The impact of progressive automation and digitalization on employees’ work competences

Prepared for the Association of Independent Trade Unions by

Národní vzdělávací fond, o.p.s.

June 2023

The study was prepared as part of the project of the Association of Independent Trade Unions ‘The Future of Collective Bargaining in the Czech Republic and the Effects of Technological Changes as a Result of Digitalization and Automation on the Requirements for Work Competence of Employees’, financed from the contribution to activities pursuant to Section 320a(a) of Act No 262/2006 Sb., the Labour Code, as amended, to promote social dialogue.

Národní vzdělávací fond

NÁRODNÍ OBSERVATOŘ NVF ČESKÁ REPUBLIKA

Table of contents

Introduction

The presented study is prepared according to the requirements of the Association of Independent Trade Unions as part of 'The Future of Collective Bargaining in the Czech Republic and the Effects of Technological Changes as a Result of Digitalization and Automation on the Requirements for Work Competence of Employees' project. The aim of the study was to collect and evaluate relevant information on the impact of progressive automation and digitalization on employees' work competences.

The study is divided into three chapters. The first chapter focuses on the characteristic features of technological processes affecting the demands on workers' skills. Attention is given to robotics, differences in the use of basic types of robots in individual sectors and to virtual and augmented reality and the use of 3D printing by companies. The chapter also deals with the penetration of individual forms of digitalization into production, but also into management and administrative activities through specific programs (ERP, CRM, EDI), the potential of artificial intelligence and the current level of its use in the economy.

The second chapter is the core of the study and is specifically focused on the changing demands on knowledge and skills of the labour force. It describes basic trends in the development of individual types of skills, i.e. technical, social and emotional and two levels of cognitive skills, and the dependence between skills and the level of education is monitored. Changes in skill requirements are identified for 8 selected sectors: banking and insurance; energy and mining; healthcare; industry; retail; tourism and food service activities; construction; agriculture. The last third chapter contains a summary of the findings.

The study is based on an extensive search and secondary analysis of local and foreign literature and data sources, including research reports and statistics published on the topic. Statistics published by Eurostat, OECD and the Czech Statistical Office are mainly used. The situation in the Czech Republic is compared with the EU27 average and selected EU Member States, development in individual aspects is affected depending on the availability of relevant data.

1 Technological trends affecting the need for work skills

Trends in automation and digitalization affecting processes in production and services, and thus the need for work skills, have accelerated in recent years. Their effects on the functioning of companies and organizations are becoming increasingly apparent, as automatic devices and digital systems intertwine with each other, they are integrated into complex systems, thus increasing their efficiency. Moreover, they can be combined with artificial intelligence elements, especially machine learning, in recent years and it allows for a much higher quality of functions and a higher degree of autonomy, including independent decision-making.

1.1 Robotics

Robots that were used in the past mainly for material handling or machining are now capable of more complex, inspection and control tasks that are constantly repeated and would mean a demanding daily physical load for humans. Current robots are becoming more sophisticated, as they integrate elements of advanced SW, sensorics and artificial intelligence. Their dynamic implementation is motivated by the benefits of (i) increased productivity and flexibility, where robots can be adapted to different tasks and rates of production, (ii) greater quality, precision and elimination of errors in production processes, (iii) increased safety provided by visual aids and sensors, (iv) higher speed with which it is possible to respond to fluctuations in demand and the introduction of new products and innovations. Robots of various designs and functions are used mainly in production activities, but also in services.

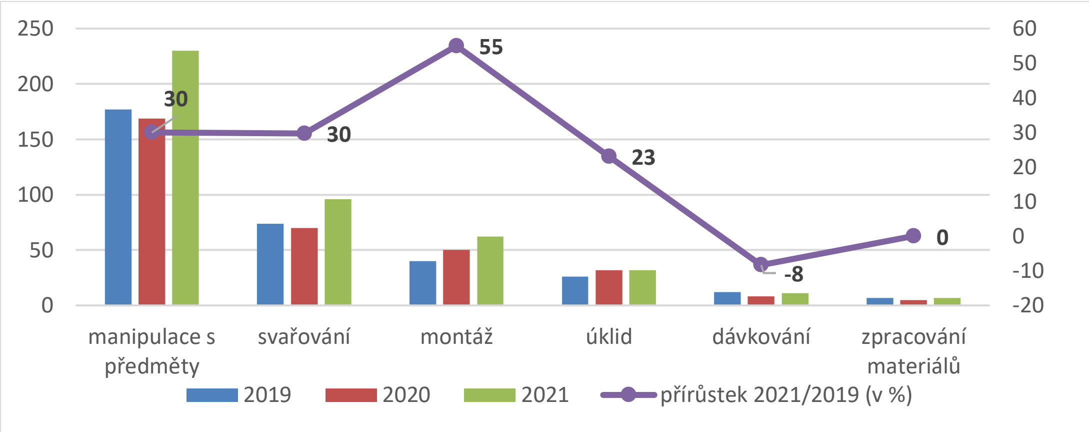
Industrial robots

An industrial robot is a machine that has a programmable control system and performs actions that can be changed based on the program. Most industrial robots work as a robotic arm with a fixed base. This robotic arm can move in space (in 3 or more axes). The use of industrial robots significantly increases production quality, reliability of operations, production capacity and productivity. They are usually used for repetitive operations such as CNC machine operation, palletizing, loading and unloading, processing of various materials, assembly and screwdriving, packaging, tests and inspections, application of adhesives and seals, polishing, welding, painting.

These are often robotized automotive production lines in the manufacturing sector. Robots are also used where compliance with strict production standards is crucial and robots guarantee high accuracy and quality of production, i.e. in the aviation sector, in the production of pharmaceuticals and medical devices. Industrial robots are also common in operations with a high degree of mass production, they are often used for handling operations (industrial manipulators). Robots can also be used in agriculture, where they can plant, weed, water, fertilize, milk, transport or store products when combined with artificial intelligence management.

Robotic applications create new demands on information as feedback from sensors in order to control the robot, direct its operation and make repairs in time if necessary. An effective application of robots thus depends on the accuracy and speed of data transmission in the shortest possible time. Pressure can be expected on the amount of information collected for predictive maintenance and remote access to robot management in the near future. The mechanisms that ensure the safety of people operating increasingly advanced robots are also being improved with the boom of robotic applications.

Chart 1: Installation of industrial robots in the world by forms of use (in thousands of units)



Source: World Robotics 2022; own processing.

handling items; welding; assembly; cleaning; dosage; material processing;
2021/2019 increase (in %)

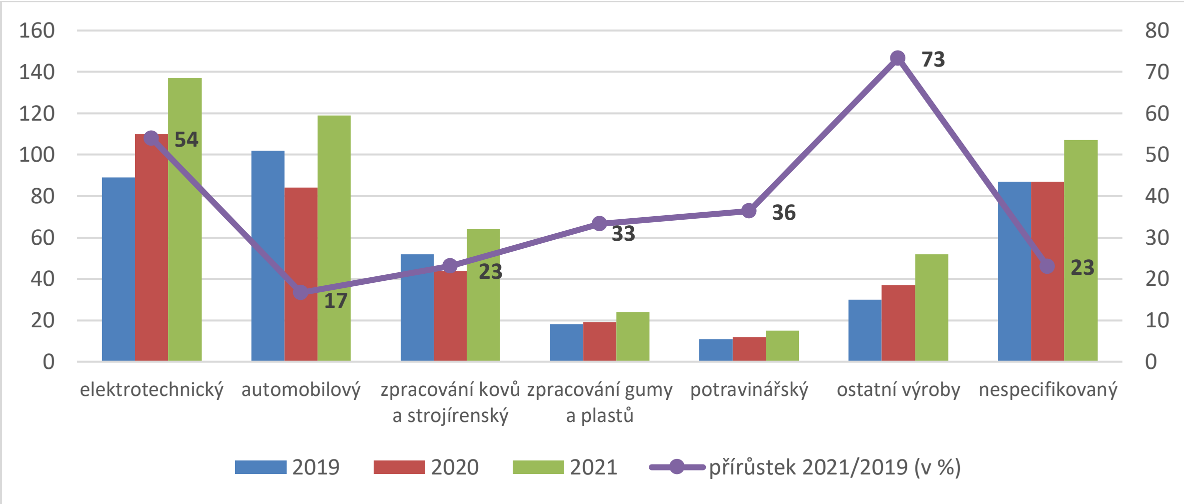
Data collected by the International Federation of Robotics[1] show that robots handling items are most often installed, followed by robots intended for welding and assembly on production lines. They make up about three quarters of all industrial robots and despite the robotization of other types of activities, their share is still growing (Chart 1).

The degree of use of industrial robots in individual production sectors varies depending on the nature of production and the structure of enterprises and differences in the representation of small and medium-sized enterprises and, conversely, large corporations, often multinational. The largest range of installations of industrial robots is in the electrical engineering industry, which is also one of the fastest growing customers of these devices. The potential for further robotics is probably still open in this sector. In contrast, the second sector with the largest application of industrial robots, i.e. the automotive sector, is already slowing down with the installation of new devices. On the contrary, the installation of industrial robots in other sectors where it was not so frequent before is dynamically accelerating. Significant acceleration also applies to the food industry, where robotics has so far been at a low level (Chart 2). The total annual installation volume of new robots is expected to grow further in the future period until 2025, albeit only by half compared to the previous period from 2019 to 2021 (*Electrical engineering; automotive; metal processing and mechanical engineering; rubber and plastic processing, food; other productions; unspecified;*

2021/2019 increase (in %)
Chart 3).

[1] International Federation of Robotics: World Robotics: https://ifr.org/downloads/press2018/2022_WR_extended_version.pdf

Chart 2: Installation of industrial robots by application sector (in thousands of units)

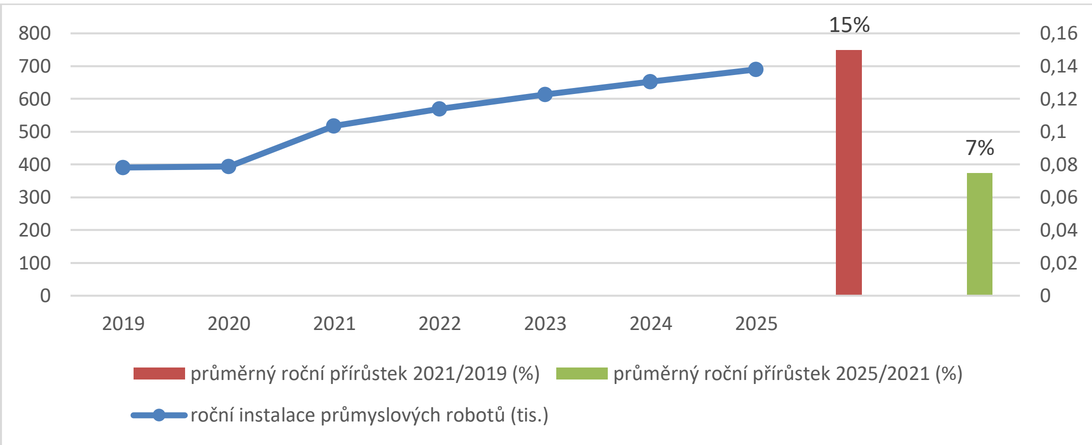


Source: World Robotics 2022; own processing.

Electrical engineering; automotive; metal processing and mechanical engineering; rubber and plastic processing, food; other productions; unspecified;

2021/2019 increase (in %)

Chart 3: Prediction of installation of industrial robots by 2025 (thousands of units)



Source: World Robotics 2022; own processing.

2021/2019 average annual increase (%);

2025/2021 average annual increase (%);

annual installation of industrial robots (thousands)

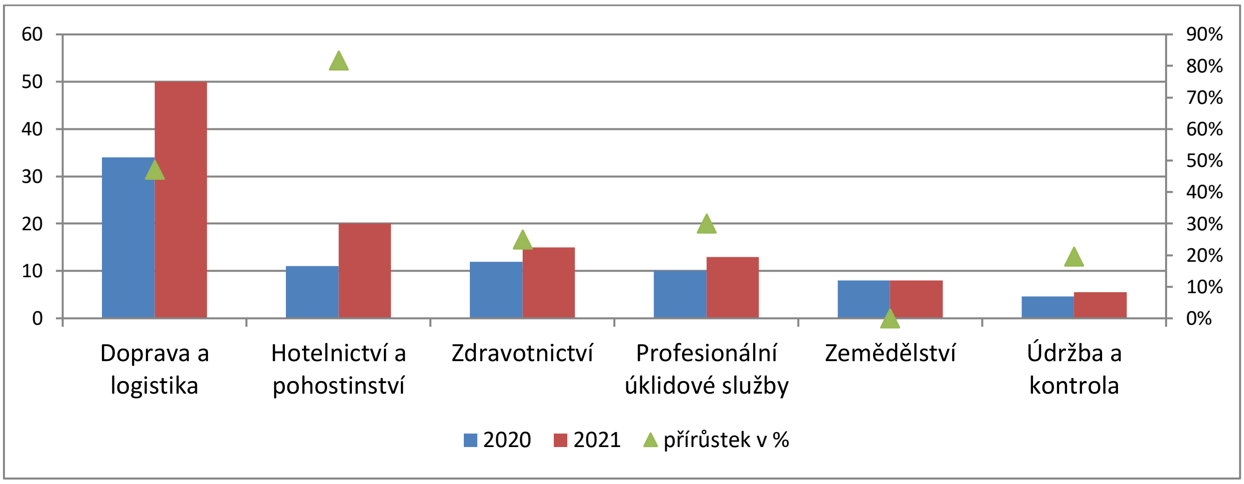
Service robots

A service robot is a machine capable of moving independently in space and independently performing work tasks that are not production operations, including deciding how to perform such activities. It can interpret, plan and implement a given task based on its control system and sensors. Service robot should be able to work safely with people as well as with other machines or devices. It is also able to work on land, in the air or under water and operate in an environment in which it is necessary to interact with its surroundings. Companies use them mainly in transport and logistics, where they are used to move goods, and also in warehouses, where they create a robotic warehouse system, perform robotic palletizing, packaging of goods, etc. Service robots are widely used in the hotel and food service sectors and in cleaning services. They are also used for support activities in medical facilities. In addition, they are often used for security, where they perform tasks like surveillance or inspection of buildings by drones, provide robotic fire protection, carry out examination, evaluation and resolution of dangerous situations in the protection of buildings or infrastructure, etc.

In addition to professional activities in industry and services, service robots are also used in other areas. They can take the form of consumer goods and be adapted for normal use in households, leisure activities, etc.

The application of professional service robots does not reach the same dimensions as that of industrial robots, but the dynamics of its growth in the world is relatively fast (Chart 4).

Chart 4: Areas of the most extensive application of service robots for professional purposes in the world (in thousands of units)



Source: World Robotics 2022

Transport and logistics; hotel and food service activities; healthcare; professional cleaning services; agriculture; maintenance and control; *increase in %*

Collaborative robots (cobots)

Collaborative robots cooperate with humans and help in various tasks that are either strenuous, dangerous or require high and still the same accuracy. They are used in operations where it is necessary to multiply the human force or for welding, screwing, gluing, placing items or for precise measuring of substances. Human workers can use their cognitive abilities to control the robot's activities.

State-of-the-art cobots have vision functions, including a 3D machine vision sensor, which allow the cobot to collect various types of production components and place them in the hands of a human worker. In addition, they also have a stop function which stops them immediately in the case of a collision with a person.

The advantage of cobots is easy programmability, it can be put into operation within one to two working days, without the need for complex programming. The implementation can be handled by a technologist with a basic knowledge of algorithms. A simple production operation can also be set, for example, by 'manual guidance of a robotic arm', when the robot can be taught to move for the production task. The robot will then perfectly copy the learned movement, including the speed of work. The entrusted task will be performed precisely and accurately. The operation speed can be easily adjusted at any time, for example with regard to the type of product material. Compared to the traditional programming of stationary industrial robots, the programming of cobots is several times shorter and easier without the need to cooperate with a programmer-specialist and is thus significantly cheaper. In addition to cheaper installation, cobot prices are gradually decreasing and investments in cobots will return within one or two years according to current estimates.

Cobots will increasingly replace single-purpose production machines over time. In addition to lower investment costs, their great advantage is their versatility, allowing them to be transferred to another task if necessary. The ease of programming will allow this change to be made in a very short time. This area of robotics will undergo tremendous development in the coming years and will be widely open for use also in SMEs or in sectors where classical robotics has not yet been so widespread. An example may be the food industry, which was unsuitable for robotics until recently due to compliance with strict hygiene standards. Robotics in this field has experienced huge growth in recent years and it is estimated that the number of robots in this area will triple in the next twenty years. It will be largely due to the expansion of using cobots, as they are suitable for processes that require special hygiene.

Further development of cobots will also focus on improving human protection and meeting strict safety standards. Therefore, progress is also expected in ensuring easy and safe human-robot interaction, e.g. using interactive touch tables or augmented reality (AR). Robots will also become more sensitive and safer and will better adapt to the human work pace and respond to the wider environment. They will soon acquire 'intelligent' feel to easily cope with the handling of soft and deforming items.

Collaborative robots complement workers rather than directly replace them. Thanks to them, people can better focus on their work which requires creativity, reflection and critical thinking. It is estimated that cobots currently account for only 3% of all robot sales. However, their deployment is expected to expand significantly over the next five years and the share of cobots in all installations of robotic devices could reach up to 30% in the next five years[2]. Cobots will be applied not only in large industry, but their benefits will also be used by SMEs which are based on small-scale production, where it is not yet worthwhile or impossible to comprehensively robotize entire lines. The use of cobots will allow these companies to multiply the productivity of workers while maintaining the flexibility required by their diverse orders and not requiring as much time to train the workers who work with them.

Advanced robotics

Robotic devices are increasingly interconnected with artificial intelligence systems and the so-called advanced robotics is developing in recent years, which includes robotic systems capable of receiving commands and responding to them in an intelligent way. They are autonomous, mobile and cooperative robots. For example, a robot that carries out the task of transporting material in a

[2] https://automatizace.hw.cz/soucasny-stav-a-vyvoj-trhu-kolaborativnich-robotu.html

warehouse can face an unexpected obstacle by redefining and choosing a new optimal route to fulfil its mission. Progress in ground-breaking technologies such as the Internet of Things (IoT), big data, artificial intelligence or cognitive automation/machine learning plays a significant role in the development of advanced robotics. These technologies enhance the capabilities of mobile robots which now achieve higher levels of intelligence and autonomy. Equipped with sensorization and a powerful combination of software and hardware for intelligent decision-making, they are able to move flexibly, make autonomous decisions while maintaining high accuracy and reducing errors. Multitasking, collaborative robots with greater autonomy and increasingly accurate sensing are the future of advanced industrial robotics.

These types of robots are not limited to the production environment or Industry 4.0, although a large part of them are focused on this sector but are also useful in various other sectors – such as construction, healthcare, agriculture or ensuring property protection and safety.

Virtual and augmented reality

Virtual and augmented reality allow simulation of real items and processes, thus helping not only to speed up, control and refine work operations, but also to perform them remotely. These technologies create a reality without any tangible presence and they are used both directly in the production and maintenance of equipment and in the service sectors, especially in medical fields, retail, logistics, in the training of workers, even in professionally demanding jobs, e.g. doctors and paramedics, etc.

Virtual reality experienced very rapid development in the last five years or so, mainly due to technological progress in the field of high-resolution imaging devices, motion sensors, scanning cameras and computing power. Augmented reality represents a higher level where the user is no longer separated from the surrounding environment and moves in it, with textual or visual instructions and contextual information being projected into their field of vision through special glasses in real time. Another development category is mixed reality, which has separated from augmented reality thanks to the advent of more sophisticated glasses that allow 3D items to be projected into the user's field of vision and credibly mix elements of real and virtual environments.

Surveys made by Gartner among respondents from large multinational enterprises show that while virtual reality dominates corporate practice, especially in the field of training and simulation (it is used to a slightly lesser extent in the areas of product design and visualization, cooperation in a virtual environment or data display and analysis in virtual reality), augmented reality is mainly applied in practice in the operational and technical field, such as maintenance and technical support, where field workers (or even untrained users) are connected with an expert providing remote guidance and advisory support in real time[3].

The implementation of augmented reality in practice has not yet progressed very quickly. It is mainly used by large companies because creating relevant content or applications is quite difficult and

[3] Pět oblastí, kde můžete nejlépe využít rozšířenou realitu. ICT REVUE: 9/2019

requires a specialist, the problem may be battery life, size and durability of the device or privacy protection.

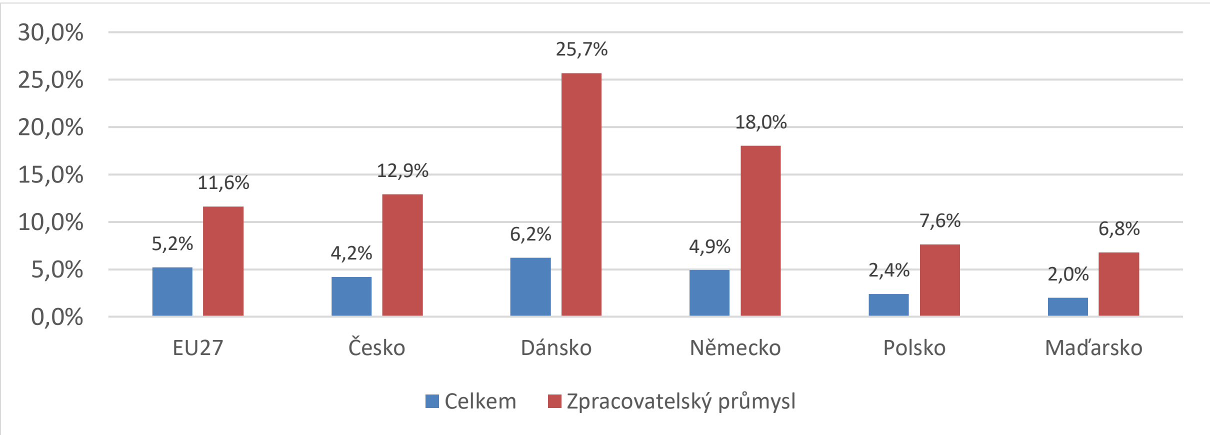
3D printing

3D printing or additive manufacturing allows producing lighter and safer components in less time and at less cost. So far, it is primarily used for prototyping, but it is also being used for product innovation, preparation of spare parts and in some segments of high-volume production. It can produce specific components or parts made of multiple materials and with individual characteristics. It is also expanding in small batch or custom production and the current trend of mass personalization of production will accelerate this trend.

7% of enterprises with 10 or more employees used 3D printing in the Czech Republic in 2021. The dominant use of additive manufacturing is mainly in large companies with more than 250 employees. A third of large enterprises, 12% of medium-sized and 5% of small enterprises used 3D printing in 2021.

In international comparison,[4] Czech companies ranked below the EU average in the use of 3D printing. Additive manufacturing was used by 4.2% of enterprises in the Czech Republic this year, the average for EU Member States was 5.2% of enterprises (see Chart 5). This is significantly more than in other Central and Eastern European countries, but our companies still fall behind the leaders in the use of 3D printing, especially in SMEs. On the other hand, when it comes to large enterprises in the manufacturing industry with more than 250 employees, Czech companies are at the top of the European ranking (26%).

Chart 5: Enterprises using 3D printing (2019)



Source: CZSO, Využívání komunikačních technologií v podnikatelském sektoru [Use of communication technologies in the business sector], 2022; own processing.
Note: Source table for all EU Member states is available in Table 6 in the annex.

EU27; CR; Denmark; Germany; Poland; Hungary;
- *Total;*
- *Manufacturing*

[4] The source of data for international comparison is the Eurostat database, last updated in December 2022. **However, the latest available international data for 3D printing relate to 2019**: http://ec.europa.eu/eurostat/web/digital-economy-and-society/data/comprehensive-database

Three-dimensional products are printed and used mainly in the manufacturing industry – most of them in the manufacture of computers, electronic and optical products (49% of enterprises), in the automotive sector (35%), in the electrical and mechanical engineering industries and in other sectors of the manufacturing industry, e.g. in the production of musical instruments or sports equipment.

3D printing was usually used to produce prototypes or models (88% of those that used 3D printing). Additive manufacturing is also used in the production of semi-finished products, components, tools and other products; 72% of those that used 3D printing produced them in 2021. They are most often produced by entities from the electronics industry, other manufacturing industry or companies engaged in research and development.

Companies using 3D printing most often print on their own or rented 3D printers, i.e. they perform these operations by their own employees. They prefer this to buying custom 3D printing from other entities. Controlling a 3D printer is not complicated and does not require special knowledge or skills. Preparation of printing and, in particular, programming the printing of more complex items is more demanding and requires certain digital skills and knowledge of 3D modelling of varying degrees of difficulty.

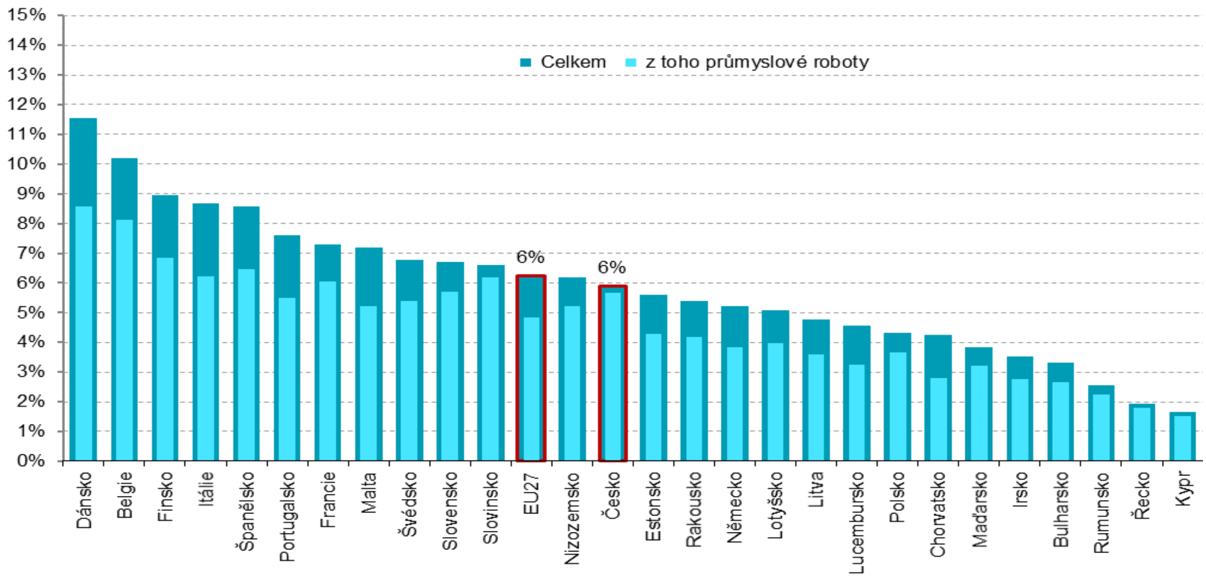
Use of robotics in the Czech Republic

Robotics in the activities of Czech enterprises is at a relatively high level, although it still lags behind the most developed countries, so the potential for further penetration of robotics into Czech industry and services is still relatively high and will certainly be reflected in further restructuring of professional activities in the future.

According to data from the Czech Statistical Office (CZSO), Czech companies were approximately at the EU27 average in the use of various categories of robots in total in 2022 in international comparison. If the ranking were compiled only from large companies with more than 250 employees, Czech enterprises (36% of large enterprises) would rank 4th above the European average. The 2022 European average was 26% of large enterprises.

If we focus only on the use of industrial robots, Czech companies (5.7%) are, similarly to robotics, slightly above the EU average (4.9%). However, if we compare the situation only for large enterprises, large Czech enterprises (34%) ranked 2nd, high above the European average (22%; see Chart 6).

Chart 6: Enterprises with 10 or more employees in EU countries using robotics; 2022



Note: Share in the total number of enterprises with 10 or more employees in a given country

Source: CZSO, Eurostat, December 2022

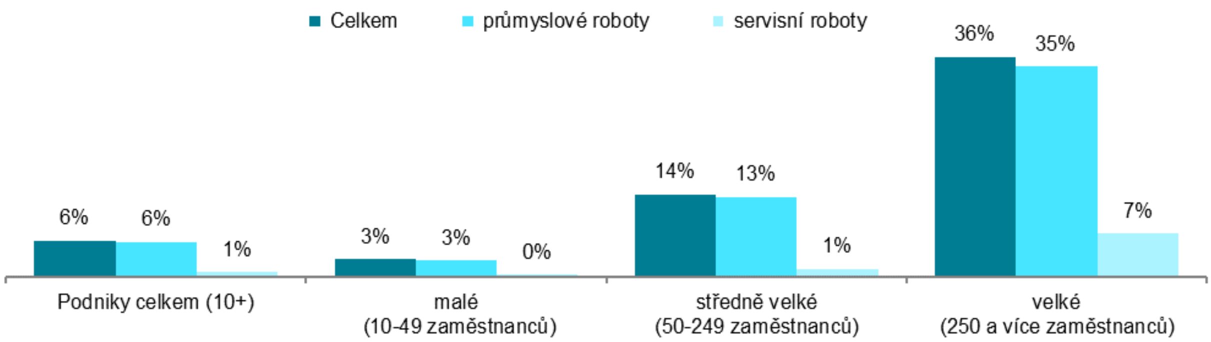
Total;

Of which industrial robots;

Denmark; Belgium; Finland; Italy; Spain; Portugal; France; Malta; Sweden; Slovakia; Slovenia; EU27; Netherlands; CR; Estonia; Austria; Germany; Latvia; Lithuania; Luxembourg; Poland; Croatia; Hungary; Ireland; Bulgaria; Romania; Greece; Cyprus

The vast majority of robots used in the Czech business environment are **industrial robots** or industrial manipulators used as robotic arms with a fixed base. These are machines with a programmable control system, which are mainly used for automation of production activities. Industrial robots were used by a total of 6% of companies, 35% of large enterprises with more than 250 employees in 2022 (Chart 7).

Chart 7: Enterprises with 10 or more employees in the Czech Republic using robotics; 2022



Source: CZSO, 2022

Note: Share of enterprises using robots in the total number of enterprises with 10 or more employees in a given group

Total;

Industrial robots;

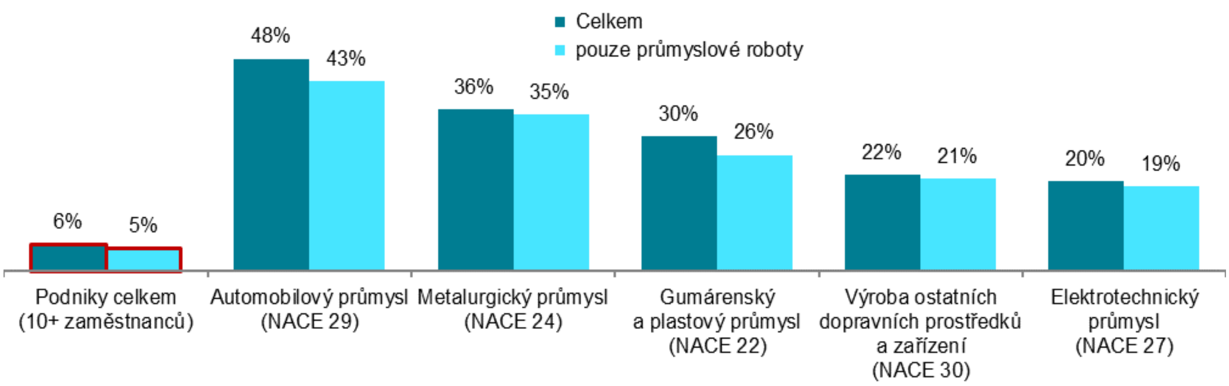
Service robots;

Total enterprises; Small (10-49 employees); Medium-sized (50-249 employees); Large (250+ employees)

Industrial robots are used by 16% of companies in the **manufacturing industry**, more than 63% of them are among large enterprises. Robotic manipulators are most often found in car manufacturing (48% of enterprises), in the metallurgical industry (36%) or in the rubber and plastic industry (28%). The vast majority of Czech companies using robotics use only industrial robots and do not have service robots. Only industrial robots are used by 15% of enterprises in the manufacturing industry, most often companies operating in automotive production (43% of enterprises).

Service robots are used by 6 times less companies compared to industrial robots and it was only 1% of all companies and only 7% of large entities in 2022. Regarding the manufacturing sectors, they are most often used in the automotive industry or in the production of computers, in both sectors around 4% of enterprises. Regarding the service sector, transport and storage are the most common (4%), (see Chart 8).

Chart 8: Manufacturing sectors in the Czech Republic using robots most often (2022)



Source: CZSO, 2022

Note: Share of enterprises using robots in the total number of enterprises with 10 or more employees in a given sector

Total;

Only industrial robots;

Total enterprises (10+ employees); Automotive (NACE 29); Metallurgical industry (NACE 24); Rubber and plastic industry (NACE 22); Manufacture of other transport equipment (NACE 30); Electrical engineering industry (NACE 27)

In addition to the industry that is dominant in the application of robotics, robotic technologies are also beginning to penetrate industries that have so far stood aside. Progress in robotics towards mobile devices and the application of artificial intelligence has allowed these technologies to become more widely used in sectors such as construction, agriculture and others.

1.2 Digitalization

Digitalization represents a wide range of activities and processes that are converted on a digital basis. This allows information to be collected, shared and analysed in real time. Digitalization of individual activities to a certain extent grows into a digital transformation of the entire business model, i.e. a change in all production, organizational, administrative and business-market conditions for the functioning of organizations in the digital world.

Digitalization of production

All engineering activities in the company in production are gradually **digitalized** from the pre-production phase (modelling, virtual prototyping and 3D printing, simulation, visualization, big data analysis for production, testing of materials and systems), through the use of robotics and cybernetics in the production phase and subsequently to product maintenance[5]. Thus, digitalization makes it possible to monitor, control and intervene in the process of creation and handling of the product throughout its life cycle.

As part of production digitalization, the **Internet of Things** (IoT) is developed, which allows physical objects to use the Internet to communicate data about their status, position or other attributes. This means technologies and applications that generate information about devices and places for the purpose of data analysis, based on which subsequent optimization will take place. Several prerequisites must be met for the IoT to work in practice: components, machines and devices must be equipped with sensors that collect data; compatibility of different types of hardware and software must be ensured in order to increase their interoperability; there must be a wireless network connection that allows devices to communicate with each other; a platform, application or cloud solution that allows the integration of the previous elements into the user interface through which data analysis and control take place.

In addition to industry, IoT has the potential to transform other sectors such as healthcare, transport and agriculture. This could enable more efficient and personalized services while adequately ensuring privacy and security. The IoT makes it possible to implement predictive maintenance, speed up medical care, improve customer service and offer other innovations that we cannot even imagine yet. Forecasts indicate that a massive network of IoT-based interconnected devices will emerge by 2030, encompassing everything from smartphones and sophisticated devices in manufacturing and services to end products used by customers. New technologies such as 5G are expected to accelerate the development of the IoT in the coming years. Some surveys predict that the scope of Internet of Things application will roughly triple worldwide over the next five years.[6]

The IoT application raises the need for experts with knowledge of software development, information security, AI and the basics of machine learning, networks, hardware interface, data analysis, automation. Experts in embedded systems with knowledge of the design of devices and products in which SW, sensors, etc. communicating within the IoT are also important.

The advanced use of digital technology in production is the so-called digital twin of the product and process. It is a complex technology based on the use of 3D data and data from production systems. Most often, we encounter a product digital twin which is used mainly at the product design stage, in simulations and introduction into production. According to the findings of the National Centre for Industry 4.0,[7] digital twins of production processes using real-time data are still not very common in Czech manufacturing companies (see Chart 9). This is mainly due to the fact that these are more demanding models to create and maintain, with a longer return exceeding one to two years. That is why many companies are currently using the product digital twin for simulation and for monitoring the condition of the device.

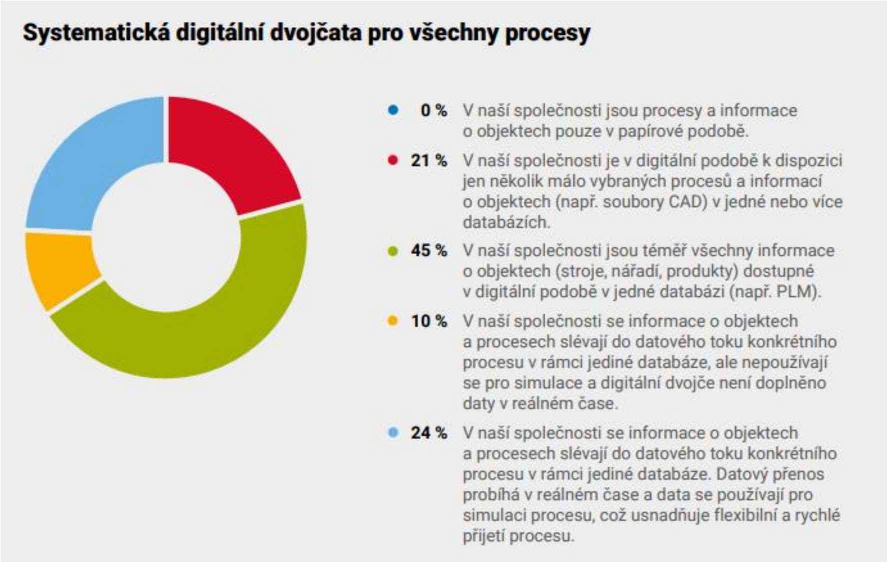
---

[5] The Office of the Government of the Czech Republic. Podkladový analytický materiál: Podklad k naplňování NP VaVal 2016 - 2020

[6] Fenomén internetu věcí: Data budou odesílat stroje, auta, zásuvky i osobní váhy. Online: https://www.systemonline.cz/clanky/fenomen-internetu-veci.htm

[7] Source: Národní centrum průmyslu 4.0: Analýza českého průmyslu 2020. https://www.ncp40.cz/files/analyza-ceskeho-prumyslu-2020-updated.pdf

Chart 9: Use of digital twins in Czech industry



Source: National Centre for Industry 4.0: Analýza českého průmyslu 2020

Systematic digital twins for all processes;
Processes and data about items are in paper form only in our company.;
Some selected processes and data about items (e.g. CAD files) in one or more databases are available in digital form in our company.;
Almost all data about items (machines, tools, products) in one database (e.g. PLM) are available in digital form in our company.;
Data about items and processes merge into a data flow of a specific process within one database in our company, but are not used for simulation and the digital twin is not supplemented with real-time data.;
Data about items and processes merge into a data flow of a specific process within one database in our company. Data transmission is done in real time and data are used for process simulation, thus facilitating flexible and fast process adoption.

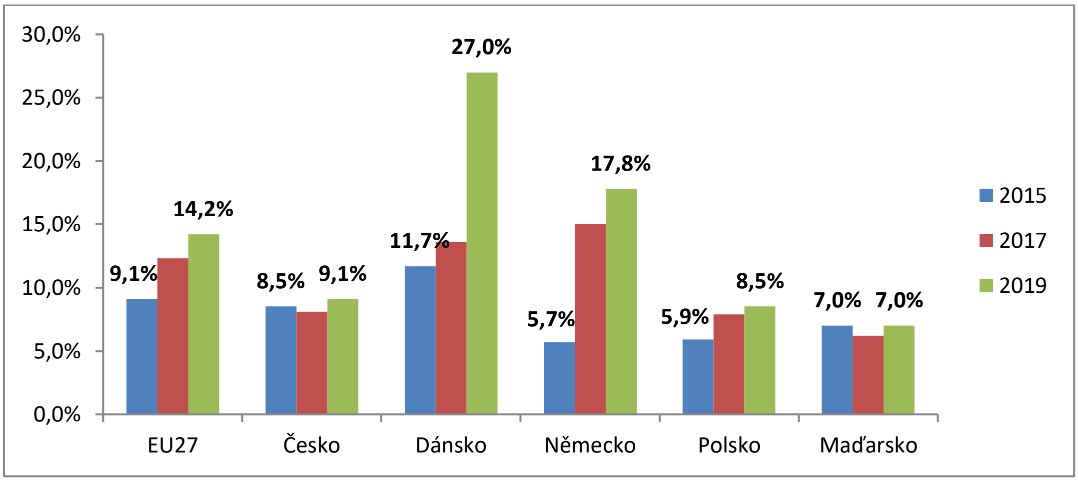
Cloud computing allows businesses to rent and use data and computing services such as storage, databases, analytics software, etc. via the Internet. Because companies pay only for the services they actually use, the price for software – which is immediately available – is reduced. Almost two-thirds of the total number of industrial enterprises currently use cloud computing, according to data from the Ministry of Industry and Trade[8]. The expansion of cloud services could be even faster, but it is hindered by some concerns of enterprises about the misuse of data and information shared and stored in a virtual place.

The amount of data available to companies is also growing with the development and expansion of the Internet of Things. **Big Data** systems use a huge amount of data from the production process, from social networks and various autonomous sensors. Using analyses and artificial intelligence, enterprises try to extract information about customer and system behaviour from these unstructured data to better predict future developments and optimally plan production, sales and maintenance.

Although the use of data in Czech companies is slightly growing, it is progressing relatively slowly. From the European perspective, the Czech Republic is relatively significantly below the EU average and it is rather stagnant compared to other countries that have made a significant leap in recent years. Although it is in a slightly better position than some Central and Eastern Europe countries, a significant gap is evident compared to its Western partners (see Chart 10).

[8] MPO: Panorama průmyslu 2019, https://www.mpo.cz/assets/cz/prumysl/zpracovatelsky-prumysl/panorama-zpracovatelskeho-prumyslu/2019/10/panorama_cz_web.pdf

Chart 10: Enterprises analysing big data (share in %)

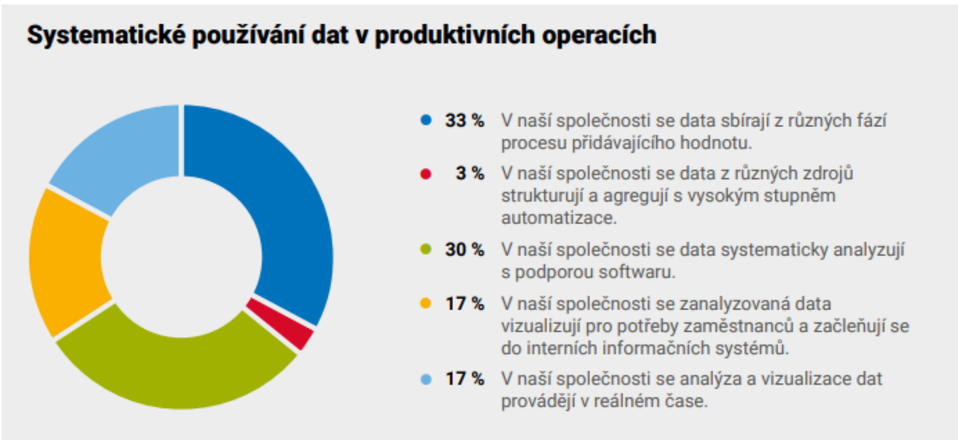


Source: Eurostat, CZSO https://www.czso.cz/csu/czso/podnikatelsky_sektor. Own processing.
Note: Share in the total number of enterprises with 10 or more employees in %

EU27; CR; Denmark; Germany; Poland; Hungary

As far as industrial enterprises are concerned, the situation is not more favourable. According to the findings of the National Centre for Industry 4.0, only one-fifth of industrial companies are able to use data in a structured and integrated way that directly supports their activities and brings fundamental value to customers and suppliers. In contrast, more than 40% of companies do not use data in a systematic way or do not know how to use them. It is very common for companies to collect data from IT systems and operating technology systems, but they do not know how to get the right information from these systems, they do not have a concept of what data are crucial for them, how to verify them and for what to use them. Companies often lack experts in data analytics, so they resort only to the interpretation of simple parameters or basic correlations. But this cannot be enough in today's complex environment of a modern manufacturing company (see Chart 11).

Chart 11: Systematic use of data in Czech industry



Source: National Centre for Industry 4.0: Analýza českého průmyslu 2020

Systematic use of data in production operations;

Data are collected from various phases of value-adding process in our company.;

Data from various sources are structured and aggregated with a high level of automation in our company.;

Data are systematically analyses using software in our company.;

Analysed data are visualized for the needs of employees and are integrated into internal information systems in our company.;

We have real-time data analysis and visualization in our company.

The need to analyse big data also raises the need for analysts and the need to store these data safely. Analysts usually work on predictions of customer behaviour and consumer patterns, plan demand and plan fulfilment to allow for smoother operations in the supply chain or predicting errors in production. The security requirements for corporate data shared with employees are increasing.

As digitalization grows into all processes, the need for **cybersecurity** increases. It is necessary to ensure reliable and secure storage and backup of data, secure communication, prevention of the spread of malicious software and prevention of cybercrime. All this is becoming increasingly important as companies acquire more and more data, many of which concern not only their own production and business operations, but also their employees, customers or suppliers.

To ensure data security, companies are using ever wider teams of specialists in the field and, in addition to traditional ones, new occupations responding to the new digital architecture are emerging. The demand for these professionals is high and still unsaturated. Evidence of the strong need for cybersecurity professionals is the fact that the number of cybersecurity jobs in the world is growing three times faster than other technology jobs[9]. Key occupations to ensure digital security include cybersecurity analysts, ethical hackers, security engineers, security architects, security automation engineers, network security analysts, malware analysts.

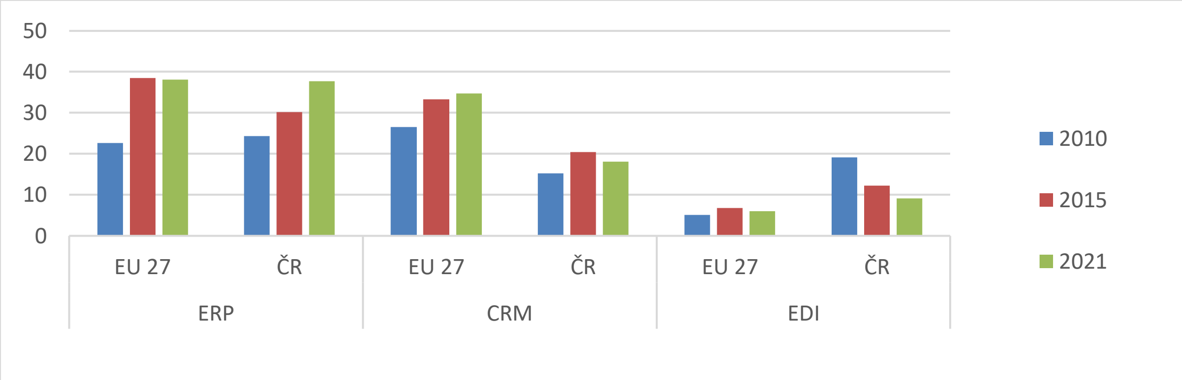
Digitalization of management and administrative activities

In addition to production operations, **digitalization** is changing very quickly the ways of organizing the **management and administrative activities of companies**, expanding and implementing new information systems and especially interconnecting both within the company and externally with the systems of suppliers and customers. Vertical integration of systems and processes relates to real-time management, ERP systems and strategic decision-making systems at the management level. Horizontal integration of systems and processes concerns contact with suppliers, engineering activities, own production and distribution.

It is based on ERP (Enterprise Resource Planning) management information system integrating and automating a large number of processes related to the production process (production, logistics, storage, sales, invoicing, accounting, asset management, etc.). ERP enables access to current data using a unified and interconnected database. Other basic systems include a customer relationship management (CRM) system, a system that allows real-time management of the entire supply chain (SCM – Supply Chain Management) and electronic data interchange (EDI), which exchanges electronic business documents (orders, invoices) and allows their electronic transmission in real time, immediate control and subsequent processing.

[9] Gartner: The TOP 8 cybersecurity predictions for 2021-2022. https://www.gartner.com/en/articles/the-top-8-cybersecurity-predictions-for-2021-2022

Chart 12: Enterprises using ERP, CRM, EDI systems (share in %)



Source: Eurostat, CZSO https://www.czso.cz/csu/czso/podnikatelsky_sektor. Own processing.
Note: Share in the total number of enterprises with 10 or more employees in %

The introduction of ERP or CRM, or a combination thereof, means higher productivity for businesses. According to the findings of the CZSO, almost 40% of companies have a management system in place, which is roughly at the level of the EU average. However, when it comes to CRM systems that organize and support their relationships and business operations with customers, these systems are used by a significantly smaller share of Czech enterprises and are significantly lagging behind other companies in the EU (see Chart 12).

There are more significant differences between large and small companies. Business applications used throughout the group or systems operated in multiregional or multinational shared services centres are being implemented relatively quickly in order to ensure compatibility on the part of Czech manufacturers that are part of multinational groups.

Another level of digitalization of management and administrative processes in the company is the development of the above-mentioned systems and their integration with artificial intelligence. It is a **robotic process automation (RPA)**, which is based on the use of software with artificial intelligence and machine learning to handle large-scale repetitive activities that were previously done by employees in the field of administrative and commercial transactions. These tasks include: addressing queries, performing calculations, keeping records, performing transactions. Thus, RPA comprehensively manages all the activities that need to be performed to complete a specific task, i.e. from collecting data, including extracting data from documents, sorting and entering them into databases, through their evaluation to the automatic implementation of subsequent final activities such as invoicing, document creation, communication with customers, including answering emails, etc. Examples of using RPA in the automation of business processes are:

Invoicing process: RPA can be used to automate the invoicing process in the ERP system. The RPA 'robot' can perform activities such as checking invoicing data, verifying addresses, creating invoices and then sending them to customers. This process can be fully automated without the need for human intervention.

Accounting processes: RPA automates accounting processes in the ERP system. The RPA 'robot' can process and classify accounting documents, create accounting entries and generate financial statements. This process can be automated with minimal human intervention, enabling efficient accounting management.

Warehouse management: RPA can help with warehouse management in the ERP system by processing order requests and tracking the movement of goods in the warehouse. The RPA 'robot' can process orders, update inventory, send alerts and automatically generate orders to the supplier.

Order processing: RPA can also be used to automate the order processing process in the ERP system. The RPA 'robot' can receive orders from customers, process them, generate invoices and track payments. The entire process can be automated, allowing for a fast and efficient way to process orders.

RPA will replace a large range of activities previously carried out by workers, especially at the medium qualification level. Its application raises the need for new professional skills such as RPA developer, RPA analyst, RPA architect.

It can be summarized as follows: Czech companies currently have their production and administrative processes partially digitalized. So far, they have focused on the digitalization of the construction process (two-fifths of companies have fully implemented it – 40.9%), while the product documentation is rather neglected and more than half of companies have these processes in digital form only partially. Businesses that are at the forefront are trying to digitalize those processes where the highest benefits and financial returns are expected. In production, these are the areas of data collection, visualization, prediction and monitoring. In offices, these are areas where workers perform repetitive tasks and automation eliminates these activities. All these actions lead to greater flexibility, reduced costs and efficient decision-making. Thanks to digitalization, companies are also able to immediately respond to the constantly growing and, above all, individual customer requirements, thus gaining the opportunity for new areas of their business.

As part of the last European Skills and Jobs Survey (ESJS2),[10] it was investigated whether and how the new digital technology changed the composition of tasks in the work of employees. Most of the employees who had tasks transferred had to do some other or new tasks. Only 4% of the labour force had some of their tasks replaced by new digital software or machines without expanding their activities in other areas. On the other hand, the share of those workers who performed completely different work tasks than before under the influence of digital transformation was also relatively low (9%). For the vast majority of employees, the impact of digitalization is characterized by leading to a dynamic redistribution of work tasks and redesign of the content of jobs, when some activities are replaced by machines and additional or new activities are created.

1.3 Artificial intelligence

Artificial intelligence (AI) has begun to transform the economy in recent years and the potential for its effects in the future is enormous, as it allows machines to perform increasing amount of cognitive tasks that were once performed only by humans. In its basic form, which consists in the ability to process data, evaluate them and predict the next steps based on an externally created fixed program, artificial intelligence has long been used in various information systems or robotic devices. However, the recent development of artificial intelligence has been greatly accelerated due to advances in machine learning

[10] Cedefop (2022). Setting Europe on course for a human digital transition: new evidence from Cedefop's second European skills and jobs survey. Luxembourg: Publications Office. Cedefop reference series; No 123 http://data.europa.eu/doi/10.2801/253954

(ML) and neural networks, where programs are trained on large sets of data and are able to improve themselves. Other conditions have also contributed to its rapid development, such as increasing the scope and quality of digital data that AI can use, increasing the computing power of computers and improving program algorithms. For example, image recognition algorithms improved so much over the past ten years that they outperform humans. There have also been significant improvements in voice recognition and natural language processing, machine translation, decision support systems, gaming and many more. Since skills such as vision, speech and decision-making are essential for most occupations, it is logical that substantial changes in the nature of work in a wide range of occupations can be expected when applying AI.

Despite this significant progress, AI is still far from being able to perform the full range of human cognitive activities in practice. This raises questions about what tasks can AI do well and what tasks are best handled by humans? What are the implications for jobs, industries and different geographical areas? How can we quantify the changing value of human skills for businesses? The answers to these questions have already been researched by various research teams around the world. Mostly, these researches were based on interviews with experts, interviews in enterprises and data from available databases or job advertisements, when the possible impact of AI on individual activities/tasks performed in various occupations was examined[11]. Each occupation performs a wide range of activities, some of which are more suitable for the application of AI than others, so AI exposure does not necessarily mean that human work will be reduced or even completely replaced in such occupation. A job can be maintained even with the deployment of AI because AI will complement human activities and increase their performance, reduce costs and increase corporate profits, which will make it possible to expand company jobs.

The physical tasks that are currently most often transferred to AI are usually routine, data-intensive, optimization-based and do not require social interactions or more specific manual dexterity, but they require a structured work and technical environment, such as a regularly running assembly line, etc. The cognitive tasks that are currently most often transferred to AI are routine, data-intensive and do not require more complex social communication, such as customer support, basic office support, taking out insurance or contracts for financial products, etc.

Studies examining in detail the possibilities of influencing the performance of individual occupations by the introduction of AI concluded that existing AI technologies, despite their advancement, are not able to automate all tasks included in individual occupations but are sufficiently advanced to perform at least some tasks in almost every occupation. For example, the MIT research team[12] demonstrated on data that almost all jobs involve at least one activity that has a high probability of AI exposure. This activity will be transferred to AI and the structure of activities performed by a worker in a given occupation will have to be adapted to the new situation. This suggests that in order to use the potential

[11] Methodologically, it is difficult to separate the influence of AI on the performance of the occupation from other influences, which are mainly economic factors, changes in demand, outsourcing, changes in production program, etc.

[12] Brynjolfsson, E.; Rock, D.; Tambe, P.: How Will Machine Learning Transform the Labor Market? Essey. MIT, 2019. https://www.hoover.org/research/how-will-machine-learning-transform-labor-market

of AI, a substantial restructuring of work activities within individual occupations and a significant addition of workers' qualifications will be needed.

The MIT study further notes that businesses have significantly increased IT-related investments in recent years, which now account for around 40% of property, buildings and equipment. This means that companies must take further steps to use these installed AI devices and systems. In the area of work organization, the involvement of artificial intelligence in production and services will require profound structural changes in companies. The role of ICT departments in companies will be strengthened, overall there will be closer interconnection and cooperation of various structures within a company and with cooperating organizational structures on the part of suppliers and customers. This often requires large investments in related IT skills, such as cloud computing, data engineering and specialized data management and protection. Companies must also supplement the qualifications of employees in executive positions, change the assignment of their tasks as well as the entire business processes needed to actually implement the effects promised by AI in practice. The MIT study suggests that the magnitude of these necessary changes is so great that it will likely take years for AI to be fully integrated into business practice. The same was true of earlier technological breakthrough innovations.

Considering the current technological level in artificial intelligence, it can be expected that technologies will be able to replace more than 50% of the skills required for the occupation in 11% of occupations within 5 years. Automation can replace more than 50% of skills in the vast majority of current occupations within 30 years. In parallel, new occupations will be created on an ongoing basis, but they will place different demands on their performers and will require different skills and abilities compared to current occupations.

Occupations where significant changes in the nature of work can be expected in the future as a result of automation and the introduction of AI include occupations with a high proportion of routine skills in both manual tasks (machine operation, packaging and palletizing, dosing) and knowledge (counting, accounting, data collection and processing, text and data correction, measurement of physical quantities, quality control). There is less risk of replacing human work in occupations with a higher proportion of non-routine and creative skills in both manual tasks (repairs and renovations, services and personal care) and knowledge (research, analysing, planning, designing, creating rules and procedures, negotiating, organizing, learning and training, leading people, entertaining and presenting), (see Table 1). The possibilities of replacing or supplementing work activities with AI will rapidly expand based on the recent progress in the processing of information, texts and language based on generative AI models, in particular GPT (see below).

Table 1: Estimation of the impact of the application of AI on performance of work in occupations

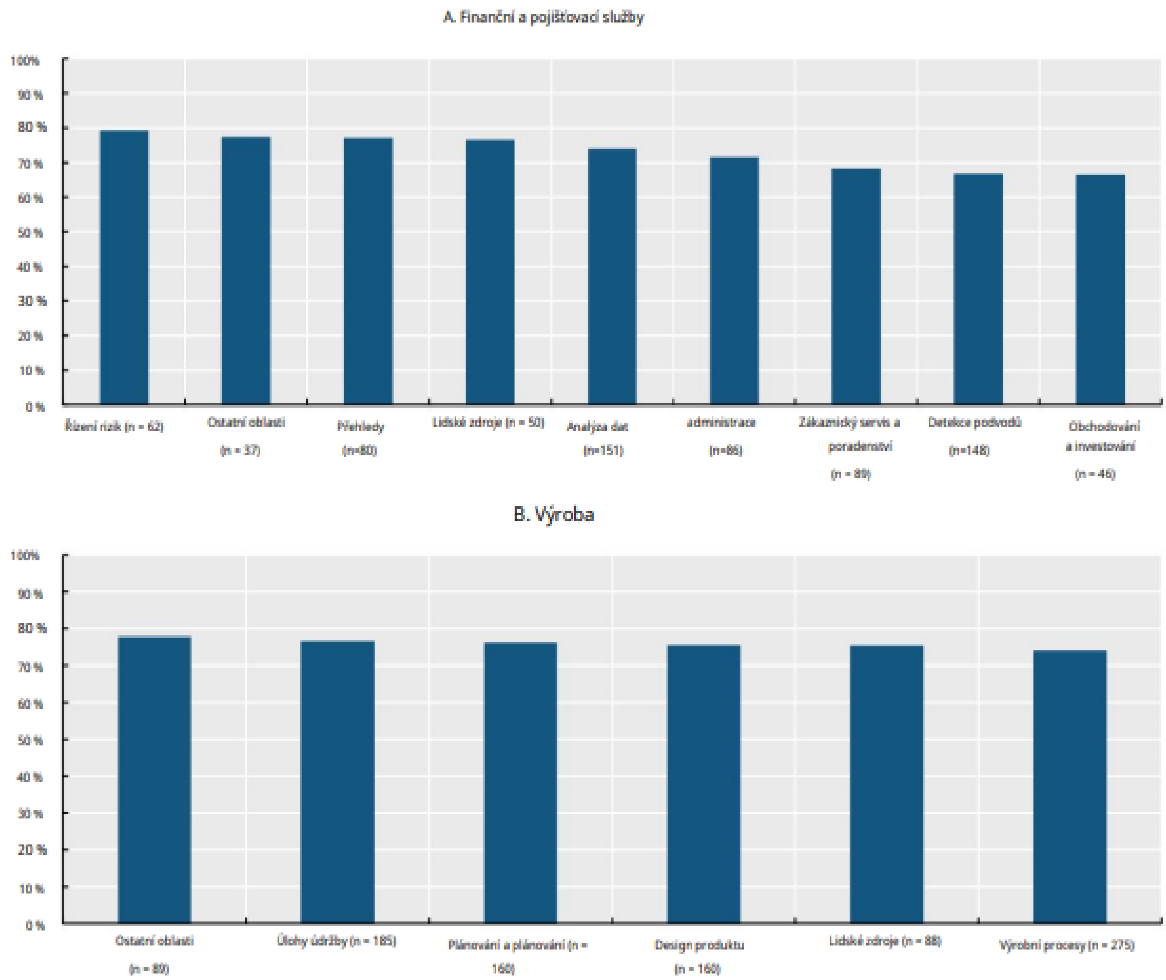
Occupation group	**The degree of influence of artificial intelligence technologies on the performance of occupation**
Occupations in installation, maintenance and repair activities	0.48
Occupations in construction and mining	0.52
Occupations in transport	0.54
Occupations in production	0.55
Occupations in trade and related activities	0.65

Occupations in administration and office support	0.66
Occupations in natural, physical and social sciences	0.71
Occupations in legislation	0.82
Occupations in computer science and mathematics	0.83
Architects and engineering occupations	0.84
Business and financial operations	0.87

Source: Milanez, A.: The Impact of AI on the Workplace: Evidence from OECD Case Studies of AI Implementation. Working Paper No 289. OECD, 2023.

A look at the current situation and previous experience with the introduction of AI is provided by the OECD analysis[13], which is based on a survey between employers and employees in the form of semi-structured interviews regarding the scope and impact of the introduction of AI technologies on jobs, working conditions and required skills of workers in two sectors: the financial services sector and the manufacturing industry sector[14].

Chart 13: Types of activities using AI the most – examples of financial and production sectors



Source: OECD (2023): Impact of AI on the workplace – survey.
Note: Share of employers who have introduced AI.

[13] Milanez, A.: The Impact of AI on the Workplace: Evidence from OECD Case Studies of AI Implementation. Working Paper No 289. OECD, 2023.

[14] Due to the fact that it is difficult to conduct an online interview with production workers, this group of respondents is underrepresented in the survey.

A. Finance and insurance services; Risk management; Other; Reporting; HR; Data analysis; Administration; Customer service and advice; Fraud detection; Trade and investments;
B. Manufacturing; Other; Maintenance tasks; Planning and scheduling; Product design; HR; Production processes

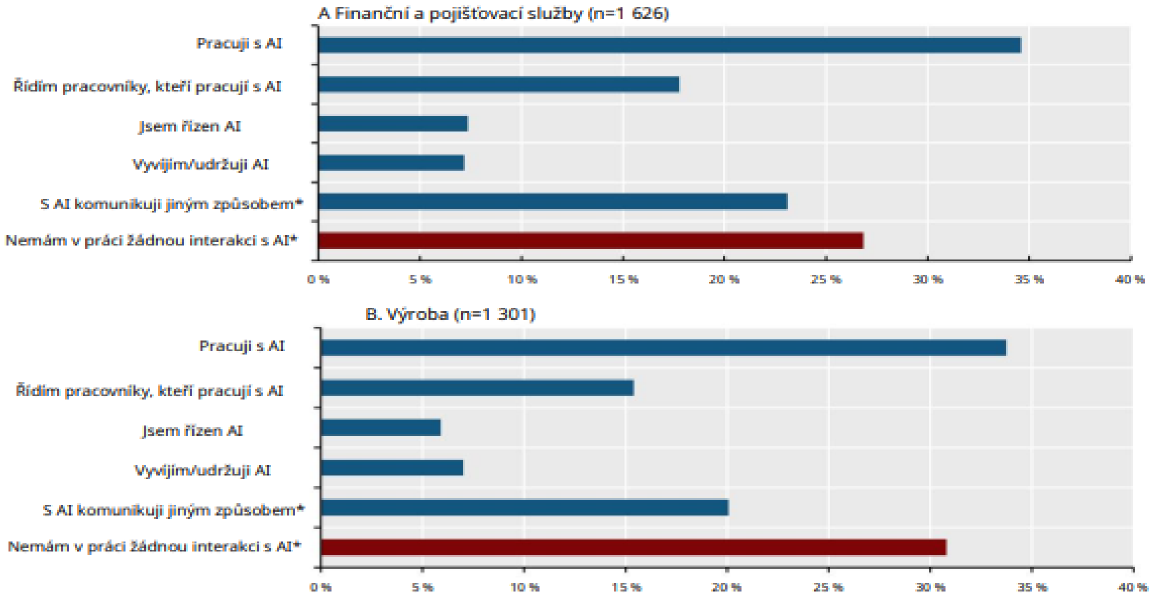
The survey has shown that hitherto applied AI technologies have had an uneven impact on different groups of workers and that their introduction poses a risk to older workers and low-skilled workers. Younger workers, who are perceived as more technically proficient and open to new opportunities, mostly accept the introduction of AI technologies positively. In contrast, older workers, especially in manufacturing, find it difficult to cope with changing skill requirements. They lack the basics in ICT skills needed to build and expand their knowledge. The training of these employees should thus be very instructive when systematic support and demonstrative coaching is given to the employees in addition to information on new procedures. Older workers are also often sceptical about the benefits of AI technologies and this reduces their willingness to adapt to changes and participate in training programs. Stimulating their interest in new practices is therefore also important.

The introduction of AI technologies has a negative impact on low-skilled workers, as they are less adaptable and are usually not sufficiently prepared to cope with new tasks or to move to new jobs. It turns out that all workers who come into contact with AI are now expected to understand the mechanisms of data acquisition, processing and evaluation and even have limited knowledge of the AI principles. Companies may perceive the gap between current and required skills as too large for low-skilled workers without these skills and prefer to hire new workers rather than fund training for the existing ones.

Case studies from certain countries have shown that artificial intelligence facilitates the employment of foreign workers who do not know the language of the country in which they work, as it facilitates communication with them and allows them to be trained using automatic translations and AI-based video. The use of AI in communication is also an opportunity to better use the qualifications of foreign workers who have achieved higher professional or university education, but the language barrier has so far prevented them from using their qualifications to the full and allowed them to work only in manual jobs.

According to the OECD study, the rate of use of AI varied slightly, but not significantly, between the financial services sectors and the industrial sector. The application of AI in the financial sector was slightly larger. More than a third of workers are currently using some form of AI at work in both sectors. On the contrary, about a quarter to a third of employees do not use these technologies at all (see Chart 14).

Chart 14: Share of workers using AI in companies that have implemented AI



Source: OECD Survey of Employers on the Impact of Artificial Intelligence on the Workplace (2022). OECD (2023): Impact of AI on the workplace-survey.

A. Finance and insurance services; I work with AI; I manage workers who work with AI; I am managed by AI; I develop/maintain AI; I interact with AI in another way; I have no interaction with AI at work;

B. Manufacturing; I work with AI; I manage workers who work with AI; I am managed by AI; I develop/maintain AI; I interact with AI in another way; I have no interaction with AI at work

The introduction of AI technologies had no impact on the overall scope of jobs in a significant majority of case studies.[15] In cases where the introduction of AI led to a reduction in the number of jobs in certain occupations, companies dealt with this reduction through reallocation to other jobs or by slowing down recruitment, when retiring people were no longer replaced by new workers. In addition, companies introducing AI technologies focused on finding new employees with specialized skills in AI. Greater exposure to AI is associated with higher employment growth in occupations where the use of computers is high.

Data analyses show that the demand of companies and employment in occupations related to the further development and maintenance of AI are growing significantly. This is not only a quantitative increase in these specialists, but also new professional specializations are emerging. For example, there is an obvious growing demand for a new profile of specialists who are experienced in the development, maintenance and machine learning of AI models, they can be called 'AI product owners'. They are top experts who can monitor and evaluate the effectiveness of established AI models and ensure that they remain accurate over time in terms of their predictive outputs and characteristics. These experts must also have expert knowledge in the field of technology and must be able to evaluate in a timely manner when the model needs to be re-trained, which data and how they need to be prepared, etc.

[15] It should be noted that current surveys on the impact of AI in enterprises may, for understandable reasons, capture short-term or at most medium-term effects of AI, rather than estimates of their possible long-term effects.

There is also a strong demand for professionals who prepare and provide an operational environment for machine learning models, mastering new tasks related to data selection for machine learning and knowledge of how to handle them correctly. Emerging professional jobs are often focused on creating files for teaching AI models, checking their outputs and, if necessary, correcting AI settings. The learning phase is about assigning, tagging or labelling data to help machine learning algorithms understand and classify the information they process. The degree of expertise required depends on the nature and sophistication of the data processed. Its level certainly differs significantly depending on whether there are simple data/images distinguishing simple phenomena or whether it is information that only an expert in the field may assess. The same applies to checking the outputs of AI and their comparison with the specified goal to be achieved in a given operation and to design and implement the necessary correction on the corrected set of learning data.

Skill requirements for jobs using AI

The introduction of AI technologies often provokes changes in the skill requirements on employees in executive positions using AI tools. However, this may not be the case in all cases, as more than half of the case studies (59%) reported that the requirements for work skills remained the same. If there is a change in skills, these are most often new skills, including analytical skills, and specialized AI skills. New analytical skills included understanding and applying new ideas and evaluating and critically assessing outputs generated by AI technologies. These analytical skills were often required in combination with specialized skills.

In addition to new skills, companies also rely on existing skills, which are often still used even after the introduction of AI technology, but at a higher level. This occurs in cases where AI technology automates simpler activities and where the workers can do more complex tasks requiring greater technical skills and expertise. An example is the introduction of a chatbot for processing basic customer queries, where customer service specialists can deal with a larger share of complex problems. Maintaining the existing skills of employees, their high expertise, ability to verify and critically assess AI recommendations is important, as there may be inconsistency of input data and distortion of information that could distort the outputs of AI. Although there may be a reduction in the number of employees in companies as a result of the reduction of activities taken over by technology, it is still necessary to maintain a basic group of qualified employees who understand the essence of traditional activities and are able to control the outputs of AI.

There is also often a redundancy of skills in those jobs in industrial manufacturing where AI technologies have completely automated the whole task or part of the activities after the introduction of AI. As a result, workers no longer use the previously necessary skills and only knowledge of starting the machine and loading the material is sufficient to do the job. Skills previously required from the worker are now built directly into the machine. New technology thus allows even completely unskilled workers to work in certain jobs.

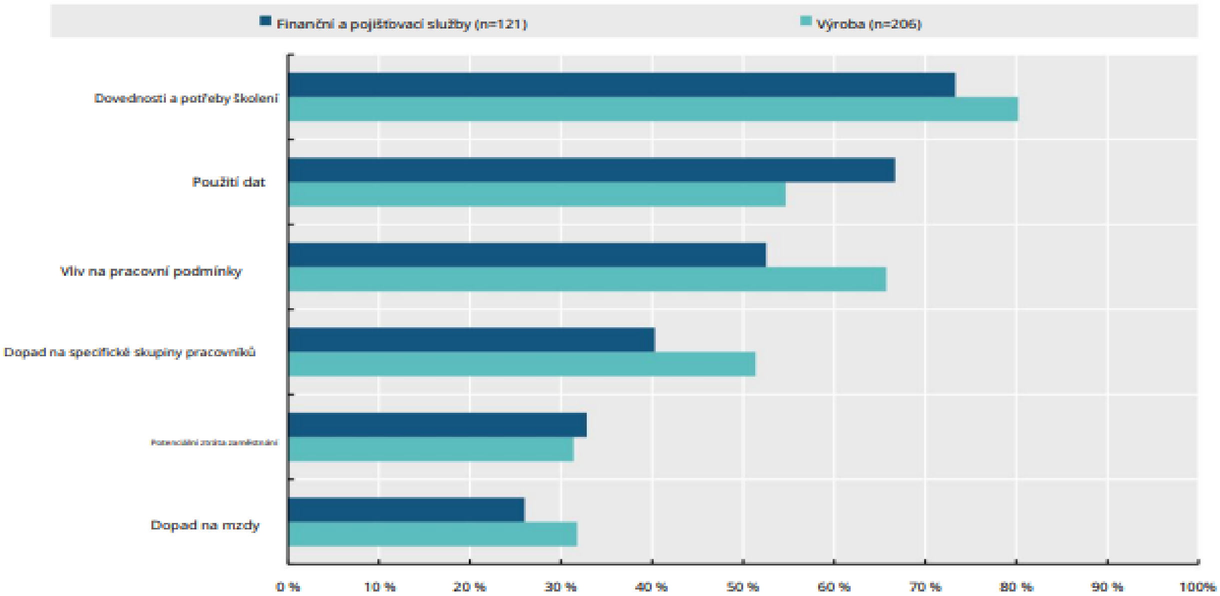
Measures to manage the impact of AI on jobs

Consultations with employees affected by the changes are an important factor in the success of the implementation of AI. The initiator of these negotiations is usually the employer, whose goal is to involve workers in the preparation of the implementation of AI and gain their trust. It is about organizing workshops where employees are introduced to AI technology, how it will be implemented, how it fits into the company's strategy and how it will affect jobs. This leads to a reduction in employees' fear of losing their jobs.

In many cases, the involvement of workers in the process of developing and applying AI is also triggered by the need for AI developers to better understand the work being done. Meetings of AI developers with executives help them identify new instances of using AI. Executives can alert developers to problems with repetitive activities, difficult work tasks or frustrating work situations. In addition to the research phase, it is advisable to involve executives in the testing of AI prototypes, as they have practical experience and can assess the performance of the developed AI technology, identify errors and help with the selection of higher quality training data.

Consultations of companies with employees result in collective agreements in some cases and these may explicitly include AI implementation issues. According to the results of case studies, collective agreements mostly cover the basic aspects of the use of AI and its implications for the skills and education of workers, personal data protection, health and safety at work, privacy, monitoring and evaluation of work performance and decisions on recruitment and dismissal of workers (see Chart 15).

Chart 15: Topics related to AI application most often included in collective agreements



Source: OECD Survey of Employers on the Impact of Artificial Intelligence on the Workplace (2022). OECD (2023): Impact of AI on the workplace-survey.

Finance and insurance services;

Manufacturing;

Skills and training needs; Use of data; Impact on working conditions; Impact on specific groups of workers; Potential job loss; Impact on wages

Education and training for AI implementation

The creators of AI tools emphasize that technology interfaces are often designed to be intuitive to use and that extensive further training is not necessary. Surveys confirmed that in some cases workers did not have to go through lengthy and demanding courses and that a brief training in the use of AI tools was sufficient, as the technologies themselves were simple. Companies offered webinars, presentations, workshops, etc. to introduce workers to AI tools and provide knowledge of their functions. Only some large companies implement training programs that offer more extensive learning opportunities.

Basic training was often provided by technology vendors, where the vendors either visited a company's production line or rented space and organized training for employees from several companies at the same time. Internal training provided by internal or external lecturers still prevails in larger companies, as in the case of other technological innovations.

Studies point out that in order for training to be successful, it must be focused on practical procedures for working with AI systems and must be illustrative. Videos accompanied by instructions for working with the use of AI, explaining all procedures step by step, proved to be successful in the training. Larger companies are building a more systematic AI training framework, where the content of the AI training is on a corporate digital learning platform that is available to every employee and includes mandatory and optional learning units that cover industry-specific and interdisciplinary seminars. Employees may participate in training during working hours at their discretion and the company bears all related costs.

Basic knowledge and skills that are a prerequisite for the development and use of AI should be developed at secondary school and university level so that they can be followed up in professional practice. Every university graduate who wants to work in a wide range of occupations in technical fields or in other fields should be trained in coding (especially Python) and be able to understand the broad principles of machine learning and artificial intelligence.

Impacts of GPT-based artificial intelligence

There has been remarkable progress in the field of generative artificial intelligence and large language models (LLM) in recent years and months, which will significantly accelerate the progress in the application of AI both in terms of the scope of its use and in terms of the effects and impacts on the performance of work in individual occupations.

The Open AI research organization prepared an analysis of the impacts of the latest development phase of artificial intelligence based on GPT (generative pre-trained transformer) models[16]. Recent findings reveal that approximately 80% of the US workforce could have at least 10% of their work tasks impacted by the introduction of LLM, while it could be at least 50% of tasks in approximately 19% of workers.

Unlike previous AI phases, jobs with higher incomes will potentially face greater exposure to LLM. The analysis suggests that about 15% of all work activities in the USA could be carried out significantly faster at the same level of quality with the partial use of these technologies. This share can increase to 47% to 56% of all activities with the full integration of software and comprehensive use of LLM-based tools. It is clear that these technologies are universal in nature, suggesting that they could have significant economic and social impacts.

[16] Eloundou, T.; Manning, S.; Mishkin, P.; Rock, D.: GPTs are GPTs - An Early Look at the Labor Market Impact Potential of Large Language Models. Working Paper. OpenAI, University of Pennsylvania. March 27, 2023. (https://arxiv.org/pdf/2303.10130.pdf)

However, they will not have the same impact on individual segments of the labour market and occupation groups. Naturally, work in services compared to production fields will be affected more by such use because they are to a much greater extent based on the processing of information and its transfer to clients within mutual communication. In terms of qualification intensity, according to the analysis, groups in the upper half of the spectrum will be significantly more affected, i.e. more demanding positions compared to less qualified ones. Activities where lower tertiary education is required, i.e. bachelor's or higher vocational education, will be most affected. This is followed by activities at a higher level of tertiary education, i.e. at the master's and doctoral levels. Activities carried out by secondary school students with secondary school leaving certificate will be less affected and jobs held by workers with lower secondary or primary education will be affected the least.

In terms of occupations, it will affect the most occupations such as financial and investment brokers and consultants, data processing workers, workers in hosting, information services, professional, scientific and technical services for enterprises, telecommunications workers, business managers, bank officials incl. central bank workers, internet traders, health service professionals.

Generative AI technologies will have moderate impact on the performance of occupations in the field of public services, wholesale trade, medical occupations and the functioning of medical facilities and in education. Moderate impacts can be expected in some manufacturing segments such as computer and electronic equipment manufacturing, mechanical engineering and transport.

The impact is likely to be low in occupations such as childcare, social assistance, personal services and restaurant services. It also includes manual occupations with low qualifications requirements, especially in the field of construction, accommodation and in most sectors of the manufacturing industry (food, textiles, wood, paper, chemistry, heavy engineering, etc.).

Demand for specialists with skills for the development and implementation of AI

Skilled labour force is one of the pillars of the AI development and implementation in practice. Future progress in the development of AI will thus depend primarily on the human capital of its developers and on the dynamic labour market with talents in the field of AI. Little is known about the labour force in AI development. It is not possible to know exactly who is involved in AI development. The current ISCO statistical classification of occupations is not sufficiently detailed and adapted to capture newly emerging occupations or segments of professional activities and skills that are newly required in occupations, especially in the areas of rapidly developing AI.

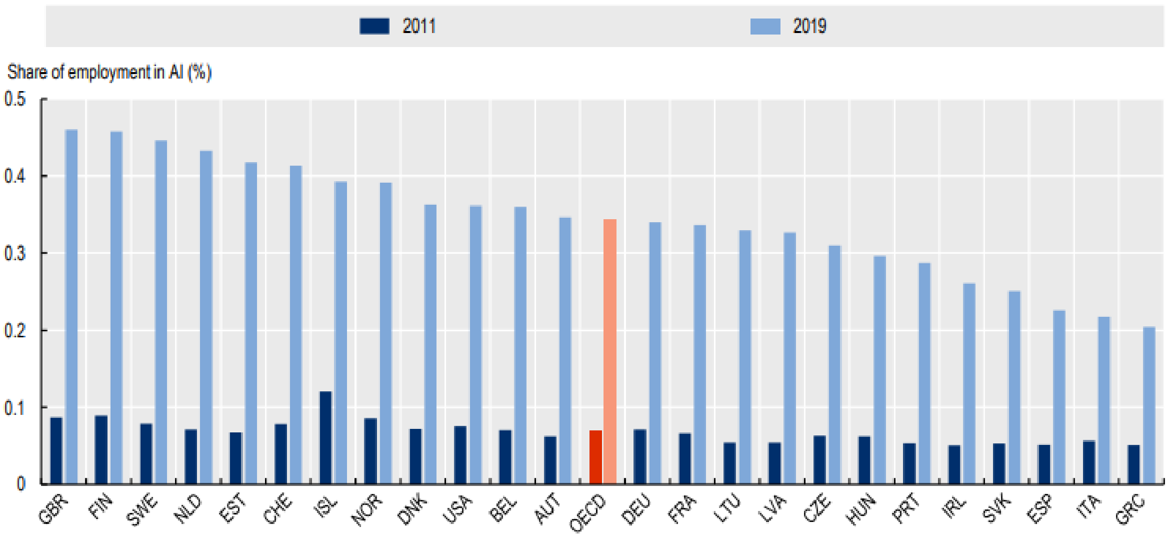
In order to overcome the shortcomings of statistical data, experts prepared a study[17] for the OECD using information from job advertisements, where the occurrence of requirements related to skills for the development and application of AI was identified. The demand for AI workforce was monitored, which is defined as workers who have skills and competences in statistics, computer science and machine learning and who could actively develop and maintain AI systems (e.g. knowledge of specific programming languages, software packages or statistical models, etc.). These employees do not have to develop or apply AI systems in their current jobs, but they constitute a potential talent pool for

[17] Green, A. and L. Lamby (2023), The supply, demand and characteristics of the AI workforce across OECD countries. OECD Social, Employment and Migration Working Papers, No. 287, OECD Publishing, Paris, https://doi.org/10.1787/bb17314a-en

companies looking for employees for these positions, as these employees have the appropriate competences.

The study notes that the current share of professionals with specific skills necessary for the development and implementation of AI is still low. Their employment share is just slightly above 0.3% on average in OECD countries, ranging from 0.5% in the UK to 0.2% in Greece. Although the number of AI workers is small, it is growing rapidly from less than 0.1% in 2012 to more than 0.3% in 2019. The analysis also shows that a workforce with specific AI skills is limited to a narrow demographic segment of the population. Most of the AI workforce has at least a university degree (around 75%). There are disproportionately more men among workers in AI and women make up only 35%, with women making up around 50% in the whole group of tertiary educated people.

Chart 16: Share of workforce with skills for the development and implementation of AI in total employment (in %)



Source: Green, A. and L. Lamby (2023), The supply, demand and characteristics of the AI workforce across OECD countries. OECD

The demand for workers with skills for the development and implementation of AI is generally very high in all OECD countries and its growth is dynamic over time (see Chart 16). Compared to the average employment growth in the respective economies, it is several times faster (employment growth for the labour force with specific AI qualifications was 63%, but only 3% for workers in general between 2017 and 2019). The Czech Republic is below the OECD average, both in terms of the total scope of this group of experts and in terms of the speed of its expansion.

2 Changes in skills requirements in the labour market

2.1 Basic skill development trends

Trends in the development of skills in connection with modern technologies are addressed by both European and international organizations (European Commission, Cedefop, OECD) and large multinational advisory institutions. Long-term research in this area is carried out e.g. by McKinsey[18], which analysed how the need for workers' skills would develop in the 2030 horizon while introducing new automation technologies, including artificial intelligence. These analyses are based on a micro-macro approach, where microeconomic information from economic sectors and enterprises (questionnaire surveys in enterprises, interviews with company managements and HR managers) and modelling and calculations based on statistical data are used to identify future trends19. This made it possible to identify some key skill changes in the future. The company processed two analyses at staggered intervals, with the last one from 2021 already taking into account the latest developments in digitalization accelerated by the COVID-19 pandemic and in artificial intelligence.

The research findings confirmed that shifts in the demand for skills required on the labour market accelerated. The study examines the basic skill groups in a detailed breakdown into 25 sub-skills (see Table 2), the development of which is highly differentiated.

Table 2: Change in demand for skills – 2018-2030 scenario (increase/decrease in %)

SKILLS		FR	GER	JAP	UK	USA
Technical	Basic computer skills	52	25	31	49	37
	Scientific research and development	21	12	13	21	26
	Technology design, engineering and maintenance	18	6	14	13	15
	Advanced IT skills and programming	10	1	2	2	14
	Data analysis and computational skills	-26	-21	-21	-19	-29
Social and emotional	Interpersonal skills and empathy	32	25	25	28	42
	Leading and managing others	23	15	17	18	28
	Advanced communication and negotiation skills	22	13	15	17	24
	Entrepreneurship and initiative	22	19	26	18	25
	Adaptability and lifelong learning	11	-2	8	9	16
	Teaching and training others	14	6	4	11	13
Higher cognitive	Creativity	24	15	24	18	31
	Critical thinking and decision-making	15	6	6	10	15
	Comprehensive information processing and interpretation	-4	-7	-5	-4	1
	Project management	0	-5	-4	-5	1
	Quantitative and statistical skills	-25	-36	-25	-21	-28
	Advanced literacy and writing	-19	-24	-4	-17	-26
Physical and manual	Gross motor skills and strength	8	-4	-10	2	2
	Fine motor skills	-1	-8	-11	2	5
	Mechanical skills and simple equipment repairs	1	-7	-8	3	1
	Craft and technical skills	-12	-17	-20	-8	-4

[18] McKinsey Global Institute (2018): Skill shift: Automation and the future of the workforce. May 23, 2018, Discussion Paper

[19] The modelling of labour demand was based not only on the prediction of the loss of workers due to automation, but also considered factors that would affect the creation of new jobs: investment in technology, income growth, population aging, investment in infrastructure, transition to new energy sources, professionalization of previously unpaid work.

	General operation of equipment and navigation	-12	-19	-25	-4	-7
	Control and monitoring	-19	-23	-21	-14	-7
Basic cognitive	Basic literacy in reading, mathematics and communication	-11	-16	-9	-12	-11
	Basic data entry and processing	-26	-29	-29	-26	-29

Source: McKinsey Global Institute (2021): The future of work after COVID

Note: The change in % represents an increase/decrease in the working time of activities requiring a given skill. The estimation of the demand for work by occupation until 2030 was made on the basis of a model including the impact of basic technological and long-term trends (robotics, automation, population aging, income growth, etc.) and the effects of COVID-19 (work from home, accelerated automation and increased e-commerce, etc.).

The largest increase in demand in the period until 2030 is expected in the area of **technological skills, both advanced and basic, including digital ones**. Advanced technologies require workers who understand how these technologies work and are able to innovate, adapt to changed conditions and newly develop them. The time spent using advanced technological skills will increase by 13 to 27% in advanced economies by 2030. It is the most in the field of technological research and development, as well as the design of technology application and maintenance. When it comes to skills such as data analysis, data processing and performing calculations, it should be noted that the new MGI forecast estimates a completely different future development compared to the older forecast made 5 years ago in 2017 (see Chart 25 in the annex). Compared to previous estimates, which could not yet capture the latest knowledge about possible AI applications and the impact of post-COVID changes, a decrease in the need for these skills is predicted (see Table 2).

However, in addition to advanced skills, it will also be essential for every worker to develop their **basic digital skills** for the new age of automation. Basic digital skills are the second fastest growing category among the 25 skills defined. Basic digital skills will be needed by workers in most occupations. Basic digital skills include the ability to communicate via email or social media, create and edit digital documents and search for information or protect personal data in the online environment.

The requirements for basic digital skills are already rapidly increasing at all levels in the sphere of manufacturing, especially in the areas of purchasing, sales, in-house processes, supply chain management, financial transactions, etc., and this trend will continue. In addition, the share of the digital component of activities will expand in a number of occupations, such as doctors and nurses or construction workers, where digital skills have not been required to a greater extent so far.

Most workplaces require managers and non-technical professionals equipped with a certain level of basic digital skills (e.g. doctors and nurses, teachers, accountants, officials, shop workers, lawyers, media workers, etc.).Basic digital skills are often required even in manufacturing companies to perform the work of blue-collar occupations such as construction workers, operators of production machines, skilled workers in agriculture or employees in auxiliary occupations. However, there are still workplaces that do not consider digital skills important for some occupations.

The need for social and emotional skills will grow rapidly. There will be an increasing need for workers who master skills that neither robots nor artificial intelligence can replace as advanced technologies will be adopted in the workplace. Overall, the demand for social and emotional skills across all sectors will grow and it will grow faster than originally anticipated. Tasks that use these skills – including interpersonal skills and empathy, negotiating, leading and taking initiative – are less automated (e.g., caring for patients or children, managing people, leading an organization, coaching employees, negotiating, etc.). An increase is also expected due to the expansion of jobs in the healthcare sector. While some of these skills, such as empathy, are innate, others, such as advanced communication and presentation skills, can be developed through training.

The growth in demand for skills such as entrepreneurship and taking the initiative will be the fastest growing one in this skill category. The need to lead and manage others will also grow significantly. An increased need for adaptability and continuous learning skills is also expected, reflecting the need to manage emerging technologies and job changes.

There will be a **shift in demand from basic cognitive skills to higher ones**. The demand for **basic cognitive skills** (reading literacy, numeracy, data entry and performing basic calculations) will decrease significantly. Activities that require these skills are highly automated, i.e. call centre workers are replaced by chatbots, cashiers are replaced by self-checkouts and data input is taken over by natural language processing algorithms. Unlike data processing, other basic cognitive skills, i.e. basic reading literacy, numeracy and communication, will also decrease significantly, but will not lose their significance completely. However, it is clear that they will no longer be sufficient for most jobs without additional skills in the future. Workers will switch from jobs that involve routine tasks requiring basic cognitive skills to jobs that require more technological and social and emotional skills. Work activities will shift towards technological and higher cognitive skills even among workers who will keep their jobs. For example, delivery drivers now use GPS to calculate the fastest routes and use applications to provide real-time tracking of shipments.

The demand for **higher cognitive skills** will have an internally differentiated development. This category includes advanced literacy and writing skills and quantitative and statistical skills, as well as creativity, critical thinking and decision-making; complex information processing and interpretation; and project management. Overall, this category does not show significant growth in most countries, but there are different trends behind it. Automation and artificial intelligence can increasingly perform tasks related to writing texts, conducting searches, processing basic reports, quantitative and statistical tasks, so the demand for workers with these skills is decreasing. Robotic process automation (RPA) can also perform certain complex information processing and project management, so these skills show negligible growth. On the contrary, the need for creativity, critical thinking and the ability to make flexible decisions is expected to grow strongly, as the need to understand and explain the conditions, context and technical details of products and services to customers/clients increases and to react and make decisions in a timely manner.

The need for most **physical and manual skills** will decline, but they will form the most extensive category of workforce skills. Demand for physical and manual skills has been declining for 15 to 20 years and this decline will continue with automation. Demand for these skills will fall by 11% in the US overall and by 16% in Europe overall by 2030. The mix of physical and manual skills required in occupations will change depending on the extent to which work activities can be automated (e.g., vehicle operation or product storage and packaging are more susceptible to automation than assisting patients in a hospital or some types of cleaning). However, physical and manual skills will continue to be the largest skill category (measured by the extent of working time).

In addition to skills requirements, **management systems, work organization and human resource management** will also change in connection with the introduction of automation and AI. The basic **organizational structure** of enterprises will move towards teamwork across jobs with an emphasis on agility. Unlike traditional hierarchies that promote stability, but also show some inertia, agile organization of work activities brings higher dynamics. Agile structures usually consist of a network of teams and are characterized by fast learning and fast decision-making cycles.

The structure of work activities within occupations will change, with some tasks being divided and newly structured, so that even lower-skilled workers are able to perform them. Changing the allocation of work will allow companies to make the most efficient use of the different skill levels of their workforce. 40% of companies implementing automation and AI expect to shift the tasks currently performed by highly qualified workers to lower-skilled workers. Separating and regrouping work increases efficiency and can also create a new set of medium-skilled 'new-collar' jobs. For example, registered nurses and medical assistants now perform some tasks that were once performed by doctors, such as vaccinating or examining patients with common diseases.

Companies are signalling that their **approach to education** will change and it will be based on providing continuous learning opportunities. This change in corporate culture is rated by companies in most sectors as most needed for workforce development.

Changes will occur in the field of **company and HR management** – almost a fifth of companies report that their top managers lack sufficient technology knowledge to direct the organization towards the introduction of automation and AI. In addition, human resource management will also change, as the structure and nature of the workforce will change.

The workforce will change – more work will be done by freelancers and other subcontractors. Increased use of different types of freelancers and temporary workers is expected to be one of the main organizational changes (61% of respondents expect to hire more temporary staff).

Linking general skills to education level

Skills that are of a more general nature and are applicable in any occupation or sector can be traced within the entire range of skills. It is the ability to work with the use of automated systems and intelligent devices, work in a digital environment and the ability to constantly adapt to new ways of working and new occupations. The need for these skills is increasingly emphasized by employers, which is why some studies focused on examining the factors that contribute to the development of these skills.

Based on its own research[20] and experience from business practice, the McKinsey[21] analytical team examined the **dependence of detailed structured general skills on the educational level** (Chart 17).Four categories of general skills (cognitive, digital, interpersonal and self-leadership) were defined, which were then elaborated into 13 separate groups of skills and 56 partial skills were defined that within them, combining both skills and attitudes.

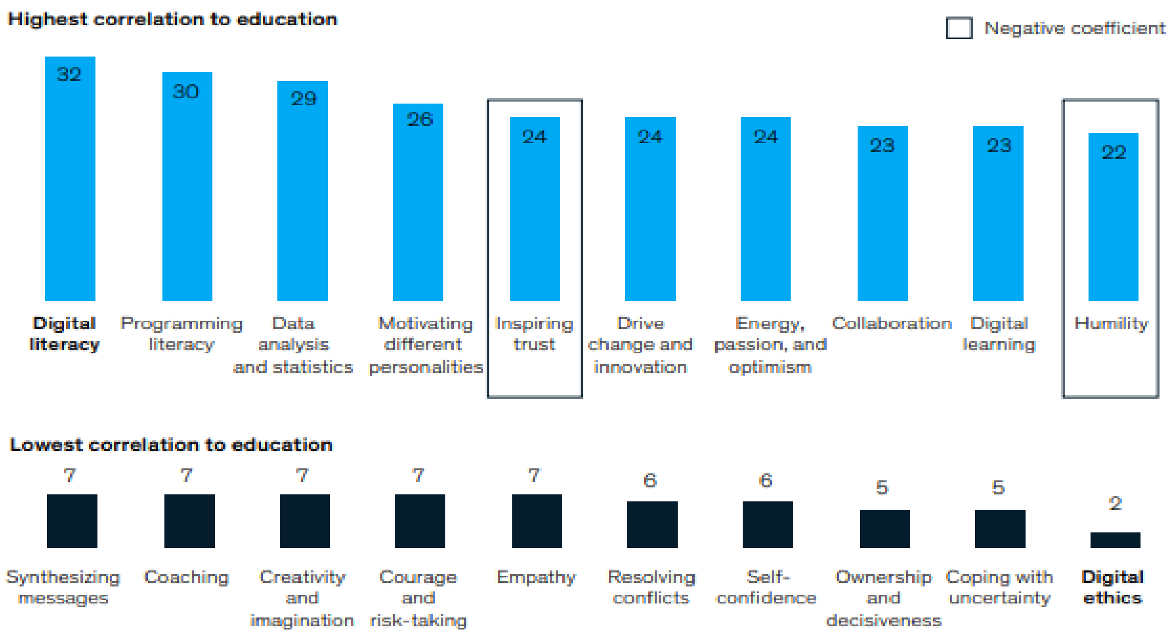
General skills were found to have varying degrees of strength in relation to the link to education, and even that not all important general skills have a directly proportional link to education. Therefore, it is

[20]Research through a questionnaire survey of 11,000 respondents from 15 countries. The questionnaire contained assigning to certain categories based on the respondents' self-assessment.

[21] Study by McKinsey (2021): Defining the skills citizens will need in the future world of work. https://www.mckinsey.com/~/media/mckinsey/industries/public%20and%20social%20sector/our%20insights/defining%20the%20skills%20citizens%20will%20need%20in%20the%20future%20world%20of%20work/defining-the-skills-citizens-will-need-in-the-future-of-work-final.pdf

not always true that the higher the education, the higher the skill score. Some skills, such as credibility or humility, are even inversely proportional to the level of education.

Chart 17: Dependence between skills and educational attainment



Source: McKinsey (2021): Defining the skills citizens will need in the future world of work.

Skills that are very strongly and directly proportional to the level of education achieved include ICT skills, cognitive analytical skills, motivation, passion and ability to cooperate, the ability to learn using digital resources. This corresponds to the fact that certain motivational and cognitive abilities are necessary just to achieve a higher level of education. The strong link between education and digital competences also suggests that higher-level educational programs are already dedicated to the development of these skills and the higher the education attained, the higher the readiness of people to work in the digitally rich world. It also suggests that a low level of education cannot be enough to manage these tasks.

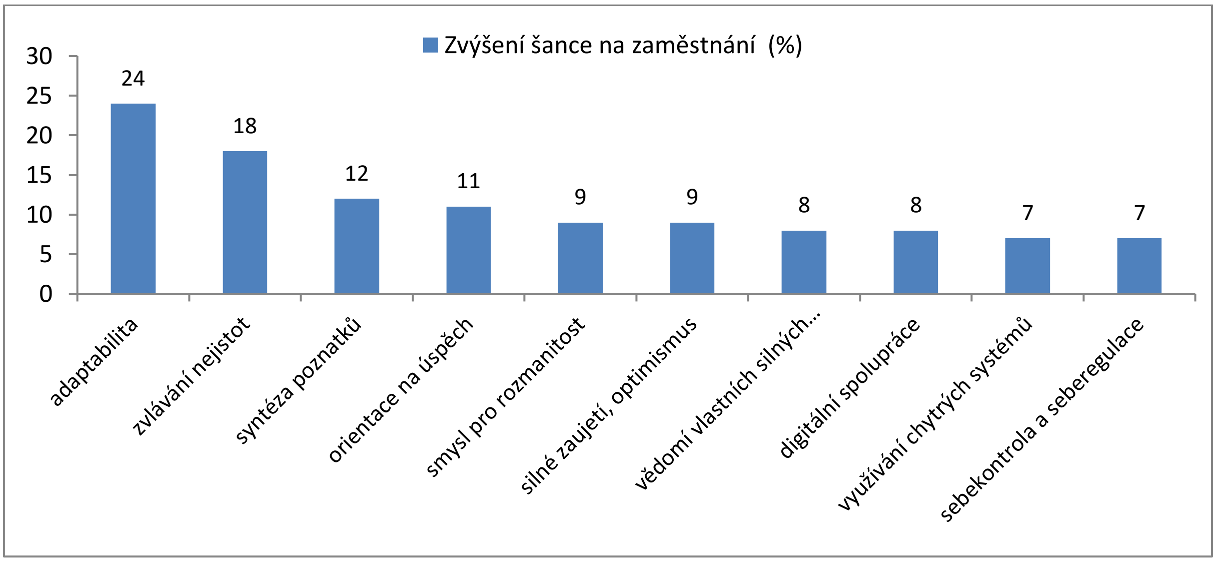
Skills that are associated with soft skills and personal attitudes such as the ability to lead people – coaching, creativity, entrepreneurship and willingness to take risks, empathy, conflict resolution, self-confidence, responsibility and decision-making, the ability to cope with uncertainty and digital ethics – show very low level of dependence on the level of education. The fact that these very important skills depend more on personal dispositions and on completely different factors than education indicates that educational programs at higher levels are insufficiently devoted to the development of these skills or are not focused on them at all. Although these facts were established on the basis of international data, they are certainly valid for the Czech Republic to the same, if not to a greater extent.

Importance of general skills for employment and high income

The McKinsey analysis also looked at identifying the **dependency between skills and the likelihood of finding employment** or the likelihood of being ranked among the best-paid workers.

It was found that the ten most important skills that increase the chances of getting a job include soft skills such as adaptability, coping with insecurities, focus on success, a sense of diversity and openness to different points of view, passion, awareness of one’s own strengths and the ability of self-control and self-regulation. Cognitively more demanding skills based on certain knowledge important for increasing the employability of the individual include the ability to synthesize and generalize the acquired knowledge, the ability to communicate through digital tools and the ability to use digital devices in everyday activities.

Chart 18: Higher likelihood of employment depending on the level of skills (in %)

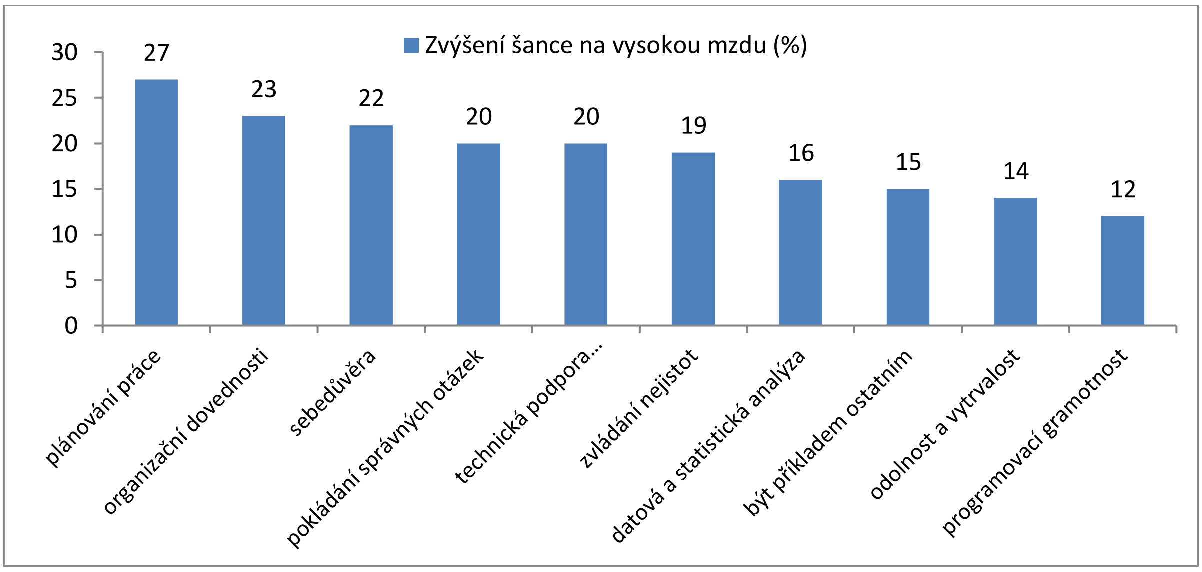


Source: McKinsey (2021): Defining the skills citizens will need in the future world of work.
Note: Higher likelihood (in %) of employment with an increase in skills by 1 level

Higher likelihood of employment (%);
Adaptability; Coping with uncertainty; Synthesizing messages; achievement orientation; Fostering inclusiveness; Passion, optimism; Understanding own strengths; Digital collaboration; Smart systems; Self-control and regulation

Skills for increasing the likelihood of high income were identified that are mainly related to the performance of higher job positions and team leadership in organizations such as work-plan developments, organizational skills, self-confidence, asking the right questions important for solving problems, the ability to be a role model and to be resilient and persistent even in difficult situations. Skills that are necessary for the application and implementation of new technologies and digital systems into everyday practice are also important, such as technical support and the use of opportunities to implement digital tools in production and services, the ability to evaluate the data obtained through data and statistical analysis and programming literacy (see Chart 19).

Chart 19: Higher likelihood of higher income depending on the level of skills (in %)



Source: McKinsey (2021): Defining the skills citizens will need in the future world of work.
Note: Higher likelihood (in %) of higher income with an increase in skills by 1 level.

Higher likelihood of high income (%);
Work-plan developments; Organizational awareness; Self-confidence; Asking the right questions; Tech translation and enablement; Coping with uncertainty; Data analysis and statistics; Role modelling; Grit and persistence; Programming literacy

Based on the research results, the study proposes measures to improve the conditions for the development and cultivation of skills crucial for success on the labour market. In the field of education system reform, these are:

- Revisions and updates of educational programs to focus more on key skills. Due to the weak correlation between education on the one hand and skills in self-leadership, interpersonal relationships (especially empathy, conflict resolution) and entrepreneurship on the other, it is essential that the curriculum at higher levels of education is strongly focused on the development of these soft skills. This also applies to the lack of cultivation of ethical attitudes in the use of digital technologies.

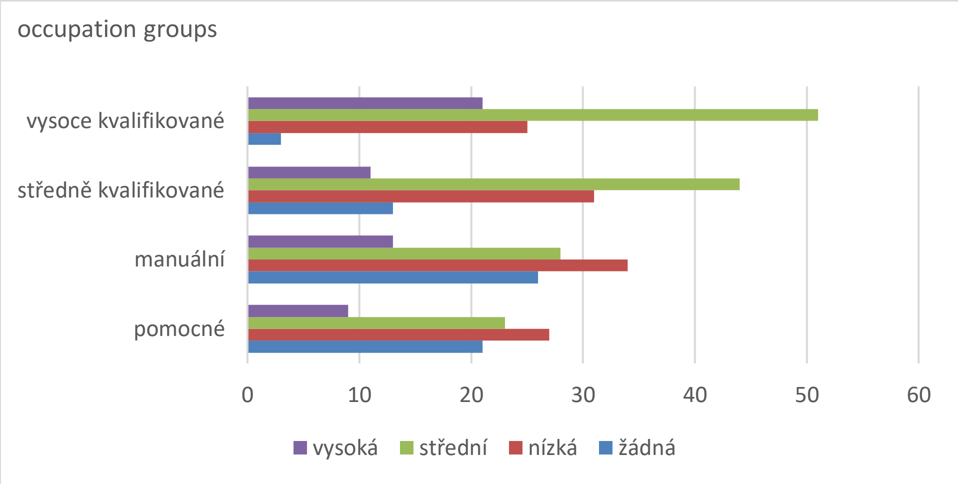
- Reform of adult education systems – to ensure the availability of courses focusing on identified skills important for employability and to increase the chances of better earnings. Support these learning opportunities financially and improve awareness of them.

2.2 Digital skills

Despite relatively broad research, there is no standard or agreed definition of digital skills, which in a broad sense represent the ability to search, organize, understand, evaluate, create and share information using digital technology at different levels of competence.

The current level of digital skills requirements required for individual occupations was mapped by the Cedefop study through the **Digital Intensity Index** (DII)[22]. The DII reflects the scope of digital activities performed and their complexity, expresses whether the performance of four broad groups of occupations defined according to the level of qualification intensity is associated with high, medium or low digital intensity.

Chart 20: Required level of digital skills by occupation group



Source: Cedefop, Setting Europe on course for a human digital transition; own processing
highly skilled; medium skilled; manual; auxiliary; high; medium; low; none

The fact that there is a certain percentage of workers within all occupation groups who are **not required to have any digital skills** clearly points to the fact that there is still considerable scope for ICT deployment in the economies of the EU Member States, which is expanding towards less skill-intensive occupations. While only 3% of workers in skill-intensive occupations perform activities for which they do not need digital skills, it is about ¼ of workers in manual and auxiliary occupations.

There is a certain proportion of workers who do not need digital skills to perform their occupation within all defined occupation groups; similarly, there is also a certain proportion of workers who cannot do without a **high level of digital skills**. The requirements for this level of digital skills are increasing with the increasing skill demands of occupation groups. Almost ¼ of people holding skill-intensive occupations have this level of digital skills, while it is only about 10% of workers for the other three occupation groups.

The performance of a high or medium skill intensity occupation is most often associated with a **medium level** of digital skills, which must be acquired by 51% of those working in skill-intensive occupations and 44% of those working in medium skill-intensive occupations. Undemanding

[22]The DII consists of two sub-indices: (a) a quantitative index that evaluates individuals according to the number of digital activities performed per individual with low, medium or high frequency of digital activities performed (0-4 or 5-7 or 8-10 activities); (b) a qualitative index that categorizes individuals according to whether they perform digital activities with low complexity of skills (web browsing, word processing, use of spreadsheets, preparation of presentations), medium complexity (use of specialized software, use of macros or formulas in spreadsheets, database merging or management) or high complexity (programming, use of AI methods, maintenance or repair of ICT systems).

occupations in terms of skills most often require only a **low level** of digital skills from workers, which must be acquired by 34% of manual workers and 27% of persons in auxiliary occupations.

2.3 Changes in skills requirements in selected sectors

Using various analytical studies and the results of surveys conducted among employers, it is possible to make a deeper insight into the situation of individual economic segments. Six main sectors of the economy covering both production sectors and services were selected for a more detailed analysis of changes in skills requirements. Although the basic trends in the development of skills requirements are similar throughout the economy, there are some significant sectoral differences. For example, while demand for social and emotional skills will grow in all five sectors, the need for basic cognitive skills will decline in banking and manufacturing, stagnate in healthcare and only slightly decline in retail.

Banking and insurance

Financial services are already at the forefront in the implementation of digitalization. Financial sector services include a number of activities where artificial intelligence can potentially be used, especially in administration, marketing, customization of products for customers, risk assessment and management, etc. The number of workers such as cashiers, accountants, brokers, legal and sales representatives will decrease due to the introduction of automation. In this context, the need for a workforce that uses only basic cognitive skills such as data entry and processing, basic reading literacy and basic numeracy is likely to decline, while the number of technology experts and other professionals will grow, as will the number of occupations that require team management and customer interaction. This increase will lead to strong growth in demand for social and emotional skills.

All financial institutions will increasingly need IT specialists, AI experts who will develop and manage their systems and applications and ensure their security. As a result, the demand for technological skills will grow, although not as strongly as in other sectors, as banking and insurance is already one of the most digitalized sectors.

The organization of work in the sector changes with artificial intelligence (AI), robotic process automation (RPA), blockchain technology and augmented reality (AR) in financial operations.

- AI in the financial sector is used, for example, in virtual assistants and chatbots that can answer customer questions and provide 24/7 support. It is also used for risk analysis, fraud prevention (e.g. detection of money laundering or other suspicious transactions) and personalization of offers for customers.
- RPA is introduced into repetitive tasks and processes using software robots. RPA in the financial sector is used, for example, in processing payments, creating reports and accounting, which allows companies to redirect human work to more complex tasks.
- Blockchain technology: Blockchain is a decentralized system for recording transactions and securing data. It is used in the financial sector for more efficient and secure execution of transactions such as international payments and investment management. Blockchain can also reduce the cost of intermediaries and shorten the time delays associated with traditional processes.

- AR is used to improve customer experience and train employees. AR in the financial sector can provide customers with interactive guidance on how to use banking products and services and employees with virtual training and support in complex tasks.[23]

The concept of FINTECH has become established within the financial sector in the context of digitalization. It stands for 'finance' and 'technology' and refers to innovative technological solutions in the financial sector and the companies that apply them. FINTECH is often understood as financial startups in contrast to traditional banking companies. Rather than a sharp division of companies according to this criterion, FINTECH can be understood as a set of practices that are implemented with varying intensity and speed across the sector.[24] These practices include innovation in payments and transactions (mobile payments, digital wallets, online money transfers, peer-to-peer payments), online lending and crowdfunding, digital tools for financial advice and investment, the use of AI to calculate insurance rates and provide personalized insurance products, the use of blockchain for security and transaction efficiency in the insurance industry. These innovations generate a demand for adequate regulatory instruments, sometimes referred to as REGTECH by analogy.

Technological changes lead to changes in the job description of employees in the financial sector by automating routine tasks and processes. Overall, the workload of employees in the financial sector is changing towards a higher level of data analysis, strategic decision-making and providing more comprehensive advice to customers. Activities that become less necessary include, for example, manual processing of paper documents, routine accounting and payment processing. On the contrary, analytical skills, knowledge in the field of data processing, programming, cybersecurity and the ability to communicate effectively both with clients and with virtual assistants are becoming more necessary.[25] Some studies emphasize the great importance that employers in the banking sector attach to soft skills, especially adaptability, learning abilities and social competences. The role of these skills may go beyond the importance of 'hard' skills, including IT skills that are easier to outsource. However, the requirement for basic digital literacy of job seekers in banks is becoming a matter of course.[26]

A recent study on the banking sector in France and Spain[27] points to two options for how the sector has evolved after 2010 against the backdrop of accelerating digitalization and AI implementation. One way was the creation of new entities to compete with traditional banks that specialize in online banking services. Within them, there was a significant polarization between young workers focused on online services and a small number of more experienced personal advisors of wealthy clients. On the contrary, the work of existing advisors in traditional banks was enriched by the provision of online services requiring an extended range of skills. It strongly depends on the management's approach also

---

[23] Mehdiabadi, A. et al. (2020). Are We Ready for the Challenge of Banks 4.0? Designing a Roadmap for Banking Systems in Industry 4.0. *International Journal of Financial Studies*, 8(2). Mavlutova, I., Volkova, T. (2019). Digital Transformation Of Financial Sector And Challengies For Competencies Development. *Advances in Economics, Business and Management Research, volume 99, 7th International Conference on Modelling, Development and Strategic Management of Economic System (MDSMES 2019),* s. 161–166.

[24] Puschmann, T. (2017). Fintech. *Business & Information Systems Engineering*, 59(1), 69–76. doi:10.1007/s12599-017-0464-6.

[25] Mavlutova, I., Volkova, T. (2019). Digital Transformation Of Financial Sector (…).

[26] Arefjevs, I. et al. (2020). Financial sector evolution and competencies development in the context of information and communication technologies. *Research for Rural Development,* 35: 260–267.

[27] Perez, C., Martin, F. (2018). Digitalisation and Artificial Intelligence: the New Face of the Retail Banking Sector. Evidence from France and Spain. *Université Paris1 Panthéon-Sorbonne (Post-Print and Working Papers) halshs-01884121, HAL Open Science,* online: https://ideas.repec.org/p/hal/wpaper/halshs-01884121.html

in other areas of work organization (e.g. standardization of tasks, pressure on performance) whether technological innovations are used as an impulse to expand the space for using employees' competences or whether this space and, as a result, the quality of working conditions, tend to narrow. Overall, banks are limiting direct communication with clients in favour of computer work, while the share of highly qualified specialists is growing. As a result, the share of university-educated workers in finance is growing faster than in other sectors.[28]

By contrast, changes in the workload of financial specialists are less pronounced in more stable organizational environments. For example, the analysis of advertisements for internal finance controllers (outside the financial sector itself) showed that employers' requirements are kept within the limits of traditionally understood work roles and tasks of this occupation. So far, the very widespread ideas about the shift of finance controllers towards data analysts do not seem to be fulfilled in the specialized literature.[29]

There are cases of redundancies in the financial sector as a result of technological changes and efforts to increase efficiency. Traditional banking branches are being phased out as part of the spread of online and mobile banking. Banks are investing in digital channels and self-service systems, leading to a reduction in staff at branches. Some major banking institutions announced the closure of hundreds of branches and related dismissals.[30] Closed branches are also reflected in 'big numbers'. The number of branches in the EU per 100,000 inhabitants has decreased from 30 to 20 since 2004.[31]

Saving human work is possible not only at branches. Many financial operations are simplified and automated using RPA and AI and some manual tasks, such as payment processing, reporting or accounting management, are replaced by automated systems. This can lead to a reduction in the number of jobs previously responsible for these tasks. As a result, companies in the financial sector are sometimes consolidated and restructured due to technological changes. For example, when merging banks or switching to new digital platforms, redundancies may need to be made in order to achieve greater efficiency and reduce costs.

Digitalization and automation therefore undoubtedly offer the potential for dismissals in the financial sector. However, the impact on jobs is not necessarily fatal, as shown by the comparison of bank restructurings in the UK and Luxembourg. The relevant study32 shows that institutions and employment players have an impact on the direction of digital transformation adaptation processes. Although market pressures and technology in the two countries' service sectors were relatively strong, the labour restructuring process and its outcome differed. Adapting to the digital transformation in Luxembourg was not left entirely to market forces. Trade unions and employers worked together in sectoral negotiations to tailor informal solutions and mobilize legal tools of a neo-corporate nature,

[28] Eurofound (2022). Going digital: Restructuring trends in retail banking. Luxembourg: Publications Office of the European Union. Online: https://www.eurofound.europa.eu/publications/report/2022/going-digital-restructuring-trends-in-retail-banking

[29] Oesterreich, T. D. et al. (2019). The controlling profession in the digital age: Understanding the impact of digitisation on the controller's job roles, skills and competences. *International Journal of Accounting Systems*, 35.

[30] https://www.computerweekly.com/news/252495585/Commerzbank-announces-big-job-cuts-and-branch-closures; https://www.sabcnews.com/sabcnews/standard-bank-to-cut-1200-jobs-close-91-branches-for-digitisation/; https://www.theuxda.com/blog/banks-will-cut-millions-of-jobs-in-the-next-decade

[31] Eurofound (2022). Going digital: Restructuring trends in retail banking.

[32] Kornelakis, A. et al. (2022). The digitalisation of service work: A comparative study of restructuring of the banking sector in the United Kingdom and Luxembourg. *European Journal of Industrial Relations*, 28(3): 253–272.

such as social plans, to ensure a softer transition and prevent mass dismissals. Collective agreements acted as an institutional constraint on a technology-driven race to reduce costs. On the contrary, the UK lacked a supporting role of the state, which withdrew from initiatives in retraining in the sector. This deepened the disintegration of sectoral negotiations and created an institutional void. Adaptation to digitalization was unilaterally managed by employers, while trade unions were rather only informed about the planned changes. They limited themselves to fragmented reactions, such as campaigns against the closure of local branches. The authors also emphasize that outsourcing continues to be a more pronounced driver of job loss than automation and digitalization and agree that job loss expectations due to automation are often exaggerated. In addition to the differences between the liberal and coordinated model of capitalism, the approach of specific employers also plays a role. A recent case study from the Czech Republic highlights the orientation of the relevant large bank towards retraining without the need for large-scale redundancies.33

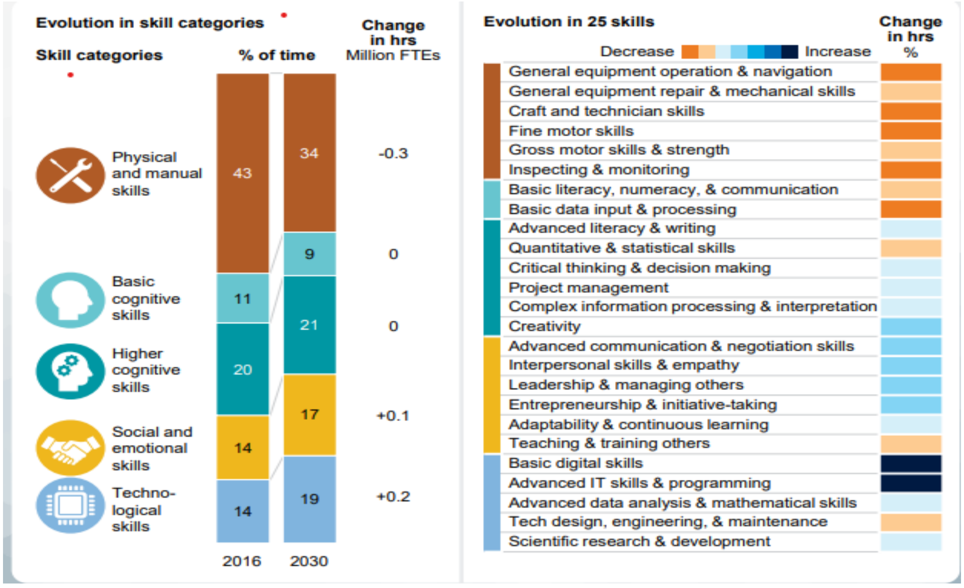
Energy and mining

Automation and artificial intelligence enable companies to exploit new inventories, increase mining and production efficiency, where integrated digital platforms can optimize production processes, manage power grids, predict equipment failures, perform predictive maintenance, manage and coordinate operations in real time. As a result, up to 30% of predictable manual work can be released, including the activities of power plant operators and operators of various equipment. Predictable non-manual work, which includes administration, monitoring activities, meter readings, simple calculations, etc., will also be replaced by automation. On the other hand, the number of technological jobs will rapidly expand, especially in software development, ensuring the operation of computer systems, their analysis and security protection.

The demand for physical and manual skills, along with basic cognitive skills, is expected to decline, while the demand for higher cognitive, social, emotional and technological skills is expected to grow.

[33] Mazurchenko, A. et al. (2022). Demand for employees' digital skills in the context of Banking 4.0. *Business Administration and Management*, XXV(2): 41–58.

Chart 21: Development of skill demand in the USA and Western Europe by 2030 – energy and mining sector



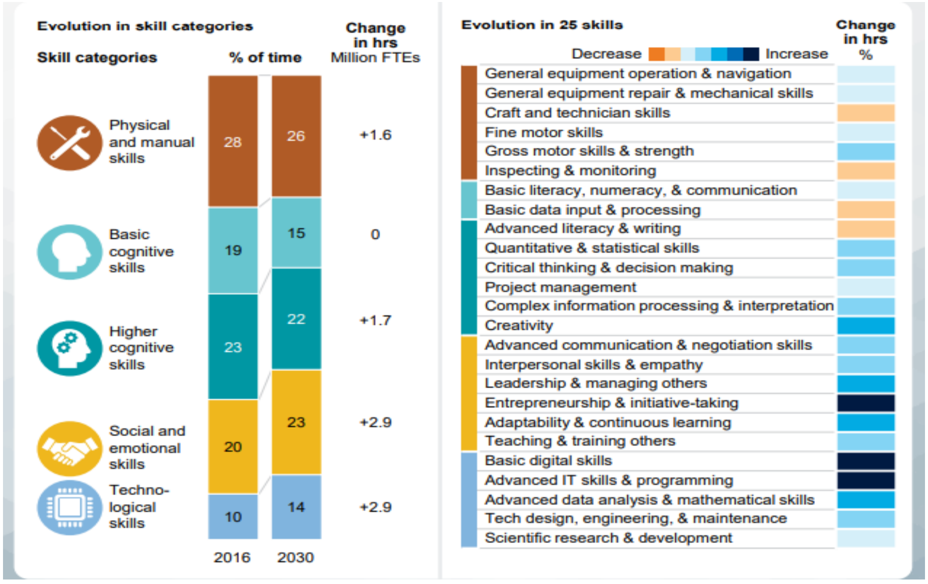
Source: MGI: Skill shift: Automation and the future of the workforce

Healthcare

The healthcare sector will also grow significantly in the future due to the aging of the population and increasing demands on the quality of health care. Automation and AI will change the interaction between patients and healthcare professionals. Demand for care providers such as nurses will continue to grow, while demand for support staff in receptions and data administration will decline due to automation of record-keeping and management activities. There will be the largest, double-digit growth in demand for advanced IT skills, basic digital skills and adaptability. However, demand for skills such as controlling and monitoring patients' vital signs and medical equipment will stagnate despite overall growth in healthcare as AI takes over a large part of routine activities.

Healthcare is the only sector in which the extent of the need for physical and manual skills will grow quantitatively in the period up to 2030, both in terms of gross motor skills and the strength needed for activities such as elderly care and physical therapy and fine motor skills, but their share in the total range of skills will decrease relatively.

Chart 22: Development of skill demand in the USA and Western Europe by 2030 – healthcare sector



Source: MGI: Skill shift: Automation and the future of the workforce

Recent or ongoing technological changes affecting the job organization and description in the healthcare sector include:[34]

- Electronic health records: The shift from paper-based records to electronic health records enables physicians, nurses and other healthcare professionals to handle patient data more efficiently. This further leads to better coordination of care, reduced risk of errors and faster decision-making.
- Telemedicine and remote care: The development of technologies makes it possible to provide health care remotely. Patients can consult with doctors through video calls or applications, which is especially useful for those who live in remote areas or have limited mobility.
- Robotics and automation: Robots and automated systems are increasingly used in healthcare to assist in surgical procedures, pharmacy, physiotherapy and other areas. These technologies increase accuracy, reduce the risk of human error and enable more efficient use of human resources.
- Virtual and augmented reality (VR and AR) are already widely used, for example, in the treatment of pain, mental illness (anxiety, post-traumatic syndrome) and invasive medicine.
- Data analysis and artificial intelligence: The importance of data collection and analysis with the use of artificial intelligence is growing also in health and social care, as in other sectors. These technologies help identify patterns, predict diagnoses and treatment plans, improve epidemic surveillance and drug development. Digital devices that monitor patient's health in real time, such as smartwatches with heart rate sensors, sweat-based glucose meters for diabetics and various types of biosensors, are a significant incentive for the increase in health data collection.

Medical staff must adapt to new systems, learn to work with electronic records, telemedicine and robotic assistants. This requires education and possibly retraining. Some routine tasks can be automated, allowing employees to focus on more complex and high-value tasks such as patient care,

[34] Popov, V. et al. (2022). Industry 4.0 and Digitalisation in Healthcare. *Materials*, 15(6).

coordination of care, and communication with patients and their families. Health and social care, even more than other sectors, have to cope with ethical and security challenges and the need to maintain direct interpersonal interaction and empathy, which is absolutely irreplaceable in these fields.

Unfortunately, digitalization is associated with some negative effects on the working conditions of medical staff. A recent study among healthcare professionals across European countries[35] found that digitalization in the workplace worsens psychosocial stress, mainly due to increased time pressure, impaired interpersonal relationships with colleagues, job insecurity and irregular working hours. Thus, the digitalization of the workplace increased the exposure of employees to virtually all sources of psychosocial stress at work. The key sources of this negative effect of digitalization are the reduction of direct human contact and the 'everywhere and always' work culture thanks to the possibility of online remote connection. Qualitative research among nurses in Sweden[36] also points to significant risks of digitalization for working conditions. The interviewees complained mainly about the chaos and lack of support during the implementation of uncoordinated digital systems, they were worried about the threat to direct interactions with negative impacts on patients. This research also shows an increase in the volume of work and thus time pressure for medical staff due to the introduction of digital systems. Similar findings appear in the scientific literature in a basically systematic way. A meta-analysis of the literature on digitalization in healthcare, conducted in 2021[37], states that all 22 studies included identified a causal link between digitalization and increased 'technostress' in healthcare professionals. This is a consequence of the negative impact of digitalization, among others, on the time load, work autonomy and on the perception of one's own role and competences.

Another meta-analysis of literature focused on the competences and skills needed by medical staff in connection with digitalization.[38] Key areas of competences and attitudes in this context include:

- knowledge of digital technologies;
- social and communication skills adapted to digital technologies;
- ability to make ethical choices about the use of technology;
- motivation to collect experience with digitalization in their own professional context.

The same meta-analysis mentions a favourable organizational and friendly environment and targeted support from employers and superiors so that workers can cope with new technologies and related changes as a key factor for the successful implementation of technological changes in healthcare workplaces.

As far as the overall need of healthcare workers is concerned, there are no convincing signals about the reduction in the number of medical staff as a result of automation of certain tasks. The significant decline does not affect occupations that have been assessed as largely at risk by the well-known Frey and Osborn study (nurses in dentistry, auxiliary nurses, home caregivers, radiographers and dental

---

[35] Palumbo, R., Cavallone, M. (2022). Is work digitalization without risk? Unveiling the psycho-social hazards of digitalization in the education and healthcare workplace. *Technology Analysis & Strategic Management* (online first).

[36] Öberg, U. et al. (2017). Swedish primary healthcare nurses' perceptions of using digital eHealth services in support of patient self-management. *Scandinavian Journal of Caring Sciences*, 32(2), 961–970.

[37] Virone, C. et al. (2021). Which Factors of Digitisation Bias the Work-Related Stress of Healthcare Employees? A Systematic Review. *Studies in Health Technology and Informatics,* 281: 916–920.

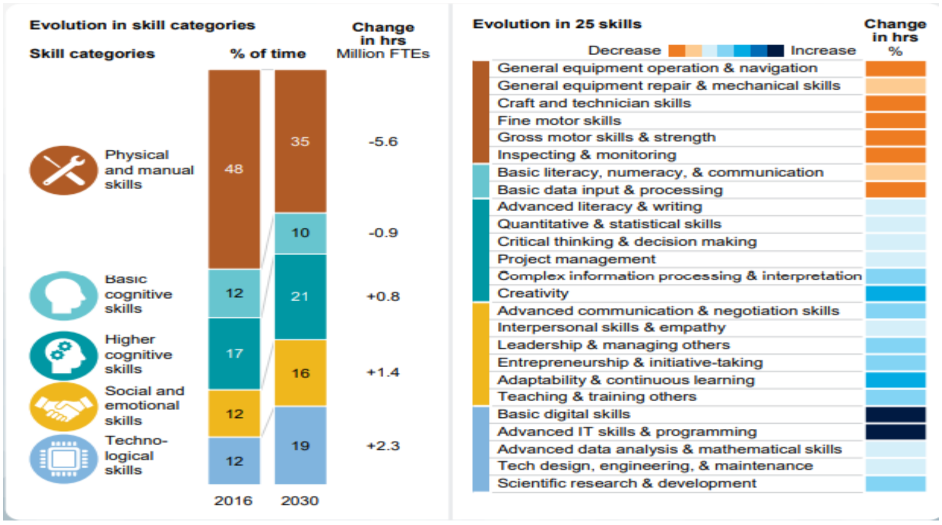
[38] Konttila, J. et al. (2017). Healthcare professionals' competence in digitalisation: A systematic review. *Journal of clinical nursing*,28(5-6): 745–761.

technicians). The transformation of the content of work in medicine thus appears to be a more likely scenario so far, especially by the entry of machines and technologies into the relationship between staff and patients.[39]

Manufacturing

The next wave of automation and AI in industry will change not only the production process itself, when work will be replaced by technology, including the use of the Internet of Things, and machines will increasingly cooperate with humans and complement their physical and sensory skills. Significant impacts will also be on company management, when automatic systems for collecting, coordinating, evaluating information and ensuring its security are introduced. There will also be significant impacts on product development and on marketing, sales and customer communication.

Chart 23: Development of skill demand in the USA and Western Europe by 2030 – manufacturing sector



Source: MGI: Skill shift: Automation and the future of the workforce

Most jobs will change significantly – the average stability of skills (measured as the share of basic skills needed to perform a job that stays the same) is estimated to be around 58% based on empirical studies[40], meaning that 42% of skills will change significantly. It can be said that hitherto different production processes will converge, as similar autonomous production facilities, robots and information systems will be used.[41] Workers who will work with them will no longer be specialized to the same extent as before, but they will be required to have both technical and other knowledge at a higher level of generality and abstraction.

The overall need for physical and manual skills in this sector is declining more than twice as fast as in the economy as a whole. The need for basic cognitive skills is also decreasing as administrative and

---

[39] Sætra, H. S. et al. (2021). Healthcare Digitalisation and the Changing Nature of Work and Society. *Healthcare*, 9(1007).
[40] World Economic Forum: The Future of Jobs Report. WEF, 2018
[41] Industry 4.0. A Discussion of Qualifications and Skills in the Factory of the Future: A German and American Perspective. Online: http://www.vdi.eu/fileadmin/vdi_de/redakteur/karriere_bilder/VDI-ASME__2015__White_Paper_final.pdf

office activities are increasingly automated. In contrast, skills the importance of which will increase significantly include:

Knowledge of information and communication technologies[42]:

- knowledge of information technologies and their use adequately at the level of qualification requirements of the occupation, thinking like a programmer;
- 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 competences 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;
- typical '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;
- the importance of moral attitudes, emotional and social intelligence, self-organization will increase compared to the present.

The number of professionals such as sales representatives, engineers, managers and executives is expected to grow. This will lead to an increased need for social and emotional skills, especially advanced communication and negotiation, leadership, management and adaptability. The need for technological skills, both advanced IT skills and basic digital skills, will grow as the number of technology professionals increases and the use of smart devices in production grows. Demand for higher cognitive skills will grow, driven by the need for more creativity and comprehensive information processing.

[42] Source: Skill Development for Industry 4.0: http://www.globalskillsummit.com/Whitepaper-Summary.pdf, own processing

Specialists in engineering and technical occupations will have to be familiar with a wider range of technologies, be able to assess problem solving or proposals for new solutions in a much broader context than before, as the complexity of tasks increases and production becomes more variable. They will need to be able to manage projects, work in interdisciplinary and international teams and communicate effectively. There is an increasing emphasis on the ability to ensure quality in all parts of the production process, when it needs to be ensured 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 user and more demanding programming software.

Workers in blue-collar occupations will also have to master programming work when adjusting machines and will also work more with information systems. Material handling operators and workers 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.

Retail

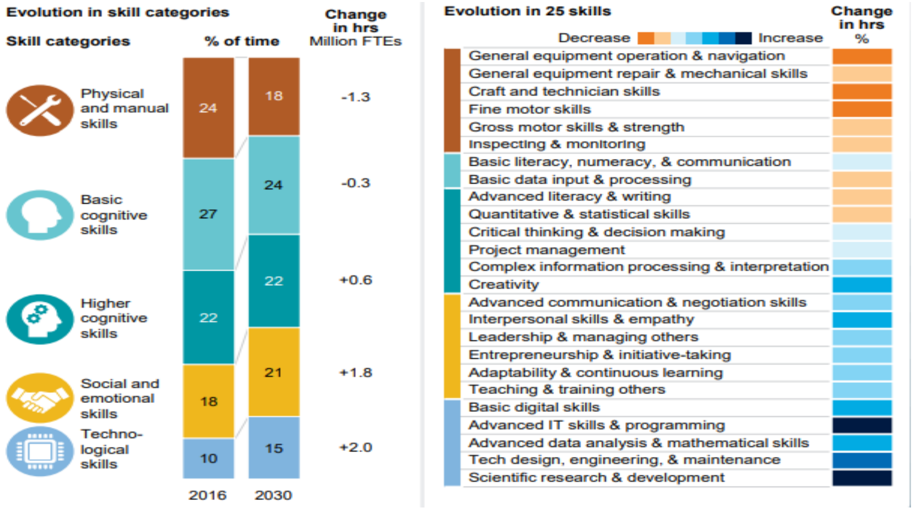
Automation and AI will be massively introduced in self-checkouts, robots for replenishment of goods, data collection and evaluation to predict customer demand and sensors assisting in storage, management and transport of inventory.

The share of predictable manual work, such as work in the transport of goods, packaging and storage, or some types of work in shops will decrease significantly (by up to 25%). The remaining tasks will tend to focus on customer service, management and technology deployment and maintenance.

Demand for all physical and manual skills and for basic data collection and processing activities will decline, while demand for interpersonal skills, creativity and empathy will grow by almost 50%. Advanced IT skills and programming, along with complex information processing skills, will also see a surge in demand as a result of harnessing the potential of data analytics and AI.

Total employment in this sector is likely to decline in Western Europe by 2030, despite the expected increase in population incomes and an increase in effective demand for goods because the application of new technologies will lead to a significant increase in labour productivity. Part of the vacancies will be offset by the expansion of e-commerce hubs. Development of e-commerce accelerated significantly due to the COVID-19 pandemic and the share of e-commerce in retail sales grew two to five times faster in 2020 than before the pandemic. It is assumed that the shift to e-commerce will translate into a demand for a range of skills; an increase in the need for digital skills on the one hand and a lower need for basic communication skills on the other hand because distribution centre employees are not in direct contact with customers.

Chart 24: Development of skill demand in the USA and Western Europe by 2030 – retail sector



Source: MGI: Skill shift: Automation and the future of the workforce

Tourism and food service activities

Digital technologies have had a significant impact on tourism since the beginning of the spread of the Internet. The Internet was mainly used by companies as a marketing and sales tool in the first phase, which was reflected in the establishment of websites and online booking systems. The second phase (2000–2010) brought the development of e-commerce with tourist services, the emergence of online intermediaries (e.g. Expedia) as a competition to traditional travel agencies and a decrease in the use of tourist information centre services with increasing availability of information and shopping opportunities online. In addition to the next wave of technologies (cloud, mobile, VR and AR), the third phase after 2010 is characterized by the integration and interoperability of digital systems and their ability to intervene more significantly in the physical world. The development of social networks, websites with tourist reviews (e.g. TripAdvisor), platform economies (e.g. Uber, Airbnb) and the expansion of GPS to mobile devices played a significant role in tourism. These changes are changing previously established business models, which is particularly reflected in the transition of some customers from tourist agencies to online platforms of various types. Compared to before, tourists take a much more active role in organizing their trips, while the role of companies lies primarily in mediating and building capacity for tourism. On the other hand, the direct influence of companies on the organization of tourist trips is decreasing.[43]

The individual segments of tourism and food service activities have experienced the following changes related to digitalization in recent years:[44]

[43] Dredge, D. et al. (2019). Digitalisation in Tourism. In-depth analysis of challenges and opportunities. *Aalborg Universitet.* Online: https://vbn.aau.dk/ws/files/296441087/REPORT_TourismDigitalisation_131118_REV_KB_EM_4_.pdf
[44] OECD (2021). Preparing the tourism workforce for the digital future. Paris: OECD. Online: https://www.oecd-ilibrary.org/industry-and-services/preparing-the-tourism-workforce-for-the-digital-future_9258d999-en

- Travel and package travel: There was a boom in online search and booking platforms in this area, disrupting the former format of travel and ticket sales. In addition, virtual travel assistants are being developed (e.g. *Pana*) as a tool for personalizing services while travelling.
- Accommodation services: The rating of services through review sites and social networks such as TripAdvisor has massively expanded. New technologies allow accommodations to turn some of the services previously provided by staff into self-service mode. This includes, in addition to booking systems, self-service check-in and check-out, the use of sensors to adjust ventilation or lighting. Some hotels are also experimenting with the use of robots for direct communication with their guests.
- Air transport: Self-service check-in and automatic identity recognition based on face or fingerprints at passport control are introduced at airports. 3D printing has entered the aircraft parts manufacturing process, making it possible to produce cheaper and lighter parts.
- Organization of meetings, incentives, conferences and exhibitions (MICE): The COVID-19 pandemic has significantly accelerated the transition of this segment to a hybrid mode, when a number of events are fully or partially organized in a virtual format.
- Gastronomy: Self-service ordering via mobile phone using a QR code or on self-service ordering screens (in fast food) is developing. During the pandemic, the trend of electronic payments in gastronomy also accelerated.

According to a recent OECD study[45], the potential of technologies to replace human labour in tourism and food service activities is considerable, but so far there have been no dramatic shocks in this segment of the labour market. The reasons include especially the fact that personal contact is perceived by customers as an essential and valuable part of tourist and food services. This also results in adverse customer feedback in some experiments with the deployment of robots in hotels. However, some efforts of companies in this sector to replace human work are driven by long-term difficulties in finding workers for occupations such as chefs or waiters. A study based on a meta-analysis of existing sources on this topic and on expert opinions from OECD member countries does not register requirements for new specific skills that would be specific to the sector. For example, competences in the field of digital marketing and communication with customers via social networks, operation of booking and sales digital systems or data analytics are mentioned in this context. The need for similar digital competences as in other sectors and their interconnection with existing activities seems more likely. The specifics of the sector are rather contextual and consist of a large representation of SMEs with limited opportunities to provide education to employees, a large part of which would need retraining due to the low qualification level and the level of digital skills.

The need for digital skills in tourism and food service activities was specifically addressed in an extensive questionnaire survey among workers in this sector in eight European countries in 2019.[46] The study identified online marketing and communication, basic office software, monitoring of online reviews, the ability to handle digital security procedures and the installation of digital equipment (wireless networks, projectors, sound systems) as the most needed both now and in the future. Gastronomy workers were assessed as the ‘least digital’ in terms of the current job description throughout the sector, who also estimated the lowest level of digital skills for the future. On the contrary, the highest expectations of the future need for digital skills were declared by workers in

[45] Ibid.

[46] Carlisle, S. et al. (2023). The digital skills divide: evidence from the European tourism industry. *Journal of Tourism Futures*, 9(2): 240–266.

travel agencies. However, a similar survey in Slovenia, which focused on a wider range of skills,[47] shows that tourism workers consider interpersonal skills (customer-friendliness, cooperation with partners and emotional intelligence) to be the most important for the performance of their work in the future. In contrast, workers perceive digital skills as less important.

Construction

The construction industry is largely based on ununified production, largely dependent on handicraft skilled manpower and has thus far been considered a sector that can hardly be robotized. Despite these limitations, robotics is beginning to be gradually introduced into the processes that make it possible to do so. According to a CEEC Research survey, only 15% of the surveyed construction companies actively use robotics. Of the remaining 85% of companies that do not yet use robotics, only 34% plan to implement it in the near future. The main reason for their introduction is to make their work more efficient in terms of solving labour shortages, saving time, materials and human labour costs. Under current conditions, 42% of construction companies consider robotics unrealistic, but it is perceived as an important development factor in the future and the vast majority of companies (84%) believe in the automation of human work at least in some areas of construction[48].

The most widespread modern technologies used in the construction industry include: augmented reality, laser scanning using drones, 3D printing of buildings. 3D concrete printing is still in its development phase, but its potential is considerable. It will be necessary to solve not only technical but also legislative aspects for the massive use of 3D printing in practice. Transport construction is currently much closer to automation of production, where 3D guidance of construction mechanization has been used for years. It can be expected in the future that the practical use of autonomously controlled construction machines will be possible.

In order to use robots more effectively in the construction industry, it is necessary to constantly improve the design of robots and adapt them to various conditions on construction sites because it is obvious that robots created for industry cannot be used on the construction site. The faster progress of robotics will also depend on how the procedures for the preparation and implementation of buildings will change so that robotic devices can be better applied. The use of modern technologies in the construction industry must be included in the initial stages of projects, i.e. in planning and design works, otherwise they will not be able to be fully used later in the construction or subsequent operation of buildings. This places higher demands on the implementation of information systems that would facilitate the management and coordination of all complex processes. Building Information Modelling (BIM) is a system that collects and transmits information about a building throughout its entire life cycle. The system is created gradually and creates a comprehensive virtual model of a building enabling the generation and management of information representing the physical and functional characteristics of the building, including its elements. It facilitates the exchange of information as part of the design, construction and use process of the building.

In connection with the expansion of digitalization and robotic technologies in the construction industry, it will be necessary to ensure enough high-performance skilled staff able to install, control,

---

[47] Meknic, J. et al. (2022). Educational and training imperatives for future tourism competencies: The case of Slovenia. *Human Systems Management*, Pre-press.

[48] Quarterly analysis of the Czech construction industry Q3/2022, published on www.ceec.eu

cooperate with and repair automated devices. The need will increase for medium- and high-skilled technical and managerial occupations that will be able to work with digital tools and to insert and evaluate information from data and planning systems.

Agriculture

New technologies are increasingly used in agriculture, as evidenced by the fact that over 60% of agricultural enterprises in the Czech Republic have invested in new technologies, robotics and automation in recent years. The reason for this is the optimization of production, economic benefits and, above all, the lack of workers, which will continue to deepen[49].

Robots are used for feeding, milking, servicing animals and cleaning stables in livestock production. Sensors allow detecting milk quality, animal health, weight gain, etc. In plant production, robots can sow, pick fruits and vegetables, apply protective equipment, weed, etc. Robotic devices can now also map erosion, drought, lack of nutrients and the occurrence of harmful plant organisms, the condition of stands and the degree of their maturity. Scanned data can be transmitted from drones or autonomous robots to the laboratory via mobile devices and automatic field data evaluations in combination with weather data subsequently help farmers to apply protective measures or start harvesting in a timely and most effective manner. Drones can apply plant protection products in places where it is really necessary and help reduce unwanted impacts on the environment and human health.

Some of these technologies have already established themselves in Czech agriculture, but the use of others is not yet very widespread. Navigation systems and autopilots have already become standard equipment in tractors. The use of precise navigation in combination with the correct adjustment of the machine significantly improves the accuracy of machine operation, accurate sowing, more efficient use and targeted application of fertilizer, protective substances or seeds. Eight out of ten agricultural entities already use agricultural navigation or map systems.

Greenhouses and polyhouses with controlled production systems used primarily for growing vegetables became widespread in the Czech Republic in the last few years. They are characterized by a high degree of automation including irrigation and plant nutrition systems, atmospheric, lighting and temperature control. Post-harvest lines are also increasingly equipped with modern post-harvest treatment, handling and storage management systems, using optical sorters with remote control, more efficient and gentler transport processes, etc.

On the other hand, Czech farmers work very little with sensor data or satellite images. Only a third of farmers track their production data via web or mobile applications. It can be assumed that under the pressure of competitiveness and also with the possibility of drawing program subsidies, the introduction of new technologies in Czech agriculture will accelerate and areas in which Czech agriculture is still lagging behind will be filled in the near future.

From the point of view of further development, it is clear that digitalization and robotics in agriculture intertwine with measurement and control technology, software and hardware of communication technologies and statistics. Experts are needed for the application of new technologies in agriculture

[49] https://www.csas.cz/cs/firmy/articles/inovace-v-zemedelstvi-jak-si-stoji-cesi

who combine knowledge of agricultural practice with knowledge of IT management and control of the most modern devices – autonomous systems, satellite imagery, the use of drones and ground sensors. Many of them will not work in the field, but will remotely program devices from the office, monitor and evaluate data from systems and make the necessary process corrections.

Thus, modern technologies require qualified operators and standard computer literacy may not be enough. There is a lack of specialists in working with navigation systems, computer technology, geodetic information systems and map files, databases or statistical data processing. Sometimes even the language skills are insufficient. It may be necessary when introducing innovations, such as when buying special equipment from foreign manufacturers. Knowledge of logistics and law with respect to European and national standards will also be important.

New skills requirements will also affect medium- and low-skilled workers. New jobs will be created at the medium level, such as programmers and repairers of robotic machines, operators of agricultural machinery who can control the work of robotic machines from the headquarters. The content of the work of blue-collar occupations that will handle technology will also have to change. Although manufacturers of modern agricultural technology meet the needs of users and try to make the operation of the technology simple and intuitive, the basic skills of working with sophisticated equipment must also be mastered by manual workers in order to understand signals and data, be able to respond to them and communicate with remote support.

3 Summary

Trends in robotics

Current robots, both industrial and service ones, are becoming more sophisticated, as they integrate elements of advanced SW, sensorics and artificial intelligence. **Industrial robots** are currently common in operations with high degree of mass production and in productions demanding precision and quality. The largest range of industrial robot installations is in the electrical engineering industry and it is still growing rapidly, so the potential for robotics is probably still open in this sector. In contrast, the second sector with the largest application of industrial robots, i.e. the automotive sector, is already slowing down with the installation of new devices. On the contrary, the installation of industrial robots in other sectors where it was not so frequent before is dynamically accelerating. **Service robots**, which move in space and can independently perform work tasks, are mainly applied by companies in transport and logistics, hotel and food service activities and cleaning services. They are also used for support activities in medical facilities. **Collaborative robots** cooperate with humans and help in various tasks, complementing rather than displacing workers. Collaborative robots are expected to increasingly replace single-purpose machines over time. In addition to lower investment costs, their great advantage is their versatility allowing them to be transferred to another task in a short time if necessary, thanks to simple programming. This area of robotics will undergo tremendous development in the coming years and will be widely open for use also in SMEs or in sectors where classical robotics has not yet been so widespread. **Additive manufacturing** is so far primarily used for prototyping, but it is also being used for product innovation, preparation of spare parts and in some segments of high-volume production. However, it also has the potential to be used in small-scale or custom production and in the construction industry.

Overall, it can be stated that the **robotics in the activities of Czech enterprises** is at a fairly decent **level of the European average**. Robotics is mainly applied by large enterprises with more than 250 employees, which belong almost exclusively to the manufacturing industry (two-thirds of large enterprises). However, from the point of view of the entire economy and especially from the point of view of SMEs, the Czech Republic lags behind the most developed countries, so the potential for further penetration of robotics into Czech industry and services is still relatively high and will certainly be reflected in further restructuring of professional activities in the future. In addition to the industry that is still dominant in this area, robotic technologies are also beginning to penetrate sectors that have so far stood aside, such as construction, agriculture, services, including healthcare, for example.

Digitalization

Digitalization represents a wide range of activities and processes that are converted on a digital basis, thanks to which information can be collected, shared and analysed in real time and, to a certain extent, grows into the digital transformation of the entire business model. **Digitalization of production operations** makes it possible to monitor, control and intervene in the process of creation and handling of the product throughout its life cycle. As part of production digitalization, the **Internet of Things** (IoT) is developing and it has the potential to transform industry and other sectors such as healthcare, transport and logistics, agriculture. The IoT application raises the need for experts with knowledge of software development, information security, artificial intelligence and the basics of machine learning, networks, hardware interface, data analysis. Experts in embedded systems with knowledge of the design of devices and products in which SW, sensors, etc. communicating within the IoT are also important. The advanced use of digital technology in production is the so-called **digital twin** of the product and process. But this technology using real-time data is still not very widespread in Czech companies.

Along with the expansion of digitalization, the amount of data available to companies from the production process, autonomous sensors, business operations and also from social networks is also growing. **The weak point of Czech enterprises is the use of the obtained data**, which is progressing slowly and is significantly below the EU average. More than 40% of Czech companies in the industry do not use data in a systematic way or do not know how to use them. Companies often lack data analytics experts. The importance of **cybersecurity** is also growing. The number of jobs in this field is growing three times faster in the world than other jobs in the field of technology. Key occupations in this field include cybersecurity analysts, ethical hackers, security engineers, security architects, security automation engineers, network security analysts, malware analysts.

In addition to the production itself, digitalization is changing very quickly the ways of organizing **management and administrative activities**, their interconnection both internally and externally with the systems of suppliers and customers. It is based on ERP (Enterprise Resource Planning) system integrating and automating a large number of processes related to the production process. Other basic systems include a management information system about customers and related processes (CRM), a system enabling real-time management of the entire supply chain (SCM) and electronic data interchange (EDI). According to the findings of the CZSO, almost 40% of Czech companies have a management system in place, which is roughly at the level of the EU average. However, when it comes to CRM systems that organize relationships and business operations with customers, these systems are used by a significantly smaller proportion of Czech enterprises and are significantly lagging behind the EU level. There are significant differences between large and small companies. To ensure compatibility, a relatively fast implementation of corporate applications used throughout the group takes place in companies that are part of multinational groups. The next stage of digitalization is robotic **process automation (RPA)**, which is based on the use of software with artificial intelligence and machine learning. RPA automates processes in invoicing, accounting, warehouse management, order processing and replaces a large range of activities previously performed by employees, especially at the medium skill level. Its application also raises the need for new professional skills such as RPA developer, RPA analyst, RPA architect.

Artificial intelligence

Artificial intelligence has experienced rapid development in recent years thanks to advances in machine learning, where AI systems trained on large data sets are able to improve themselves. While the deployment of previous AI generations has been focused on the performance of repetitive routine activities of a mostly manual nature and only some cognitive activities of a routine nature, the new generation of AI will be able to perform cognitive activities that are not repetitive and even those that require a certain degree of creativity.

Despite significant progress, AI is not yet able to perform the full range of human cognitive activities, but it is sufficiently **advanced to perform at least some tasks in almost every occupation**. Therefore, the structure of activities carried out by a worker in a given occupation will have to be adapted to the new situation and it will be necessary to supplement the qualifications of employees and change the functioning of entire organizations. The extent of the necessary changes will probably require a relatively long period of time before the new generation of AI is fully integrated into the practice of economic entities. It can be expected that technologies will be able to replace more than half of the skills required to perform the occupation in about 11% of occupations in the horizon of up to 5 years; this will apply to the vast majority of current occupations in the horizon of up to 30 years. Occupations where significant changes in the nature of work can be expected include occupations with a high proportion of routine skills in both manual tasks (machine operation, packaging and palletizing, dosing) and knowledge (counting, accounting, data collection and processing, text and data correction, measurement of physical quantities, quality control). There is less risk of replacing human work in occupations with a higher proportion of non-routine and creative skills in both manual tasks (repairs and renovations, services and personal care) and knowledge (research, analysing, planning, designing, creating rules and procedures, negotiating, organizing, learning and training and leading people). The possibilities of replacing or supplementing activities with AI will rapidly expand based on the recent progress in the processing of information, texts and language based on generative AI models, in particular GPT.

The AI technologies applied so far have had **an uneven impact on different groups of workers**. Risk groups included older people and low-skilled workers who lack the basic ICT skills to build on and expand their knowledge. The training of these employees should thus be very instructive when systematic support and demonstrative coaching is provided to the employees in addition to information. All workers, including low-skilled ones, who come into contact with AI are now expected to understand the mechanisms of data acquisition, processing and evaluation and even have limited knowledge of the AI principles. It turns out that artificial intelligence can facilitate the employment of foreign workers who do not know enough the language of the country in which they work, as it allows communication and training using automatic translations and AI-based videos.

The introduction of AI technologies **has not yet had an impact on the overall range of jobs**. If there was a reduction in jobs in certain occupations, companies transferred workers to other positions or did not replace retirement with new workers. Companies introducing AI technologies were looking for new employees with specialized skills in the field of AI. Greater exposure to AI is associated with higher employment growth in occupations where the use of computers is high.

New professional specializations triggered by digitalization are emerging. For example, there is an obvious growing demand for a new profile of specialists who are experienced in the development, maintenance and machine learning of AI models, they can be called 'AI product owners'. They are top experts who can monitor and evaluate the effectiveness of established AI models and ensure that they remain accurate over time in terms of their predictive outputs and characteristics. These experts must also have expert knowledge in the field of technology and must be able to evaluate in a timely manner when the model needs to be re-trained, which data and how they need to be prepared, etc. There is a strong demand for experts who prepare and provide the operating environment for machine learning models, mastering new tasks related to creating data sets for machine learning, checking outputs and, if necessary, correcting the settings of AI models. The degree of expertise required depends on the nature and sophistication of the data processed.

In addition to new skills, companies also rely on existing skills, which are performed at a higher level. This is especially true in the financial sector. It sometimes happens in industry that traditional positions are largely automated, existing skills are no longer needed and there may be a dequalification. Even in the event of a reduction in positions, enterprises must maintain a basic group of skilled workers who understand the essence of professional activities and are able to control the outputs of AI.

Using the **latest generation of AI** based on LLM and GPT tools will increase the range of activities that will be affected by its use. Naturally, work activities in services will be affected more compared to production fields. In terms of qualification intensity, according to the analysis, **groups in the upper half of the spectrum will be significantly more affected**, i.e. more demanding positions compared to less qualified ones. Activities where lower tertiary education is required, i.e. bachelor's or higher vocational education, will be most affected. This is followed by activities at a higher level of tertiary education, i.e. at the master's and doctoral levels. Activities carried out by secondary school students with secondary school leaving certificate will be less affected and jobs held by workers with lower secondary or primary education will be affected the least. Generative AI technologies will have **moderate impact** on the performance of occupations in public services, wholesale trade, medical occupations and the functioning of medical facilities and in education. Similar impacts can be expected in some manufacturing segments such as computer and electronic equipment manufacturing, mechanical engineering and transport. **The impact is likely to be low** in occupations such as childcare, social assistance, personal services and restaurant services. It also includes manual occupations with low qualifications requirements, especially in the field of construction, accommodation and in most sectors of the manufacturing industry (food, textiles, wood, paper, chemistry, heavy engineering, etc.).

Consultations with employees affected by the changes are an important factor in the success of the implementation of AI. It is about familiarizing employees with AI technology, how it will be implemented and how it will affect jobs, which alleviates employees' fears of losing their jobs. It is also useful to involve executives in the process of developing and applying AI, as their experience can guide the work of developers and contribute to testing prototypes of developed technology, detecting errors and helping in the selection of higher quality training data. **Collective agreements** which include issues of AI implementation are concluded in some enterprises. These issues include the basic aspects of the use of AI and its implications for the skills and education of workers, personal data protection, health and safety at work, privacy, monitoring and evaluation of work performance and decisions on recruitment and dismissal of workers. **Training**, often provided by technology vendors, was usually sufficient when introducing AI. Training provided by internal or external instructors predominates in larger companies. It is important that the training is sufficiently illustrative and focused on practical procedures for working with AI systems. Videos with step-by-step instructions proved to be successful.

Changes in skills requirements in the labour market

The conclusions of numerous studies on the impact of technology on occupations and the performance of work activities have confirmed that shifts in the demand for skills required on the labour market have accelerated. Development is very differentiated according to the types of competencies required. The largest increase in demand in the period until 2030 is expected in **technological skills, both advanced and basic, including digital ones**. Advanced technologies require workers who understand how these technologies work and are able to innovate, adapt to changed conditions and newly develop them. The time spent using advanced technological skills will increase by 13 to 27% in advanced economies by 2030. It is the most in the field of technological research and development, as well as the design of technology application and maintenance. When it comes to skills such as data analysis, processing and performing calculations, it is worth noting that new predictions considering the latest findings on the development of artificial intelligence estimate the need of these skills compared to previous ones. In addition to advanced digital skills, it will also be essential for every worker to develop their **basic digital skills.** The requirements for basic digital skills are already rapidly increasing at all levels in the sphere of manufacturing, especially in the areas of purchasing, sales, in-house processes, supply chain management, financial transactions, etc., and this trend will continue. They will also increase in blue-collar occupations, such as operators of production machines, skilled workers in agriculture or employees in auxiliary occupations. In addition, the share of the digital component of activities will expand in a number of occupations, such as doctors and nurses or construction workers, where digital skills have not been required to a greater extent so far.

Overall, the demand for **social and emotional skills** across all sectors will grow and it will grow faster than originally anticipated. Tasks that use these skills, such as social skills and empathy, negotiation, leadership and taking initiative, are difficult to replace in fields such as patient or child care, people management, organizational leadership, employee coaching, negotiation, etc. The growth in demand for skills such as entrepreneurship and taking the initiative will be the fastest growing one in this skill category.

The demand for **basic cognitive skills** (reading literacy, numeracy, data entry and performing basic calculations) will decrease significantly. Activities that require these skills are highly automated (chatbots, self-checkouts, data input and processing). Unlike data processing, other basic cognitive skills, i.e. basic reading literacy, numeracy and communication, will also decrease significantly, but will not lose their significance completely. However, it is clear that they will no longer be sufficient for most jobs without additional skills in the future.

The demand for **higher cognitive skills** will have an internally differentiated development. This category includes advanced literacy and writing skills and quantitative and statistical skills, as well as creativity, critical thinking and decision-making; complex information processing and interpretation; and project management. Overall, this category tends to stagnate, but different trends are hidden behind it. Automation and artificial intelligence can increasingly perform tasks related to writing texts, conducting searches, processing basic reports, quantitative and statistical tasks, so the demand for workers with these skills is decreasing. Robotic process automation (RPA) can also perform certain complex information processing and project management, so these skills show negligible growth. On the contrary, the need for creativity, critical thinking and the ability to make flexible decisions is expected to grow strongly, as the need to understand and explain the conditions, context and technical details of products and services to customers/clients increases and to react and make decisions in a timely manner.

The need for most **physical and manual skills** will decline, but they will form the most extensive category of workforce skills.

The above-mentioned general trends in the requirements for skills demanded under the influence of new technologies on the labour market are reflected differently in the employment of different categories of workers according to the nature of the economic sectors in which they operate. Thus, attention was also paid to the specific impacts of digitalization and robotics on the organization of work and the need for skills in several selected economic sectors.

Skills requirements in selected sectors

Intensive digitalization in the **financial sector,** especially the development of online banking, allows banks to significantly reduce their branch network. This has not yet led to a decrease in total employment in this sector in the EU or the Czech Republic, despite the fact that there are known cases of banks that proceeded to more extensive redundancies. The nature of work is changing, with direct communication with clients decreasing in favour of working with a computer and other technologies. It depends on the approach of bank management whether this development leads to standardization and routinization or, vice versa, to expanding the range of skills that workers need. The space can expand especially for analytical skills, knowledge in the field of data processing, programming, cybersecurity and communication with virtual assistants. Some studies emphasize the great importance that employers in the banking sector attach to soft skills, especially adaptability, learning abilities and social competences, the role of which may even exceed the importance of ‘hard’ skills, including IT skills.

Regarding **healthcare**, health records are being computerized, which requires workers to be able to control the relevant digital hardware and software. With the development of telemedicine and remote care, there is also a need for medical staff to know how to communicate with patients without direct personal interaction and to know how to work with related devices (especially sensors that monitor patients’ health data). Advanced technologies that some doctors have to learn to work with include robotics and virtual or augmented reality. Digitalization in healthcare is often associated with worsening working conditions due to greater time pressure and reduced contact with the patient. It is particularly important to provide targeted support to workers and to take into account the risks associated with the depersonalization of care with digitalization in this sector.

The manufacturing industry is characterized in particular by a rapid decrease in the need for manual labour and administrative activities and an increase in the level of employment. There are increasing demands for higher cognitive and social skills and for the control of new machines, which also leads to the need for advanced digital skills on the part of their operators. The high rate of automation in the industry also increases the demand for experts implementing it. Less specialized staff in many sectors and operations must then at least understand how machines and systems communicate with each other, how ICT security and data protection are ensured.

The need for cognitive and social competences at the expense of manual work is also growing in **retail**. Total employment may also decline here in the future due to the development of e-commerce or the introduction of self-checkouts. **Tourism** has been mainly affected by the rise of the platform economy and the growing personalization of travel agency services in recent years. The demand is mainly for basic digital skills and competences in online sales and marketing. This sector, together with **gastronomy**, is largely based on personal contact with clients, which reduces the risk of a significant reduction in the volume of human work. Interpersonal competences are often more important than digital skills.

So far, the **construction** industry has been considered a sector the automation of which is difficult, but recently, despite various limitations, robotics and digitalization are gradually starting to be introduced into the processes that make it possible. Although used only by about 15% of construction companies so far, robotics and automation are perceived as an important factor in the development of this sector in the future. The most promising technologies include augmented reality, laser scanning using drones, 3D printing of buildings, the potential of which is considerable. It can be expected in the future that the practical use of autonomously controlled construction machines will be possible. Faster progress of robotics will depend on how the procedures for the preparation and implementation of buildings will change, which places higher demands on the implementation of information systems that would facilitate the management and coordination of all complex processes. Building Information Modelling (BIM) is such a system, it is a comprehensive virtual building model enabling the generation, management and exchange of information as part of the design, construction and use of a building.

In connection with the expansion of digitalization and robotic technologies in the construction industry, it will be necessary to ensure enough high-performance skilled staff able to install, control, cooperate with and repair automated devices. The demand will increase for medium- and high-skilled technical and managerial occupations that will be able to work with digital tools and to insert and evaluate information from data and planning systems.

With regard to **agriculture**, new technologies are increasingly used in agriculture and over 60% of farms in the Czech Republic have invested in them in recent years. Currently, some robotic and sensory devices are used to monitor the condition and to attend to animals, as well as in crop production, including the controlled production of greenhouse vegetables with a high degree of automation, and in post-harvest lines and storage systems. It is also common to use navigation systems and autopilots to control agricultural machines. On the other hand, Czech farmers work very little with data obtained from sensors or satellite images. Only a third of farmers track their production data via web or mobile applications. It can be assumed that under the pressure of competitiveness and also with the possibility of drawing program subsidies, the introduction of new technologies in Czech agriculture will accelerate in the near future.

Experts are needed for the application of new technologies in agriculture who combine knowledge of agricultural practice with knowledge of IT management and control of autonomous systems, satellite imagery, the use of drones and ground sensors. There is a lack of specialists in working with navigation systems, computer technology, geodetic information systems and map files, databases or statistical data processing. Knowledge of logistics and law with respect to European and national standards will also be important. New skills requirements will also affect medium- and low-skilled workers. New jobs will be created at the medium level, such as programmers and repairers of robotic machines, operators of agricultural machinery. The basic skills of working with sophisticated equipment must also be mastered by manual workers in order to understand signals and data, be able to respond to them and communicate with remote support.

List of abbreviations

3D	Three-dimensional printing
AI	Artificial intelligence
Cedefop	European Centre for the Development of Vocational Training
CNC machine	Numerically controlled machine tool
CRM	Customer Relationship Management
CR	Czech Republic
CZSO	Czech Statistical Office
EDI	Electronic data interchange
ERP	Enterprise resource planning
ESJS	European Skills and Jobs Survey
EU	European Union
EU27	27 Member States of the European Union
Eurostat	Statistical Office of the European Union
FINTECH	Financial start-ups
GPS	Global positioning system
GPT	Generative pre-trained transformer
HR	Human resources
ICT	Information and communication technologies
IoT	Internet of Things
ISCO	Statistical classification of occupations
LLM	Large language models
MGI	McKinsey Global Institute
MIT	Massachusetts Institute of Technology
ML	Machine learning
OECD	Organisation for Economic Co-operation and Development
REGTECH	Regulatory instruments
RPA	Robotic process automation
SCM	Supply chain management
SW	Software
USA	United States of America

Annexes

Table 3: Installation of industrial robots in the world by forms of use (in thousands of units)

Forms of use of robots	2019	2020	2021	2021/2019 increase (in %)
handling items	177	169	230	30
welding	74	70	96	30
assembly	40	50	62	55
cleaning	26	32	32	23
dosage	12	8	11	-8
material processing	7	5	7	0
other uses	55	60	80	45

Source: World Robotics 2022

Table 4: Installation of industrial robots by application sector (in thousands of units)

Robot application sector	2019	2020	2021	2021/2019 increase (in %)
electrical engineering	89	110	137	54
automotive	102	84	119	17
metal processing and mechanical engineering	52	44	64	23
rubber and plastic processing	18	19	24	33
food	11	12	15	36
other productions	30	37	52	73
unspecified	87	87	107	23

Source: World Robotics 2022

Table 5: Enterprises in EU countries using industrial robots (share in %)

	Enterprises using industrial robots				
	Total	10 to 49	50 to 249	250+	Manufacturing
EU27	**4.9%**	**3.3%**	**10.2%**	**22.0%**	**16.3%**
Belgium	8.1%	6.1%	15.1%	30.3%	26.1%
Bulgaria	2.6%	1.7%	5.8%	13.7%	9.0%
Czech Republic	**5.7%**	**2.6%**	**13.1%**	**34.4%**	**16.3%**
Denmark	8.6%	6.4%	15.2%	28.6%	36.9%
Estonia	4.3%	2.5%	11.3%	19.3%	13,2.%
Finland	6.8%	4.7%	14.6%	26.9%	26.8%
France	6.1%	4.7%	11.3%	21.3%	25.1%
Croatia	2.8%	0.8%	10.2%	22.8%	8.6%
Ireland	2.8%	1.4%	8.0%	15.3%	17.2%
Italy	6.2%	4.8%	14.6%	22.5%	15.8%
Cyprus	1.5%	1.2%	3.4%	3.4%	9.0%

Lithuania	3.6%	2.0%	8.3%	19.1%	13.3%
Latvia	4.0%	2.2%	11.9%	20.0%	12.0%
Luxembourg	3.2%	2.1%	7.4%	11.9%	22.9%
Hungary	3.2%	1.6%	8.6%	28.8%	11.1%
Malta	5.2%	4.2%	9.0%	11.7%	26.3%
Germany	3.9%	2.2%	8.6%	20.4%	14.7%
Netherlands	5.2%	3.7%	10.2%	15.7%	22.0%
Poland	3.7%	1.9%	7.7%	27.1%	10.8%
Portugal	5.5%	4.0%	12.3%	21.8%	16.7%
Austria	4.2%	2.4%	10.5%	25.3%	16.3%
Romania	2.2%	1.5%	4.0%	11.8%	6.3%
Greece	1.8%	1.3%	5.1%	4.1%	9.6%
Slovakia	5.7%	3.3%	11.3%	28.1%	17.2%
Slovenia	6.2%	3.2%	15.9%	39.3%	19.2%
Spain	6.5%	5.1%	11.8%	23.1%	18.5%
Sweden	5.4%	3.7%	11.5%	24.4%	27.7%

Source: CZSO, Využívání robotů v podnikatelském sektoru. 2022

Table 6: Enterprises in EU countries using 3D printing (share in %)

	2017		2019	
	Total	**Manufacturing**	**Total**	**Manufacturing**
EU27	**3.9%**	**9.0%**	**5.2%**	**11.6%**
Belgium	5.7%	-	6.2%	-
Bulgaria	1.8%	3.1%	2.9%	5.4%
Czech Republic	**4.2%**	**7.6%**	**6.2%**	**12.9%**
Denmark	6.2%	16.8%	9.2%	25.7%
Estonia	1.8%	3.1%	2.5%	4.8%
Finland	6.5%	16.8%	7.5%	21.1%
France	3.7%	10.6%	4.2%	12.8%
Croatia	3.4%	5.7%	5.4%	10.0%
Ireland	3.0%	8.2%	2.3%	10.5%
Italy	4.4%	9.1%	4.7%	9.9%
Cyprus	1.0%	3.3%	5.5%	10.4%
Lithuania	4.0%	8.2%	3.0%	5.8%
Latvia	1.3%	2.5%	2.3%	4.5%
Luxembourg	3.9%	8.8%	3.7%	18.2%
Hungary	2.0%	5.2%	3.4%	6.8%
Malta	5.9%	11.8%	8.2%	15.7%
Germany	4.9%	12.9%	7.3%	18.0%
Netherlands	4.6%	10.6%	6.0%	16.0%
Poland	2.4%	5.0%	3.4%	7.6%
Portugal	3.9%	7.2%	4.5%	7.2%
Austria	4.3%	14.0%	4.9%	13.7%
Romania	2.1%	2.0%	1.6%	2.5%

Greece	1.9%	-	-	-
Slovakia	3.0%	4.2%	3.9%	8.0%
Slovenia	4.5%	10.3%	4.8%	11.8%
Spain	3.0%	6.7%	5.3%	8.4%
Sweden	4.7%	10.5%	6.0%	15.6%

Source: Eurostat, CZSO calculations.

http://ec.europa.eu/eurostat/web/digital-economy-and-society/data/comprehensive-database

Table 7: Enterprises in EU countries analysing Big Data

	2015	2017	2019
EU27	**9.1%**	**12.3%**	**14.2%**
Belgium	17.0%	20.5%	22.9%
Bulgaria	7.2%	6.7%	6.3%
Czech Republic	**8.5%**	**8.1%**	**9.1%**
Denmark	11.7%	13.6%	27.0%
Estonia	12.7%	10.8%	9.9%
Finland	14.8%	19.0%	21.6%
France	11.3%	16.2%	21.7%
Croatia	9.3%	10.3%	13.6%
Ireland	9.0%	20.3%	22.7%
Italy	2.6%	7.1%	8.6%
Cyprus	12.0%	4.7%	6.2%
Lithuania	12.5%	13.7%	10.5%
Latvia	-	7.7%	8.5%
Luxembourg	12.5%	16.4%	18.7%
Hungary	7.0%	6.2%	7.0%
Malta	18.6%	24.4%	30.7%
Germany	5.7%	15.0%	17.8%
Netherlands	19.1%	22.0%	27.3%
Poland	5.9%	7.9%	8.5%
Portugal	13.4%	12.9%	10.6%
Austria	-	6.3%	8.7%
Romania	11.2%	11.1%	5.1%
Greece	11.4%	12.6%	12.9%
Slovakia	10.8%	9.4%	5.6%
Slovenia	11.0%	10.2%	6.6%
Spain	8.3%	10.7%	9.0%
Sweden	9.9%	9.5%	19.2%

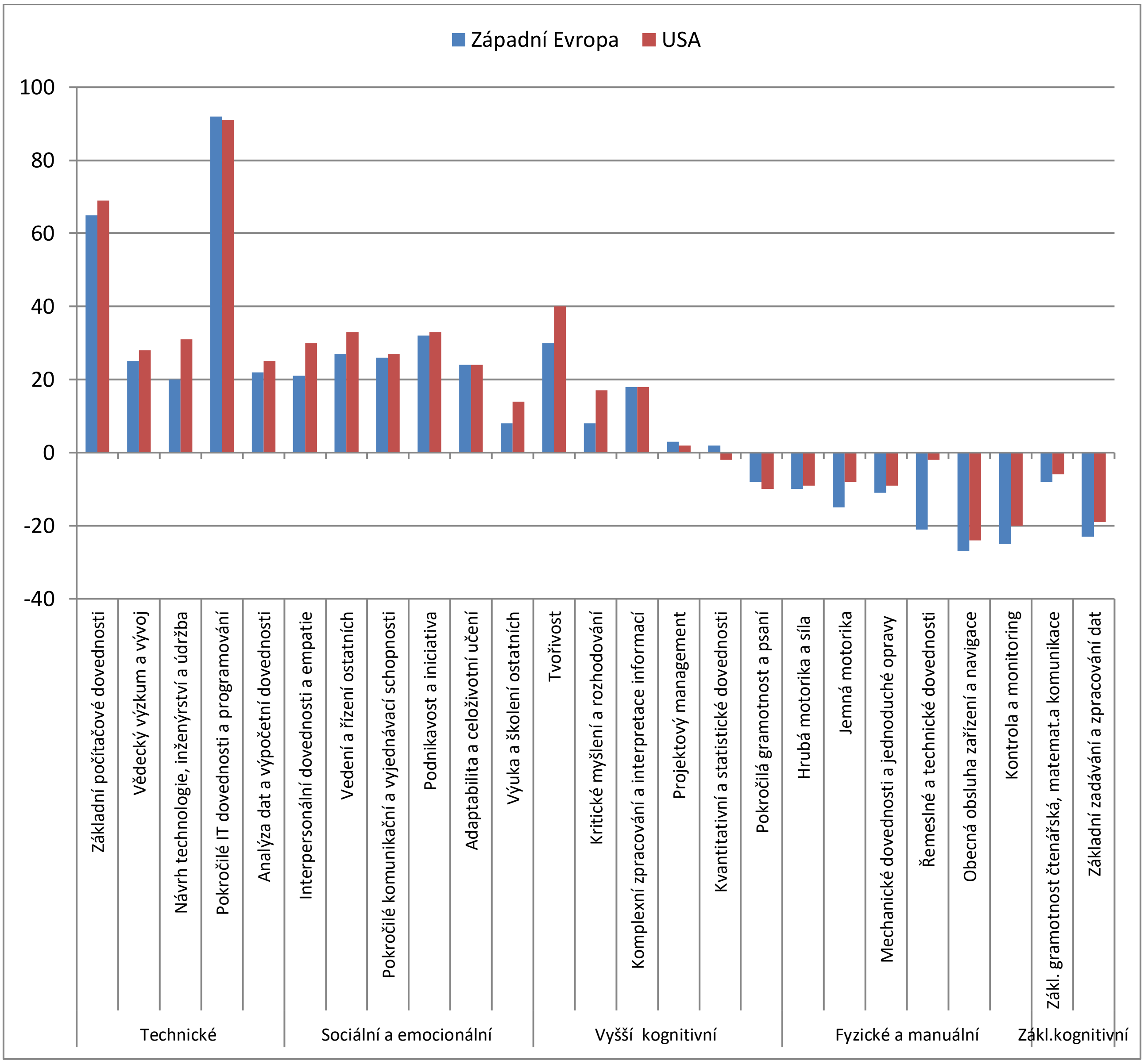
Source: Eurostat, CZSO https://www.czso.cz/csu/czso/podnikatelsky_sektor.

Note: Share in the total number of enterprises with 10 or more employees in %

Table 8: Enterprises using ERP, CRP, EDI information systems (share in %)

		2010	2015	2021
ERP	EU27	22.6	38.5	38.1
	CR	24.3	30.2	37.7
CRP	EU27	26.5	33.3	34.7
	CR	15.2	20.5	18.1
EDI	EU27	5.1	6.8	6
	CR	19.1	12.3	9.1

Chart 25: Estimation of change in demand for individual types of skills in selected developed countries in 2016-2030 (in %)



Source: MGI (2016): Skill shift: Automation and the future of the workforce. Own processing.
Note: The development estimate was made on the basis of the analysis from 2015-2016.

Western Europe
USA

See Table 2, page 30

List of charts

List of tables

Literature and sources

Acemoglu, D., Autor, D., Hazell, J., and Restrepo, P. (2020). Ai and jobs: Evidence from online vacancies. Technical report, National Bureau of Economic Research. https://www.nber.org/system/files/working_papers/w28257/revisions/w28257.rev1.pdf

Arefjevs, I. et al. (2020). Financial sector evolution and competencies development in the context of information and communication technologies. *Research for Rural Development,* 35: 260–267

Brynjolfsson, E.; Rock, D.; Tambe, P.: How Will Machine Learning Transform the Labor Market? Essey. MIT, 2019. https://www.hoover.org/research/how-will-machine-learning-transform-labor-market

Carlisle, S. et al. (2023). The digital skills divide: evidence from the European tourism industry. *Journal of Tourism Futures*, 9(2): 240–266

CEEC Research: Kvartální analýza českého stavebnictví Q3/2022. zveřejněno na www.ceec.eu

Cedefop (2022). Setting Europe on course for a human digital transition: new evidence from Cedefop's second European skills and jobs survey. Luxembourg: Publications Office. Cedefop reference series; No 123 http://data.europa.eu/doi/10.2801/253954

Curtarelli, M; Gualtieri, V; Jannati, M; Donlevy,V: ICT for work – Digital skills in the workplace. European Commission, 2016. https://digital-strategy.ec.europa.eu/en/library/ict-work-digital-skills-workplace

Ecorys: ICT for work - Digital skills in the workplace. Study for European Commission. 2017. https://digital-strategy.ec.europa.eu/en/library/ict-work-digital-skills-workplace

Demin g, D., Kahn, L. (2018): Skill Requirements across Firms and Labour Markets: Evidence from Job Postings for Professionals.

Dredge, D. et al. (2019). Digitalisation in Tourism. In-depth analysis of challenges and opportunities. Aalborg Universitet. Online: https://vbn.aau.dk/ws/files/296441087/REPORT_TourismDigitalisation_131118_REV_KB_EM_4_.pdf

Eloundou, T.; Manning, S.; Mishkin, P.; Rock, D.: GPTs are GPTs - An Early Look at the Labor Market Impact Potential of Large Language Models. Working Paper. OpenAI, University of Pennsylvania. March 27, 2023. (https://arxiv.org/pdf/2303.10130.pdf)

Eurofound (2022). Going digital: Restructuring trends in retail banking. Luxembourg: Publications Office of the European Union. Online: https://www.eurofound.europa.eu/publications/report/2022/going-digital-restructuring-trends-in-retail-banking

Eurostat Database: http://ec.europa.eu/eurostat/web/digital-economy-and-society/data/comprehensive-database

Eurostat Database: Participation rate in education and training, https://ec.europa.eu/eurostat/databrowser/view/TRNG_LFS_01/default/table?lang=en

Eurostat Database: Continuing vocational training in enterprises, https://ec.europa.eu/eurostat/data/database

Felten, E.; Raj, M.; Seamans, R.: Occupational, industry, and geographic exposure to artificial intelligence: A novel dataset and its potential uses. *Strategic Management* Journal, 2021. https://onlinelibrary.wiley.com/doi/10.1002/smj.3286

Green, A. and L. Lamby (2023), The supply, demand and characteristics of the AI workforce across OECD countries. OECD Social, Employment and Migration Working Papers, No. 287,

OECD Publishing, Paris, https://doi.org/10.1787/bb17314a-en

Hunt at all: Measuring the impal of AI on jobs at the organization level: Lessons from a surfy of UK business leaders. Measuring the impact of AI on jobs at the organization level: Lessons from a survey of UK business leaders - ScienceDirect

Inovace v zemědělství: Jak si stojí Češi. (https://www.csas.cz/cs/firmy/articles/inovace-v-zemedelstvi-jak-si-stoji-cesi)

International Federation of Robotics: World Robotics, https://ifr.org/downloads/press2018/2022_WR_extended_version.pdf

Konttila, J. et al. (2017). Healthcare professionals' competence in digitalisation: A systematic review. *Journal of clinical nursing*,28(5-6): 745–761

Kornelakis, A. et al. (2022). The digitalisation of service work: A comparative study of restructuring of the banking sector in the United Kingdom and Luxembourg. *European Journal of Industrial Relations*, 28(3): 253–272.

Lane, M., Williams, M., Broecke, S.: The impact of AI on the workplace: Main findings from the OECD AI surveys of employers and workers. OECD, Working Papers 287. OECD, 2023. file:///X:/Observatory/projekt%20ASO%202023/PODKLADY/OECD%202023-Impact%20of%20AI%20on%20the%20workplace-survey.pdf

Manca, F.: Six questions about the demand for artificial intelligence skills in labour markets. Working Paper No 286. OECD, 2023. https://www.oecd-ilibrary.org/docserver/ac1bebf0-en.pdf?expires=1683548717&id=id&accname=guest&checksum=1F3BC5A2745A2315859CB2677F77A393

Mavlutova, I., Volkova, T. (2019). Digital Transformation Of Financial Sector And Challenges For Competencies Development. *Advances in Economics, Business and Management Research, volume 99, 7th International Conference on Modeling, Development and Strategic Management of Economic System (MDSMES 2019)*, s. 161–166.

Mazurchenko, A. et al. (2022). Demand for employees' digital skills in the context of Banking 4.0. *Business Administration and Management*, XXV(2): 41–58

Meknic, J. et al. (2022). Educational and training imperatives for future tourism competencies: The case of Slovenia. *Human Systems Management*, Pre-press

Mc Kinsey, https://www.mckinsey.com/capabilities/operations/our-insights/building-the-vital-skills-for-the-future-of-work-in-operations

McKinsey (2021): Defining the skills citizens will need in the future world of work. https://www.mckinsey.com/~/media/mckinsey/industries/public%20and%20social%20sector/our%20insights/defining%20the%20skills%20citizens%20will%20need%20in%20the%20future%20world%20of%20work/defining-the-skills-citizens-will-need-in-the-future-of-work-final.pdf

McKinsey Global Institute (2018): Skill shift: Automation and the future of the workforce. May 23, 2018, Discussion Paper

Mehdiabadi, A. et al. (2020). Are We Ready for the Challenge of Banks 4.0? Designing a Roadmap for Banking Systems in Industry 4.0. *International Journal of Financial Studies*, 8(2)

Milanez, A.: The Impact of AI on the Workplace: Evidence from OECD Case Studies of AI Implementation. Working Paper No 289. OECD, 2023.

Národní centrum průmyslu 4.0: Analýza českého průmyslu 2020. NCP 4.0., CIIRC, 2020. https://www.ncp40.cz/files/analyza-ceskeho-prumyslu-2020-updated.pdf

Occupational, industry, and geographic exposure to artificial intelligence: A novel dataset and its potential uses, https://onlinelibrary.wiley.com/doi/10.1002/smj.3286

OECD (2021). Preparing the tourism workforce for the digital future. Paris: OECD. Online: https://www.oecd-ilibrary.org/industry-and-services/preparing-the-tourism-workforce-for-the-digital-future_9258d999-en

OECD: Průzkum zaměstnavatelů OECD o dopadu umělé inteligence na pracoviště (2022). OECD (2023): Impact of AI on the workplace-survey.

OECD (2023): Six questions about the demand for artificial intelligence skills in labour markets

Oesterreich, T. D. et al. (2019). The controlling profession in the digital age: Understanding the impact of digitisation on the cotroller's job roles, skills and competences. *International Journal of Accounting Systems*, 35.

Öberg, U. et al. (2017). Swedish primary healthcare nurses' perceptions of using digital eHealth services in support of patient self-management. *Scandinavian Journal of Caring Sciences*, 32(2), 961–970

Palumbo, R., Cavallone, M. (2022). Is work digitalization without risk? Unveiling the psycho-social hazards of digitalization in the education and healthcare workplace. *Technology Analysis & Strategic Management* (online first).

Perez, C., Martin, F. (2018). Digitalisation and Artificial Intelligence: the New Face of the Retail Banking Sector. Evidence from France and Spain. *Université Paris1 Panthéon-Sorbonne (Post-Print and Working Papers) halshs-01884121, HAL Open Science*, online: https://ideas.repec.org/p/hal/wpaper/halshs-01884121.html

Popov, V. et al. (2022). Industry 4.0 and Digitalisation in Healthcare. *Materials*, 15(6).

Puschmann, T. (2017). Fintech. *Business & Information Systems Engineering*, 59(1), 69–76. doi:10.1007/s12599-017-0464-6.

Sætra, H. S. et al. (2021). Healthcare Digitalisation and the Changing Nature of Work and Society. *Healthcare*, 9(1007).

Virone, C. et al. (2021). Which Factors of Digitisation Bias the Work-Related Stress of Healthcare Employees? A Systematic Review. *Studies in Health Technology and Informatics,* 281: 916–920.

Vojáček, A.: Současný stav a vývoj trhu kolaborativních robotů. Automatizace HW, 2023. https://automatizace.hw.cz/soucasny-stav-a-vyvoj-trhu-kolaborativnich-robotu.html

World Economic Forum: Future of Jobs Report 2023. WEF, 2023. https://www.weforum.org/reports/the-future-of-jobs-report-2023/