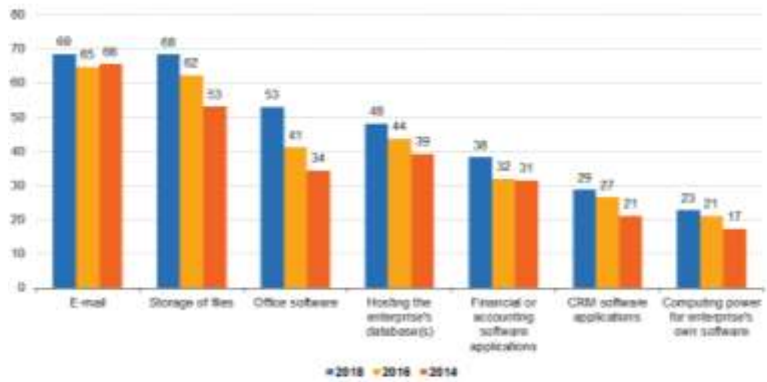


Fig. 17: Use of CC by purpose in 2014 and 2018 in Europe in % of companies [30]

Fig. 18 on the left shows a comparison of the development of global spending on IT infrastructure in the cloud and Fig. 18 on the right, in general, the percentage of IT infrastructure costs depending on the specific solution – traditional versus CC. These diagrams confirm that the use of CC is growing and can be expected to do so in the future. For an idea of the size of the CC services market in the Czech Republic, we can see the size of sales of CC services (Fig. 19), which amounted to approximately $360 million in 2017 (it is a forecast from 2018).

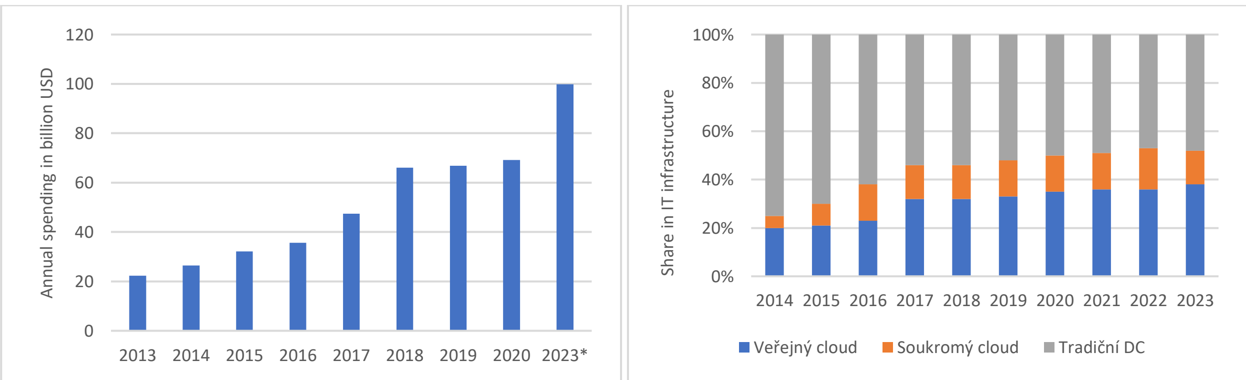


Fig. 18: (left) Annual spending on cloud IT infrastructure worldwide between 2013 and 2023 (in billion USD); (right) Global spending on information technology, breakdown (by value) between 2014 and 2023, by type of solution [31,32]

Public cloud
Private cloud
Traditional DC

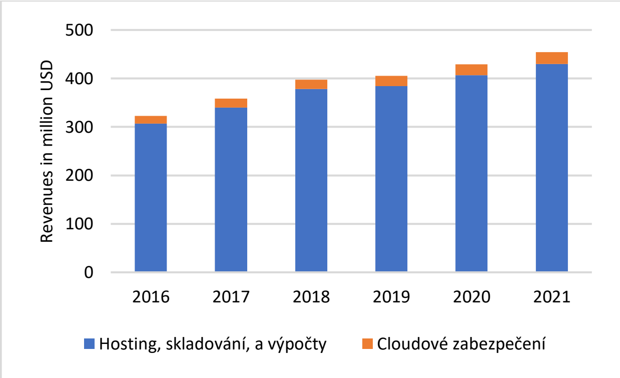


Fig. 19: Market revenues of cloud services in the Czech Republic between 2016 and 2021, by segment (in million USD) [33]

Hosting, storage and calculations
Cloud security

1.2.7 Cybersecurity

Along with the growing use of modern ICTs, the need for protection against cyber-attack threats is growing significantly, and new challenges in the field of cybersecurity need to be addressed. In general, there are two types of threats to defend against, namely:

- Attacks to control and manage the attacked object or the entire system and, as a result, either damage the system or, for example, achieve the production of degraded products.
- Attacks aimed at obtaining (stealing) or devaluing sensitive business or private data and information (a significant corporate asset) relating not only to the business activities and processes, but also to employees, customers or suppliers.

Fig. 20 shows that, for example, security improvements are one of the most common causes of IoT spending.

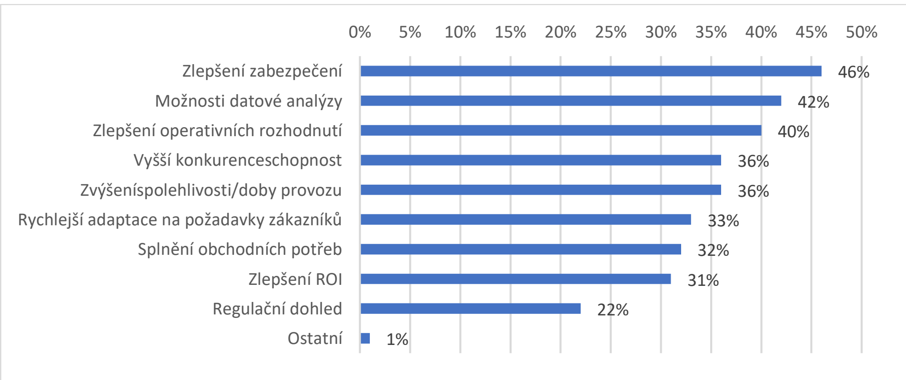


Fig. 20: Reasons for the Internet of Things (IoT) spending worldwide, in 2019 [34]

Security improvement

Data analysis options
Operative decision improvement
Higher competitiveness
Increase in operation reliability/time
Faster adaptation to customers' requirements
Fulfilment of business needs
ROI improvement
Regulatory supervision
Other

Given that the use of modern ICTs or, for example, increased connectivity are now inevitable, the goal should be to ensure cybersecurity consistently. It should focus on ensuring secure communication and analysis, ensuring a reliable and secure network connection, secure and reliable data storage and back-up, regular firmware and software updates, as well as, for example, sophisticated management of machine and user identities and accesses to the network, in general, on preventing the spread of malicious software and preventing cybercrime. We must also not forget the need to educate ordinary employees or customers and suppliers about cyber threats (working with data, network behaviour, etc.). [35]

The growing importance of cybersecurity is also supported by the development of expenditures, which are growing again in the long run and their growth is expected in the future as well. Cybersecurity spending generally amounted to $34 billion in 2017, $36.6 billion in 2018, and was expected to reach $42 billion worldwide in 2020 (Fig. 21, left). As for purely industrial cybersecurity, spending in 2017 was $1 billion and was expected to increase by 80% in 2020 (Fig. 21, right).

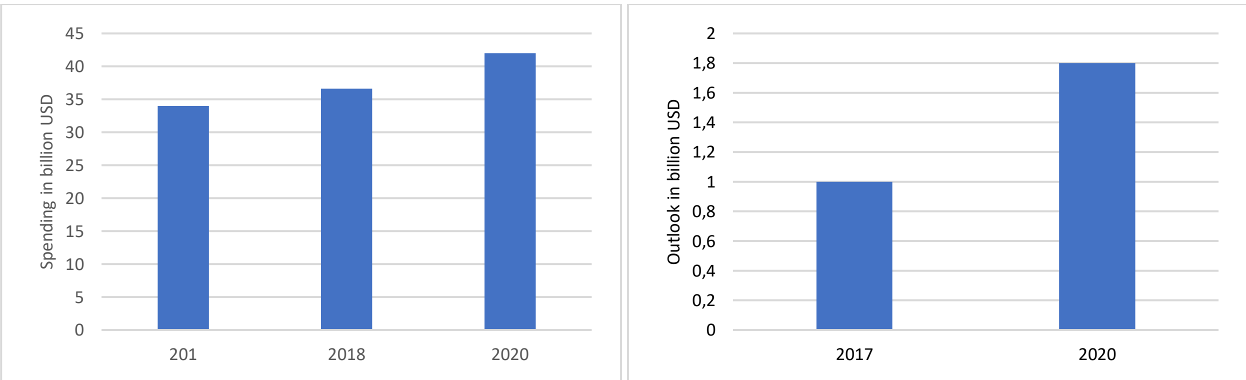


Fig. 21: (left) Global security spending in 2017, 2018 and 2020 (in billion USD); (right) Market outlook for industrial HW, SW and services related to cybersecurity in 2017 and 2020 (in billion USD) [36,37]

1.2.8 Modern business software and system integration

Modern software tools are beginning to play, or are already playing, a significant role in the functioning of today's companies. In this context, the aim is to make the work and operation of a company more efficient overall. We would find many important SW tools, the most important ones undoubtedly include tools for online communication, work sharing and management, BI SW, APS, MES and SCM SW and, in general, SW tools associated with the creation of digital twins and computer simulation.

Tools for online cooperation and communication, data sharing or, for example, work management are becoming almost a necessity, and companies cannot do without them in the future. Email or phone is no longer enough. Reasons include expanding working from home (not only due to the global COVID-19 pandemic), but also frequent travel (to/from work, to clients, on holiday), increasing work intensity, the need for fast work, response and communication or growing cooperation of different professions and specializations or workers from different parts of the world.

BI (Business Intelligence) SW is a fast and flexible tool (technology/platform) supporting the understanding of data, their relationships and trends. Alternatively, it can be said that these are tools for data collection and analysis facilitating reporting and visualization (dashboard creation), querying, analytical activities, etc. The benefit or purpose of use is mainly the possibility of monitoring the development over time (e.g. sales, number of pieces produced, etc.), comparing the plan and reality (e.g. costs, sales, etc.), finding the causes of development (why it is so, who is responsible for it, etc.), evaluating performance (e.g. workers, machines, etc.), predicting potential problems. The expansion of BI SW occurs mainly in connection with the growth of processed data and with the effort for their quality analysis and related activities.

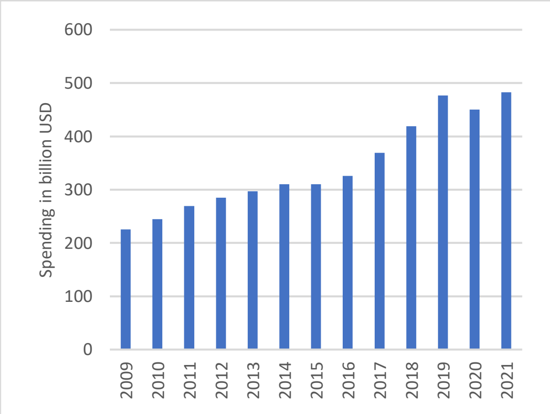
APS (Advanced Planning and Scheduling) SW is a tool for primarily operational and workshop synchronized planning and scheduling of resources (machines, equipment, workers, etc.) with respect to the given limitations. In relation to the efficient operation and fast customer satisfaction, it is an area with significant reserves for companies. Traditional paper and pencil methods, basic MS Excel or 'just' ERP SW are still often used in businesses. It can be and often is sufficient for smaller businesses with a small number of resources (machines, workers, etc.) and a small variety of production. Not for larger companies with many products and resources. The reason is low flexibility, a long optimization time or, for example, the inaccuracy of the resulting plan/schedule. In this context, the task of APS is to use special algorithms to find the optimal option of the solution (plan/schedule) based on defined initial conditions (minimization of costs, minimization of work in progress, etc.) and input parameters (resource availability and capacity, material availability, etc.).

MES (Manufacturing Execution System) SW is used primarily to implement production management and evaluation to achieve the greatest possible efficiency. MES represents a layer between ERP/APS (unless APS is already part of MES) and the technological process (machines, workplaces, terminals, PLC, IoT, etc.) and has links to other tools such as SCM (Supply Chain Management) used to manage the supply chain. MES SW helps to assign tasks to resources and vice versa and helps to manage these tasks, enables online transmission of documents, files or e.g. production documents, enables collection and evaluation of data e.g. on productivity and thus contributes to increasing operational efficiency.

Other important trends are the digital twin and computer simulation. It is nothing new, computer simulation has been known for decades and digital twin since 2003. However, both are developing, among other things, due to the development of other technologies, the growth of hardware performance and the general decline in hardware and software prices. A digital twin is a model of a physical product (e.g. an aircraft), a process (e.g. a production line) or an entire system (e.g. a production hall). It is usually a real, but it can also be a future, newly designed product, process or system. Depending on the specific needs, it is then possible to simulate and optimize various activities, behaviours, states and operations in a given digital model. It gives us space to find potential problems and risks and to propose the optimal solution, which can ultimately save time and money, increase utility value, etc. If we then want to have a constant overview of the current state of the 'physical' twin and have the ability to control the physical twin, it is necessary to have individual sensors on the product or IoT device in the process/system connected by a data network through which data are transmitted to a platform (and hence the whole digital twin) to visualize and work with it. [90]

From a long-term perspective, expenditures on business software are growing, more significantly between 2016 and 2019, when they increased by about $150 billion from $326 to 477 billion (Fig. 22, left).

In connection with COVID-19, a decline is logically expected for 2020, but it will grow again in 2021. COVID-19 is expected to harm short-term sales of software for marketing, IT support, project management or HR, finance and accounting (Fig. 22, right).



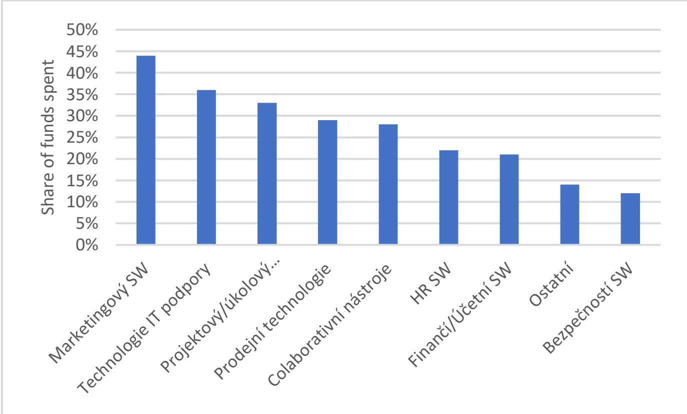


Fig. 22: (left) Spending on business software worldwide, between 2009 and 2021 (in billion USD); (right) What types of SW are business funds spent on? [38,39]

Marketing SW
IT support technology
Project/task…
Sales technology
Collaborative tools
HR SW
Financial/Accounting SW
Other
Security SW

Not only in connection with SW tools, a significant trend is also system integration, the aim of which is to connect all systems (equipment, hardware, software) and entities (suppliers and customers) into a single functional unit with a high degree of automation. The result should be a smooth and fast purchase process for both the customer and the manufacturer and supplier, from the order to the delivery of goods. Higher growth in investment in system integration has been taking place since 2015 (Fig. 23).

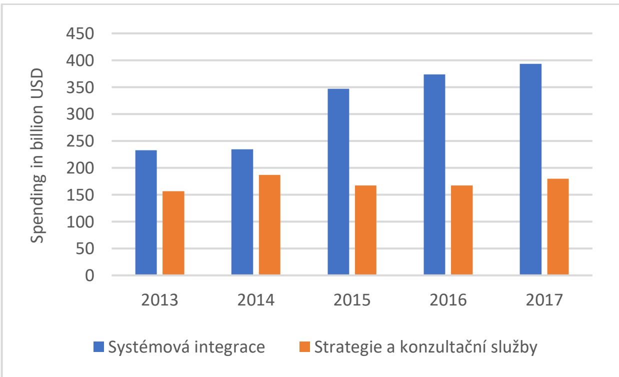


Fig. 23: Outlook on business and national spending on IT consulting and system integration between 2013 and 2017, by segment (in billion USD) [40]

System integration
Strategies and consulting services

1.2.9 Automation, robotics

Automation and robotics are already widely used in a number of business processes and their use, as with other technologies mentioned here, has a significantly growing trend. We would undoubtedly find more reasons, but we list at least some of the most important ones:

1. The average robot costs are decreasing in the long term. Fig. 24 shows the development of the cost of an industrial robot. At the same time, labour costs are increasing in the long term.
2. New types of robots are being developed that are smaller, able to monitor stimuli and events in their environment, and can possibly work with humans.
3. An aging population in some regions and labour shortages in some areas (e.g. logistics).
4. Digitization and development of other technologies and benefits associated with mutual integration (IoT, industrial SW, etc.).

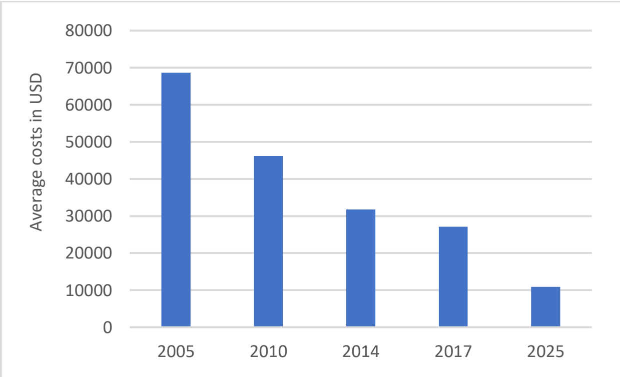


Fig. 24: Average costs of industrial robots in selected years from 2005 to 2017, with a view to 2025 (in USD) [41]

The main benefits of automation and robotics are saving human labour, lower operating costs, often also more efficient production with higher quality and more economical material handling, higher speed, minimization of errors and risks associated with them, etc. In the longer term, when robotic devices and automated systems are equipped with artificial intelligence, these devices will be able to adapt and learn new tasks without demanding (re)programming. [2] It is already partially possible and will be possible to emulate the human senses: visual and sound distinguishing, motion detection, collision avoidance, etc.

In addition to manufacturing operations, automation and robotics are also used in industry for transport, testing, packaging, parts inspection or loading and unloading. Expansion is also taking place in services such as healthcare or servicing, as no major robot modifications are required. The use of robots in agriculture is also growing.

The number of industrial robots delivered annually worldwide has been growing relatively steadily since 2010, except in 2012 and 2019, and their growth is expected in the future (Fig. 25, left). However, the question is exactly what impact the global COVID pandemic will have. Its impact can be both negative, as companies will not be able to invest due to insufficient financial resources, and positive, as some labour-dependent companies have been forced to close down, which might not have happened to them with automation. However, without the total number of robots operated in the world, the statistics of delivered robots would not be completely relevant. We can see that a large part of the delivered robots represents a new installation, not a replacement of existing robots (Fig. 25, right).

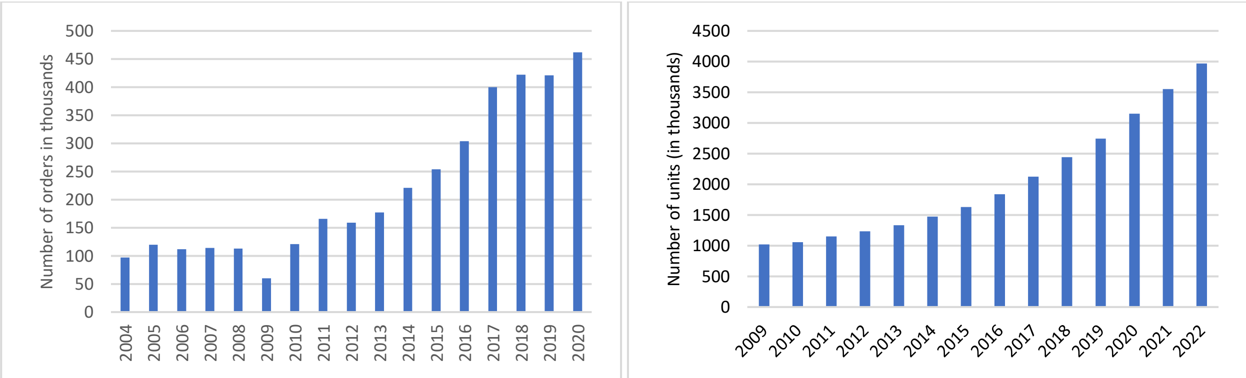


Fig. 25: (left) Number of industrial robots delivered annually between 2004 and 2022 (in thousand units); (right) Number of robots operated worldwide from 2009 to 2022 (in thousand units) [42,43]

Naturally, not all robots sold are traditional, some of the robots sold are collaborative. However, they accounted for about 2.75% in 2017 and about 3.3% in 2018 (Fig. 26). It is still a small percentage, which also lags behind the original estimates. A significant growth of this type of robots can still be expected without discussion in the future.

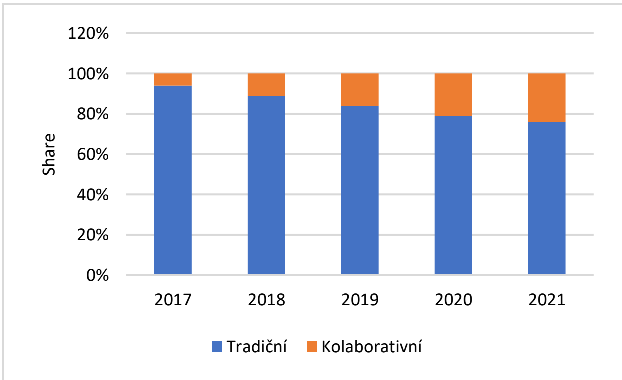


Fig. 26: Share of worldwide sales of traditional and collaborative robots between 2017 and 2021 [44]

Traditional
Collaborative

An important indicator is also the comparison of the number of installed robots in different countries. According to the IFR methodology, the 'robot density' indicator is used for comparison, i.e. the number of industrial robots per 10,000 persons employed in the manufacturing industry. This indicator amounted to approximately 74 industrial robots worldwide in 2016 and to 99 in 2018 (Fig. 27). This indicator has long been highest in Singapore and South Korea (831 and 774 in 2018, 488 and 631 in 2016), and both countries experience significant growth compared to other countries. Significant growth is also shown in China when the indicator increased from 68 to 140 in two years.

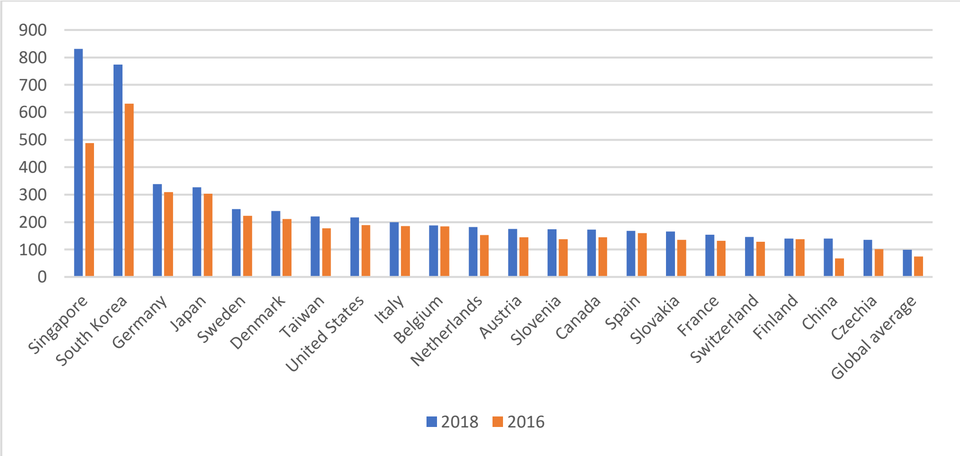


Fig. 27: Number of robots per 10,000 workers employed in manufacturing industry by country [45]

This indicator was at 135 in the Czech Republic in 2018, which is an increase of 34 compared to 2016. Although the indicator was above the world average in both years, it was still more than twice lower than, for example, in Germany and ¼ lower than in other small, industrialized countries in Europe, such as Belgium and the Netherlands. It was even lower than in Slovakia, which has seen a very dynamic implementation of industrial robots in recent years. Given that the Czech Republic is significantly dependent on the manufacturing industry, this comparison shows a great potential for the introduction of robots in the near future. Both to make up for the shortage of workers in the labour market and, in particular, to make it competitive and to maintain a good position in the world within the manufacturing chains. [2]

Looking at the application of robotics in individual industries, we can see that it does not go the same way. The differences reflect both the nature of production itself, and therefore the technological possibilities of its automation, and the economic conditions of producers, especially their investment opportunities and, last but not least, the relationship between the cost of new technologies and labour. [2]

According to the estimates by the International Federation of Robotics (IFR) (Fig. 28), the largest use of robots in production takes place within the global economy in the automotive industry and in production that is linked to it by suppliers. Robots are expanding at a fast pace in the electrical engineering and electronics industries, which are rapidly catching up with the automotive industry and where the number of robots in the world has doubled in recent years. Mechanical engineering and the metalworking industry occupy the third place in the scope of application of industrial robots and in the dynamics of their growth. Given that these three segments represent more than half of employment in the Czech manufacturing industry (approximately 56%), it can be expected that the intensity of robotics will be strongly reflected in technological changes and will also affect labour demand in the relatively near future. In particular, we can expect a change in the requirements for work performance and adequate knowledge, the ability of employees to handle modern expensive technology and modern information systems. [2]

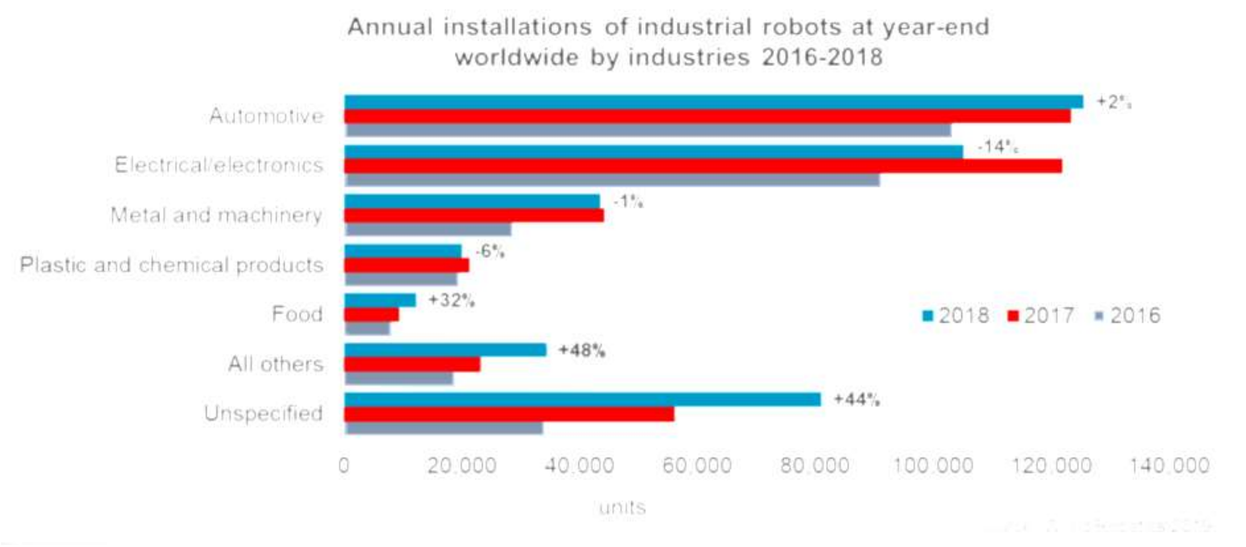


Fig. 28: Estimation of the number of robots by industry (in thousand units) [46]

In addition to industrial, there are also service robots for professional use. This includes various types of robots such as AGVs (Automated Guided Vehicles) for logistics (transport, storage), medical robots, agricultural robots, cleaning robots or exoskeletons. The largest group and at the same time the group where significant growth is expected in the near future are AGVs, of which approx. 111,000 units were sold in 2018 and it is expected that the annual volume sold could increase up to 712,000 units by 2022 (Fig. 29). The reason for such growth is mainly the lack of workers in the logistics sector. A significant number of sales are also achieved by control robots, around 100,000 units in 2018, however, only a minimum growth is expected in this area. One reason may be that this is a type of robot that is a relatively well-established standard.

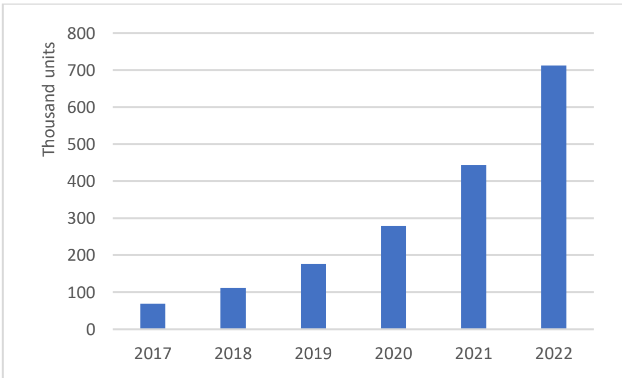


Fig. 29: Development of annual sales of AGV in thousand units [47]

However, it may not only be automation and robotics using physical robots, which comes to most people's mind first, but it can also be automation and robotics of administrative activities (marketing, public relations, intelligence, accounting, etc.). Computer robots are used here – we talk about the so-called RPA – Robotic Process Automation. This sector is also gradually growing, at a rate of approximately $1 billion per year since 2017, but growth in this market is expected to accelerate soon (Fig. 30, left). This is confirmed by a survey, where 34% of companies are testing a pilot use of RPA and 27% are preparing to put it into practice (Fig. 30, right).

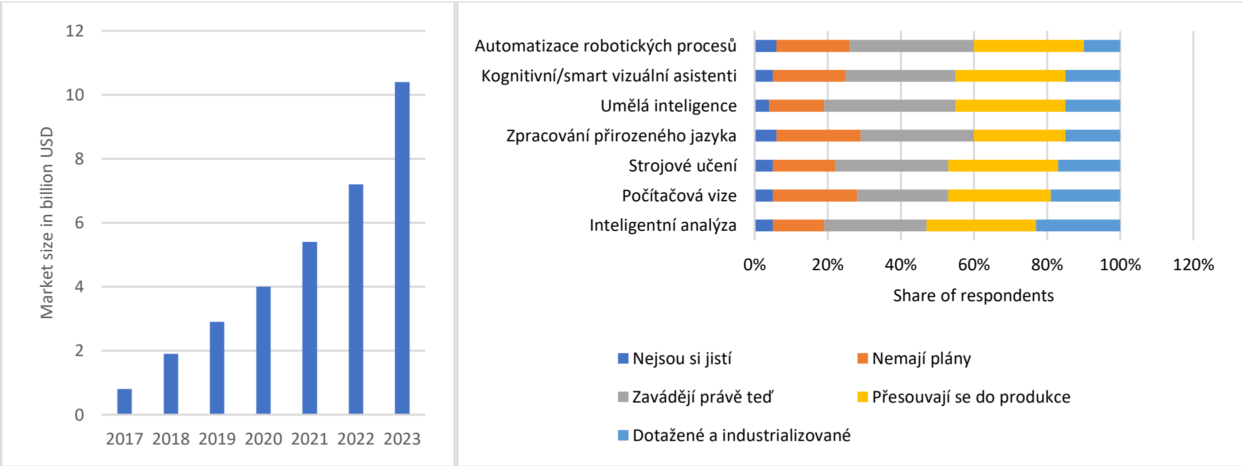


Fig. 30: (left) Global market revenues from RPA implementation between 2017 and 2023 (in billion USD); (right) Adoption of intelligent automation technologies in organizations around the world in 2019 [48,49]

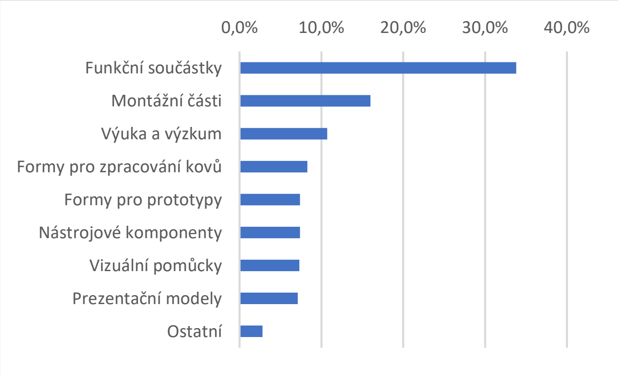
Automation of robot processes
Cognitive/smart visual assistants
Artificial intelligence
Natural language processing
Machine learning
Computer vision
Intelligent analysis

Not sure	*Do not have plans*
Implementing right now	*Moving to production*
Finished and industrialized	

1.2.10 Additive manufacturing

A crucial element of modern manufacturing businesses is advanced technologies that can produce industrial products faster and more accurately compared to traditional manufacturing processes. To some extent, additive manufacturing is such production technology, often inaccurately referred to as 3D printing, which is only a certain sub-area. Additive manufacturing transforms a 3D model of an object into a final object based on fusing its individual (‘2D’) layers, so that a new layer is always placed on the previous one (e.g. SLS technology) without the use of partial tools.

Additive manufacturing helps especially in the production of complex geometric shapes, which are difficult to manufacture by traditional production methods. The resulting products can therefore be produced with less design constraints, from more materials and with individual properties. Thanks to these facts, it is used mainly in the production of prototypes. Furthermore, in productions that work with expensive materials, in productions where there is a high share of custom or small series production, for which it is necessary to prepare specific components – additive manufacturing eliminates, for example, the need to produce moulds, thus shortening production time (realization of the whole order). Recently, additive manufacturing has also been used in the production of moulds (e.g. for pressing) or their parts, such as cooling. A percentage overview of the various purposes of use can be seen in the following diagram (Fig. 31, left). According to surveys from 2018, it is assumed that the largest application of additive manufacturing in the future will continue to be in the automotive and aerospace industry and especially in the healthcare sector (Fig. 31, right).



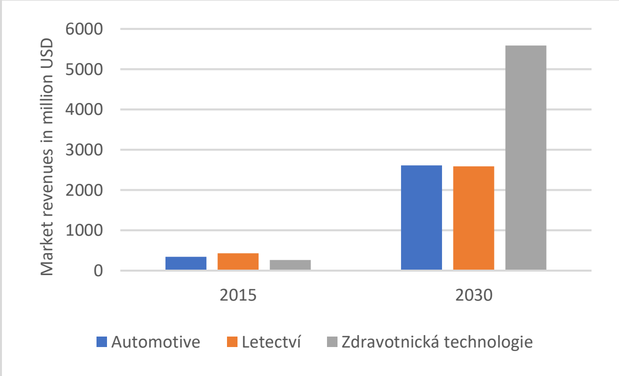


Fig. 31: (left) Worldwide use of additive manufacturing systems in 2017, by type of use; (right) Market potential in leading sectors between 2015 and 2030 (in million dollars) [50,51]

Functional parts
Assembly parts
Education and research
Metal processing moulds
Prototype mould
Tool components
Visual tools
Presentation models
Other

Automotive
Aviation
Medical technology

The most common reasons why companies use additive manufacturing or are preparing for it include the acceleration of product development, the effort to offer customized products and the effort to achieve greater flexibility in production (Fig. 32).

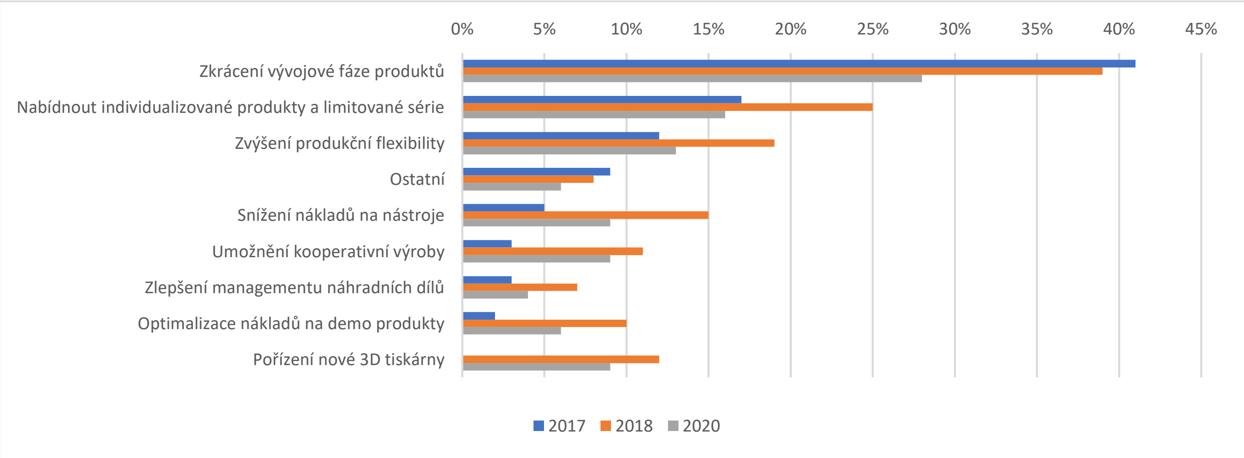


Fig. 32: What is your main goal associated with additive manufacturing in 2020? [52]

Reduction of product development phase
Offer of custom products and limited series
Increase in production flexibility
Other
Decrease in tool costs
Allows collaborative production
Improvement in spare parts management
Demo product optimization costs

Thanks to the relatively new additive technology HP Jet Fusion, which has a uniform production time per printing space regardless of the fullness, additive manufacturing can become competitive, especially for some types of products done in small series. In general, additive manufacturing is not yet competitive for larger volumes of serial products, especially with regard to the relatively long production time of one piece, which results in higher costs for this piece. The problem may be the quality of products which might not always be the same. Thus, additive manufacturing cannot be expected to replace other technologies (pressing, machining, etc.) in the foreseeable future. However, it will play an important role for business models based on custom (customized or even personalized) production.

In connection with additive manufacturing, a change in the supply chain is often mentioned, when printers will be much closer to the end customer and it will be possible to significantly reduce transport costs, reduce the volume of transported goods and reduce the amount of inventory required. This is a highly debated and controversial advantage, as current production systems and supply chains work so efficiently that the question is whether lower costs could actually be achieved without really changing business models towards custom (customized or even personalized) production.

According to a survey conducted by Ernst & Young in 2016, Czech manufacturing companies are strongly oriented towards additive manufacturing and succeed in international comparisons (56% of manufacturing companies have either actively used this technology or plan to introduce it in the next 5 years, compared to 36% of companies surveyed globally in the E&Y survey). In 2016, 21% of the surveyed Czech manufacturing companies actively used additive metal manufacturing, 72% of companies planned to introduce it by 2021. More than 65% of respondents used additive manufacturing in the USA in the same year, according to another PwC survey. [2,53]

Despite the undeniable advantages, additive manufacturing does not reach the use that was expected in the past. However, sales of additive technologies are, of course, constantly growing and were expected to reach 6.7 million machines by 2020, which is about 30 times more than in 2015 (Fig. 33).

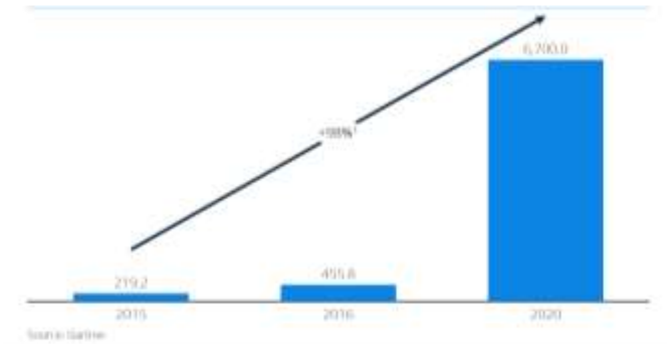


Fig. 33: Number of sold 3D printers in thousand units [54]

There are undoubtedly more barriers to development, but they are at least partially being phased out, and further expansion of additive manufacturing can potentially be expected. Barriers include the inability to use this technology especially for new business models that are based on customization and personalization of products. Furthermore, for example, the limited offer of material compared to traditional technologies, or the environmental friendliness of these materials and the already mentioned speed of serial production (always depends on the specific application). Let's just note that the relatively new additive HP Jet Fusion technology eliminates the speed problem to some extent. At the same time, other additive technologies seek to increase speed by adding laser heads, which, however, increase the price and thus require companies to make the most of machines. Undoubtedly, the lack of know-how is also a barrier, to which the insufficient offer of relevant fields of study at technical secondary schools and universities also contributes.

1.2.11 Virtual and augmented reality

Virtual reality is a computer-generated simulation of an environment (it can be real in origin, but also fictitious), which is often associated with the possibility of interaction with such environment. Augmented reality is a computer simulation that creates a virtual environment that reflects the real environment and adds virtual enhancements to it. Augmented reality is often associated with users interacting with this environment. Both virtual and augmented reality aim to enable the user to experience a specific situation first-hand.

The use of both technologies in industrial practice is still in its early stages. However, according to Gartner 2017 hype curve, virtual reality can be expected to break through regular operation in average businesses by 2022, and augmented reality in 2022–2027 (Fig. 34).

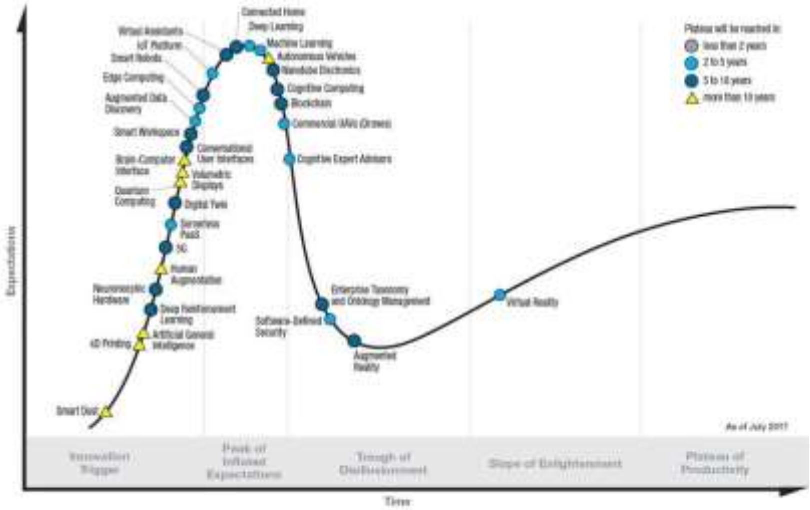
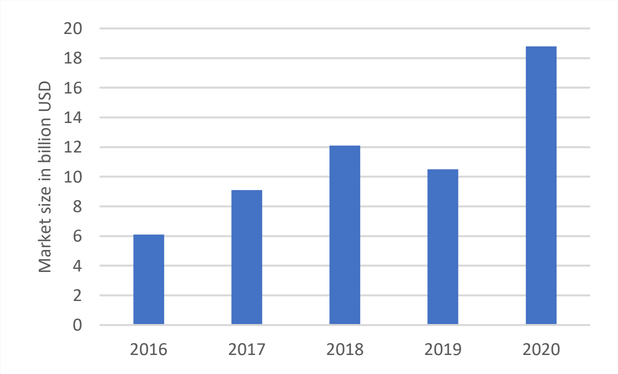


Fig. 34: Hype Cycle – Virtual and augmented reality 2017 [55]

According to Gartner's forecast, there are estimates of the size of the market with both technologies, the market is currently worth only about $12 billion. $. However, despite the slump in 2019, its further growth is predicted. The European market accounted for 1/3 in 2018, and in Europe alone it could reach as much as $50 billion in 2026, which is 10 times more than in 2018 (Fig. 35, left). Globally, it is assumed that the size of the augmented reality market alone could reach the size of almost $200 billion by 2025. $. Both technologies are used mainly by ordinary consumers, whose share for 2020 was estimated at 37.4%. The manufacturing industry, of the economic sectors, dominated with 19.3% and the public sector with 13.9% (Fig. 35, right).



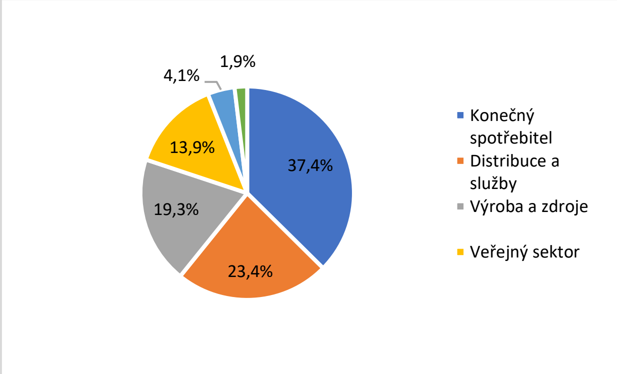


Fig. 35: (left) Estimated spending on augmented (AR) and virtual (VR) reality in 2020; (right) Projected distribution of spending on augmented (AR) and virtual (VR) reality by sector worldwide in 2020 [56,57]

End consumer
Distribution and services
Production and sources
Public sector

The following diagram shows the sales were mainly driven by mobile virtual reality (for phones) until 2017, which is the simplest solution (Fig. 36). The situation is gradually changing since 2018 and with further development, sales growth of other types of virtual and augmented reality and thus the growth in total sales are expected.

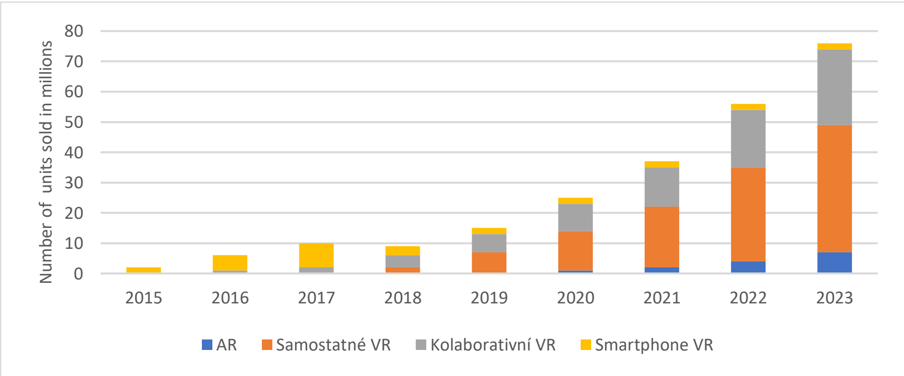


Fig. 36: Number of augmented (AR) and virtual (VR) reality devices sold worldwide between 2015 and 2023 (in million units), by product type [58]

AR
Separate VR
Collaborative VR
Smartphone VR

However, both technologies are already used for a wide range of operations from pre-production to basic production and even support processes such as maintenance and training. They help, for example, to select components from stock, to obtain instructions for repairs, to assist in the design or verification of products or production operations, to help train staff to perform specific operations (e.g. assembly), to increase the safety of workers, they are used for quality control or for risk management in placing various devices. They can also be used for support within the supply chain. Both technologies are gradually used in e-commerce, where they help the customer to better present the purchased product or set its specific parameters.

There are several reasons why these technologies are spreading relatively slowly. In particular, it is still a technical imperfection (or poor quality to some degree), complexity of hardware and software, insufficient preparation for their use in industry, a certain reluctance or fear of this technology.

The overall state of adoption of some technologies is summarized in the statistics from 2019 for Europe and North America (Fig. 37). According to a survey carried out by Spiceworks, companies mastered IT automation and fast network connection the most, and virtual reality or artificial intelligence the least. Approximately 20–30% of companies plan to introduce some of the modern technologies in the future.

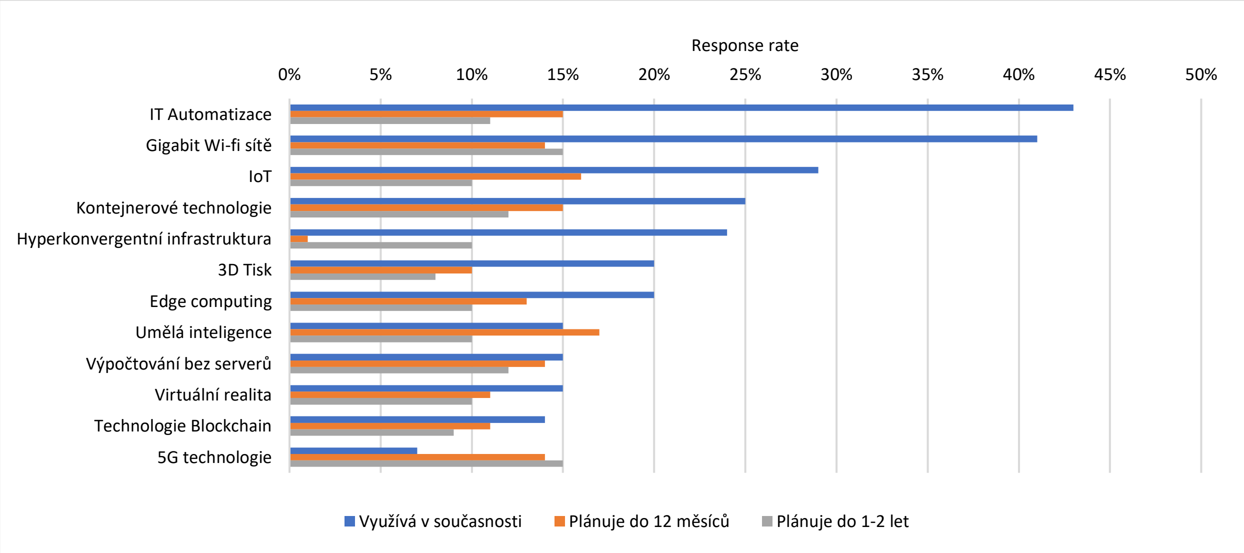


Fig. 37: Level of acquisition of trends in information technology (IT), present and future, in organizations in North America and Europe, by 2019 [59]

IT automation
Gigabit Wi-Fi networks
IoT
Container technology
Hyper-converged infrastructure
3D printing
Edge computing
Artificial intelligence
Settlement without servers
Virtual reality
Blockchain technology
5G technology

Used now
Planned within 12 months
Planned within 1–2 years

1.3 Demographic change

The labour market situation is also affected by demographic change. The population is aging in many developed countries. The number of people aged 65 or more is growing compared to the number of people aged 15–64. These people will therefore gradually leave the work process and retire. The question is whether there will be anyone to replace them. A solution, at least in some areas, may be the automation of these vacancies. It is assumed in the Czech Republic, for example, that the number of people aged 65 or over may represent up to 55% of the population aged 15–64 in 2050 (Fig. 38). It is almost two times more than in 2015. The Czech Republic is one of the countries with a lower number of university graduates in the EU. The worst situation will be in Japan, Italy, Spain, Portugal, Greece and South Korea in 2050. Best of all, logically, less developed countries such as South Africa, Indonesia or India.

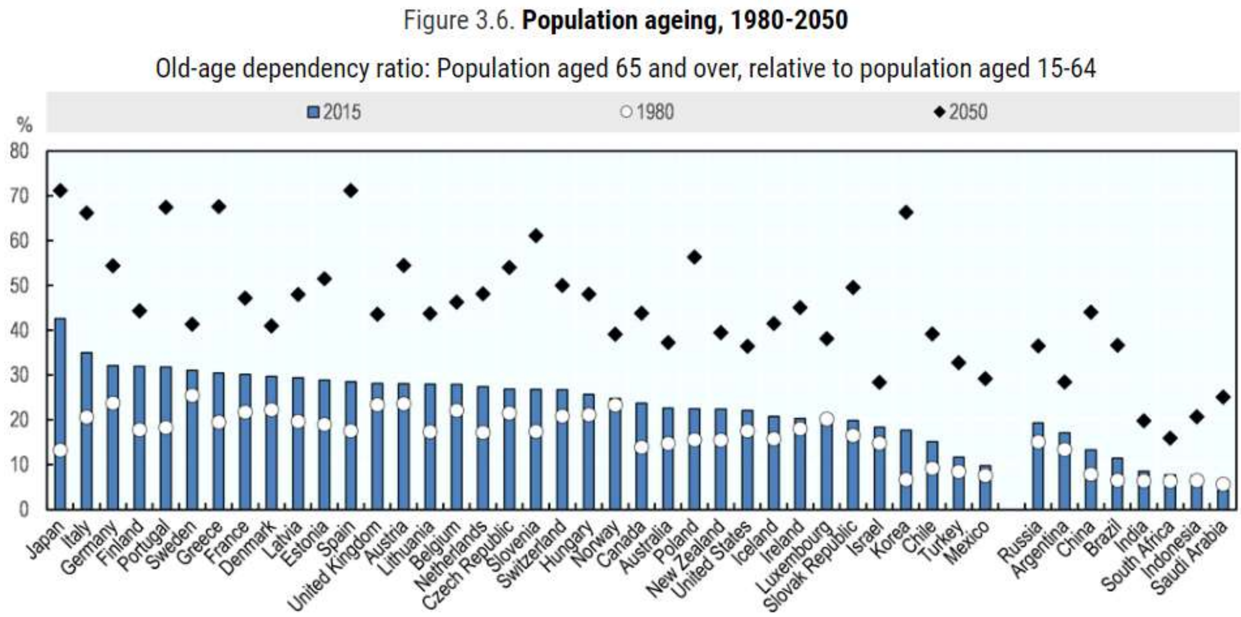


Fig. 38: Population aging, old-age dependency ratio of people aged 65 or over to people aged 15–64 [60]

2 Impacts of technology on the labour market

It is worth noting that the changes that the labour market is currently undergoing in relation to modern trends and technologies (especially in the field of production) are not sudden. Changes have been taking place for a long time and we may not even be aware of them. This fact is quite obvious in (Fig. 39) based on analyses carried out by the OECD. It shows how the percentage change in employment in individual sectors of the economy between 1995–2015 and people moved in the direction from the manufacturing sectors to services. We could look for more reasons, but it is undoubtedly the relocation of production to other countries and automation and robotics.

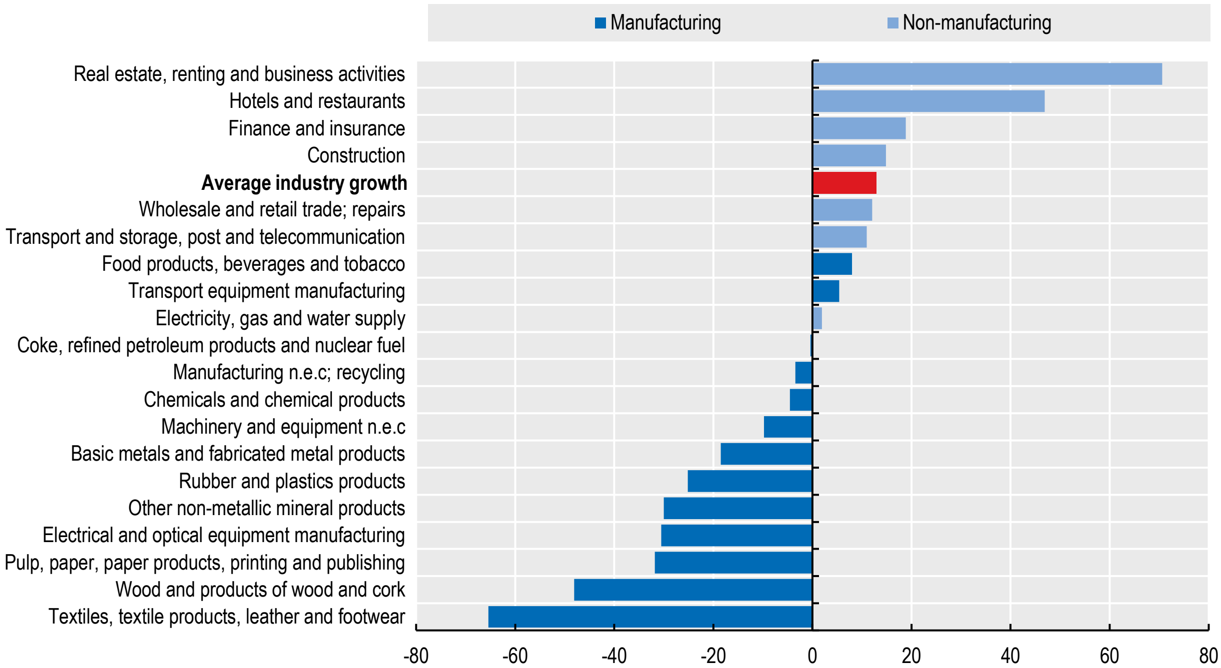


Fig. 39: Percentage decrease in the number of employees in individual sectors of the economy in OECD countries in 1995–2015 [61]

We can therefore expect that changes in jobs will continue to take place gradually in line with how current trends, especially technological ones, will be implemented in companies. At the same time, it should be borne in mind that some technologies (e.g. artificial intelligence, augmented reality, etc.) are only at the beginning of their long-life cycles and it will take some time before they reach a sufficient level of maturity necessary for normal implementation in practice.

The latest studies focused on estimating the impact of automation on jobs are in line with the fact that, in general, the application of modern technologies, especially automation, will take place in different forms, with different intensity and in different time periods. There will also be different courses in individual sectors and professions, depending on their nature.

Estimates of quantitative impacts on the labour market have been dealt with by some foreign research and analytical organizations. Their results are affected by the calculation methodology and focus on both the quantification of job losses and the quantification of job creation due to higher demand for new products, higher labour productivity or lack of qualified professionals for new technologies. Some studies also deal with the issue of retraining and transfer of workers to other, related jobs.

Recent studies have also taken greater account of the fact that different professions contain different ranges of routine activities that are automated. Computers/robots always represent a certain part of the total amount of work activities necessary for the performance of a profession, and it can be assumed that most professions do not disappear completely, but their content, i.e. work tasks performed, changes significantly. It is obvious that even professions identified as highly endangered contain a significant proportion of activities that can hardly be replaced by technology, or only at a more advanced stage of technological development.

Not all operations can be effectively robotized even in the area of manual activities, even those that are simple and do not require high qualifications. [2]

The implementation of Industry 4.0 is therefore associated with growing demands on education and human resources skills and generally assumes an increase in the level of human capital in the society – increasing the competencies and knowledge of employees. From this point of view, it means a significant shift towards the so-called knowledge society. Rapid technological development together with the growing demands on the knowledge and skills of employees is not only reflected in the situation on the labour markets, but also significantly changes companies. There are changes in the organizational structure of companies (towards flattening and decentralization) as well as changes in management style (from command-and-control to leadership and knowledge management). The importance of work teams in companies is growing and emphasis is placed on streamlining their communication, for example, by creating virtual teams. Virtual links will enable the communication of experts on a global scale (i.e. the creation of a team will not be limited by a company, region, country, etc.). This, on the one hand, creates enormous opportunities for knowledge sharing and its use, for effective problem solving and task performance, etc., on the other hand, this form of cooperation places high demands on team members, their knowledge, language skills and communication skills. This opportunity also has a strong impact on the labour markets of individual countries because it is possible to process orders from abroad at once and offer lower prices than is usual in a given country for a given service. So it is not just a number of opportunities that open up before us, but also certain risks that need to be viewed with respect. [2]

One of the essential characteristics of Industry 4.0 is the mass individualization of production, i.e. the ability to respond flexibly to customer requirements. There will be closer cooperation and communication between the manufacturer and service provider and the final consumer. However, this ability requires more flexible forms of employment and the organization of working time and also changes the demands on workers' knowledge and skills.

2.1 Ratio of human work to machine work

Compared to previous years, when experts largely expected mass replacement of the workforce by robots, opinions are now beginning to change in part. An analysis commissioned by the World Economic Forum suggests that in the short to medium term, some human positions will be strengthened rather than completely replaced by machine and computer work. Replacing routine and repetitive tasks will lead to better use of human potential and talent and thus increase productivity and competitiveness. Much of automation occurs at the level of tasks, not at the level of entire jobs or professions. It is estimated that about 2/3 of jobs contain at least 30% of automated tasks and ¼ jobs contain more than 70% of automated work tasks. Nevertheless, it is quite clear that the share of tasks processed by machines and computers will grow in the long run – the most burdened are positions dealing with information and data processing, performing complex and technical activities, performing physical and manual work activities or administering. Increase in the work of machines/computers is expected in these jobs by up to 17% by 2022 (**Chyba! Nenalezen zdroj odkazů.**). [62]

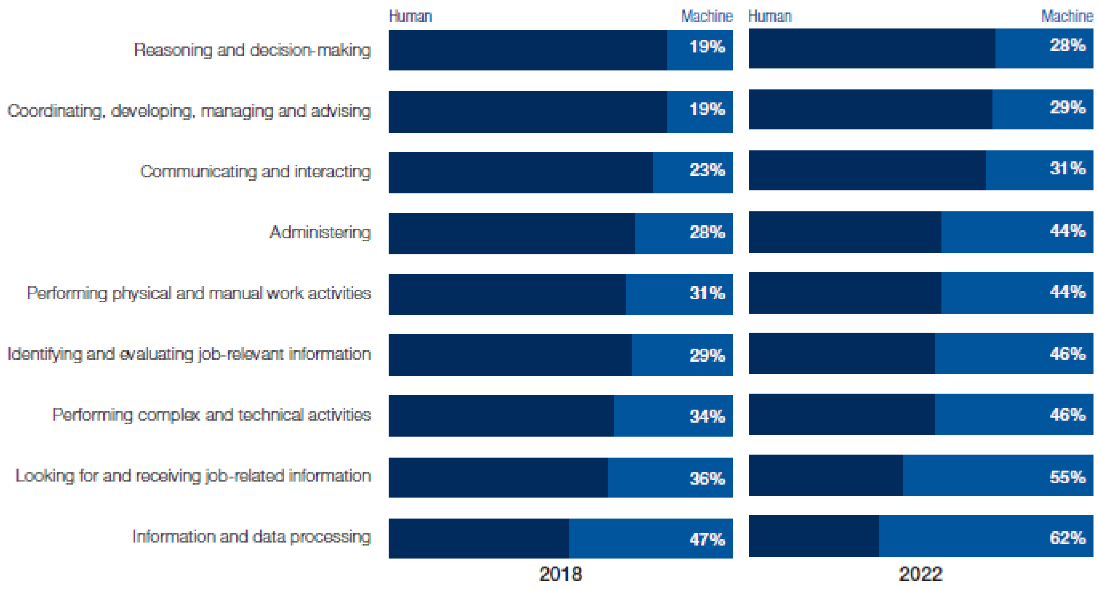


Fig. 40: Proportion of work performed by man and machine, 2018–2020 [62]

A more detailed look at the situation around 2023 can then be seen in the diagram from the summary report of the Research on the Potential of Artificial Intelligence Development in the Czech Republic. It compares a relatively large number of professions, jobs. For some, the share of skills that can be replaced by artificial intelligence is expected to be around 53% (**Chyba! Nenalezen zdroj odkazů.**).

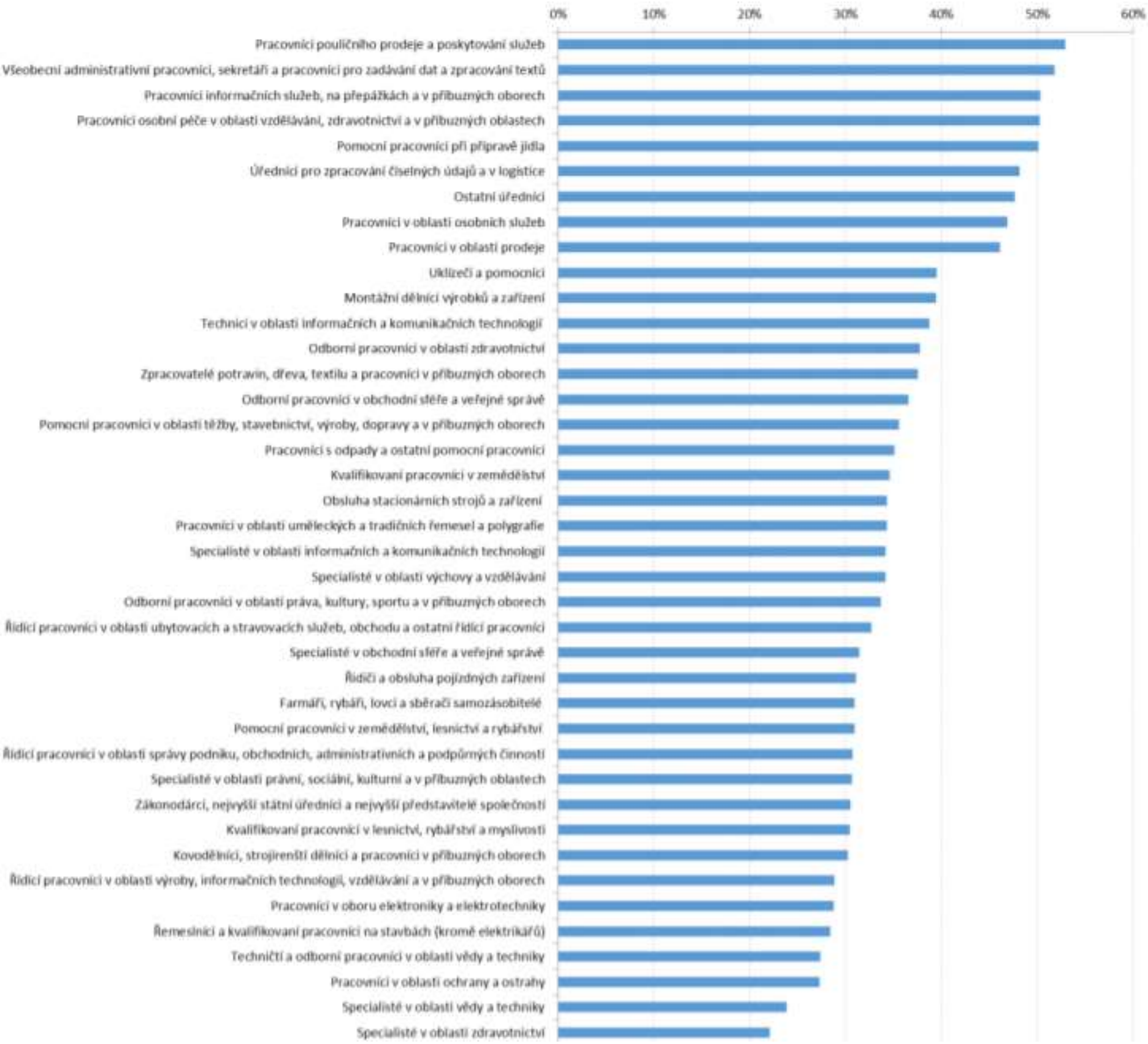


Fig. 41: Proportion of substitutable skills over a 5-year horizon [64]

Street trade and service provision workers
General administrative workers, secretaries and data entry and text processing workers
Workers in information services, counter staff and related areas
Personal care workers in education, health care and related areas
Auxiliary labour in food preparation
Office workers in numerical data processing and in logistics
Other office workers
Workers in personal services
Workers in trade
Cleaning staff and auxiliary labour
Product and equipment assembly workers
ICT technicians
Specialists in health care
Food, wood, textile processors and related areas
Specialists in business and public administration
Auxiliary labour in mining, construction, production, transport and related areas
Workers in waste processing and other auxiliary labour
Qualified workers in agriculture
Stationary machine and equipment operators
Workers in arts and crafts and traditional crafts and printing
ITC specialists
Education specialists
Specialists in law, culture, sports and related areas

Managers in accommodation and catering services, trade and other managers
Specialists in trade and public administration
Drivers and mobile equipment operators
Self-supply farmers, fishermen, hunters and pickers
Auxiliary labour in agriculture, forestry and fishing
Managers in business management, business, administrative and support activities
Specialists in law, social, cultural and related areas
Legislators, chief state officials and company top management
Qualified workers in forestry, fishing and game management
Metal workers, engineering workers and related areas
Managers in production, IT, education and related areas
Workers in electronics and electrical engineering
Craftsmen and qualified workers in construction (excl. electricians)
Technical and specialized workers in science and technology
Security guards
Specialists in science and technology
Specialists in health care

An estimate of the time horizon of technological substitutability of key skills from 2018 is shown in **Chyba! Nenalezen zdroj odkazů.**. The estimate is divided into 4 time periods: up to 5 years, 6–15 years, 16–30 years and over 30 years. For example, mobility or natural language creation is not expected until 2034 at the earliest. Logic, problem-solving ability, creativity, understanding of natural language or emotional intelligence are not expected until 2048 at the earliest.

Do 5 let	6 – 15 let	16 – 30 let	Nad 30 let
• Optimalizace a plánování • Rozpoznání známých kategorií • Získávání informací • Navigace • Hrubá motorika	• Jemná motorika • Vytváření nových kategorií • Prezentace výsledků • Sensorika	• Mobilita • Interakce a koordinace ve skupině • Tvorba přirozeného jazyka	• Logika a schopnost řešení problémů • Kreativita • Porozumění přirozenému jazyku • Sociální a emoční dovednosti

Fig. 42: Estimating the time horizon of technological substitutability of key skills [64]

Within 5 years
Optimization and planning
Recognition of known categories
Obtaining information
Navigation
Gross motor skills

6–15 years
Fine motor skills
Creation on new categories
Presentation of results
Sensorics

16–30 years
Mobility
Interaction and coordination in a group
Creation of natural language

Over 30 years
Logic and problem-solving skills
Creativity
Understanding of natural language
Social and emotional skills

2.2 Assumptions of affected jobs in individual countries

From a theoretical point of view, digitization should not fundamentally affect the number of jobs in a global or closed economy. There are fewer new jobs than jobs extinct, but the employee's remuneration should generally be higher, due to potentially increased productivity, although the total volume of wages under the isolated effect of digitization is strictly lower. In practice, however, we can still expect job losses, which will also correspond to a reduction in the productive base (see below).

In addition to regions where capital gains are consumed, the positive effects of digitization will be of greater benefit to economies and regions, which will be able to attract these funds with their professional structure. Therefore, the relative distribution of professional readiness for digitization (especially in the aspect of low impact of destruction) within the EU has a strong predictive value of the relative positive impact of digitization. [63]

The risks to the labour market from accelerated automation can be divided so that the first is the current professional structure of the Czech Republic, which can be more or less affected by the automation process. The Czech Republic is slightly above average in the distribution of this risk of the negative impact of digitization within the EU, while the level of threat tends to increase as it moves from the northwest to the southeast of the EU (Fig. 40) [63]

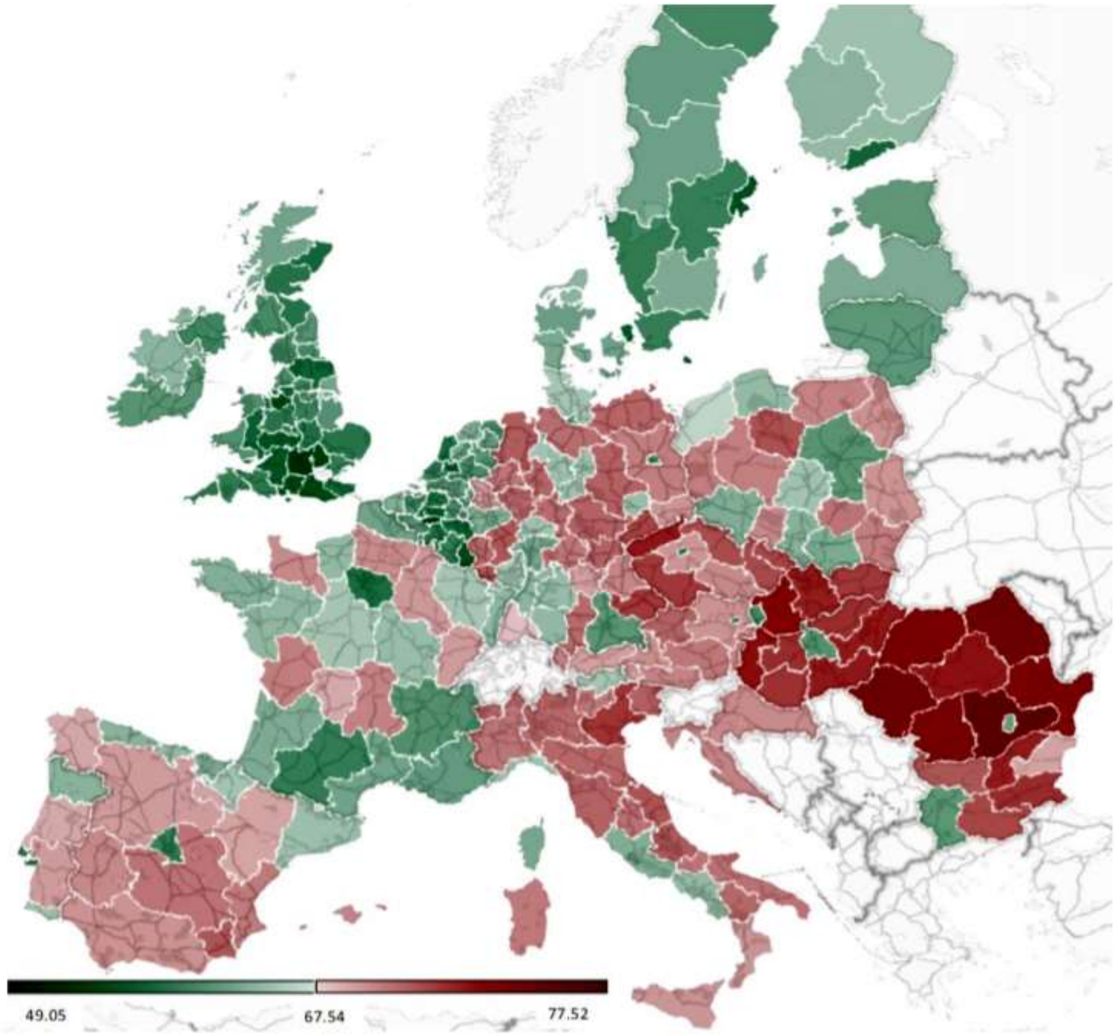


Fig. 43: EU according to the job digitization risk index [63]

The second aspect affecting the future returns of the Czech economy from the digitization process is the economic and capital structure of the Czech economy, which determines the ability to create and manage physical capital (which will be used as a substitute for job losses) and especially the ability to consume or invest capital gains. Due to the relatively small level of domestic ownership, the declining level of reinvestment and the low level of research and development in the Czech Republic compared to the EU, this structure is not in favour of the highest possible absorption of positive externalities in the area of capital substitution. Unless there is a fundamental change in the structure of the Czech economy, these activities will tend to be concentrated in capital-richer countries with developed research infrastructure, either within the EU or globally. [63]

As part of the still relatively current extensive analysis of the OECD from 2018, which took into account various factors (including requirements for the level of skills and activities necessary for the performance of individual professions), it is assumed that automation will burden about 14% of jobs and another 32% of professions with significant changes in the next 10–20 years (Fig. 44). These estimates are significantly more positive than in the past. The situation of the Czech Republic in comparison with other countries corresponds approximately to the average, which, when recalculated to the labour market of the Czech Republic, means that around 780,000 jobs have a high risk of being affected by automation and over 1,560,000 more can undergo extensive changes (according to the state of employment in 2017). [2] The best are the Nordic countries, the USA or the United Kingdom, where the services segment is strongly developed, the worst then Slovakia, but also Germany or Japan.

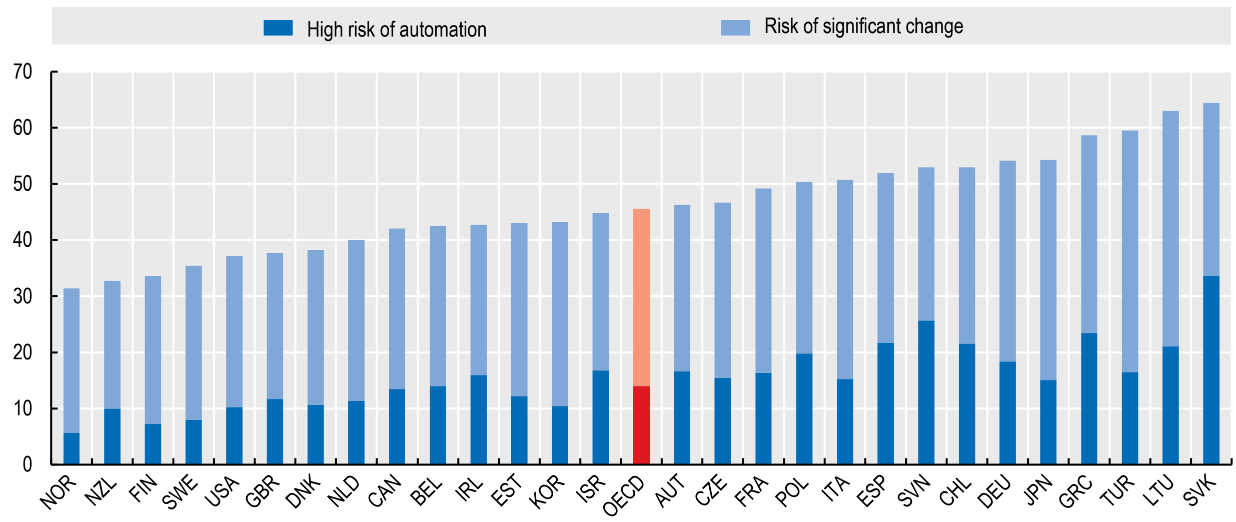


Fig. 44: Proportion of places with a high risk of automation risk and places with a risk of significant change (%) [65]

If we look at what the situation looks like regionally (Fig. 45), according to the OECD, the region of Central Moravia is the most endangered in the Czech Republic (27%), where the manufacturing industry mostly is. The least endangered is, quite logically, Prague (9.5%).

Fig. 45: Regions with the highest and lowest risk of job automation in OECD countries [66]

The analysis of the impacts of automation and robotics on the labour market in 2018 was also carried out by the consulting company PwC, its analysis is based on similar principles as the OECD analysis, but considers other factors such as the level of technology in relation to their implementation in practice, various sectors of the economy, different composition of workers (gender, age, education). As part of its analysis, PwC distinguishes three waves of automation and robotics: [67]

1. The algorithm wave (will run until the mid-2020s) – Focuses on simple computational and analytical tasks over data in the field of finance and information and communication technologies.
2. The augmentation wave (will run mainly in the 2020s) – Focuses on recurring tasks associated with filling in forms, communication and data exchange, statistical analysis.
3. The autonomy wave (will run especially in the 2030s) – Focuses on automating physical and manual work and solving problems requiring real-time response.

According to PwC's analyses, jobs will be most affected by job automation in Slovakia, the Czech Republic, Slovenia and Italy, especially in the second and third waves (Fig. 46). This is mainly due to the fact that these are countries with a strong manufacturing industry. However, these waves will also strongly affect the USA, where the problem is lower education, or Italy, where there is a population with a relatively old age for a change. In the case of the Czech Republic, up to 39% of jobs may be affected in all three waves, specifically 3% of jobs in the first wave (approx. 155,000), 22% of jobs in the second (1,150,000) and about 14% of jobs in the third wave (730,000). [2] Estimates are based on data (state of employment) in 2017.

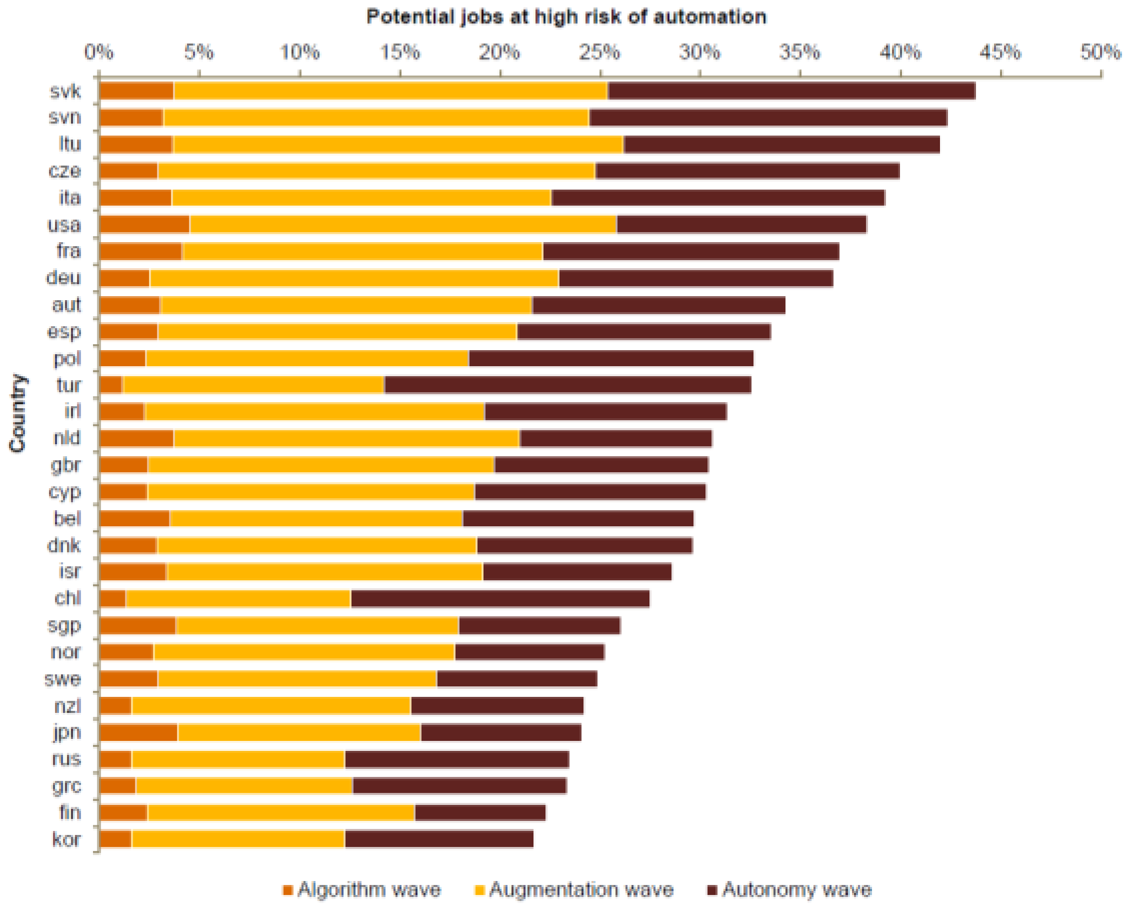


Fig. 46: Potential of automation of professions by waves and countries [67]

If we look at the workers at risk of automation depending on the size of their income, the OECD analysis shows that more than 20% of low-income workers in all Member States are at risk of automation (Fig. 47). However, automation has recently begun to cover not only manual routine tasks, but also 'cognitive routine' tasks (e.g. image and speech recognition). This can and will most likely have an impact in the future on high-skilled jobs and thus on middle- and high-income groups. On average for OECD countries, it is estimated that about 18% of middle-income workers and 11% of higher-income workers are at risk. As for the Czech Republic, the situation here is close to the OECD average. In countries that are at their best, such as Finland, South Korea or the USA, a maximum of about 14% of the lowest-income workers, up to 10% with middle-income workers and up to 6% with higher are at risk. [68]

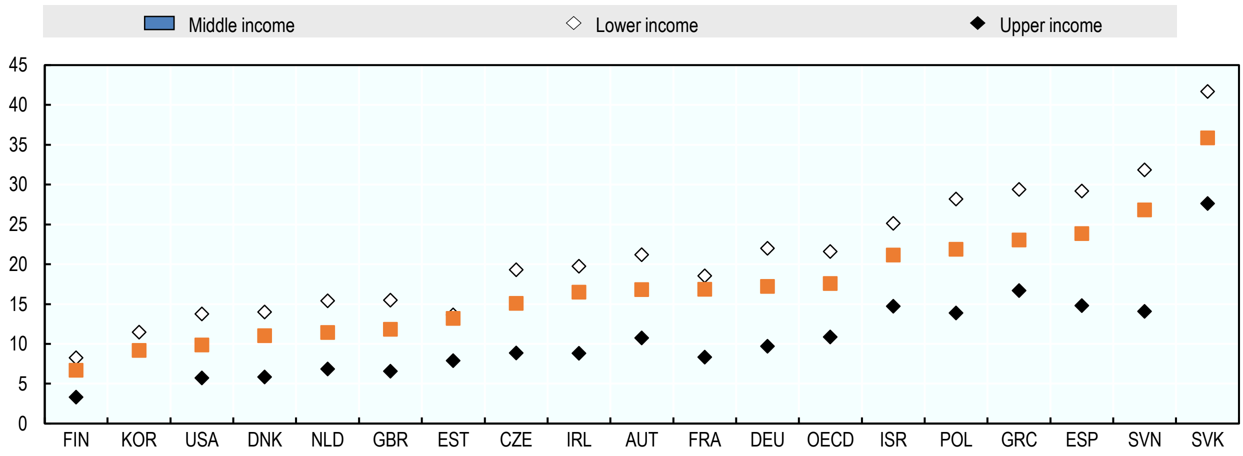


Fig. 47: Workers at risk of automation depending on the size of income [69]

Note: Workers with a 'low income' are defined as workers with their income below 75% of the national median. Middle-income workers are workers with an income between 75% and twice the national median. High-income workers are workers with their incomes higher than twice the national median. Automation risk is calculated as the average of automation risks by occupation, weighted by the share of each occupation in the income class.

2.2.1 Assumptions of affected jobs in the Czech Republic

The Czech Republic's ability to capitalize on the digitization process must be actively and strategically created. A passive approach can lead to negative relative aggregate effects on the Czech economy. Digitization tends to have self-reinforcing effects, i.e. greater potential for more developed regions and less potential for less developed regions, both within the EU and within the Czech Republic. This entails the risks of regressive regional development, to which it is possible to respond, for example, by projects for the development of advanced ICT in regions with little natural potential in this area, such as priority building of ICT infrastructure, university and research centres, financial instruments and consultation hubs in regions with higher degree of risk of the extinction of professions as part of the digitization process. [63]

Potentially increased social spending is also crucial. Even within the positive trend of substituting lower-paid jobs for better-paid jobs, there will be an increased need for continuous retraining, which, due to the complexity of future jobs, will lead to a higher risk of low employability of people currently practicing the professions most affected by digitization. These will lead to higher costs for the state budget to ensure reintegration into the work process, active employment policy and social protection. To minimize the negative consequences, it is possible to consider special tools or funds for continuous retraining and lifelong learning. [63]

The professional groups most at risk are those prone to being replaced by increasingly available digital technologies or simple automation. Some of them are substitutable today, but they persist in the labour market due to marginal wage costs still lower than automation spending (Fig. 49).

ISCO-3 Kód	Název profese	Index ohrožení digitalizací
431	Úředníci pro zpracování číselných údajů	0,98
411	Všeobecní administrativní pracovníci	0,98
832	Řidiči motocyklů a automobilů (kromě nákladních)	0,98
523	Pokladníci a prodavači vstupenek a jízdenek	0,97
621	Kvalifikovaní pracovníci v lesnictví a příbuzných oblastech	0,97
722	Kováři, nástrojaři a příbuzní pracovníci	0,97
441	Ostatní úředníci	0,96
412	Sekretáři (všeobecní)	0,96
834	Obsluha pojízdných zařízení	0,96
612	Chovatelé zvířat pro trh	0,95
921	Pomocní pracovníci v zemědělství, lesnictví a rybářství	0,95
811	Obsluha zařízení na těžbu a zpracování nerostných surovin	0,94
814	Obsluha strojů na výrobu a zpracování výrobků z pryže, plastu a papíru	0,94
432	Úředníci v logistice	0,94
821	Montážní dělníci výrobků a zařízení	0,93
816	Obsluha strojů na výrobu potravin a příbuzných výrobků	0,93
961	Pracovníci s odpady	0,93
421	Pokladníci ve finančních institucích, bookmakeři, půjčovatelé peněz, inkasisté pohledávek a pracovníci v příbuzných oborech	0,93
831	Strojvedoucí a pracovníci zabezpečující sestavování a jízdu vlaků	0,92
818	Ostatní obsluha stacionárních strojů a zařízení	0,92

Fig. 48: Twenty jobs with the highest job digitization risk index [63]

ISCO-3 code Job Digitization risk index

Numerical data processing clerks
General administrative workers
Riders and drivers (excl. trucks)
Cashiers and ticket sellers
Qualified workers in forestry and related areas
Blacksmiths, tool setters and related workers
Other office workers
Secretaries (general)
Mobile equipment operators
Animal breeders (for market)
Auxiliary labour in agriculture, forestry and fishing
Mining and mineral processing equipment operators
Rubber, plastic and paper product processing and production machine operators
Office workers in logistics
Product and equipment assembly workers
Machine operators in production of food and related products
Waste processing workers
Cashiers in financial institutions, bookmakers, moneylenders, debt collectors and workers in relate areas
Engine drivers and workers ensuring train assembly and operation
Other stationary machine and equipment operators

The professions which have the least potential for digitization and which have a lower risk of threat from this phenomenon and will be maintained or strengthened are those with high demands on social, organizational, physical, creative or intellectual requirements (Fig. 50).

ISCO-3 Kód	Název profese	Index ohrožení digitalizací
142	Řídící pracovníci v maloobchodě a velkoobchodě	0,000
221	Lékaři (kromě zubních lékařů)	0,001
222	Všeobecné sestry a porodní asistentky se specializací	0,002
134	Řídící pracovníci v oblasti vzdělávání, zdravotnictví, v sociálních a jiných oblastech	0,002
122	Řídící pracovníci v oblasti obchodu, marketingu, výzkumu, vývoje, reklamy a styku s veřejností	0,005
231	Učitelé na vysokých a vyšších odborných školách	0,008
133	Řídící pracovníci v oblasti informačních a komunikačních technologií	0,008
141	Řídící pracovníci v oblasti ubytovacích a stravovacích služeb	0,010
131	Řídící pracovníci v zemědělství, lesnictví, rybářství a v oblasti životního prostředí	0,011
226	Ostatní specialisté v oblasti zdravotnictví	0,011
215	Specialisté v oblasti elektrotechniky, elektroniky a elektronických komunikací	0,015
252	Specialisté v oblasti databází a počítačových sítí	0,021
143	Ostatní řídící pracovníci	0,021
312	Mistři a příbuzní pracovníci v oblasti těžby, výroby a stavebnictví	0,022
214	Specialisté ve výrobě, stavebnictví a příbuzných oborech	0,044
111	Zákonodárci a nejvyšší úředníci veřejné správy, politických a zájmových organizací	0,048
213	Specialisté v biologických a příbuzných oborech	0,050
263	Specialisté v oblasti sociální, církevní a v příbuzných oblastech	0,054
132	Řídící pracovníci v průmyslové výrobě, těžbě, stavebnictví, dopravě a v příbuzných oborech	0,054
242	Specialisté v oblasti strategie a personálního řízení	0,056
264	Spisovatelé, novináři a jazykovědci	0,058

Fig. 49: Twenty jobs with the highest job digitization risk index [63]

ISCO-3 code Job Digitization risk index

Managers in wholesale and retail
Doctors (excl. dentists)
General nurses and specialized midwifes
Managers in education, health care, social and other areas
Teachers at universities and vocational schools
ICT managers
Managers in accommodation and catering services
Managers in agriculture, forestry, fishing and the environment
Other specialists in health care
Specialists in electrical engineering, electronics and electronic communication
Specialists in database and computer networks
Other managers
Masters and related workers in mining, production and construction
Specialists in production, construction and related areas
Legislators and chief officials in public administration, political organizations and associations
Specialists in biological and related areas
Specialists in social, religious and related areas
Managers in industrial production, mining, construction, transport and related areas
Specialists in strategy and HR management
Writers, journalists and linguists

Regarding the effects of digitization within individual sectors of the Czech economy, the index expresses the extent to which individual sectors will have to be transformed internally, depending on the number of employees with a high digitization risk index. The consequences of changes in the global economic structure are likely to be more intense in sectors with a higher degree of digitization. Greater connection to the global economy means not only greater opportunities, but also a more competitive environment. It can therefore be assumed that the replacement of labour by capital will be faster here and will bring higher efficiency. Ultimately, this process is likely to have a positive impact on the global competitiveness of these sectors. Some sectors may be at relative risk in limited cases, where there may be substitution for the activities of other sectors. However, this risk is relatively small, as substitution occurs mainly at a lower level (in close fields), not at the level of sectors (Fig. 51). [63]

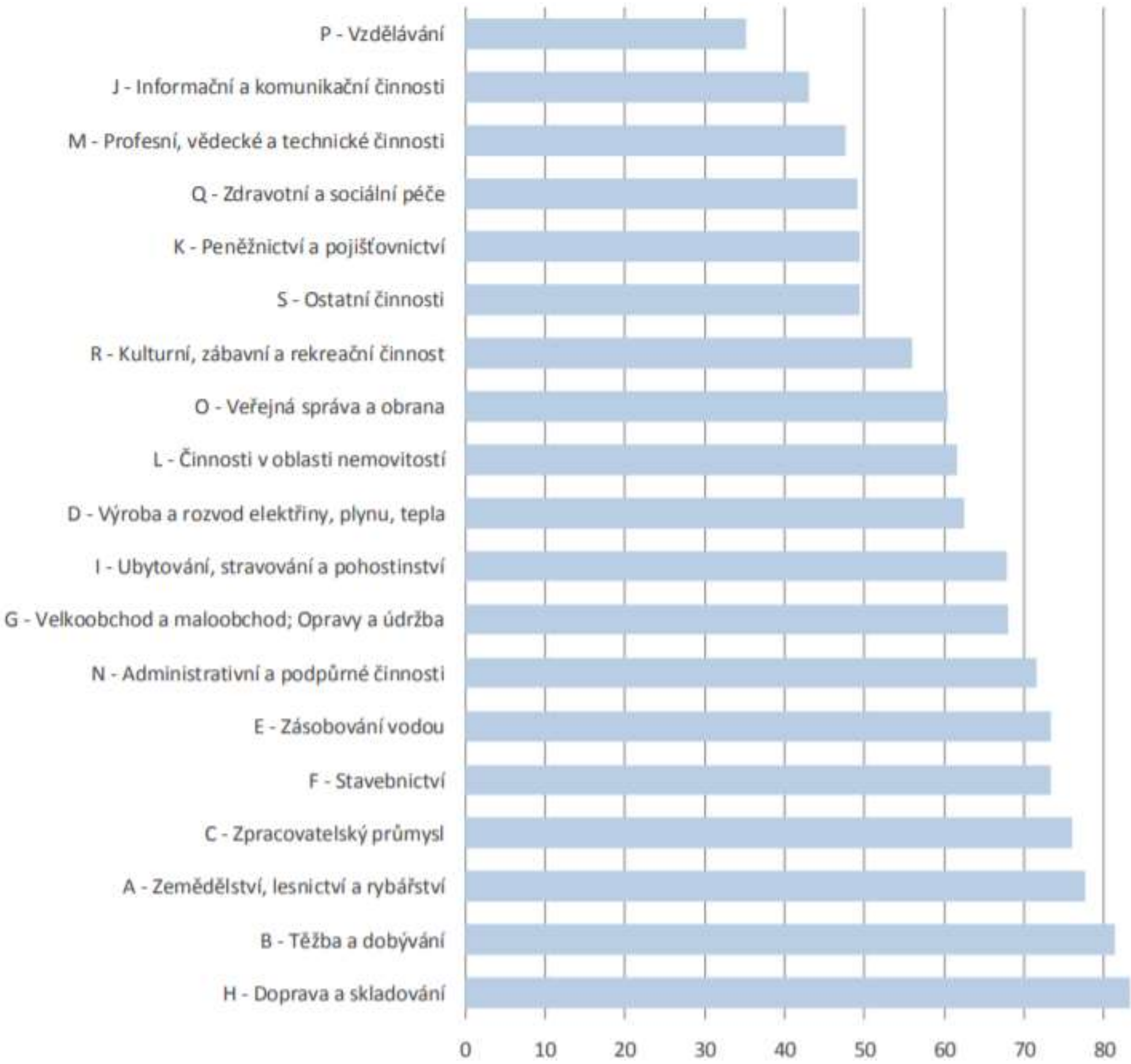


Fig. 50: Job digitization risk index (distribution by economic sectors) [63]

P – Education
J – Information and communication activities
M – Professional, scientific and technical activities
Q – Health care and social care
K – Finance and insurance
S – Other activities
R – Cultural, entertainment and recreational activities
O – Public administration and defence
L – Real estate activities
D – Electricity, gas, heat generation and distribution
I – Accommodation, catering, hospitality industry

G – Wholesale and retail; Repairs and maintenance
N – Administrative and support activities
E – Water supply
F – Construction
C – Manufacturing industry
A – Agriculture, forestry, fishing
B – Mining and extraction
H – Transport and storage

According to a study conducted by Chmelař et al., there will be a decrease in job positions on the labour market by approximately 420,000 jobs by 2029 (compared to 2015). However, this large drop in labour demand does not need to be assessed in any pessimistic way, as it will also be accompanied by a decline in labour supply. Demographic projections of the CZSO assume a significant decrease in people of working age by about 400,000 people (compared to 2015). It can also be assumed that the situation on the labour market will continue to reflect structural unemployment, the mismatch of demand and supply in terms of the required knowledge and skills, as well as the length of the training period for a profession, or other factors. [63]

For the Czech Republic, the introduction of new technologies and the advancement of digitization and automation has enormous potential for further economic growth and the creation of new jobs with a better monetary value and a consequent increase in living standards and quality of life. However, in order for this to happen, it is necessary to create an appropriate professional structure (with sufficient working knowledge and competencies), as well as a digital infrastructure.

2.3 Assumptions of affected jobs by economic sectors

As noted above, the introduction of modern technologies in the various sectors of the economy will take place at different intensities and at different times, given their different level of development. According to the aforementioned PwC survey, it is quite logical that the first wave is expected to hit services the hardest, namely the finance and insurance sectors, the ICT services sector and the professional, scientific and technical activities sector. In these sectors, automation is expected to affect around 8% of jobs.

The second wave, which already includes the automation of more complex tasks, will again hit finance and insurance, public administration, transport and storage, and the manufacturing industry most noticeably, where around 25% of jobs will always be at risk. The third wave, in which the automation of physical and manual work is already assumed, logically concerns especially transport and storage, manufacturing and construction, again about 25% of jobs will be at risk. Overall, the automation will affect the accommodation and catering services and healthcare sectors the least, where up to 23% of jobs are at risk in total for all waves, and education, where it is less than 10% for all three waves. Overall, the transport and storage sector (53% of jobs at risk) and the manufacturing industry (approximately 45% of jobs at risk) will be most affected (Fig. 51).

Within the manufacturing industry, which is an important sector in the Czech Republic, the highest risk to jobs in the second and third waves is expected. The second wave, which will take place during the 2020s, will affect about 23% of jobs (335,000 jobs). The third wave in the 2030s will affect 20% of jobs (290,000 jobs). [2]

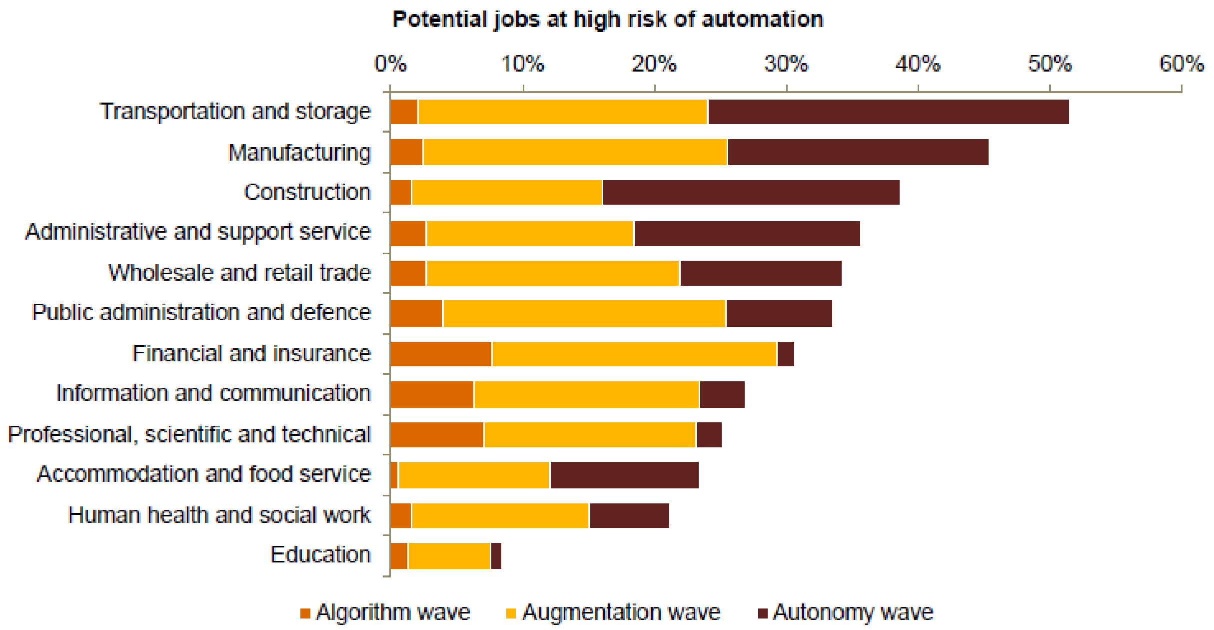


Fig. 51: Potential for automation of professions in individual sectors of the economy [67]

2.4 Assumptions of affected jobs by businesses

One thing is what changes or analyses of international organizations, consulting companies and experts expect or predict, and another thing is how the situation is perceived by the companies themselves. A recent 2019 survey by Boston Consulting Group among 1,314 companies from around the world shows that a large proportion of companies expect to lay off workers in connection with robotics. Redundancies of at least 5% of employees are expected by 56% of Asian, 50% of North American and 44% of European companies (Fig. 54). Overall, companies from China, Poland and Japan anticipate redundancies (57–67% of companies), followed by companies from Italy (34%), which may be to some extent related to the age of local population. At the same time, however, 62% of companies add that, in connection with the introduction of advanced robotics, they also expect to hire new employees – white collars, for example, to adapt new solutions to the company's needs. [70]

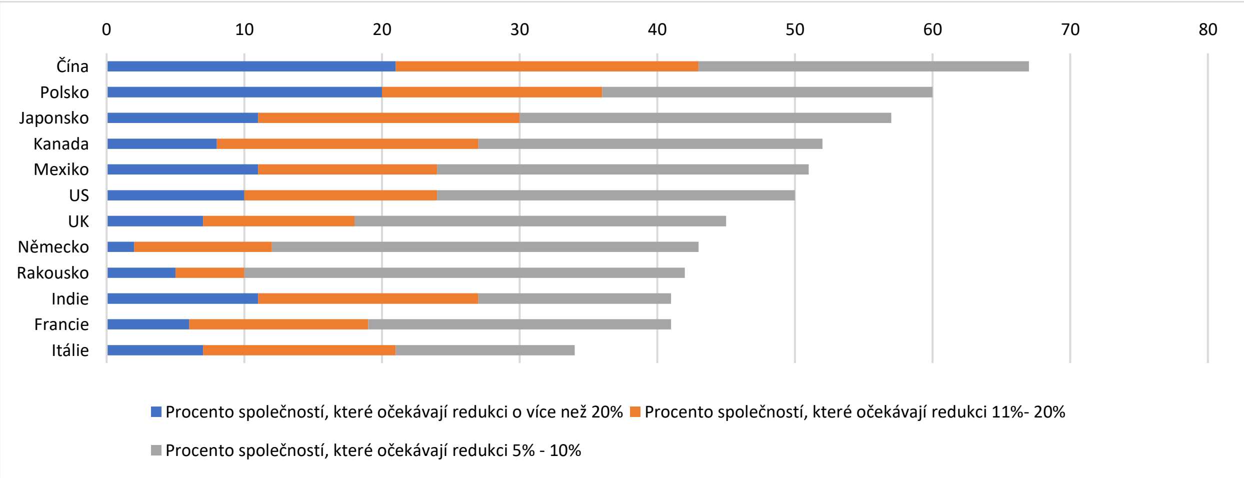


Fig. 52: Impact of the implementation of advanced robotics on the number of jobs [70]

China

Poland
Japan
Canada
Mexico
USA
UK
Germany
Austria
India
France
Italy

% of companies expecting reduction by more than 20%
% of companies expecting reduction by 11%–20%
% of companies expecting reduction by 5%–10%

The redundancies by 2022 are also expected by companies from a survey conducted by the World Economic Forum in 2018. Here, 50% of companies expect to lay off workers as a result of automation (Fig. 52). However, 38% of companies generally expect to recruit new employees and 28% of companies expect to recruit new employees due to automation.

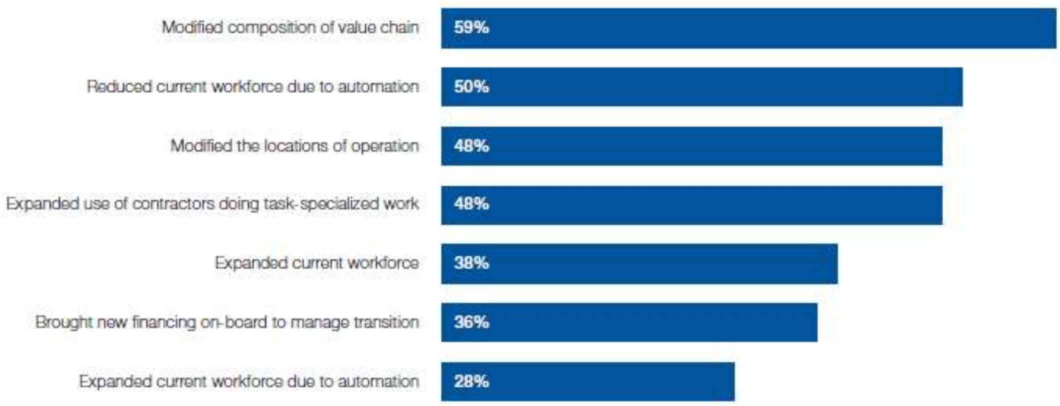


Fig. 53: Impacts of current changes on the workforce by companies [62]

2.5 Attitudes of employees in connection with automation

In connection with the previous survey, it is interesting to compare how people themselves view the risk of automation. More than 65% of people are convinced that robots and computers will or probably will do a large proportion of work in the next half century (Fig. 54). People are most convinced of this in Greece and Japan, more than 89–91% of respondents. Hungarians, Italians and South Africans are the least convinced of this, about 66–73% (the survey was conducted in the USA in 2015).

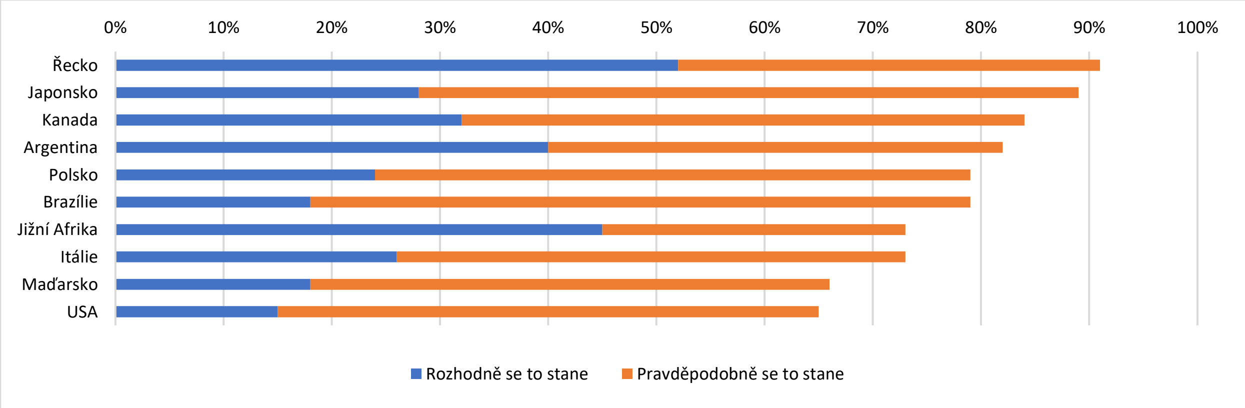


Fig. 54: How likely are you to think that robots and computers will do most of the work that humans do today in the next 50 years? [71]

Greece
Japan
Canada
Argentina
Poland
Brazil
South Africa
Italy
Hungary
USA

It will happen definitely
It will happen probably

When it comes to looking at what automation and robotics will bring to people, we have the following information from the survey (Fig. 55):

- More than 74% of all respondents assume that it will be more difficult to find a job. This fact is most expected in Greece and Argentina by 89–91%; people are more optimistic in Japan or Hungary, where only 74% expect it.
- More than 63% of people expect a larger gap between the rich and the poor. The most pessimistic in this respect are in Greece, Argentina and Japan – 3–87%, and the most optimistic in Italy, Poland or Hungary – 63–70%.
- More than 33% of people believe that the economy will work more efficiently – the most in Japan – 75%, the least in Italy, Greece and Argentina – 33–37%.
- More than 24% expect new, better-paid jobs to appear – most in Canada – 47%, and least in Italy – 24%.

The survey also showed that respondents who are more satisfied with the current economic situation view automation much more positively.

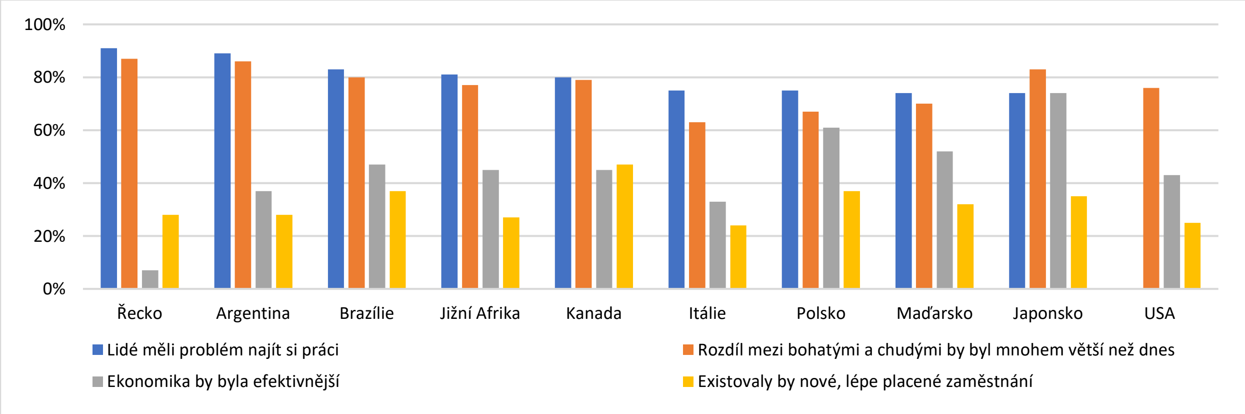


Fig. 55: Percentage of adults who think that if robots and computers were able to do most of the work currently done by humans, … [71]

Greece
Argentina
Brazil
South Africa
Canada
Italy
Poland
Hungary
Japan
USA

People would have a problem finding a job
The economy would be more efficient
The difference between the rich and the poor would be more distinctive than today
There would be new, better paid jobs

It is also interesting how people look at who has the responsibility to prepare the workforce for the future (Fig. 56). Most respondents see responsibility with the government and schools, less with themselves and least with employers. The opinion of the Japanese is particularly interesting in this context. However, according to the OECD statistics, national spending on staff training to adapt to the coming changes varies widely, from 3.22% of GDP in Denmark to 1.45% in Germany and only 0.27% in the United States.

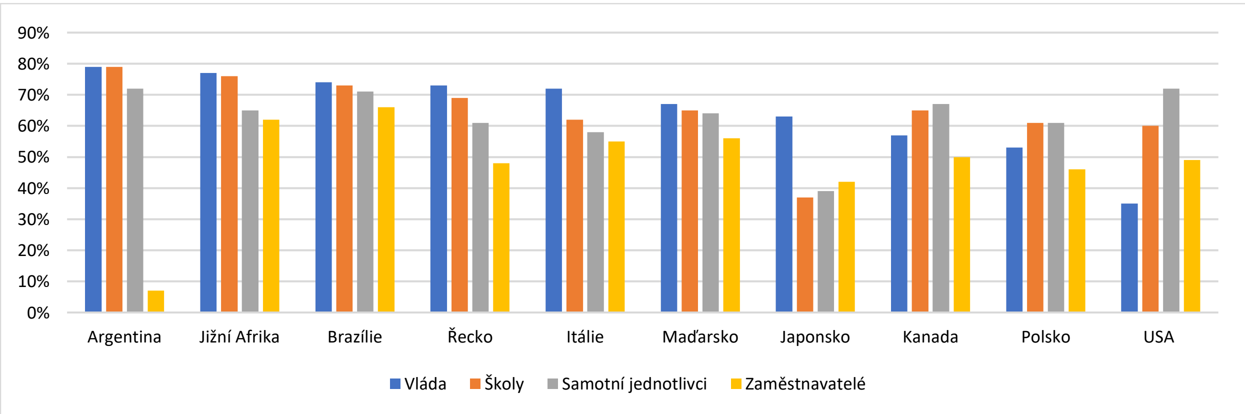


Fig. 56: Who do the adults in each country give the main responsibility to for ensuring that future generations have the right skills to succeed in the future? [71]

Argentina
South Africa
Brazil

Greece
Italy
Hungary
Japan
Canada
Poland
USA

Government
Schools
Individuals
Employers

From a survey conducted by Kantar Millward Brown in Poland in 2020, 67% of respondents are not afraid of automation of their job and 24% are rather not afraid (Fig. 57, left), which is quite surprising. A 2019 survey in Latin America (Fig. 57, right) found that they were most concerned about job loss due to automation in Mexico (41%) and the least in Brazil (21%).

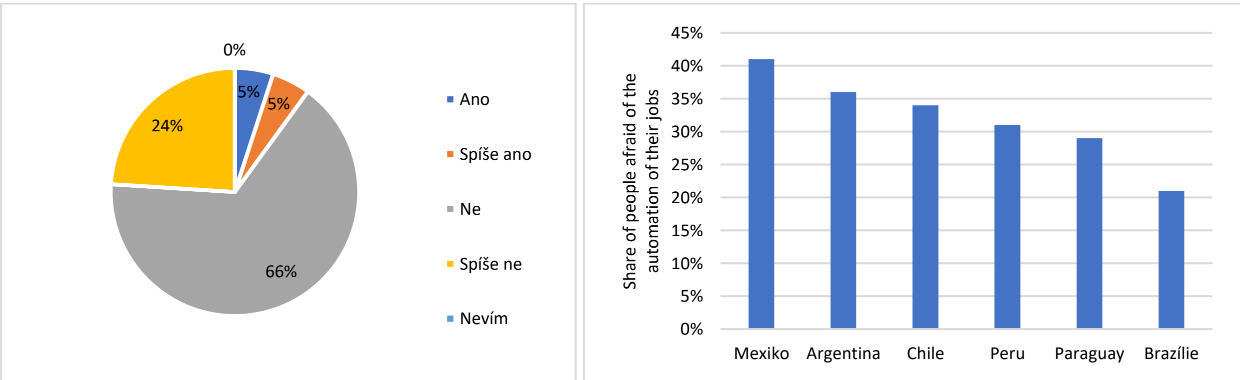
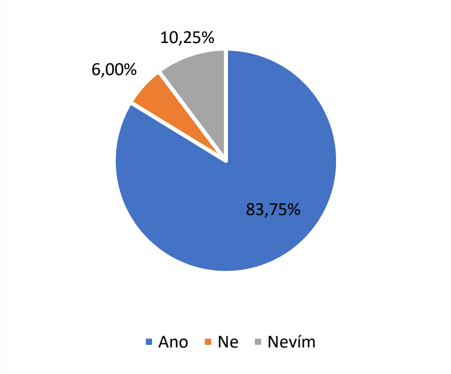


Fig. 57: (left) Survey of concerns about job automation in Poland in 2020; (right) Level of fear of job automation in selected Latin American countries in 2018 [72,73]

Yes
Rather yes
No
Rather No
I do not know

Mexico
Argentina
Chile
Peru
Paraguay
Brazil

In contrast, in a large study conducted in Italy in 2019, about 84% of people believed that artificial intelligence, which has a strong connection to automation, will affect their work (Fig. 58, left). At the same time, almost 90% of respondents in Italy expected artificial intelligence to help them at work and not deprive them of work, compared to about 8% of respondents who were afraid of losing their jobs due to it (Fig. 58, right).



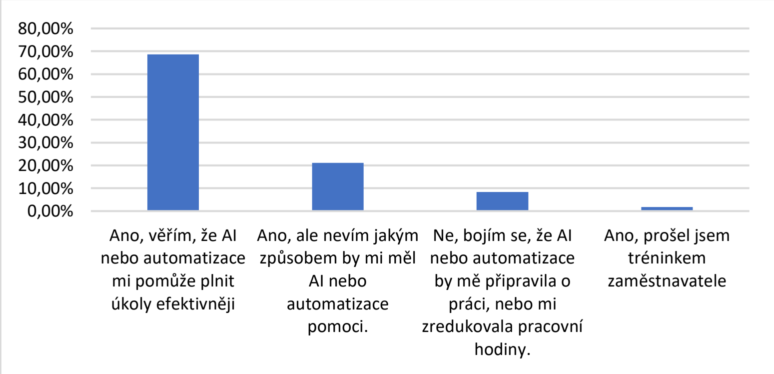


Fig. 58: (left) Do you believe that artificial intelligence (AI) will affect the way you do your work or your daily activities in the near future? (right) If artificial intelligence or automation were introduced in your workplace, do you think it would have a positive impact on your work? [74,75]

Yes
No
I do not know

Yes, I believe AI or automation can help me do task more efficiently
Yes, but I do not know how AI or automation should help me
No, I am afraid that I would lose my job or my working hours would be reduced due to AI or automation
Yes, I underwent employer's training

2.6 Stable, new and redundant professions/jobs

However, the OECD, the World Economic Forum or, for example, the consulting companies Boston Consulting Group and McKinsey & Company and others in their analyses add that current changes in the labour market do not necessarily mean lower labour demand and rising unemployment in the long run. This is mainly due to the fact that sooner or later new tasks and jobs will begin to appear in either the same or another sector of the economy. However, let's look at the situation gradually.

2.6.1 Transfer of workers to the area of services

Analyses of developments in different countries show that as countries' technological level of development grows, the workforce is gradually shifting from the primary sector (e.g. agriculture and raw material extraction) to the secondary sector with the manufacturing industry and then to the tertiary sector (services sector). This is considered to be the most dynamic component of the economy. The shift to the tertiary sector can be traced back to the 1980s, and the share of this sector in the total can be understood as a measure of a country's level of development. It can account for up to 60% of GDP in the most advanced economies. Naturally, the whole process must be accompanied by an improving economic situation of the population and their willingness to spend on services (e.g. for better health care, financial services, education, etc.), which leads to the growth of this sector. [76]

In this context, we can see, for example, how the situation on the US labour market changed from 1850 to 2015 (Fig. 59). There is a clear situation where workers in agriculture, manufacturing or mining industries are declining and employment in the services sectors is growing.

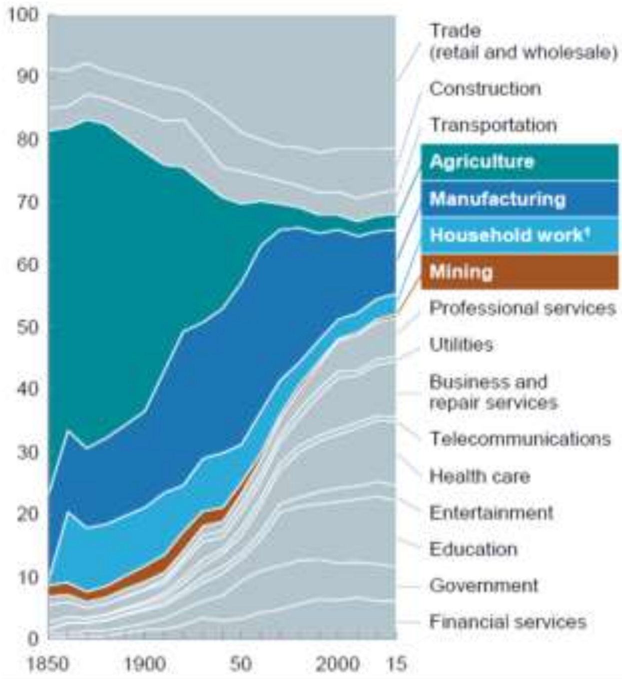


Fig. 59: Employment change in individual sectors of the US economy [77]

An example can be, according to the OECD analysis, the situation in the Venice region, which is located in the north of Italy and is one of the largest (approximately 5 million inhabitants) and the most economically dynamic regions of Italy. As elsewhere, redundancies in industry began gradually in the region in 2008 as a result of the economic crisis and lasted until 2014 (Fig. 60). From this year on, there was a gradual increase in the recruitment of workers – job creation, and employment essentially returned to the situation before the crisis in 2017. However, the labour market has undergone significant changes. Jobs have changed as a result of digitization and, in particular, there has been a gradual transfer of people to services.

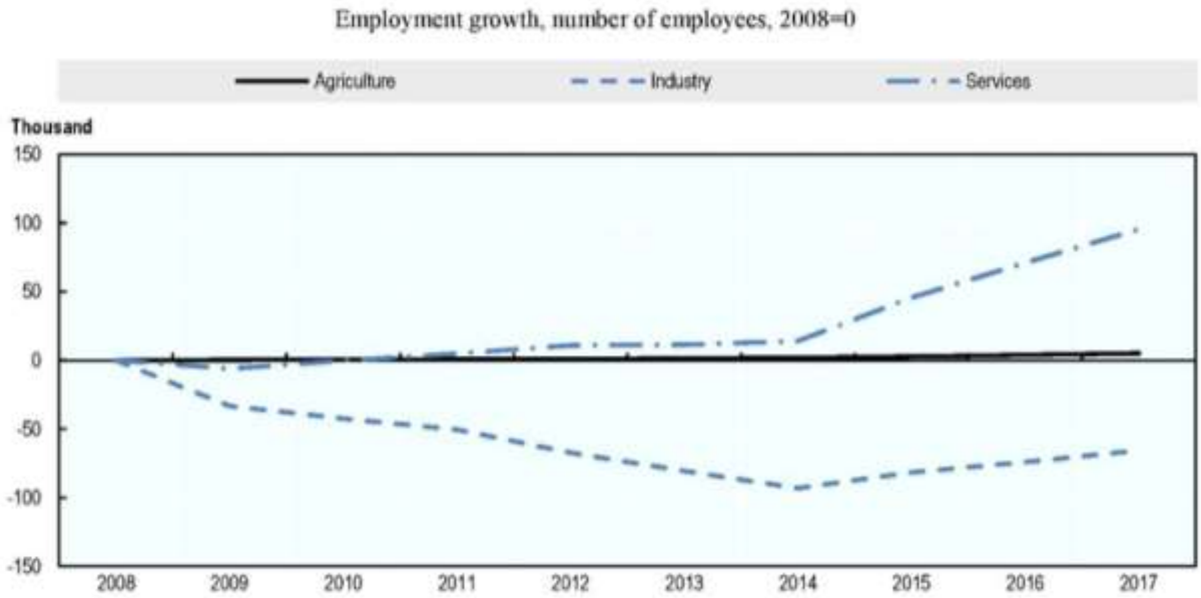


Fig. 60: Employment development in the industrial and services sector in the Venice region [78]

In recent years, there has even been talk of the creation of another, new sector, the experience economy, where the workforce from the services sector could begin to shift to, again as a result of technical progress. As a result of the improving economic situation, people are expected to want to enjoy the growing income and leisure time gained, among other things, thanks to modern technology in their work. The number of hours worked per week has been declining for a long time (Fig. 61).

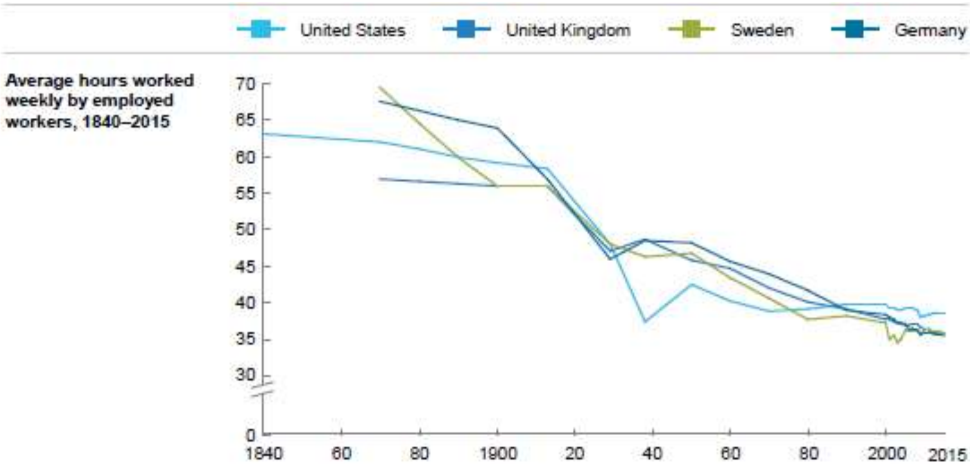


Fig. 61: Development of the average length of the working week since 1840 [77]

2.6.2 Job creation in sharing economy

The sharing economy is experiencing rapid growth around the world, made possible by modern technologies and generally easier access to them. Behind the whole idea of the sharing economy is a trend in the form of saving resources, such as carpooling, and based on less pressure to accumulate physical goods in the next generation, as well as more general distrust of established systems and efforts to break them – when we turn away from the sharing economy, also the use of cryptocurrency payments. The sharing economy allows users to save time and money and provides more flexibility. It is also a possible source of income and extra income.

From the point of view of job creation in the sharing economy and subsequent employment, the key problem is the speed of development of individual segments, to which the legislation of the given states does not manage to respond adequately. And it is not only a regulation of the labour-law environment, but also laws on consumer protection or tax obligations. With the growth of the sharing economy, it can be expected that there will be increasing pressure to adopt legal measures, but at present the size of the sharing economy in the Czech Republic is relatively small. The share of GDP is less than 0.04%, but it is expected to reach 2% by 2025. Due to a smaller share, the society resonates with problems related to, for example, a change in approach to the use of rental housing for short-term needs and a worsening situation with finding housing in larger cities or the problem of carpooling vs. taxi service. However, within the sharing economy, we can also see an effort to avoid individual intermediaries of more expensive services such as real estate market mediation or crowdfunding project financing. [91]

2.6.3 Job and profession creation

Even if we do not talk about it much, in our opinion, completely new jobs and professions will be created directly in the manufacturing industry and in other sectors thanks to technological changes. An example of such a situation from the past can be the development of computers. McKinsey & Company stated in its analysis that although computers destroyed more than 3.5 million jobs in the United States, more than 19 million jobs were created, especially in other industry segments and sectors of the economy (Fig. 62).

Typists, secretaries or typewriter repairers, for example, lost their jobs. On the other hand, new jobs and professions were created, such as software developers, scientists focused on computer development, scientists focused on the use of computers in their field, jobs focused on the production of printed circuit boards or semiconductors.

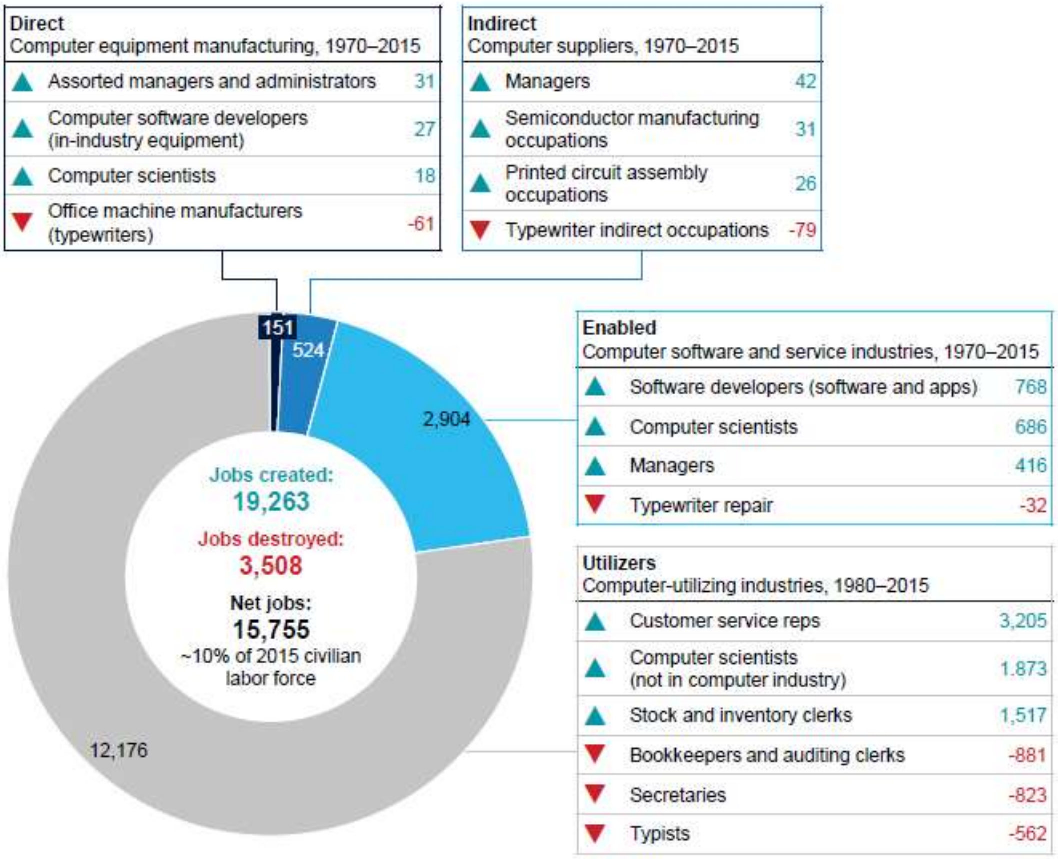


Fig. 62: Job creation and job loss caused by the advent of computers [77]

It is expected that a similar situation with computers will occur in modern technology. The main question is when, in what intensity (number of jobs) and what will happen over time. Examples are virtual and augmented reality. According to a 2019 report by PwC, up to around 23 million jobs could be created in connection with these technologies by 2030, almost 23 times more than at present (Fig. 63). And these technologies could increase GDP by up to about $450 billion by 2030.

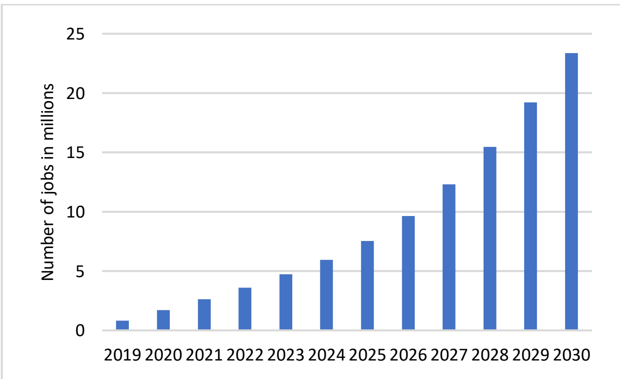


Fig. 63: Number of new jobs generated by virtual (VR) and augmented reality (AR) worldwide from 2019 to 2030 (in millions) [79]

These technologies are expected to bring social and economic benefits and increase GDP in Europe by up to about $20 billion by 2030 in the UK and up to about $14.4 billion in France. [79] At the same time, it is assumed that there will be about 400,000 new jobs created in Germany and in Great Britain by 2030 (Fig. 64, left). It is about 200,000 in France. In all three countries, however, it is a significant increase compared to the present – about 10–15,000 jobs in each country. The share of jobs generated by the development of virtual and augmented reality in relation to the total number of jobs in EU countries could be 0.75–1.25% in 2030 (Fig. 64, right).

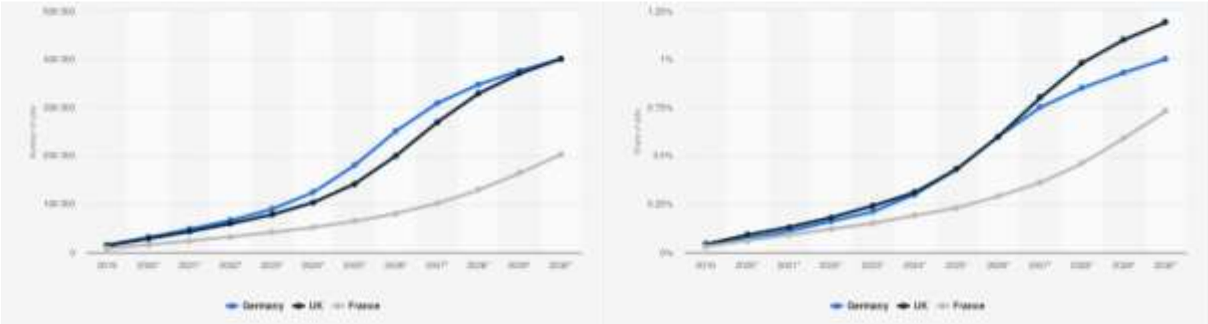


Fig. 64: (left) Development of the number of jobs generated by the development of virtual and augmented reality in EU countries; (right) Proportion of jobs generated by the development of virtual and augmented reality in relation to the total number of jobs in EU countries [80,81]

Estimates of various studies on the overall situation in the labour market will, of course, vary. A study by the World Economic Forum, which involved businesses from around the world employing around 15 million people, shows that there will be around 0.98 million jobs destroyed and 1.74 million jobs created in these companies between 2018 and 2022. Based on an extrapolation of trends, the World Economic Forum expects that up to 75 million jobs (excluding various factors) could be lost in economic sectors (excluding agriculture) and 133 million new jobs created by 2022. Various factors are included in the analysis, such as economic growth, population aging, etc. [62]

McKinsey & Company extensive December 2017 survey aimed not to accurately predict potential future changes, but to create an approximate model that would suggest where new, future jobs might be created. The model works with 2 scenarios, one assumes maintaining current spending and income trends in different countries and the other is based on expected additional investments. The model does not consider dynamic interactions between trends or across the economy. The model estimates that, according to the first scenario, approximately 390 million jobs could be created by 2030 (calculated as 1 full-time job) and, according to the second scenario, an additional 165 million jobs (Fig. 65). A total of 555 million jobs (with a more optimistic outlook, even up to 890 million). As a result of automation, up to 400 million workers could lose their jobs (medium-speed implementation), and up to 800 million with faster implementation of modern technologies. And other people are likely to move to other jobs (75–375 million). As a result, the moderately optimistic scenario expects a positive development in the labour market, when up to about 250 million new jobs (555 million – 400 million) could be created by 2030. [77]

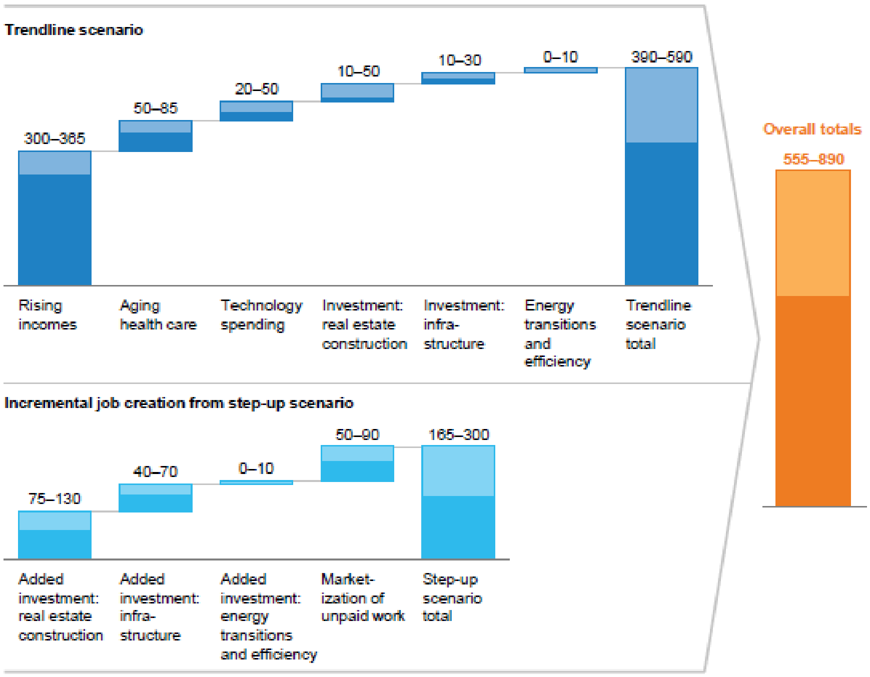


Fig. 65: Estimated number of newly created jobs in millions depending on the factor of action [77]

The main areas/factors under the first scenario that will generate new jobs will be growing incomes (300–365 million) in health services due to an aging population and growing incomes (50–85 million), the development and diffusion of new technologies (20–50 million), investments in buildings and infrastructure (20–80 million) or in renewable energy sources, energy efficiency and efforts to meet climate agreements (10 million). Growing incomes will generate jobs, especially in the automotive industry and services.

Boston Consulting Group carried out analyses of the impact of the implementation of the Industry 4.0 concept in Germany in 2015, focusing on the manufacturing industry. Considering various factors associated with the implementation of the Industry 4.0 concept, such as productivity growth, GDP growth or business investment growth, it was estimated that jobs could increase by up to 6% in manufacturing alone by 2025, with demand increasing by another 10% (Fig. 66). The analysis naturally assumes that the less skilled will be replaced by modern technologies, which will, however, contribute to a higher demand for experts with qualifications in these areas. [82]

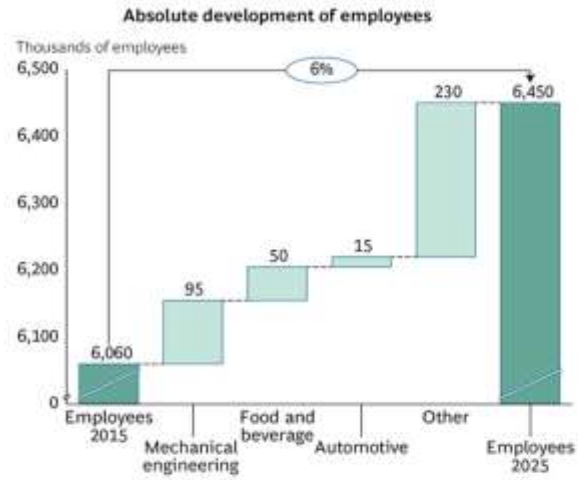


Fig. 66: Estimate of newly generated jobs in thousands due to the introduction of Industry 4.0 in Germany [82]

This study was followed by another, more detailed study, which also included a sensitivity analysis focused on the potential development of the number of jobs in the manufacturing industry depending on the income growth and the degree of implementation of the Industry 4.0 concept. We can see that for the base case, where the income growth due to implementation would be 1% and the degree of implementation at the level of approximately 50%, then there would be an increase by 350,000 jobs (approximately 5%) in manufacturing in 2015–2025 (Fig. 67). This increase would be the result of the redundancies of approximately 610,000 employees as a result of the Industry 4.0 implementation and at the same time an increase of 960,000 new jobs associated with the recruitment of professionals and the growth of incomes and demand for products. In the most optimistic scenario, it was expected that up to 950,000 new jobs could be created. The most pessimistic scenario then spoke of the redundancies of 180,000 workers. [83]

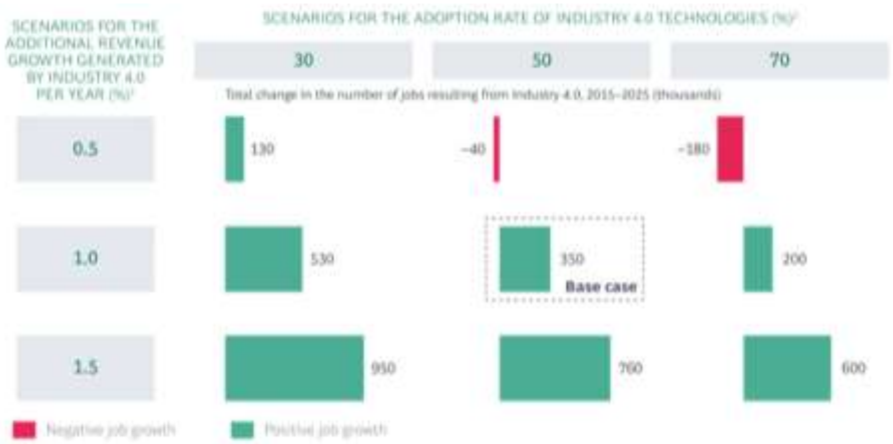


Fig. 67: Estimate of jobs created in thousands depending on the success of the introduction of new technologies and on the income growth due to these technologies in Germany [83]

Taking a detailed look at the development of employment in the German manufacturing industry until 2025 across individual sectors and across professions, BCG expects, for example, the following: [83]

- The largest decline is expected in production due to automation and robotics of production processes. Extinction of about 120,000 jobs in production, 20,000 in quality control and up to

10,000 in maintenance. Routine cognitive work will also be affected; for example, more than 20,000 production planning jobs will be eliminated.

- Creation of 70,000 new jobs associated with the growing importance of data analysis. Increased use of software and IT interfaces will also increase the demand for IT solution architects and user interface designers. The expansion of robots will then create a new role of a robot coordinator, leading to an estimated 40,000 additional jobs.
- The widespread use of intelligent machines will create a demand for 70,000 workers in this area.
- The implementation of robotics, predictive maintenance or, for example, augmented reality, will also allow manufacturers to introduce new business models that support job creation.

The whole situation can be seen in the following 3D diagram (Fig. 68).

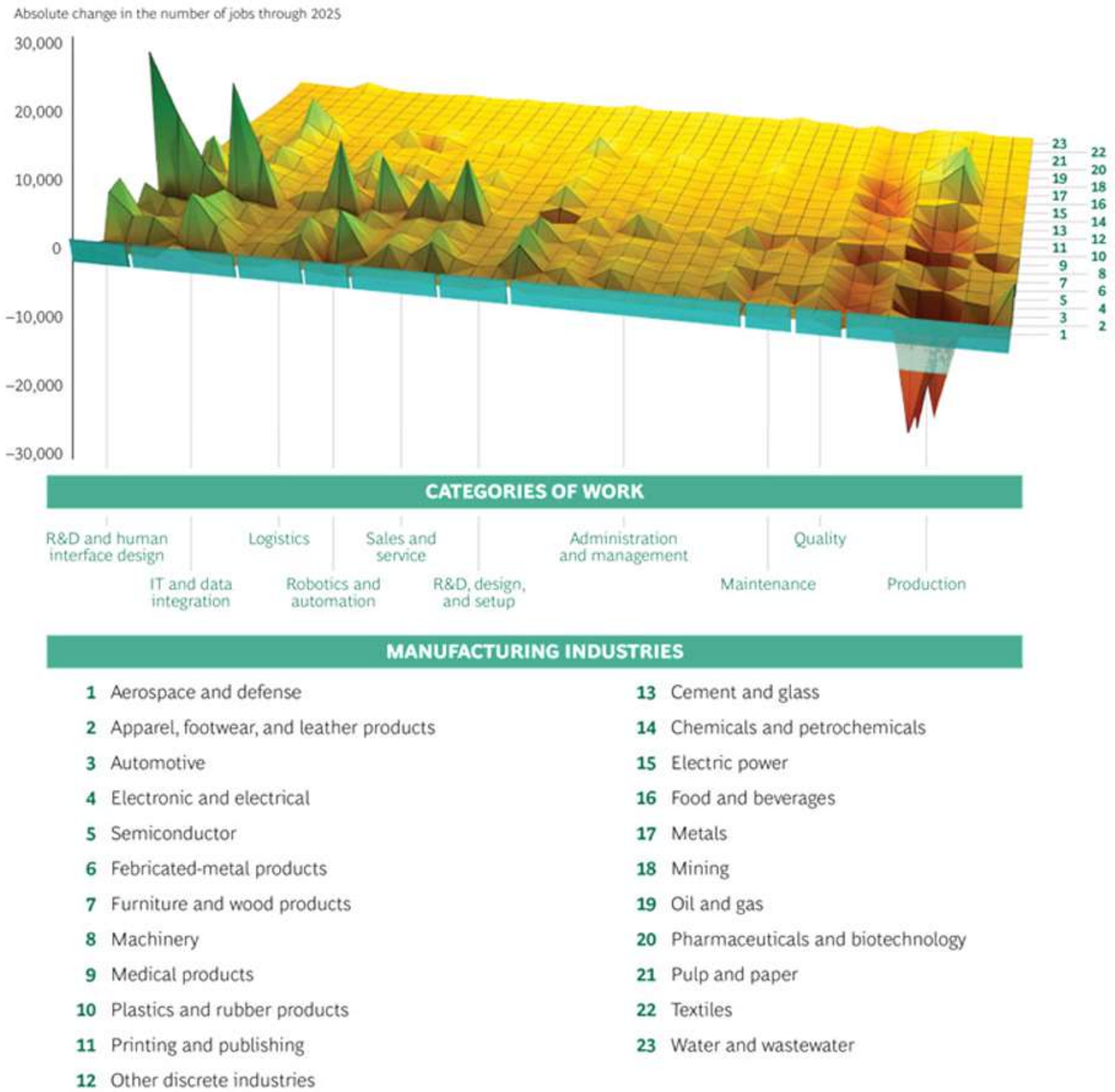


Fig. 68: Estimation of job development in Germany by type of industry and individual occupation [83]

2.6.4 Stable, new and redundant jobs and skills

As mentioned above, in connection with the introduction of modern technologies, new professions will emerge and expand, and others will disappear. Due to the fact that modern technologies are significantly connected with ICT, the development of professions in this area is expected. These are, for example, software or application developers, specialists in cloud computing, artificial intelligence and machine learning, blockchain or experts in digital transformation. Along with the development of ICT and Internet connection, cyber security specialists and workers focused on data protection, know-how, critical infrastructure security, risk assessment and management, crisis management and computer systems attacks will also be needed. With regard to the development of e-commerce, specialists will be needed in this area as well. E.g. specialists in digital marketing and strategy, social media, experts for remote support for their products.

There is also a significant increase in corporate data from companies from various sources, not only from traditional accounting and economic systems, but also data supplied by various sensors from production and other equipment, as well as from the products themselves in real time. Businesses therefore anticipate a higher need for specialists focused on BigData, data analysis, database specialists or on the creation of data models, data processing and visualization.

With the development of new production technologies, the need for workers with a focus on innovation, new technologies in general (e.g. IoT), process automation or robotics, additive technologies, industrial protocols and designers of new production facilities will also be needed.

On the contrary, redundant or increasingly endangered professions will gradually include data entry clerks, administrative staff, accountants, selected warehouse workers, bank officials, salespeople, manual production workers, machine repairers, telemarketers, etc.

The analysis of the World Economic Forum from 2018 summarizes in detail the development in the professional field for 2018–2022 (Fig. 69).

Stable Roles	New Roles	Redundant Roles
Managing Directors and Chief Executives	Data Analysts and Scientists*	Data Entry Clerks
General and Operations Managers*	AI and Machine Learning Specialists	Accounting, Bookkeeping and Payroll Clerks
Software and Applications Developers and Analysts*	General and Operations Managers*	Administrative and Executive Secretaries
Data Analysts and Scientists*	Big Data Specialists	Assembly and Factory Workers
Sales and Marketing Professionals*	Digital Transformation Specialists	Client Information and Customer Service Workers*
Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products	Sales and Marketing Professionals*	Business Services and Administration Managers
Human Resources Specialists	New Technology Specialists	Accountants and Auditors
Financial and Investment Advisers	Organizational Development Specialists*	Material-Recording and Stock-Keeping Clerks
Database and Network Professionals	Software and Applications Developers and Analysts*	General and Operations Managers*
Supply Chain and Logistics Specialists	Information Technology Services	Postal Service Clerks
Risk Management Specialists	Process Automation Specialists	Financial Analysts
Information Security Analysts*	Innovation Professionals	Cashiers and Ticket Clerks
Management and Organization Analysts	Information Security Analysts*	Mechanics and Machinery Repairers
Electrotechnology Engineers	Ecommerce and Social Media Specialists	Telemarketers
Organizational Development Specialists*	User Experience and Human-Machine Interaction Designers	Electronics and Telecommunications Installers and Repairers
Chemical Processing Plant Operators	Training and Development Specialists	Bank Tellers and Related Clerks
University and Higher Education Teachers	Robotics Specialists and Engineers	Car, Van and Motorcycle Drivers
Compliance Officers	People and Culture Specialists	Sales and Purchasing Agents and Brokers
Energy and Petroleum Engineers	Client Information and Customer Service Workers*	Door-To-Door Sales Workers, News and Street Vendors, and Related Workers
Robotics Specialists and Engineers	Service and Solutions Designers	Statistical, Finance and Insurance Clerks
Petroleum and Natural Gas Refining Plant Operators	Digital Marketing and Strategy Specialists	Lawyers

Fig. 69: Examples of stable, new and redundant jobs, all industrial areas [62]

According to a 2017 survey conducted in Italian industry, the most important jobs (skills) include IoT and BigData specialists. The lowest demand in 2017 was for specialists in artificial intelligence or industrial protocols (Fig. 70).

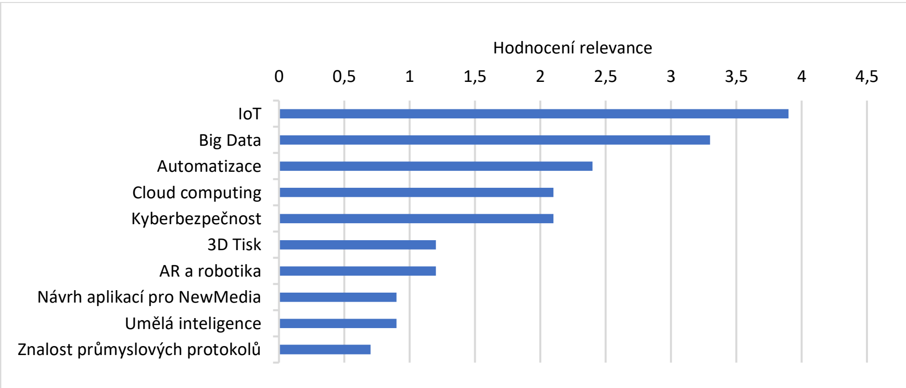


Fig. 70: The most demanded skills and jobs related to Industry 4.0 in Italy for 2017 [84]

2.6.5 Skills

However, new or modified jobs will often require a different set of skills, so proper education and training are needed to reduce the adverse effects of automation on the labour market in the future. Studies analysing changes in the number of jobs in the labour market are also based on this fact.

A World Economic Forum survey estimates that only 46% of workers will not need retraining or training. The remaining 54% will then need retraining and training to varying degrees, about 25% within 3 months, about 10% for 3–6 months, 9% for 6–12 months and 10% for more than 1 year (Fig. 71).

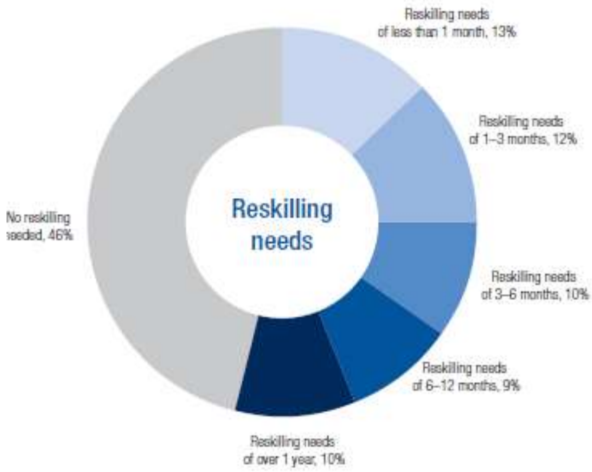


Fig. 71: Expected average retraining period in 2022 [62]

Most companies from the survey expect to use mainly their internal departments (85%) and external companies (75%) in connection with retraining and training of employees. Companies expect the least the use of employee unions (23%).

However, in the context of training and retraining, care must be taken to ensure that, as a result, workers are not either insufficiently qualified or over-qualified. This is a problem that has long been highlighted in the OECD reports. The situation is at a particularly good level in the Czech Republic, the employment of an unsuitable applicant occurs only in 14% compared to e.g. 37% in Germany. The result is improperly spent funds. [85]

Although some professions and jobs will change significantly, companies in the World Economic Forum survey expect that average skills stability – the share of basic skills required to perform work which remains the same – will be around 58%, while expecting a substantial change for the remaining 42% of skills in 2018–2022. One of the reasons is that some processes will converge thanks to digitization, automation and robotics, so such a strong specialization will no longer be necessary. Given that non-routine activities will remain non-automated, the involvement of ICT skills is expected to a large extent, which should significantly contribute to their more efficient performance.

Skills the importance of which will increase significantly overall include: [2,86]

Knowledge of information and communication technologies:

- Knowledge of information technologies and their use adequately at the level of qualification requirements of the profession, programming thinking
- Ability to use and interact with computers and smart devices such as robots, end devices, tablets, etc.
- Understanding how machines and systems communicate with each other, how ICT security and data protection is ensured

Ability to work with data:

- Ability to process and analyse data and information received from machines, ability to analyse and use data provided by modern monitoring and information systems
- Understanding the visualized data output and making decisions based on it

- Basic knowledge of statistics

Technical knowledge:

- General knowledge of technologies with interdisciplinary overlap
- Specialized knowledge of production activities and processes in operation
- Technical competence and technical abstract thinking
- Analytical thinking and innovative approaches
- Technical know-how about machines to take care of their maintenance and other related activities

Personal skills:

- Adaptability, adaptation to changing conditions
- Ability to make decisions
- Ability to work in a team
- Willingness to learn, purposefulness, service orientation
- Typically ‘human’ skills such as creativity, originality, initiative, critical thinking, persuasion and negotiation, flexibility, complex problem solving, communication (including professional communication in a foreign language), ability to work in a team
- Compared to the present, the importance of moral attitudes, emotional and social intelligence, self-organization will increase.

With regard to individual groups of professions in the manufacturing industry, the following changes in the requirements for new knowledge and competencies can be expected in the coming years.

Specialists in engineering and technical professions will need to be familiar with a wider range of technologies, be able to assess solutions or design new solutions in a much broader context than before, as the complexity of tasks increases, production becomes more variable and more adapted to the situation and customer requirements. They will need to be able to manage projects, work in interdisciplinary and international teams, communicate effectively and solve problems. [2]

There is an increasing emphasis on the ability to ensure quality in all parts of the production process, where it is necessary to manage its assurance not only within the company, but also with external partners who work in increasingly numerous networks in the supply chain and in relation to customers. Due to the fact that the use of ICT tools and systems is increasingly penetrating the production process, technical specialists already have to control both a user and a more demanding programming software. With regard to the performance of individual types of engineering professions, the following requirements can be expected: [2]

- Product engineer – Knowledge of both traditional and especially new materials and their suitable combinations, knowledge of new designs and simulation tools, knowledge of industry legislation and regulations.
- Process engineer – Knowledge of new materials and related production processes, knowledge of mechatronics, information and communication technologies for use in production systems.
- Development engineer/technician – Knowledge of the production process and design properties of products, knowledge of ergonomics, basic knowledge of supply chain operation, understanding of technological applications for advanced materials and in advanced production, understanding of market trends and ability to respond to consumer expectations.

Technical and specialized jobs: [2]

- 3D printing technicians – Knowledge of software applications and hardware, knowledge of new materials, ability to work with digitized documentation, use appropriate methods and techniques to print different components, check printing results and evaluate their compliance with required specifications, ability to work together and solve non-standard situations.
- Production technicians – Ability to perform a relatively wide range of tasks in all phases of product preparation and production, effectively use and interpret production data and documentation, prepare, use and test high-tech equipment, use advanced business information systems and methods of project planning and management.
- Sales professionals – Increased requirements not only for social and language skills but also for ICT skills for creative marketing, e-commerce application development, development and maintenance of websites and applications, work with customer databases and analysis of customer behaviour data.
- Warehouse management workers – All levels of workers will need to be able to work with information systems. Senior workers will need the ability to analyse system data and be able to use procedures to optimize supply flows. Even medium- and low-skilled workers in warehouses will be required to have the skill to work with mobile terminals, warehouse information systems, etc.

Blue-collar jobs: [2]

- Tool setters, machine operators and craftsmen will work with computer-controlled machines, programming work will increasingly be part of the tool setter's task, they will also work more with information systems responding to customer requirements; working with laser technologies replacing conventional machining requires new skills, not only professional but also to ensure work safety.
- Material handling operators and workers – They will have to master user-level IT skills and constantly expand them with new elements of work, both with technologically advanced, expensive equipment and with sophisticated components.

2.6.6 Retraining and transfer to other jobs

There will be fundamental changes in the labour market in the coming years due to various trends such as digitization, robotics, automation or changes in the demographic area. Adapting to these changes must necessarily include strengthening the field of retraining as one of the critical factors for successful labour market transformation. However, according to a study by the World Economic Forum, there are few approaches to identifying and systematically mapping realistic job opportunities for workers who will be at risk of potential change (especially redundancies). The aim of this study was to provide a tool (its description) that would help not only workers, but also governments or companies to find the right kind of work to which workers could move – retrain. Although the study or the tool presented in it was compiled for the US labour market, it should not be a problem to modify it for other conditions. [87]

The study draws data from two main sources. From the US Occupational Information Network (O*NET database), which contains the required skills, knowledge, abilities, education, training or experience necessary to perform a particular job. And from a database created based on a labour market analysis by Burning Glass. Their database is based on BigData and aggregates knowledge from more than 50 million online jobs in the US from 2016–2017. The database contains information on up to 15,000 skills, grouped into 550 subgroups, divided into basic, specialized and software skills. [87]

Both combined databases cover 958 unique job types, covering most jobs in the United States. Jobs are categorized into groups according to similarity. Key requirements for each type of job are defined such as the already mentioned skills, knowledge, etc. Individual jobs have a mutual similarity index acquiring a value of 0–1, which determines what is the applicability of the new (second) job. The study presents a computer programmer and web developer as examples – these jobs have a similarity index of 0.92. In contrast, an administrative officer and an aeronautical engineer have a similarity index of 0.81. The index values are divided into three groups – high similarity score 1–0.9, medium similarity score 0.9–0.85 and low score 0.85–0. The result is a matrix (Fig. 72), which allows searching for groups/jobs with sufficient similarity. Places with a blue colour represent jobs with a certain similarity – the darker the blue colour, the higher the similarity. [87]

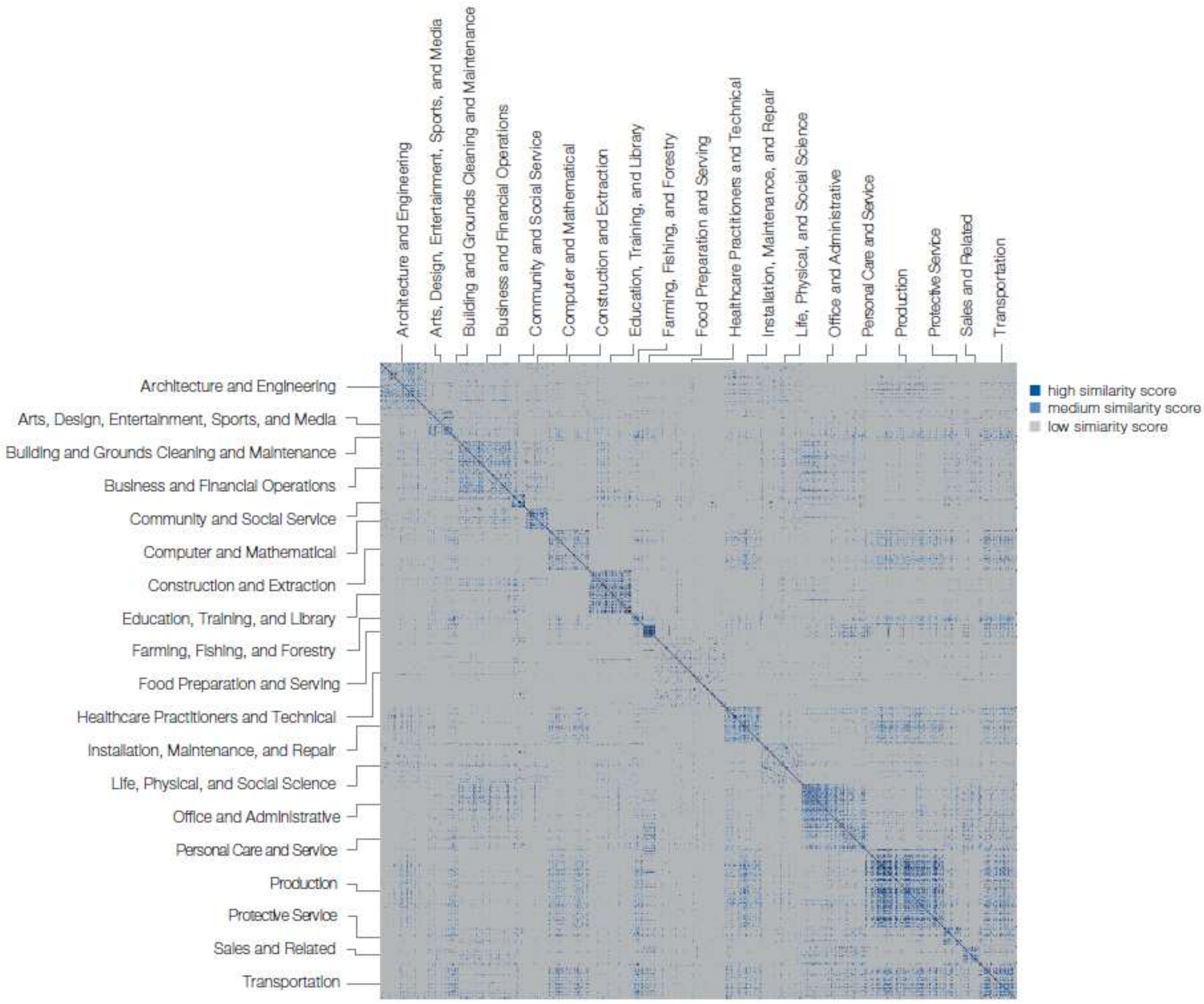


Fig. 72: Matrix of job similarity in the USA [87]

The study then focuses on the analysis of the number of US employees that could be recruited by individual groups in the future as part of retraining. It is based on predefined trends in the labour market.

2.6.7 Changes in forms of employment

The expansion of the use of modern technologies creates a much wider space for the agreement of flexible forms of employment, which are not yet among the most used in the Czech Republic but offer great potential for the future. Given the ongoing situation with COVID-19, it can be expected that more and more employers will be interested in individual forms and offer them in their companies. Many of the emerging new forms are not yet defined by labour law, but 'traditional' flexible forms of employment include, in particular, fixed-term or part-time employment (these indicators can also be used to assess the overall flexibility of countries' labour markets); newer ones include employment through employment agencies, job rotation or job sharing. It goes without saying that these new forms also include working from home, currently widely promoted in combination with job sharing. Thanks to this, companies can achieve the same performance and reduce the number of employees in the office and the risk of spreading the disease throughout the group instead of just one team.

Naturally, individual forms of more flexible employment bring benefits to varying degrees on the part of both employees and employers. As well as certain disadvantages. The main problem, however, is that employers often single out employees with more flexible hours, who, besides work benefits, often do not have the opportunity to achieve further training and knowledge exchange in the company. If the goal in the future is to create a knowledge society and increase the competences of people in the labour market, it is necessary to ensure that everyone has access to further education without distinction.

Furthermore, there is a brief overview of the most common flexible forms of employment, pointing out their benefits, shortcomings and possible sources of threat to workers. [92]

Fixed-term employment contracts

Fixed-term employment contracts are an important tool for a contractual flexibility. They are typically concluded with workers who carry out seasonal work, as well as with workers who have obtained employment through an agency or employment agency and perform a specific job for a third party, or also with workers with contracts linked to education and training programs. The regulation of this form of work has a long tradition in the EU-15 countries (e.g. in Austria since 1811). The EC Directive on fixed-term employment contributed to some harmonization, but differences in the regulation of this form of employment vary from one Member State to another. The issue is regulated by the Labour Code in the Czech Republic.

This contractual flexibility is an important tool for adapting the number of employees (both within the company and from the external labour market) to the needs that have arisen. Businesses can thus respond better to the emerging market situation; they can more easily lay off but also hire new workers. Contractual flexibility also allows employers to examine employees for qualifications, skills and abilities that sometimes cannot be assessed during a three-month probationary period.

However, fixed-term workers often have worse working conditions and legal protection than workers with permanent contracts (e.g. worse access to training, lower job autonomy, absence of benefits).

It would be desirable to ensure, above all, better access for employees to corporate training in the future. Fixed-term employment contracts should not 'isolate' workers from access to new knowledge, otherwise it could lead to a further deterioration of their position in the labour market.

Part-time jobs

Part-time work is an important tool for the flexibility of working hours (also time flexibility). It allows companies to gain a higher degree of flexibility through adjustments and better working time arrangements and more flexible pay conditions. These include part-time work, overtime work, weekend work, variable or irregular working hours. Some forms of working time arrangements will be more preferred by companies, others by workers. For example, flexible working hours, part-time work, early or deferred retirement can be beneficial for both parties.

The benefits of part-time employment are flexibility, which is particularly advantageous for women returning from maternity or parental leave, for students or for the gradual retirement of an employee. It is therefore a suitable tool for work-life balance. It usually brings higher productivity and work efficiency to employers.

Disadvantages include the fact that, although part-time workers have formally the same legal status as full-time workers, they do not receive the same benefits as regular employees or access to development and training. At the same time, it can be problematic to set a volume of part-time work to avoid overburdening the employee.

Part-time work plays an important role in the return of mothers to the labour market, so they would deserve more support or a level playing field for their use. Especially in the field of employee training, because increasing the competencies of employees is the main point of this study, so that in the future there is no total rejection of a worker in the labour market.

Temporary employment through an employment agency

Temporary agency employment belongs to the so-called triangular employment relationships, i.e. one worker between two employers. It is a relatively new, yet rapidly developing, flexible form of employment within the EU, although the proportion of temporary agency workers is still relatively low (estimated at around 2%). The harmonization framework consists of the EC Directive on temporary agency work. The biggest problem with temporary agency employment across the EU is meeting the requirement for temporary agency workers to have the same working conditions as regular workers. That directive is limited to the field of occupational safety and health. The principle of equal treatment, including wages, is therefore regulated differently in individual countries, by law or collective agreement, or at all. It is necessary to precisely define ‘comparable working conditions’ for temporary agency and regular workers, especially in blue-collar jobs, where the situation is most serious. Apparently, a certain refinement tool can also be the creation of suitable conditions for effective labour inspections. Last but not least, the conditions for the establishment and functioning of temporary employment agencies should probably be tightened.

Temporary agency employment is regulated by the Employment Act in the Czech Republic. There has been a large increase in temporary agency employment in recent years; according to the data of the Association of Employment Agencies, there were approximately 1,830 employment agencies operating in the Czech Republic in mid-2016, which annually mediate the employment of approximately 200,000 people. This flexible form of employment was used mainly by large global companies in previous years, and now increasingly also by small and medium-sized enterprises.

Temporary employment through an employment agency is traditionally used mainly to cover seasonal work, temporary jobs, time-limited projects, supplementing the number of regular workers in the case of larger contracts, etc., because this form of employment meets the employers’ demand for flexibility and reduction of administrative costs (especially in human resources and payroll accounting). It allows them to flexibly hire workers according to current needs with a quick start.

A significant disadvantage for employees is usually worse conditions than regular employees, usually in all respects – job protection, wage level, access to corporate training, minimum occupational safety, etc. In most cases, the nature of the work of temporary agency workers can be described as uncertain. Another significant disadvantage is the low enforceability of ensuring a level playing field for temporary agency workers. However, temporary agency workers can also become a problem for the company, due to the fact that they may have less motivation, consequently lower productivity and they can affect the overall work environment in the company.

Working from home

Working from home (home working) has a long tradition in the EU. However, the development of modern technologies has significantly expanded the use of this form of employment by the so-called teleworking. The law on home working differs from one Member State to another. In some states, this form of employment is regulated under labour law (e.g. Greece, Poland, Portugal), and in national collective agreements in the Scandinavian countries. The legal status of employees working from home is also different. As a rule, working from home is carried out based on a standard employment relationship, but some countries (e.g. Germany or the United Kingdom) allow the performance of home working as a self-employed activity.

Working from home is regulated by the Labour Code in the Czech Republic and is performed on the basis of a standard employment relationship.

In the case of home working, the employee works from home in up to 90%. Until a few years ago, this form of employment was used mainly by women on maternity leave or in pre-retirement age, or by people with disabilities. Today, home working is widely used in a number of professions, such as graphic designers, programmers, translators, sales representatives, insurance agents, accountants, etc.

This form of employment brings employers lower costs per employee (e.g. office operation saving), but also usually a more satisfied employee, and thus an increase in labour productivity. This approach brings a number of benefits for employees, especially the possibility of flexible time planning, saving on commuting, including time, the possibility of a better work-life balance.

On the part of the employer, the main disadvantage of working from home is the loss of full control over the employee's work performance and also his/her more demanding motivation, or possible increase in the cost of IT and telecommunication tools and services. For employees, home working is mainly associated with the cost of their own work equipment (which can be provided by the employer as a work bonus, but the question then is whether it is still a bonus) and the disadvantage is the reduction of social contacts, especially with colleagues in the workplace. However, the previous point about balancing work and personal life can also become a problem, when these levels can intertwine and influence each other – deterioration of productivity, deterioration of mutual relations.

Extension of new flexible forms of employment

In addition to the above-mentioned, currently established flexible forms of employment treated by law in most cases, a number of new approaches to employment are appearing on the labour markets, the implementation of which so far depends mostly on the agreement between the employer and the employee.

A Eurofound study identified ten forms of employment that have emerged or gained in importance in EU countries since 2010 [93]:

- Employee sharing – A group of employers hires one worker together to cover the personnel needs of different companies; the worker thus acquires full-time employment.
- Job sharing – An employer hires two or more employees to hold a specific job together; two or more part-time jobs are combined into one.

- Interim management – Highly qualified specialists are recruited for a limited period of time to manage a specific project or solve a specific problem; this integrates external management capacities within the organization of work.
- Casual work – An employer is not obliged to provide work to the employee on a regular basis but has the opportunity to call him/her as needed.
- ICT-based mobile work – Employees can perform their work with the support of modern technologies from anywhere and at any time.
- Voucher-based work – Employment is based on payment for services using a voucher, which is purchased from an eligible organization and includes wages and social security contributions. This type of employment is used mainly in the rapidly growing household services sector in Western European countries.
- Portfolio work – A type of work where a self-employed person performs smaller-scale work for a large number of clients.
- Crowd employment – Employers are looking for employees and workers are looking for employment using an online platform, with large tasks being often divided among a 'virtual group' of employees.
- Collaborative employment – It is primarily the collaboration of freelancers, self-employed persons or micro-enterprises to overcome the constraints of their size and professional isolation.

New forms of employment are also associated with new effects on labour markets that have not yet been explored in more detail. However, certain characteristics can already be traced today:

- Job sharing, employee sharing and interim management provide workers with a good level of job security and greater flexibility.
- ICT-based employment, regardless of location and performance, provides a high degree of flexibility, greater autonomy, but with the risk of higher work intensity, more stress and blurring of the boundaries between work and private life.
- Portfolio work, crowd employment and collaborative employment enable a high degree of diversification, and thus work enrichment, with the work becoming more interesting and motivating.
- Voucher-based work is associated with higher job insecurity, limited access to career development, a certain professional and social isolation, but nevertheless allows you to work legally (not in the informal zone).

It is important to realize that the current development, when there is a withdrawal from employment for an indefinite period to more flexible variants of employment, on the other hand, carries a risk balancing the flexibility just acquired. This risk is usually borne by the employee, who bears the risk of greater uncertainty.

2.6.8 Lack of workers with higher education

The development, implementation and use of modern technologies requires a sufficient number of adequately trained workers, while the need for less educated and skilled workers is declining. The lack of qualified staff can be addressed by retraining or training; however, this solution is not always possible or sufficient. Due to the fact that the adjustment of education systems is time consuming, it is necessary to prepare a potential change as far in advance as possible and with regard to the expected future development.

The statistical portal Statista dealt with the analysis of the shortage or surplus of workers with higher education until 2030, especially on the basis of data from the International Labour Organization, demographic data, the rate of graduates and the growing number of pensioners. [88]

The analysis expects a worldwide increase in the share of highly educated workers (managers and specialists) from 14% in 2019 to 17% in 2030 and middle-educated workers, trained workers (technicians, tradesmen, craftsmen, etc.) from 41% in 2019 to 43% in 2030. On the contrary, a more significant decline of the least educated (production operators, farmers, etc.) is expected, from 45% in 2019 to 39% in 2030. If we look at the situation in the EU28, the number of employees with higher education is expected to increase by 3% to 29% and the number of those with low education to decrease by 3% to 17%.

Quite logically, differently developed economies need different numbers of qualified professionals. Looking at the situation, it is especially important for us to know that Germany will face a fundamental shortage of skilled workers. An absolute shortage of educated workers is estimated at 1.95 million graduates by 2013, which is an average annual shortage of around 1.6% (Fig. 73). Given that the Czech workforce is still one of the cheaper and the Czech Republic borders Germany, this fact suggests potential problems for the Czech Republic associated with the departure of our educated workers, which are already in short supply in some areas. In contrast, a surplus of educated labour force is expected in Italy and France. Outside Europe, Japan and the United States will face a significant shortage. The real situation in the world is shown in the following diagram (Fig. 73).

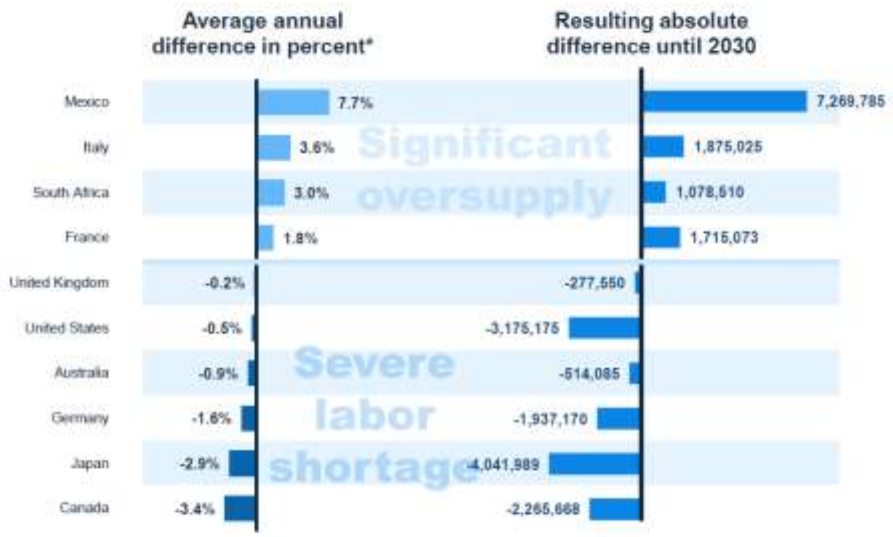


Fig. 73: Annual and resulting development of the number of university graduates by 2030 [88]

If we do not consider the need for educated workers caused by the development, introduction and use of modern technologies and other influences, but only the difference between recent graduates and new pensioners, we find that there is a lower shortage in Germany, approximately 0.7 million (Fig. 74). Thanks to this, we are able to determine that the need caused by other influences represents approximately 1.2 million graduates. The shortage is expected to occur in Germany approximately after 2022. [88]

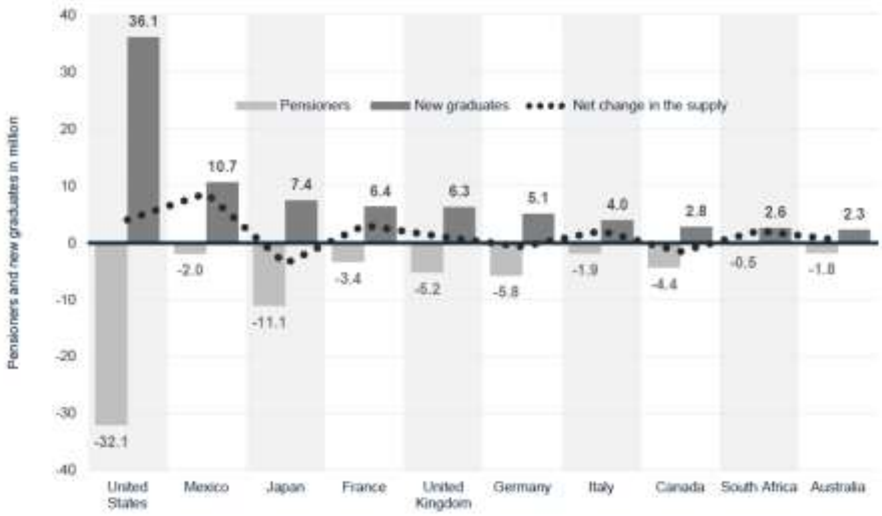


Fig. 74: Resulting number of graduates and new pensioners by 2030 [88]

Conclusions and recommendations

We are in the period of the Fourth Industrial Revolution, which brings changes to our personal and professional lives. The entire customer environment is changing significantly. An ordinary product delivered within a few days is often not enough for the customer. The customer wants a ‘tailor-made’, ‘instant’, ‘reasonably priced’ product. In an effort to focus on the customer and meet his/her needs, wishes and requirements, there are changes in the internal management of companies, which, for example, focuses on process management and greater interconnection of individual parts of the company in an effort to create a more efficient and effective organization. Also in this context, there is a higher integration of supplier-customer relationships. However, in order for the implementation of all changes in business management to be successful, it is not possible to use modern technologies. In virtually all sectors of the economy, digitization, automation and robotics in general are gradually gaining ground. The use of modern technologies such as modern SW tools, the Internet of Things, cloud computing, BigData and their analysis, artificial intelligence or, for example, additive manufacturing is growing. The changes brought about by the Fourth Industrial Revolution are therefore fundamental. It is difficult to predict them, but it is necessary to prepare for them. We can say with certainty that it will significantly affect our work and personal lives. In the current situation with COVID-19, the effect on work lives may come later – it is mainly a question of future developments and evaluations that companies will make, but in personal lives, many of us have already had to start adapting right now.

After a period of many studies predicting pessimistic developments in the labour market as a result of digitization, automation and robotics, studies are gradually becoming more optimistic. Today, mass replacement of the workforce by robots is no longer expected, but the strengthening of people’s work by machine and computer work. Much of automation occurs at the level of tasks, not at the level of entire jobs or professions. By eliminating routine tasks, it will then be possible to make better use of human potential, which will increase productivity and thus competitiveness. For the most endangered positions/activities, such as manual data recording or processing, it is estimated that the work of the machine/computer could have a share of up to 62% by 2022. It is only 28% for the least endangered positions/activities such as decision-making and argumentation.

The studies also seek to quantify both potential saving in staff reductions, job reductions or jobs at risk of automation, and the number of new jobs created by higher demand for new products, higher labour productivity or a shortage of qualified new technology specialists. It is estimated that in OECD countries, 14% of jobs are at significant risk of automation and 32% of jobs may be significantly affected. The Czech Republic is slightly above the OECD average and, in terms of jobs, it is about 780,000 jobs, or 1,560,000. Central Moravia would be the worst affected in the Czech Republic. However, there are also more pessimistic estimates, such as the PwC study, which estimates that up to 39% of jobs in the Czech Republic could be at risk in three different waves depending on the type of automation by about 2040. The reason is mainly a significant share of the manufacturing industry. In general, people in the low-income group are most at risk (about 20%), 18% of people in the middle-income group and 11% of people with the highest incomes (OECD average, Czech Republic slightly below average).

Naturally, it depends on the overall development of many factors, it is not expected that workers will still be largely unemployed due to automation, and if so, only for a short time. Three studies analysed (by the World Economic Forum, McKinsey & Company and BCG), which looked at both job losses due to automation and job creation, predict that more new jobs will be created than destroyed. There are several reasons. New technologies also generate new jobs, both within their own development and production, and in the sectors where they are used as a result, because they require experts, for example, to implement them, work with them or service them. The newly introduced technologies should then support productivity growth, which would, among other things, mean economic growth and thus the creation of new, additional jobs associated with this growth. Last but not least, the redundant workers will move to the services sector, which predominates in advanced economies, as people with rising incomes spend more on services. A study by the World Economic Forum suggests that 135 million new jobs could be created worldwide and 75 million destroyed by 2022. A study by McKinsey & Company suggests that the gap between new and extinct jobs could be as high as 250 million worldwide in favour of the new ones by 2030.

New jobs will include those that focus on the development and implementation of modern technologies and those that focus on their use in practice. These include software or application developers, artificial intelligence and machine learning specialists. With regard to the development of e-commerce, specialists in digital marketing and strategy, social media, and experts for remote support for their products will be needed. Therefore, businesses anticipate a higher need for specialists focused on BigData, data analysis, database specialists or on data creation, processing and visualization. With the development of new production technologies, the need for workers focusing on innovation, control and setting of these technologies, or workers focused on the transformation of companies towards the use of these technologies, continues to grow. On the contrary, redundant or endangered jobs will gradually include data entry clerks, administrative staff, accountants, selected warehouse workers, bank officials, salespeople, manual workers, telemarketers, etc. New skills will be needed to perform new professions/jobs: working with ICT in general, working with data, new technical knowledge and personal skills.

The expected forthcoming changes in the labour market need to be viewed with respect, not with an excess of concern or an excess of optimism. However, it is necessary to prepare for these changes as far in advance as possible and as far as possible. The one who is prepared is never surprised! In preparing for these changes, the cooperation of all players in the labour market – the state, employers, trade unions – at all levels is important. However, cooperation, initiative and open approach by the employees themselves are also needed. In connection with the forthcoming changes, it is necessary to focus on:

- Friendly and open cooperation of all entities affected by these changes.
- Explanation and communication of the nature, importance and especially the inevitability of changes to employees and all entities in general. Everyone must know why…
- Analyses that would show currently and in more detail how the numbers of new and destroyed jobs will develop in individual regions, economic sectors, professions and in general.
- Creation of a tool that would be able to help employees at risk of digitization, automation and robotics, their employers and other entities to find the most suitable jobs for retraining in the conditions of the Czech Republic.
- Creation and modification of educational and retraining programs and courses with a focus on new technologies.
- Motivation of all to further education and study.

- Creating suitable conditions for further education and study, especially for employees belonging to the most vulnerable low-income group and generally vulnerable groups (young people, aged 55 and over, women, etc.).
- Prepare in advance for a potential outflow of more graduates to Germany due to a possible shortage of graduates there. Surveys have long shown that high wages are not everything. In this context, it is important to be open to new trends in setting working conditions (e.g. partial working from home), space for creativity, etc.

Let us remember that the significance of the Fourth Industrial Revolution, and how we have succeeded in its course, how we have used it to our advantage, and for the benefit of humanity, will only be able to be understood in hindsight.

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