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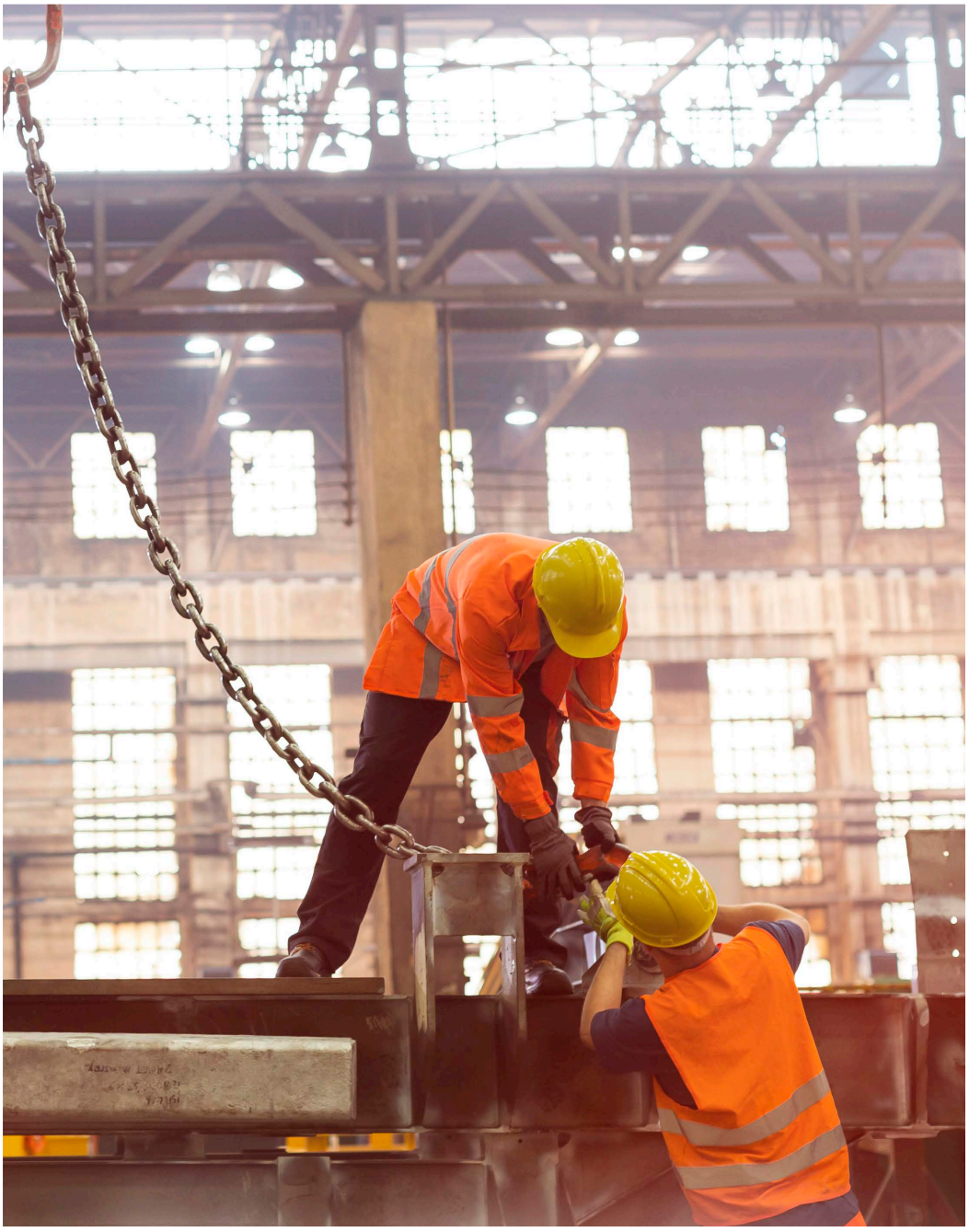
How will AI impact the Hungarian labour market?



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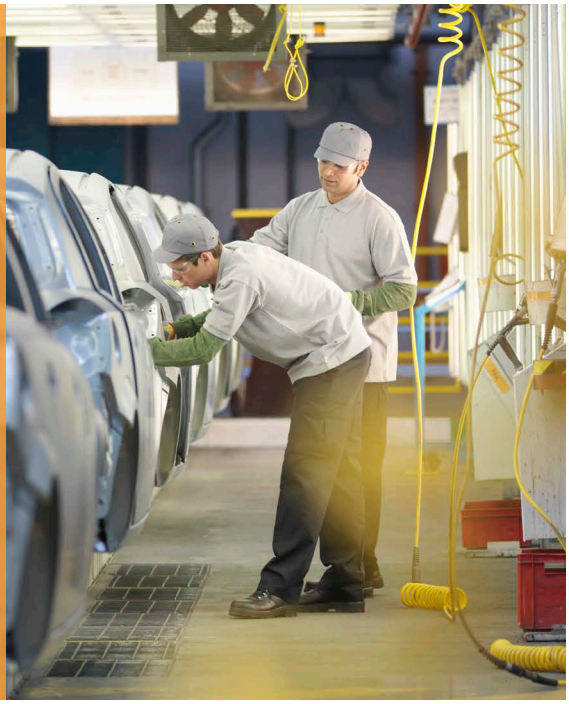
Opening statement by Antal Kerekes, Partner and Technology Advisory Leader at PwC Hungary



Antal Kerekes
Partner, PwC Hungary

Artificial Intelligence is frequently cited as a double-edged sword, because the disruptive technology solutions of automation and machine learning pose a threat and an opportunity at the same time, based on how we approach them. AI adaption forces both the individual and the decision maker to act on the opportunity in search of competitive advantages.

From a national economy perspective, preparation for AI adaption requires investment, on which the rate of return is expected to be multiplicatory. The Hungarian economy is exposed to AI in the long run, but PwC estimates that a quarter of Hungarian jobs will be affected by AI by mid 2030s. We shall use this time to invest in preparations, allowing Hungary to exploit the potential benefits of the upcoming disruptive technologies.

From global economy perspective, Hungary is a nearshore location and a popular destination for outsourcing higher added value operation. Not paying attention to preparations for AI would mean Hungary could even fall behind offshore countries, which by using AI technology for quality assurance, could provide as good a service as nearshore locations, but with lower operating costs. On the other hand, successful AI adaption would mean significant competitive advantage for the country and provide the Hungarian labor force with the ability of supplying parent company-level tasks on nearshore cost levels. Consequently, AI adaption could create opportunity for bringing in higher added value and in parallel, higher wages for Hungarian employees. The conclusion is that the only advantageous scenario for the Hungarian economy is to prepare for AI adaption quickly and effectively, thus achieving competitiveness.

Proposed actions of preparation for AI adaption:

I. Teaching the ability of Human-AI cooperation. It is crucial to define the educational frameworks in time and implement them in the primary, secondary and higher education. Also, highlighting the role of adult education in the process will be key to success. The aim is getting over the teamwork hype of the 1990s and step into the reality of hybrid cooperation between humans and machines. From now on, the strength of a team will not depend on the strength of the weakest link in the chain, but the level of enhancement in the Human-AI cooperation.

II. Identifying the role of AI in business, Teaching people to create an environment in which Human-AI cooperation best supports business processes. The other half of preparation efforts should be channeled into enabling people to understand the enhancement of Human-AI cooperation.

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Hungary is an **industrial economy**

Hungary will mostly be hit by AI effects in the **2030s**

The manufacturing industry could face the highest potential impact of automation with **384,500 jobs** affected

How and when will AI disrupt the Hungarian labour market?

We aim to give different stakeholders a broad overview of the current labour market structure and how it might be shaped over the coming decades by the impact of automation. Furthermore, the study recommends solutions for adapting AI in the future and actions for helping mitigate or turn AI risk into AI opportunity in the long run. The different ways of applying AI's features is only at the beginning of a long story, and with the right preparation we should be able to use it as an effective ancillary tool rather than as an alternative that eliminates human jobs.

The report starts by describing the Hungarian labour market and its industries. Then it defines AI and how AI could affect the Hungarian labour market. Based on benchmark data and other valuable sources, we were able to identify the number of employees that will be affected in each industry from now until the 2030s. Similar predictions can be made for countries with comparable labour market structures, such as the Visegrad countries and Lithuania and Slovenia. Furthermore, we have analyzed the effects on different occupations within various industries, based on gender, age and education level.

We have identified three consecutive waves of automation within the coming decades. Until the early 2020s, the algorithm wave will affect the financial sector, IT-related industries and the clerical workforce. These employees are mostly women and young. **The augmentation wave (2025 - 2030)** will include services, education, public administration and other basic computer-based service providers. This wave will more equally affect men and women and the more experienced middle-aged employees compared to the first wave. Finally the **autonomy wave (2030s)** will hit manufacturing-related industries on the one hand, and therefore the workforce responsible for manual work, but at the same time, high/complex-responsibility type of work. Mostly men and experienced workers are expected to be affected by the last wave.

It is important to note that the phases and our estimates are based primarily on the technical feasibility of automation. In practice, the actual extent of automation may be less, due to a variety of economic, legal, regulatory and organisational constraints. Just because something can be automated in theory does not mean it will be economically or politically viable in practice.

Not to mention, job losses from automation are likely to be broadly offset in the long run by new jobs created as a result of the larger and wealthier economy made possible by these new technologies. We do not believe, contrary to some predictions, that automation will lead to mass technological unemployment by the 2030s any more than it has done in the decades since the digital revolution began.

We have summarised our key findings according to PwC's wave framework to highlight how automation will disrupt the Hungarian labour market. We were able to analyse the **potential impact by industry sectors, occupation and worker types.**

By definition, **Hungary is an industrial economy**, which means that **major impact is expected in the manufacturing, transportation and construction industries. Hungary will mostly be hit by AI effects in the 2030s**, because the economy heavily relies on traditional industrial sectors.

We are estimating that in total, more than 900,000 jobs, one quaters of total will be affected. Based on Hungary's economic build-up, the autonomy wave restructuring manual and routine tasks will have a profound impact. Consequently, **the manufacturing industry could face the highest potential impact of automation with 384,500 jobs affected.** However, transportation (107,900 AI affected employees) and construction (106,600 AI affected employees) are expected to be highly affected.

These three sectors account for more than one third of Hungarian jobs and almost two thirds of all potential jobs that will be affected across the three wave in Hungary.

Craft workers and non-skilled trade workers will be the most affected by automation. These job types are expected to change in the autonomy wave, in the 2030s. More than 195,000 workers could face risk of automation in this category. It means that **one in every three craft/non-skilled trade worker's job will somehow change.** Another highly affected group is going to be machine operators, with more than 149,000 employees facing the potential challenge from AI by the end of the next decade.

We also found that **women will be more impacted than men in the early stages** (algorithm and augmentation waves). But **in the long term** (autonomy wave), **the chance of a man's job change because of AI's effect will be twice as high as that of jobs typically taken by women.**

The deviation arises from **gender dominance in the different occupations and industries** affected by each wave. For instance, female workers are typically represented in clerical and financial occupations affected in the first two waves, whereas male workers are typically represented in the manufacturing and transport occupations affected in the third wave. The number of women on the Hungarian labour market is lower than the number of men. For this reason, **the overall impact of AI by gender** (total number of jobs affected) **will hit men harder.**

1 Introduction

Artificial Intelligence, and automation in general, affect different areas of our lives. Real life examples also show how rapidly AI technology has evolved and shaped our environment in recent years. In fact, all industries are being disrupted by this global phenomenon, and disruption is seen as both an opportunity and a threat. The present report forecasts the possible effects of AI on the Hungarian labour market.

We begin with a general introduction to AI, explaining the different waves of AI that impact jobs worldwide, followed by a short introduction to the current state of the Hungarian economy and local labour market. Our analysis consists of three segments, which are reflected on automation waves, already defined by PwC UK. In the second chapter, we benchmark the Hungarian economy based on PwC UK methodology and break down AI's future impact on the different sectors of the Hungarian economy. The third chapter contains projections on how the different jobs will be affected by AI. In the fourth chapter, we analyze the affected employees in terms of demographics. We explain how the different worker types will be affected by AI in the future. Finally, in the last chapter we conclude our findings by highlighting possible policy implications and recommendations for businesses and the government.

PwC research was built on OECD's Programme for the International Assessment of Adult Competencies (PIAAC) database and survey, conducted in over 40 countries, measuring key cognitive and workplace skills needed for individuals to participate in society and for economies to prosper.

As Hungary has not yet been included in the group of analysed countries by OECD, we have picked the most relevant benchmark countries from the OECD database and created a peer group for the Hungarian economy. The group consists of countries that were included in OECD's conclusions and have similar economic characteristics as Hungary: Slovakia, Slovenia, Poland, the Czech Republic and Lithuania. Further information can be found in the appendix (Table 1.1).

To validate our findings regarding the future impact of AI on the Hungarian labour market, we conducted interviews with representatives of different stakeholders. In terms of economic sectors covered, we put emphasis on reaching out to numerous industries when interviewing (e.g. engineering, IT, financial services and education). The different viewpoints on the issues arising from AI impacts on the labour market serve as key qualitative inputs to our research.

1.1 Waves of automation

PwC developed the **wave method** to be able to scale the global impacts of Automation across time

Automation levels differ from country to country and **evolve over time**

Phase	Description	Tasks impacted	Industries impacted
Algorithm wave (2020s)	Automation of simple computational tasks and analysis of structured data, affecting data-driven sectors such as financial services.	This includes manually conducting mathematical calculations, or using basic software packages and Internet searches. Despite increasingly sophisticated machine learning algorithms being available and increasingly commoditized, it is these more fundamental computational job tasks that will be most impacted first.	Data driven sectors such as finance and insurance, information and communication, and professional, scientific and technical services.
Augmentation wave (2025)	Dynamic interaction with technology for clerical support and decision making. Also includes robotic tasks in semi-controlled environments such as moving objects in warehouses.	For example, routine tasks such as filling in forms or exchanging information, which includes the physical transfer of information. It is also likely to see a decreased need for many programming languages as repeatable programmable tasks are increasingly automated, and through machines themselves building and redesigning learning algorithms.	The financial and insurance sector will continue to be highly impacted, along with other sectors with a higher proportion of clerical support, including public and administration, manufacturing, and transport and storage.
Autonomy wave (2030s)	Automation of physical labour and manual dexterity, and problem solving in dynamic real-world situations that require responsive actions, such as in transport and manufacturing.	AI and robotics will further automate routine tasks but also those tasks that involve physical labour or manual dexterity. This will include the simulation of adaptive behaviour by autonomous agents.	Sectors like construction, water, sewage and waste management, and transportation and storage with the advent of fully autonomous vehicles and robots.

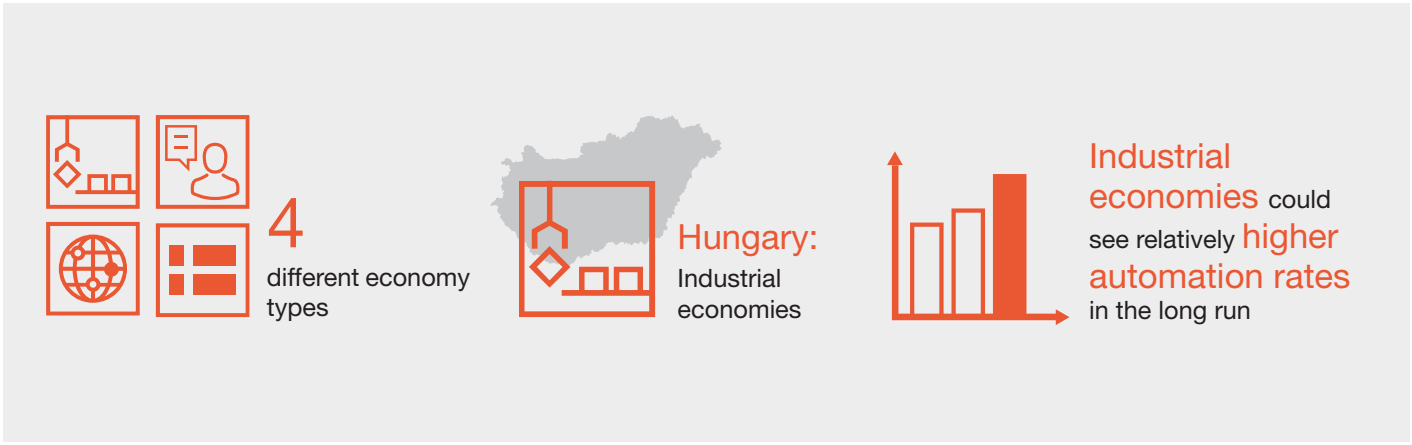
Source: PIAAC data, PwC analysis

In terms of automation risks, the period from the time of writing to the mid-2030s should unfold in three consecutive waves. The waves are mainly based on the technical feasibility of automation.

Automation levels differ from country to country and evolve over time. While jobs in more technologically advanced nations (e.g. in Asia) may be at immediate risk in the first algorithmic wave, jobs in less developed countries may not be immediately at risk but should rather prepare for a large labour force transition in the third autonomy wave.

One example of the latter is the transport industry that is not immediately affected but is at risk in a decade or two when driverless vehicles will likely replace a large number of human drivers. Furthermore, workers in countries with more stringent education requirements can have greater protection against automation in the long run. This is particularly true for European countries with higher levels of education spending as a percentage of GDP. Hungary has spent relatively less on education than most of the V4 and benchmarking countries in 2018.

1.2 Relative impact of automation on different economies



AI is a source of both huge excitement and apprehension. It has the potential to bring great benefits to the economy by boosting productivity and creating new and better products and services. On the other hand, AI can also cause severe disruption, for instance on the labour market. Thirty-seven percent of workers globally are worried about the possibility of losing their jobs due to automation *(PwC: Workforce of the future: The competing forces shaping 2030*, 2018*)*.

The debate regarding the impact of AI on labour markets worldwide has experienced added urgency in recent years. Although there is an overall understanding of the level of risk AI represents, estimates and predictions regarding the extent of the risks vary greatly, depending both on the country in question and the definition of the tasks related to the work.

According to PwC UK's methodology, when analysing the effect of automation on the Hungarian labour market, we first need to define what type of economy Hungary has. Countries with somewhat similar labour markets and economic structures have broadly similar levels of potential automation, and can be used as benchmarks for future predictions. We are relying on PwC UK's conclusions in terms of identified country groups:

Different economy types identified by PwC

Industrial economies (Hungary)

For example Hungary, Germany, Slovakia and Italy, **which could see relatively higher automation rates in the long run.** These countries are typically characterised by jobs that are relatively more automatable and (relative to the OECD average) more concentrated in industry sectors with higher potential automation rates.

Service-dominated economies

For example the US, UK, France and the Netherlands, which have jobs that are on average relatively more automatable based on their characteristics, but also a greater concentration on services sectors that tend to be less automatable on average than industrial sectors.

Asian countries

For example Japan, South Korea, Singapore and Russia, which have jobs that are relatively less automatable overall but with relatively high concentrations of employment in industrial sectors with relatively high potential automation rates.

Nordic countries

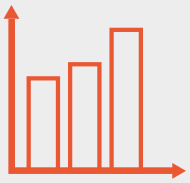
For example Finland, Sweden and Norway (in addition to New Zealand and Greece outside this region). These countries have jobs that are on average relatively less automatable and in industry sectors with relatively lower potential automation rates.

In PwC UK's study (*Will robots steal our jobs?*, 2018), the relative impact on employment shares and the rate of automatability were measured and the different country groups were laid out (Appendix – Figure 1.1) accordingly to visualise the relative impacts of automation on jobs. According to PwC UK's analysis, **AI imposes the lowest overall threat on Nordic countries and the highest on industrial economies.** The differences in labour market structures, education and government policies across the countries lead to different proportions in the share of employment across industry sectors and therefore to diverse exposure to automatability of jobs.

The waves of automation will have profound effects on the labour markets (shown in Appendix – Figure 1.2), although the percentage of jobs at risk will not be evenly shared between these waves. The **first wave**, until the mid 2020s, is expected to affect around **5-10%** of jobs on average. The **second wave** will affect around **15-20%** more jobs until the early 2030s. The **third wave** of automation is likely to have the greatest impact by having an effect on around **25-30%** of jobs.

In terms of statistical dispersion, the **divergence in percentage of jobs at risk between different country groups is expected to be the largest in the third wave** (forecasting AI effects in the mid 2030s), chiefly due to the relationship between the economic compositions of the different country groups and the maturity of the technology affecting these economies.

1.3 Macro perspective of the Hungarian economy



High-income mixed economy

High human development index

Key sectors:

- automotive (manufacturing)
- construction
- wholesale and retail trade

Hungary is defined as a **high-income mixed economy with a high human development index** and a skilled labour force (OECD), and a population of approximately 9.8 million that has come a long way since its regime change in 1989-90, introducing free trade and capitalism, and joining the EU in 2004. The country began showing promising economic results by the end of the 2010s.

Hungary is a landlocked state in the CEE region. This central geographical position has led to Hungary's emergence as a potential logistics and production hub in Europe. With EU accession, investors in Hungary became exposed to a market consisting of nearly 500 million people, resulting in the country's leading regional position in logistics and distribution in the CEE region.

During the last 20 years, Hungary has experienced average economic growth of 3.2% per year (KSH). During this period, the economy has transformed from a predominantly planned system in which most enterprises were state-owned to a market-driven system in which market forces influence resource allocation. Some of the **key sectors that have contributed significantly to the economy's growth are the automotive (manufacturing) industry, construction industry, wholesale and retail trade.**

1.4 The Hungarian labour market

In the 15-64 age group, the unemployment rate in Hungary was

3.4%

lower than the EU average in 2017, one of the lowest in the EU

In Hungary, there were around

4 million

active workers in the population aged 15-64 in 2018.

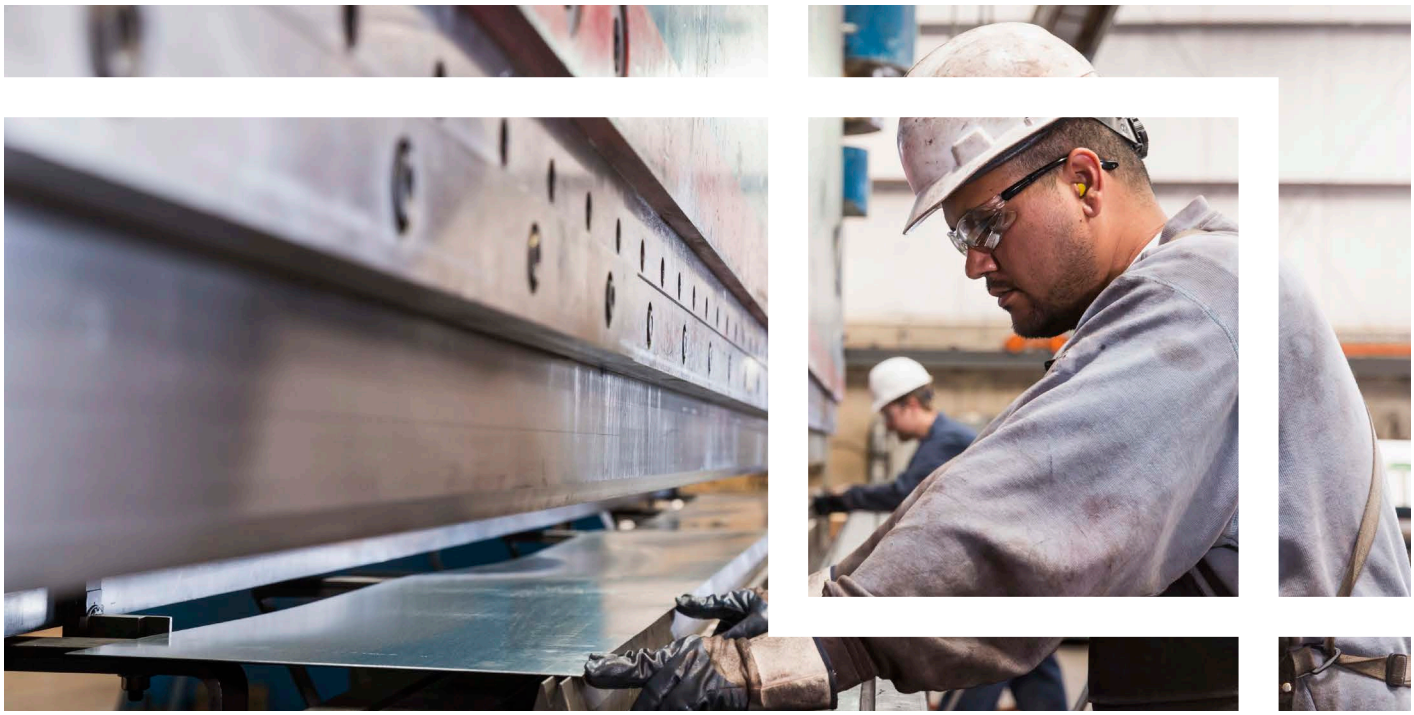
Source: KSH

In terms of workforce, the unemployment rate reached record lows of 3.6% in 2019, declining from 11% just nine years before. However, significant regional differences can be identified on the Hungarian labour market, dividing the economy geographically in two. In the regions of Budapest, and Central and Western Transdanubia, the employment rate is higher, and the unemployment rate is below the national average, whereas Southern Danubia and Northern Hungary are characterized by below average employment. Overall, the Hungarian Central Statistical Office (KSH) in 2018 reported an employment rate of 69% among the age group of 15-64 year-olds.

The unemployment rates were highest among those with primary school or lower education attainment, whereas the rates are significantly lower among the Hungarian population with college degrees (KSH). Furthermore, the unemployment indicators for men have fallen to a greater extent compared to women. In the 15-64 age group, the unemployment rate in Hungary was 3.4% lower than the EU average in 2017, one of the lowest in the EU.

Correspondingly, the employment rates are above the EU-standards of the highest educational attainment not only for college graduates, but for secondary school graduates as well.

In Hungary, there were around 4 million active workers in the population aged 15-64 in 2018. However, a large number of these registered employees are employed through the Hungarian public works scheme. It is debatable whether the approximately 200,000 people employed through public works, which accounts for 5% of the total Hungarian labor market (*KSH, 2016*), can be counted as active workers. The public works scheme aims to provide employment for those at the periphery of the labour market, and has for long been criticised for its inefficiency and not reintegrating people into the primary labour market (*European Commision, ESPN Flash Report* 2017/42). Although 5% of the total labour market is a large number of people that may not qualify as primary employees, they will not be excluded from the analysis, as these groups are included in official statistics.



2 Industry analysis

Key outcomes

Potential automation risk varies widely across industries and, based on technical feasibility, it is further predicted to unfold in three separate waves. Each industry's share of employment was therefore multiplied by the relevant automation wave.

Based on the benchmark, the estimated share of existing jobs in Hungary that could potentially be automated:
in the algorithm wave is **3%**,
in the augmentation wave **23%**,
and **40%** in the autonomy wave.

Over 900,000 jobs, one quarters of total will be at high risk of automation by the mid-2030s,
where almost half of these potential job losses are in two key industry sectors: manufacturing and wholesale and retail.

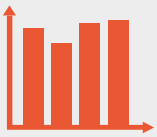
In the algorithm wave, by 2020, in
data driven industries
such as financial services, information and communication
3% of employees will be affected by automation

In the augmentation wave, by 2025, in sectors with
higher clerical support, 23% of employees
will be affected by automation. Industries such as wholesale and retail trade (108,000), public administration (96,000), administrative and support service (30,000) will be at high risk of automation.

In the autonomy wave, by the 2030s, in industries with a
greater proportion of manual and routine work 40% of employees
will be affected by automation, the highest rate. The highest share of existing jobs that could potentially be automated are in manufacturing (385,000), transportation (108,000) and construction (107,000).

Most of Hungary's employees work in **manufacturing** (965,000), **wholesale** and **retail trade** (477,000)

2.1. Potential rates of job automation



We have compared the current industry composition of Hungary within the benchmarking group.

In comparison with the benchmark countries (Hungary, Slovakia, Slovenia, Lithuania, Czechia, Poand) Hungary will be hit by automation slightly less in each wave, apart from Poland.

Industrial countries are characterised by a greater proportion of manual or routine work that is typically more susceptible to automation in the long term.

As it was stated in the first chapter, the risk levels of AI impact in different countries is based on distinctions in the labour market structure and government policies. Therefore, the key factors reflecting the overall estimation of automation rates are: first, the share of employment across industry sectors, and second, the relative automatability of jobs in different sectors.

Furthermore, the differing automation risk across industries is predicted to unfold in the three separate waves. Due to similar characteristics that some industries have in common (e.g. data-driven types, greater clerical support, manual and repetitive work routine, etc.), were summed up into predicted automation waves (Appendix – Table 2.1).

In order to analyse the effect of automation on the Hungarian labour market, we have compared the current industry composition of Hungary within the benchmarking group. These countries are believed to have a very high potential for similar automation development in the future. The result is that the industries affected by automation on the labour market in Hungary will be automated in the first wave by 3%, by 23% in the second wave and by 40% in the third wave. **In comparison with the benchmark countries, Hungary will be hit by automation slightly less in each wave, apart from Poland.** The reason is the difference in technical development levels.

We set out estimates of how the proportion of jobs at risk of automation in Hungary and benchmark countries might evolve over the three waves. (Appendix – Figure 2.1)

Industrial countries are characterised by a greater proportion of manual or routine work that is typically more susceptible to automation in the long term. Therefore, in the short run these economies have a relatively low exposure to automation and vice versa, higher exposure in the long run. Industries such as manufacturing, transportation and construction are at potential high risk of automation in the autonomy wave. With AI effect on these industries, it is estimated that the automation level in these industries will reach up to 40% in Hungary by the mid-2030s.

On the other hand, data-driven industries will be affected much sooner; already at the beginning of the 2020s. These industries constitute only 7% of the Hungarian labour market - financial and insurance, information and communication and professional, scientific and technical services (see Appendix – Table 2.1 for more detail). Therefore, we calculated the automation rate will be only 3% in the first wave. On the contrary, the more developed a country's technology level is, the higher its exposure to the automation wave. Workers in these sectors typically spend a disproportionately larger amount of their time engaged in simple computational tasks. Therefore, employees could be more exposed as algorithms outperform humans in an ever-wider range of tasks involving pure data analysis.

A higher rate of automation will be seen in the second augmentation wave by 2025. In addition to the initial three industries, which will continue to be highly impacted, also sectors involving greater clerical support will be automated – the public sector and administration, manufacturing and transport and storage.

It is important to note, that there is a huge difference when it comes to AI's impact – between the size of the company and its global or local presence. Small companies, huge corporations or start-ups have different corporate cultures, internal systems, and development pace; they even consist of different age groups and mainly, the relationship towards their employees differs significantly. All these factors affect how fast the company will be able to adjust to AI's impact. Also, job requirements differ, from both the employee's and the employer's point of view. Nowadays, advanced technology level, corporate culture, benefits and interesting projects are preferred in younger groups, but they are being offered by both startups and global companies. On the other hand, older local companies in Hungary, which are less developed, are rather old-fashioned when it comes to their demands.

Specifically, Hungary has a huge employment share in shared services. This sector requires a lot of clerical and basic computational skills, which is an advantage for Hungary in an early wave of automation. Employees of all affected industries have the relevant skills mainly when it comes to language and education, which makes the adaptation to the technology much easier.

2.2 Industrial economies as the benchmark for Hungary

Visegrad countries, together with Lithuania and Slovenia, belong to so-called industrial economies

In all of these countries the manufacturing industry dominates, employing an average of about 26% of their labour force

As it was stated in chapter 1, **Visegrad countries, together with Lithuania and Slovenia, belong to so-called industrial economies.** These countries are grouped together due to having similar levels of potential automation. This level is determined by their labour market structure. **In all of these countries the manufacturing industry dominates, employing an average of about 26% of their labour force.**

2.3 Sectors affected by automation

Three main industries employ almost 50% of the labour market

1 million were employed in manufacturing alone

Over 900,000 jobs – 23% of the 4 million employed people – could potentially be at high risk of automation by the 2030s

Broken down by industry, over one third of these impacts are in the key industry sector: manufacturing

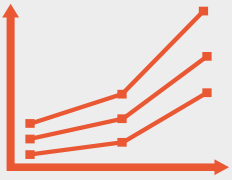
In 2018, there were over **4 million employed people in Hungary. The three main industries employ almost 50% of the labour market, and nearly 1 million were employed in manufacturing alone.** The second leading industry was wholesale and retail trade with 12%, third was public administration and defence with 11%, followed by education with 8.4% and human health and social work activities with 7.1%. A very low percentage - only 7% - is employed in IT and financial services.

If, for the sake of illustration, we apply our estimates (Appendix – Figure 2.1) to the current number of jobs in Hungary, then **we might conclude that over 900,000 jobs could potentially be at high risk of automation by the 2030s. Broken down by industry, over one third of these potential job losses are in the key industry sector: manufacturing** (Appendix – Table 2.2).

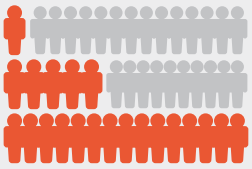
The employment share of a particular industry was taken and multiplied by the anticipated automation rate for each wave in order to reach the number of jobs at high risk of automation.

2.4 Sectors at high risk in the different automation waves

Potential job losses by sector is driven by two main components: the proportion of jobs in a sector we estimate to have potential high risk of automation, and the employment share of that sector



Each industry has a different automation rate in each wave



45,400 in the first wave; 234,600 in the second wave and 642,200 will be affected in the third wave

The magnitude of potential job losses by sector is driven by two main components: the proportion of jobs in a sector we estimate to have potential high risk of automation, and the employment share of that sector (Appendix – Figure 2.2). Each industry will be affected by automation at a different automation rate in each wave, which leads to a cumulated estimated result of 922,000 or 23% of the total amount of jobs that will be at high risk of potential automation by 2030s.

Where only 45,400 jobs in industries such as education (11,200), human health and social work (9,500), accommodation and food service (5,500) and agriculture (4,800) will be automated in the algorithm wave in then 2020s.

The augmentation wave will affect 234,600 jobs in by 2025. Mainly in wholesale and retail trade (108,400), public administration (96,300) and administrative and support services (29,900). And the highest proportion of jobs – 642,200 – will be affected in the autonomy wave in the 2030s. The industry sector that we estimate could face the highest potential impact of job automation is manufacturing (384,500), transportation and storage (107,900) and construction (106,600). Where all three sectors account for around 37% of total Hungarian jobs, or almost 65% of all potential job losses across Hungary.

In order to facilitate the transition into automation jobs, education should be changed on a system level, which require precise preparation. In order to react quickly to new technologies, adaptability skills should be taught. Furthermore, students of the 21st century need appropriate social skills in order to succeed in the labour market. Such skills would be information literacy, communication, teamwork, collaboration with technology and creating automations. These skills can be acquired in primary and secondary education through project-based learning. Also, more focus on STEM subjects (science, technology, engineering and mathematics) would be crucial. Lastly, vocational education, which is constantly updated over their working lives should get a more important role in order to always stay one step ahead of the technological revolution.

3 Occupations

Key outcomes

As Hungary is an industrial economy,

craft workers are the most affected

by automation of the occupational categories.

By the mid-2030s, more than

195,000 people

could face a risk of automation in this category, which amounts to 30% of this occupation segment.

In the augmentation wave,

by 2025, professionals, technicians and service and sales workers will be the most affected,

occupations responsible for almost 61% of the affected jobs during the augmentation wave. Potentially, there will be 47,400 professionals, 39,800 technicians and 55,700 service and sales workers affected by AI during the augmentation wave by 2025.

In the algorithm wave,

by the early 2020s, professionals and technicians will be the most affected occupations,

therefore this should be the focus in the short run. Potentially there will be 12,700 professionals and 8,900 technicians affected by AI by the early 2020s.

In the autonomy way,

by the mid-2030s, more than 149,000 machine operators will potentially face the same challenge,

which is more than one quarter of the jobs in this occupation segment. This is an area in which to focus education or re-training.

Employment in the

manufacturing industry is highly overrepresented

in these occupation segments. The

transportation industry

is highly represented in the craft worker segment. Meanwhile in the segment of machine operators, a high proportion of employees work in the retail and supply chain industries.

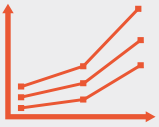
3.1 Occupation analysis

Majority is working as
technicians and
associate professionals, professionals, machine operators, assemblers

Economy is heavily dependent on manufacturing, mainly in the
automotive industry
machine operators are overrepresented

From a **total of 4,004,000 employed people** in Hungary, the **majority is working as technicians and associate professionals** (16.4% of the total employment), 15% are **professionals** and 16% are **machine operators** and **assemblers.** Hungary's **economy is heavily dependent on manufacturing, mainly in the automotive industry, where machine operators are overrepresented.** The lowest ratio of occupations in Hungary is clerical workers (7.8%), senior officials and managers (4.2%) and skilled agricultural workers (1.7%).

3.2 Potential rates of automation risk across occupational categories



Early stage: employees of data-driven industries with simple algorithmic computing are expected to be affected

Mid run: professionals, technicians and service and sales workers will be the most affected

Long run: Craft workers and machine operators will receive the highest impact

The least affected occupations at the early stages are
senior officials and skilled agricultural workers
due to low number of employees in these sectors and the difficult automation factor of their job.

Craft- and related trade-workers
are the most affected by automation of the occupational categories, more than 209,000.
Risk of automation in this category which is more than
38%

Among machine operators,
more than 168,000 people will potentially face the same challenge, which accounts for
26% of the current employment in this segment

Potential automation risk differs significantly not only across industries but also across occupational categories. **Craft- and related trade-workers are the most affected by automation of the occupational categories, more than 209,000** people could face a **risk of automation in this category which is more than 38%** of total Hungarian employment in this occupation segment. For these workers, the tasks conducted are primarily manual and routine tasks, which account for approximately two-thirds of their work activity. This concentration of labour into this particular set of tasks makes their work more **automatable especially in the long run.**

Regarding machine operators, more than 168,000 people will potentially face the same challenge, which accounts for 26% of the current employment in this segment. Clerical workers, likewise, could face much higher automation rates in the Algorithm and Augmentation waves than the most automatable industries in that period (financial and insurance, information and communication sectors). Clerical workers inherently carry out work that is most characteristic of the Augmentation wave – routine processes, simpler computational tasks and exchanging information.

The least affected categories are senior officials and skilled agricultural workers. This is due to two main reasons: (1) people employed in these occupations are significantly less in quantity than in other occupations and (2) their jobs have a task composition which is more difficult to automate.

As pointed out in the industry chapter, manufacturing, retail, construction, transport and public administration are potentially the most affected industries. By occupation, craft and trade workers and machine operators are the most affected segments in which the employment in manufacturing industry is highly overrepresented. In the craft worker segment, the transportation industry is highly represented, meanwhile in the machine operators segment a high proportion of employees work in the retail and transport and storage industry. The professional segment, which is the third occupation potentially affected by AI, mainly consists of manufacturing, public administration and transportation. Professionals are more likely to be engaged in tasks using their social skills, literacy skills and more complex computational tasks that are less automatable. They also tend to be relatively highly educated, which will help them adapt to new waves of technology, so machines would remain complementary to them, rather than replacing them. The nature of their work may change significantly over time (as it did previously with the advent of personal computers and later the internet), but they are less likely to find themselves displaced entirely by autonomous machines than a driver, factory worker or clerical worker.

AI will impact Hungarian various occupations in very different ways and time frames. Hence, in Appendix – Figure 3.1 we show the main occupational categories and Appendix – Table 3.1 shows AI's effect on them based on the waves and different occupation types.

In the early 2020s, defined by the algorithm wave, employees of data-driven industries with simple algorithmic computing are expected to be affected. Mainly clerical jobs and business support functions are going to change.

In the augmentation wave, by 2025, from the 234,600 jobs at high risk of automation, professionals, technicians and service and sales workers will be the most affected occupations as these are responsible for almost 61% of the jobs being affected in this wave.

Finally, by the mid-2030s, the autonomy wave will have the highest impact in general, being responsible for almost 70% of the jobs which will have a late reaction with AI will be affected. Craft workers and machine operators will receive the highest impact. Estimates show that 195,000 craft workers and 149,000 machine operators will be potentially affected, therefore the long term strategy should be to focus on these occupations in terms of education and re-training.

To summarize the occupation chapter, automation in Hungary will likely have the most impact on craft workers and machine operators, and that will happen in the early 2030s. The most obvious implication of our analysis, which applies to all waves, is the need for increased investment in education and skills to help people adapt to technological changes throughout their careers. While increased training in digital skills and STEM subjects is one important element in this, it will also require retraining of, for example, truck drivers, to take jobs in the services sectors where demand is high and automation will affect less due to the importance of social skills and 'the human touch'.

4 Type of workers

Key outcomes

The **core age group (25-54)** is overrepresented in all industry sectors, therefore these employees **will be significantly impacted by AI** throughout the three waves. The difference in the share of jobs with potential high risk of automation relates to educational level, task composition, required skills and the automation rate of the industry.

Males with medium- and low-level education face the highest long-term risk of automation.

Regardless of gender and age, **highly educated employees are least impacted** due to their skills and flexibility at their current workplace or move around different occupations and industries.

Despite the high risk facing the **younger generation of female employees (15-24)** in the short run – especially in data-driven sectors like financial and insurance services – they are well positioned to capitalise on the new opportunities from digital technologies if they acquire relevant training.

Due to the share of employees by gender across industries, **women can be impacted more heavily at first,** with an increased potential rate of automation in the algorithm and augmentation waves. The pace of change will not impact the different genders at the same time, but

4.1 Type of workers

Workers aged 15-24 are likely to be employed in occupations such as service, sales or clerical work

High proportion of employees between 55-64 are machine operators and assemblers and craft and related trades workers

80% of senior officials and professionals are from the core age group (25-54)

Different types of workers will be impacted by automation at different paces and rates. Our analysis highlights the groups of workers by gender, age and education level who face high potential risk of automation across the three waves.

In Hungary, 94% of employees are shared across 13 industries, while 6% is employed in sectors such as real estate activities; mining and quarrying; arts, entertainment and recreation. The latter shows lower contribution to the labour market, which is why we have chosen to focus on the main industries by employment share.

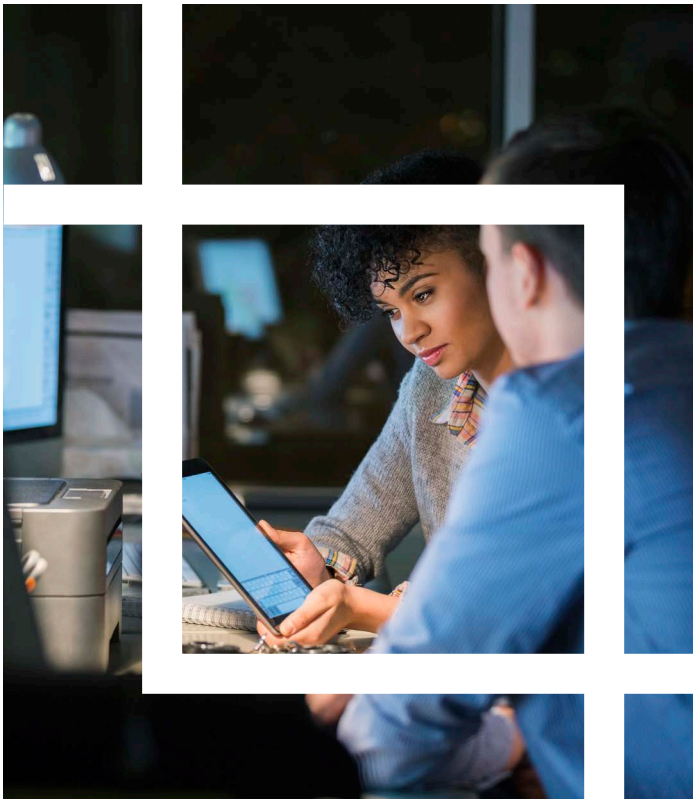
The employment share by age groups clearly reflects the characteristics of an ageing population. As Appendix – Figure 4.1 shows, the younger workers (15-24) are fairly equally shared in low proportion across industries. Core workers (25-54) represent more than 50% of the total employees in each of the 13 leading industries, and **a significant difference can be seen in the agriculture, forestry and fishing sector where the older generation (55-64) represents almost 25% of total employees.** This fact can be attributed to the traditional feature of agricultural economies, limited job opportunities in rural areas of Hungary and the required low educational level in this industry.

The different types of industries and occupational categories cannot be separated from each other. If we analyse the labour market in terms of age groups across occupational categories, it can be seen that middle-aged workers (25-54) are highly represented in all occupational categories. **Workers aged 15-24 are likely to be employed in occupations such as service, sales or clerical work,** where several years of professional experience or completed higher education are not required.

A **high proportion of employees between 55-64** are represented in occupational categories such as **machine operators and assemblers** (16%), **elementary occupations** (19%) and **craft and related trades workers** (16%). This is mostly explained by the fact that this age group is more likely to fulfil the requirement of low or medium-level education, therefore they are more likely to be employed in these occupations.

Almost **80% of senior officials and professionals are from the core age group (25-54)** which is attributed to **high education levels and the relevant experience gained** in the specific sectors.

The main industries where male workers are over-represented are manufacturing (64%), **transportation and storage** (75%), **construction** (92%) and **agriculture, forestry** (76%). Female workers are more likely to be employed in sectors such as **human health and social work activities** (80%), **education** (77%) and **financial and insurance activities** (80%).



4.2 Potential rates of automation risk across age groups

Core age group (25-54) will be mostly affected by AI

In the short term, automation will hit middle-aged females

In the long term, low educated middle-aged males will be affected the most

Automation risk depends on educational level, task composition, required skills and the automation rate of the industry.

As Appendix - Figure 4.2 shows, the **core age group (25-54) is highly affected by automation in** all occupational categories, but significantly amongst **machine operators** (75%), **clerical workers** (78%) and **service and sales workers** (80%).

Male employees aged 25-54 with medium-level education create the base workforce in manufacturing, wholesale and retail trade, construction and transportation as machine operators, craft and related trades workers. **In the short term, automation will hit those sectors heavily in which middle-aged females are overrepresented.** These two factors together account for workers aged 25-54 being impacted in the highest proportion in all occupational categories.

Female employees of older generation (65-74) are highly represented in manufacturing and public administration, while older male workers are likely to be employed in agriculture. The share of the youngest generation (15-24) does not show any significant difference either across industries or occupations, therefore this group of workers will not be affected by AI as excessively as the others.

The starkest results are those by education level, with **much lower potential automation rates on average for highly educated workers with graduate degrees or above, than for those with low-to medium-level education.** This reflects the greater adaptability of more highly educated workers to technological changes and the fact that they are more likely to be in senior managerial roles that will still be needed to apply human judgement, as well as to design and supervise AI-based systems. Such workers could even see their wages increase due to the productivity gains that these new technologies should bring.

Differences are less marked by age group, although some older workers could find it relatively harder to adapt and retrain than younger workers. This may apply particularly to men with lower-level education as we move into our third wave of autonomous automation in areas like driverless cars and other manual labour that has a relatively high proportion of male workers at present. But **female workers could be hit relatively harder in early waves of automation that affect i.e. clerical roles.**

Hungary is one of the most mature SSC (Shared Service Centre) markets in Central and Eastern Europe. These markets are represented by a large share of low added-value jobs. The biggest share of workers employed in the business support functions are people under the age of 30. These young employees have the motivation and all the relevant skills to adapt to new technologies and follow the path of continuous development and self-improvement.

Language skills and satisfactory educational level amongst employees in this group makes the young generation more adaptable to changes. There is reason to believe that they will be more flexible regarding jobs in the future. Despite the high risk (37%) facing the younger generation of female employees (15-24) in the short run - especially in the data-driven sectors like financial and insurance services -, they are well positioned to capitalise on new opportunities from digital technologies if they acquire relevant training.

The older generation (55-75) on the other hand might be at greater risk because they are not that easily adaptable. Continuous training and application of new technologies are usually not involved in their working culture. Moreover, their attitude to changes and learning are in general more negative compared to younger workers.

4.3. Potential job automation risk across gender

Women

can be impacted more heavily in the

Algorithm and Augmentation waves.

Their jobs involve computational tasks and analysis of structured data, repeatable tasks such as filling in forms, communicating and exchanging information through technological support

Men

will be affected by automation heavier in the

third – Autonomy – wave

that focuses on the automation of physical labour and dexterity. Mainly affected categories: machine operators, assembly workers, and drivers of vehicles

In the leading Hungarian industries, different types of workers face different levels of risk. 64% of male and 36% of female workers are expected to be at the greatest automation risk in the manufacturing industry. In sectors like construction (92%) and transportation (75%), a significant proportion of male employees will be affected by AI. In contrast, female workers are impacted by successive automation waves in industries such as public administration (53%) and wholesale (58%). (Appendix – Figure 4.3)

Employment share by gender will be reflected across occupations affected by AI as well.

In occupational categories like machine operators and assembly workers (male: 55%, female: 45%) and craft and skilled agricultural and fishery workers (male: 60%, female: 40%) men are employed at a higher ratio than women, therefore their jobs will be at higher risk in the autonomy wave, where the relevant industries such as manufacturing might be impacted by automation. (Appendix – Figure 4.4)

Women are more likely to be employed in occupational categories which require soft skills and higher educational attainment such as office and management occupations, technicians, associate professionals and professionals. These occupational categories are highly represented in financial and insurance sectors which will be most relevant in the algorithm and augmentation waves in terms of automation.

Due to the share of employees by gender across industries, the pace of change will not impact the different genders at the same time. By 2020, thanks to emerging technology and algorithmic methods in the data driven sectors like finance, information and communication, many tasks will be completed by software packages and machine learning activities to enhance data analysis and customer service.

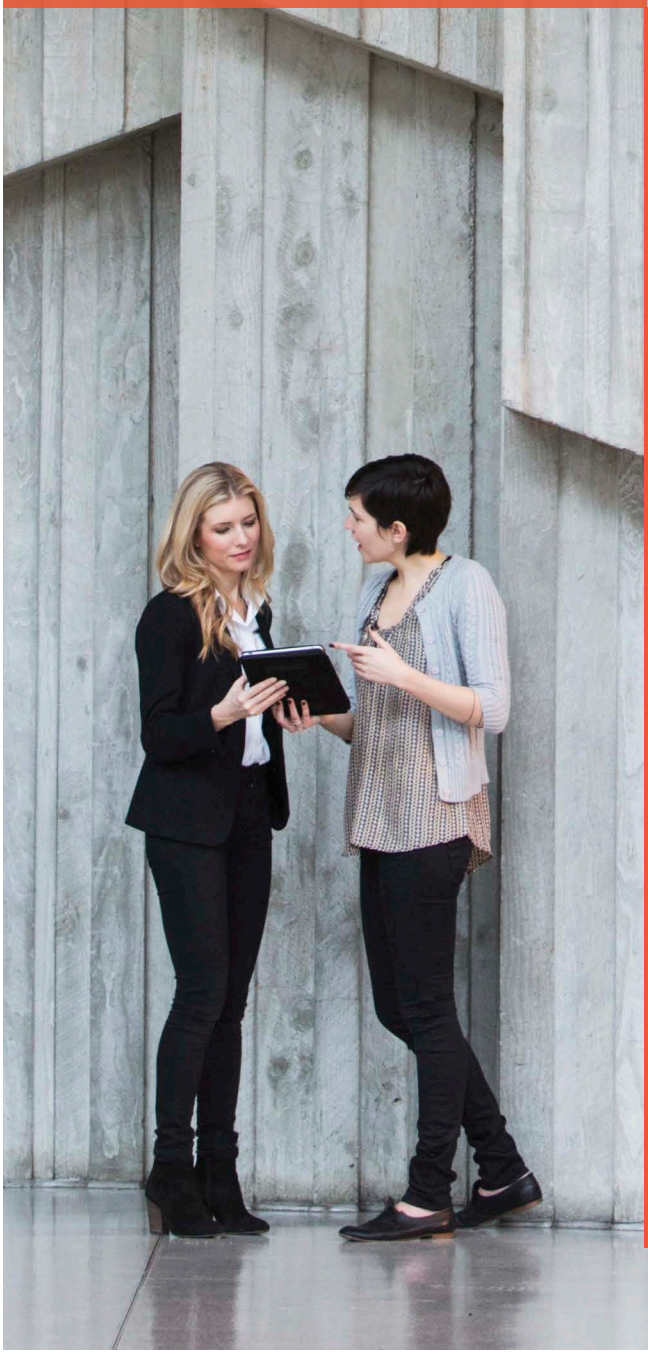
As a result, during the first two waves, women might be more affected by automation, but in the long term male workers could face higher risk (male: 20% vs. female: 10%). In the third wave, the highly automatable sectors like manufacturing, transportation and construction where the male workers are more likely to be employed, are expected to be impacted in higher ratio.

However, human workforce cannot be displaced entirely by autonomous vehicles and robots, but tasks that involve physical labour or manual dexterity will be automated to a large extent.

Women can be impacted more heavily at first, with an increased potential rate of automation in the Algorithm (male: 39% vs. female: 61%) and Augmentation (male: 46% vs. female: 54%) waves. (Appendix – Figure 4.5) Office and management occupations involve many computational tasks and analysis of structured data, repeatable tasks such as filling in forms, communicating and exchanging information through technological support. In the algorithm and augmentation wave, these tasks can be substituted with automation.

Men will be affected by automation heavier in the Autonomy wave (male: 62% vs female: 38%) that focuses on the automation of physical labour and dexterity. Occupational categories which are affected most in the third wave are machine operators, assembly workers, and drivers of vehicles and industry occupations where male workers are in a higher proportion.

5 Conclusion



Key outcomes

Employer's
retraining program
are key for
older generation's
adaptability

Younger generations will be able to adapt quickly
because of sufficient level of the soft skills needed

New generation employees need to be
educated on information literacy, communication and teamwork
in primary and secondary education by project-based learning

In the final chapter, we introduce the main results according to the three different waves (Appendix – Table 5.1) and recommendations to stakeholders for how to cope with the changes that follow from AI. Our findings on potential job automation across industry, occupation and types of workers are based on Hungary-related data gathered from official publicly available sources and benchmark data from Hungary's peer countries.

Additionally, we conducted interviews with representatives of different stakeholders in order to validate the initial findings of our research. In terms of economic sectors covered, we put emphasis on reaching out to numerous industries when interviewing stakeholders (e.g. engineering, IT, financial services and education). The different viewpoints on the issues of AI effects on the labor market serve as key qualitative inputs to our research.

In the algorithm wave, by the early 2020s, data-driven industries with a high amount of simple computational tasks will be affected such as financial services, information and communication. Considering Hungary belongs to one of the most mature SSC markets in the CEE region, a big share of workers are employed in these industries.

However, **it is advantageous from the Hungarian perspective that young workers under 30 are employed in positions that are expected to be affected by the first (algorithm) wave.** These employees have the **language skills, information literacy** and a higher rate of general ability **to adapt to new technologies** than older groups. Therefore, Hungary could benefit from this enormously. Apart from retraining employees in order to avoid job dismissals, companies should focus on finding new positions related to the new technological environment for affected people. New positions would enable employees to focus more on complex problem solving tasks in which they can have higher added value. Needless to say, motivation to adapt to AI is indispensable to both parties.

In the augmentation wave, by 2025, sectors with higher clerical support will be affected by automation, hence companies should continue focusing on re-training their employees. As the potential job automation effect is much higher in this wave, the government has a key role in supporting job creation through investments in segments that are beneficial in the longer term productivity of the economy, but should also help to create jobs that cannot be fully automated for instance infrastructure (transport, roads etc.) and housing.

In the autonomy wave, by the 2030s, industries with a greater proportion of manual and routine work will be affected by automation. As Hungary is an industrial economy, craft and related trades workers are the most affected by automation in the occupational categories. Being the most challenging wave in terms of potential job automation effect, there is a need for more radical changes by the early 2030s. Education must change on a system level, which require precise preparation. In order to react quickly to new technologies, students should be educated to attain adaptability skills. Furthermore, **new generation employees need appropriate social skills** in order to succeed in the labour market. Such skills would be **information literacy, communication and teamwork.** These skills can be acquired in **primary and secondary education by project-based learning.** Also, more focus on STEM subjects (science, technology, engineering and mathematics) would be crucial. Lastly, vocational education, which is constantly updated over their working lives should get a more important role in order to always stay one step ahead of the technological revolution.

The most obvious implication of our analysis, which applies to all waves, is the **need for increased investment in education and skills to help people adapt to technological change throughout their careers.** While increased training in digital skills and STEM subjects is one important element in this, it will also require retraining of, for example, truck drivers to take jobs in services sectors where demand is high but automation is less easy due to the importance of social skills and 'the human touch'.

Governments, business, trade unions and other organisations, all need to play their part here in helping people to adapt to these new technologies. This will include training and **retraining people in softer skills, such as creativity, communication, problem solving and flexibility.** On-the-job training will be important here, for example through degree apprenticeships that offer a mix of theoretical study and practical experience, and that are open to a wide range of people (including mature students) to promote social mobility. Furthermore, the importance of teachers cannot be emphasized enough. The teachers build the foundations of young children's knowledge and curiosity, and without proper training of teachers, the youngsters are likely to miss out on the rapid changes affecting the labour market.

Businesses also need to consider how successive waves of AI-related technologies might further break down barriers to entry in their sector and challenge existing business models. In addition to enhancing existing propositions, it also allows businesses to offer the same proposition in a more cost effective way, which may be particularly beneficial for small-to medium-sized businesses and start-ups. This will also create new opportunities for successful businesses to leverage their distinctive competencies in adjacent sectors. Given the fast pace of change, businesses need to be constantly experimenting with new technologies and creating options that they can scale up quickly where successful.

Individuals also need to be more entrepreneurial, taking responsibility for their lifelong learning and seeking to generate their own intellectual property and start new businesses. Much of the automation of the future may be driven by these new businesses replacing or challenging established companies that find it harder to change.

In conclusion, Hungary has the opportunity to boost the Hungarian economy's growth with AI both on government and company levels. The Hungarian economy can benefit from AI as it can improve its productivity and can be a potential solution for the labour market shortage in some segments. In the long run the net effect should be positive for the Hungarian economy, but preparation for the adaptation of the new technology and potential solutions for the job automation threat are essential for this to happen.

6 Annex – technical methodology

The methodology used in this study builds on previous research by Frey and Osborne (2013), Arntz, Gregory and Zierahn (2016) and our previous research on this topic in PwC's UK Economic Outlook (March 2017).

In the original study by Frey and Osborne (hereafter 'FO') a list of 702 US occupations taken from O*NET, an online service developed for the US Department of Labor, were hand-labelled by machine learning experts at Oxford University as strictly automatable or not automatable. Using a standardised set of features of an occupation, FO were then able to use a machine learning algorithm to generate a 'probability of computerisation' across US jobs, but crucially they generated only one prediction per occupation.

Using the same outputs from the FO study, Arntz, Gregory and Zierahn (hereafter 'AGZ') conducted their analyses on the OECD Programme for the International Assessment of Adult Competencies ('PIAAC') database, which includes more detailed data on the characteristics of both particular jobs and the individuals doing them than was available to FO. This allows a critical distinction that it is not whole occupations that will be replaced by computers, algorithms and robots, but only particular tasks that are conducted as part of that occupation. Furthermore, this allows for the fact that the same occupation may be more or less susceptible to automation in different workplaces.

The PwC automation rate algorithm developed in our earlier study (PwC, March 2017) involved first taking the labels from the FO study and replicating the methodology from the AGZ study using the PIAAC dataset. The methodology was then enhanced using additional data and a refined automation-rate prediction algorithm. This model was initially trained on PIAAC data for the UK, US, Germany and Japan, but then extended to over 200,000 workers across 29 countries in the present study. This much larger sample size gives increased confidence in our estimates of the relative automatability of jobs in different industry sectors and across different types of workers (e.g. by age, gender or education level).

Unfortunately, Hungary had not been included in the PIAAC research, and therefore we have based our study on benchmarking with the most similar countries. Mainly V4 countries, including Lithuania and Slovenia. The strategy lies on the assumption that countries with a similar industry structure will also develop identically in the future.

As a further extension in the present study, the initial set of labels, seeded from the study by FO, were simulated across a range of scenarios that varied the automation-rate estimates associated with both tasks and occupations. Feedback from computable general equilibrium (CGE) modelling of the economic impact of AI40 then allowed predictions for the potential jobs at high risk of automation to vary over a projected time-frame from 2018-2037. This formed the basis for the analysis of automation waves over time in the present study. However, it should be emphasised that this is only intended to give a broad indication of how automation might roll out across economies over time; our results should not be interpreted as precise point estimates for particular future years.

7 Appendix

1. Introduction

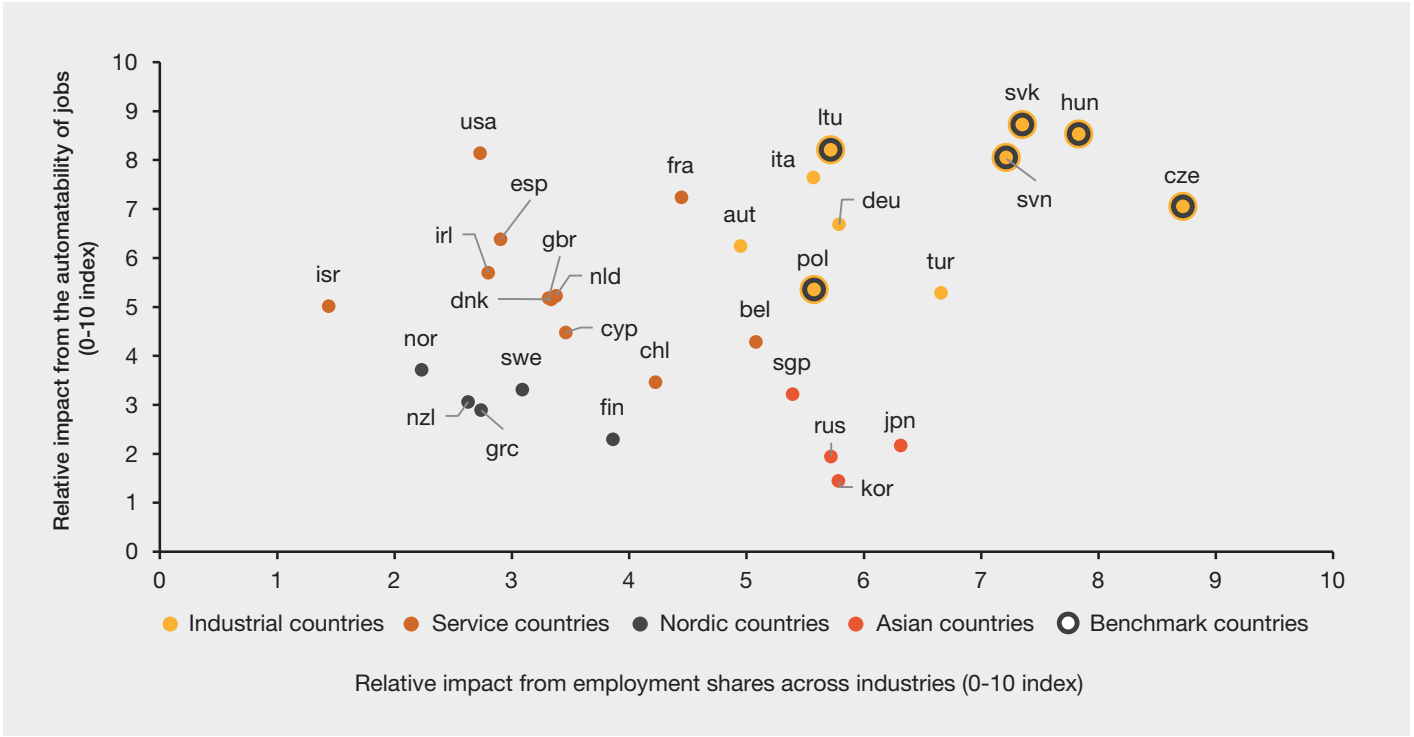
The countries used for benchmarking are the remaining of the four Visegrad countries; Slovakia, Czech Republic and Poland. Additionally, Lithuania and Slovenia will be added as benchmarks when applicable. These countries are all a part of the industrial economies group and are to a large extent similar to Hungary according to certain characteristics such as population, GDP/capita, industry compositions, public spending on education, unemployment rate and share of jobs affected by automation. These are characteristics we perceive as most relevant when determining the share of jobs affected by automation in the long run.

TABLE 1.1 – Comparison of macroeconomic factors of benchmarking countries

Country	Population (M) (2017)	GDP/capita ($/year) (2017)	Most important industries	Public spending on education (2014)	Unemployment rate 2019 (%)	Share of jobs affected by automation (%)
Hungary	9.78	14 225	Automotive, Electronics, Pharma	4.63%	3.6%	n.a
Slovakia	5.43	17 605	Automotive, Electrical Machinery, Machinery (including computers)	4.22%	5.2%	44%
Czech Republic	10.58	20 368	Automotive, Mining, Chemicals	3.99%	3.2%	40%
Poland	37.97	13 811	Agriculture, Energy, Manufacturing (Automotive)	4.91%	6.1%	32%
Lithuania	2.84	16 680	Oil Refinement, Manufacturing, Food export	4.48%	9.2%	42%
Slovenia	2.07	23 597	Mining, Manufacturing, Electricity	5.29%	8.6%	43%

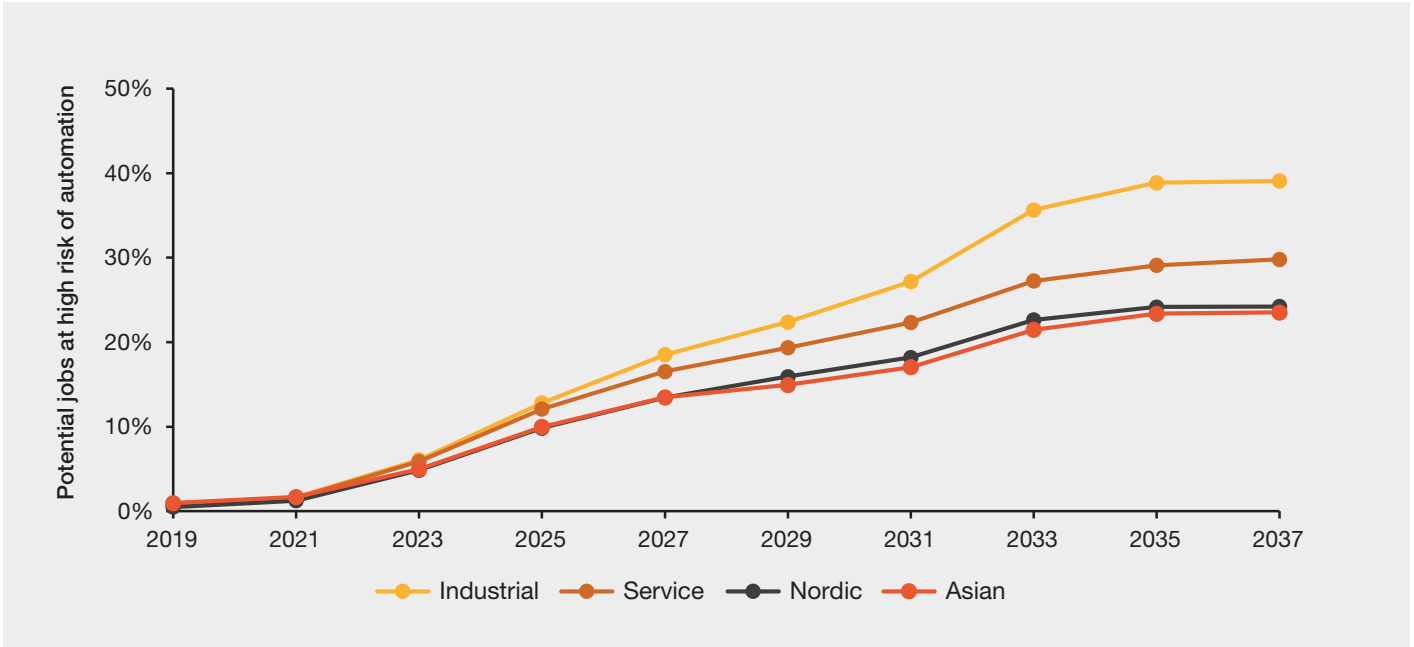
Source: OECD data

FIGURE 1.1 – Relative impact across countries by employment shares and automatability of jobs



Source: PIAAC data, PwC analysis

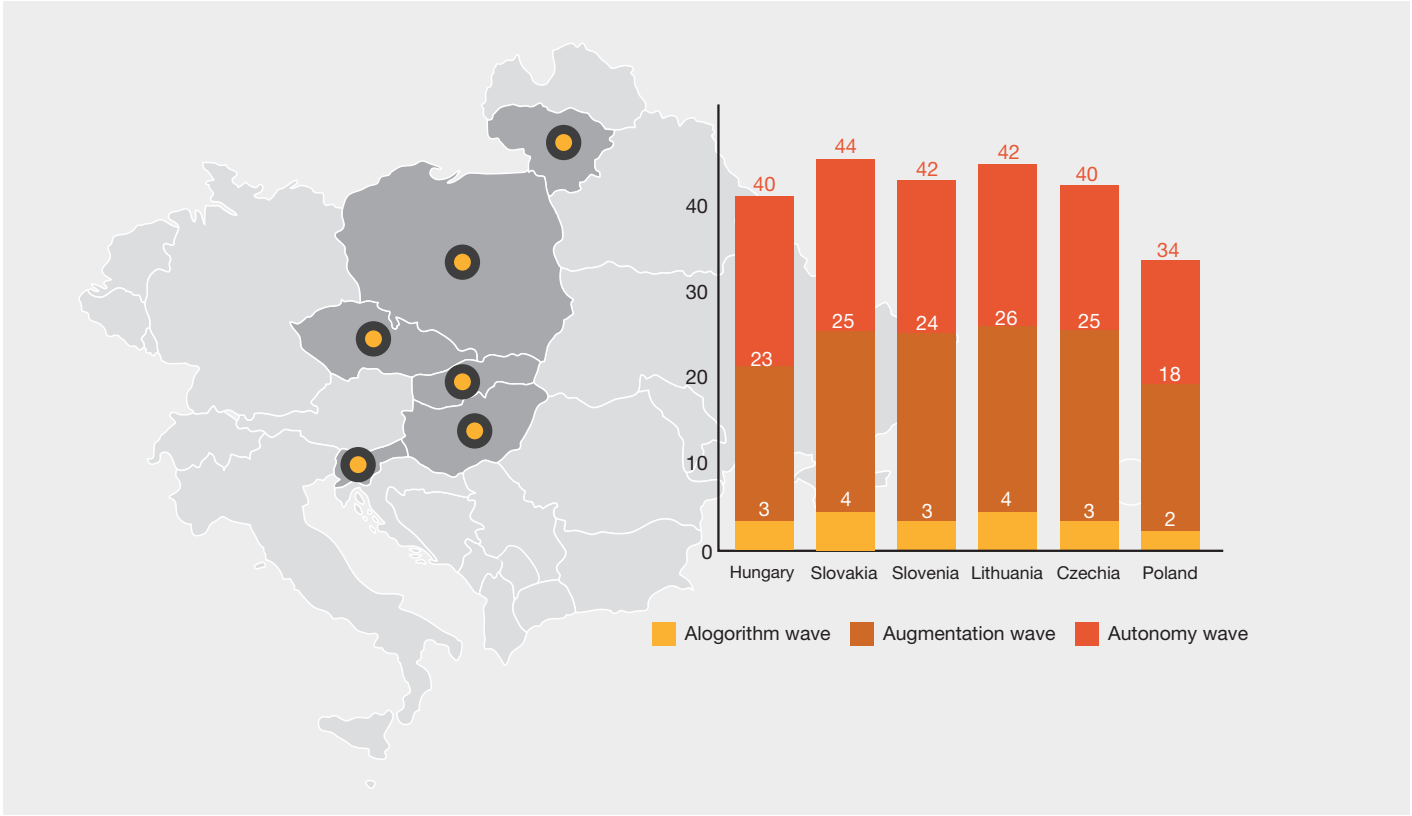
FIGURE 1.2 – Potential impact of job automation over-time across the four country groups



Source: PIAAC data, PwC analysis

2. Industry analysis

FIGURE 2.1 – Estimated share of jobs at potential high risk of automation across countries for each of the three waves



Source: PIAAC data, PwC analysis

Note: Figures shown are cumulative so those on the highest level include the estimated impacts from all three waves of automation.

TABLE 2.1 – Employment share by industry types

Economic activities by NACE Rev.2	Hungary	Slovakia	Slovenia	Lithuania	Czechia	Poland
Manufacturing	24.09%	27.12%	27.86%	16.86%	31.22%	24.64%
Wholesale and retail trade	11.91%	11.36%	12.36%	17.36%	10.98%	14.51%
Public administration and defence	10.58%	10.46%	7.27%	7.00%	7.88%	8.38%
Education	8.36%	8.35%	9.96%	11.49%	7.47%	9.06%
Human health and social work	7.14%	7.13%	8.03%	7.79%	8.09%	6.81%
Transportation and storage	6.76%	6.76%	5.13%	8.29%	6.92%	6.63%
Construction	6.68%	6.44%	5.17%	7.00%	5.30%	6.96%
Accommodation and food service	4.15%	4.34%	4.78%	2.70%	3.23%	2.51%
Agriculture, forestry and fishing	3.61%	2.51%	1.12%	1.48%	2.41%	1.82%
Administrative and support service	3.28%	2.67%	2.64%	4.53%	2.42%	3.10%
Professional, scientific and technical	2.56%	2.48%	3.70%	3.91%	3.52%	2.91%
Information and communication	2.44%	2.64%	3.43%	2.12%	2.65%	2.28%
Financial and insurance	1.98%	1.85%	2.58%	1.58%	1.99%	2.64%
Arts, entertainment and recreation	1.68%	1.39%	1.79%	2.30%	1.51%	1.48%
Water supply; sewerage, waste management and remediation activities	1.44%	1.24%	1.25%	1.34%	1.24%	1.21%
Electricity, gas, steam and air conditioning supply	1.01%	1.42%	1.09%	1.22%	1.13%	1.22%
Real estate activities	0.48%	0.52%	0.31%	1.08%	0.53%	0.95%
Mining and quarrying	0.25%	0.56%	0.29%	0.39%	0.75%	1.62%
Other	1.58%	0.76%	1.25%	1.56%	0.78%	1.28%

Alogorithm wave Augmentation wave Autonomy wave

Source: KSH 2018, OECD

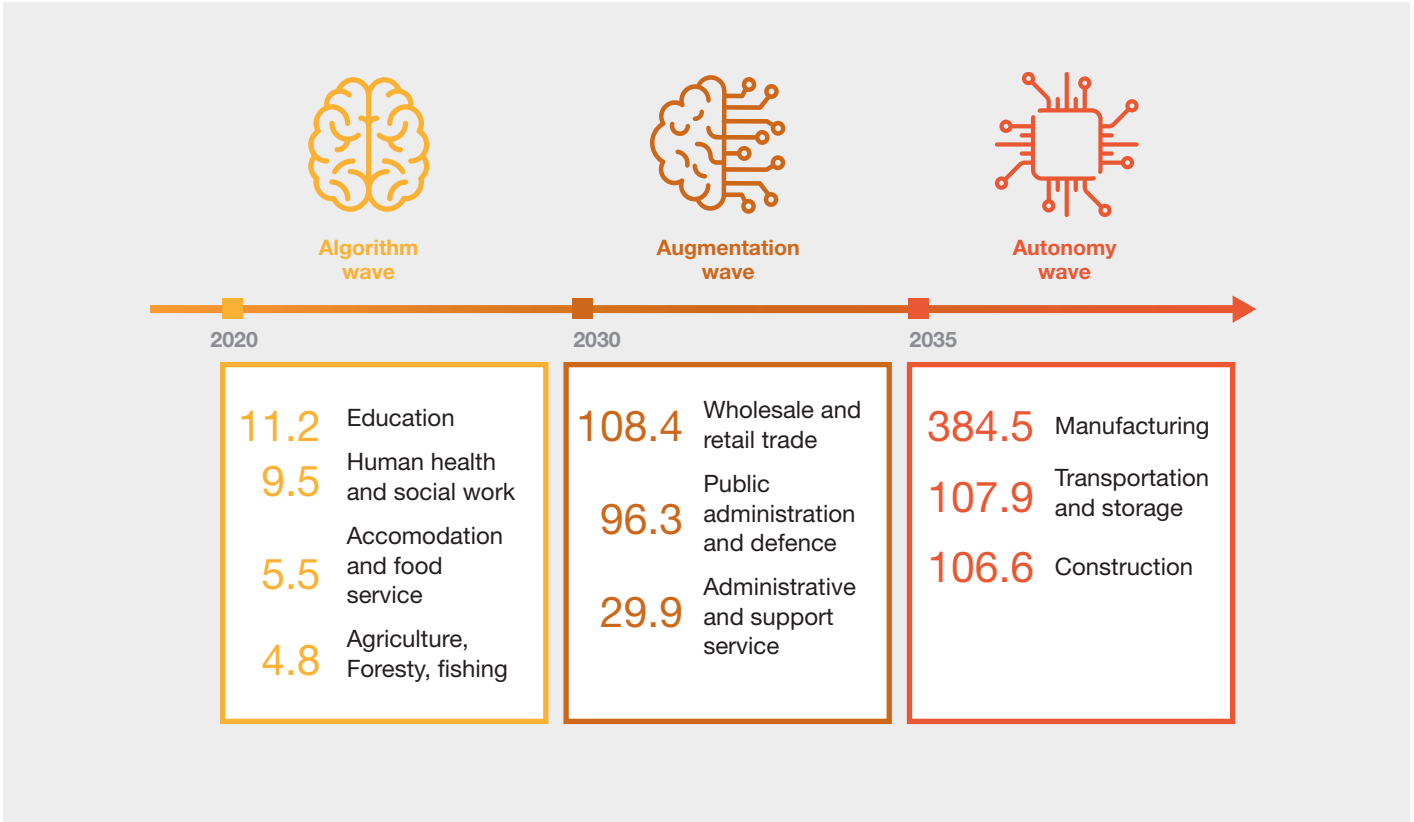
TABLE 2.2 – Employment shares, estimated proportion and total number of employees at potential high risk of automation for all industry sectors

	Employment share in %	Total employment in ths.	Automation rate by waves in %	Job automation (potential high risk in ths.)	Job automation (potential high risk in %)
Manufacturing	24.09%	964.6	39.9%	384.6	41.7%
Wholesale and retail trade	11.91%	476.9	22.7%	108.4	11.8%
Public administration and defence	10.58%	423.6	22.7%	96.3	10.4%
Education	8.36%	334.7	3.3%	11.2	1.2%
Human health and social work	7.14%	285.9	3.3%	9.5	1.0%
Transportation and storage	6.76%	270.8	39.9%	108.0	11.7%
Construction	6.68%	267.5	39.9%	106.6	11.6%
Accommodation and food service	4.15%	166.2	3.3%	5.5	0.6%
Agriculture. forestry and fishing	3.61%	144.5	3.3%	4.8	0.5%
Administrative and support service	3.28%	131.3	22.7%	29.8	3.2%
Professional. scientific and technical	2.56%	102.5	3.3%	3.4	0.4%
Information and communication	2.44%	97.7	3.3%	3.3	0.4%
Financial and insurance	1.98%	79.3	3.3%	2.6	0.3%
Arts. entertainment and recreation	1.68%	67.3	3.3%	2.2	0.2%
Water supply; sewerage. waste management and remediation activities	1.44%	57.7	39.9%	23.0	2.5%
Electricity. gas. steam and air conditioning supply	1.01%	40.4	39.9%	16.1	1.7%
Real estate activities	0.48%	19.2	3.3%	0.6	0.1%
Mining and quarrying	0.25%	10	39.9%	4.0	0.4%
Other	1.58%	63.3	3.3%	2.1	0.2%
Total		**4003.4**		**922.2**	**100.0%**

Alogorithm wave Augmentation wave Autonomy wave

Source: KSH 2018, PIAAC data, PwC analysis

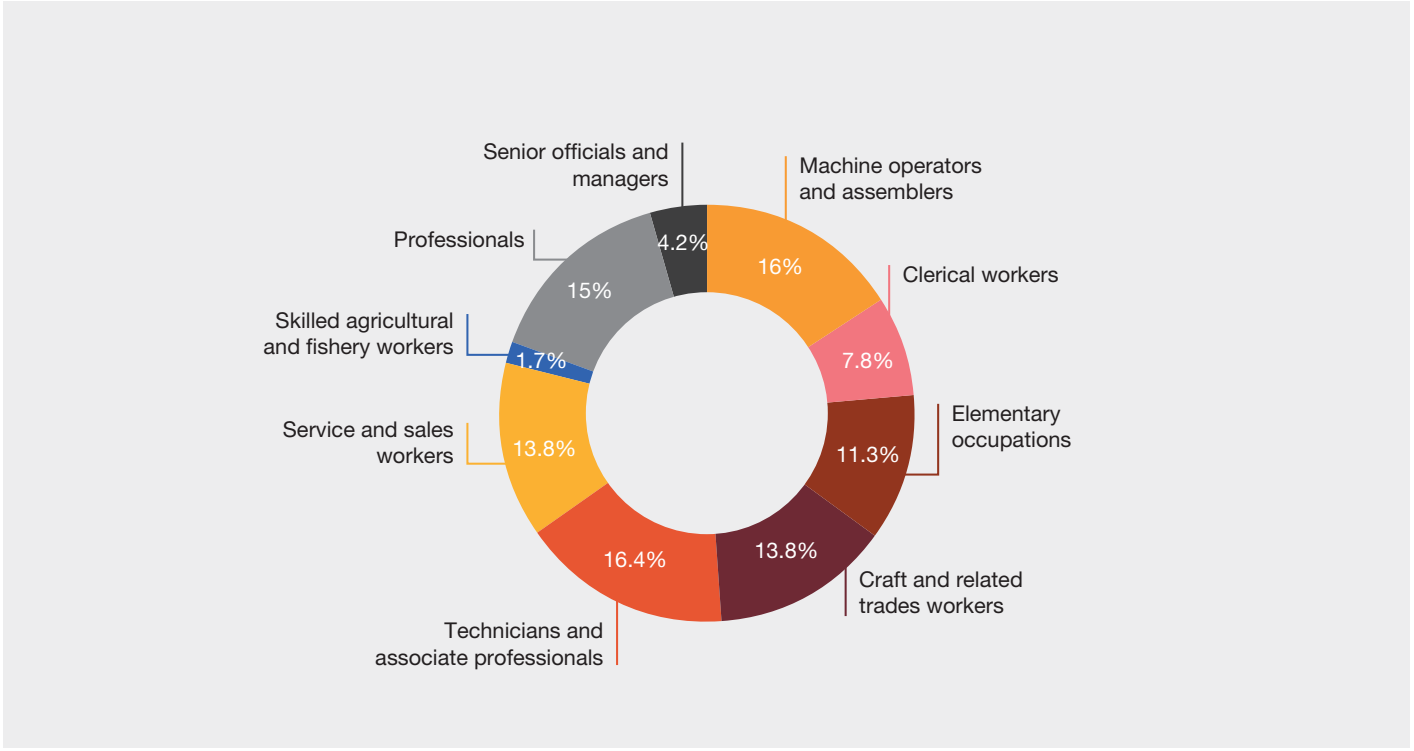
FIGURE 2.2 – The volume of jobs impacted in the most affected sectors



Source: PIAAC data, PwC analysis

3. Occupations

FIGURE 3.1 – Proportion of occupational categories in Hungary



Source: KSH 2018, PwC analysis

TABLE 3.1 – Potential impact of job automation by occupation across waves (in thousands)

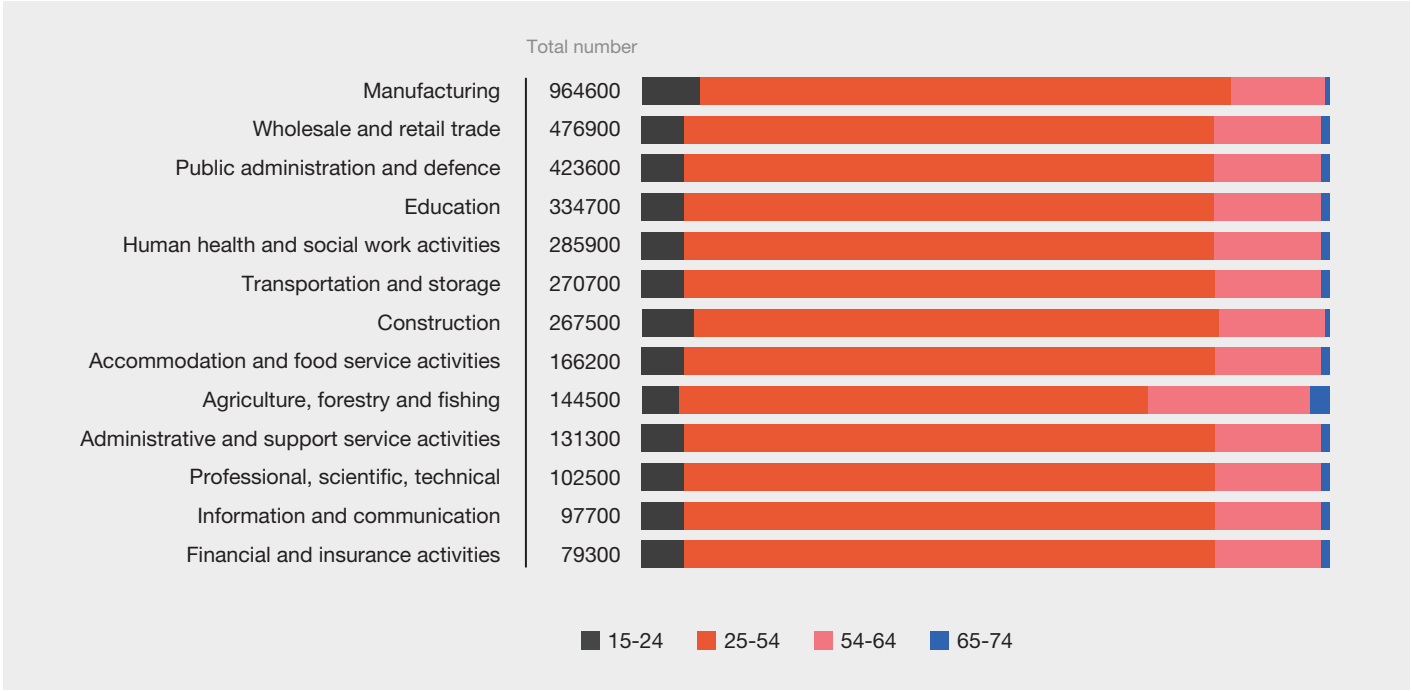
	Algorithm wave	Augmentation wave	Autonomy wave
Senior officials	2	12	32
Professionals	13	7	47
Technicians and associates	9	40	84
Clerical workers	3	17	30
Service and sales workers	6	56	53
Skilled agricultural workers	3	3	3
Craft workers	2	13	195
Machine operators	2	17	150
Elementary occupations	6	29	51

low — high

Source: PIAAC data, PwC analysis

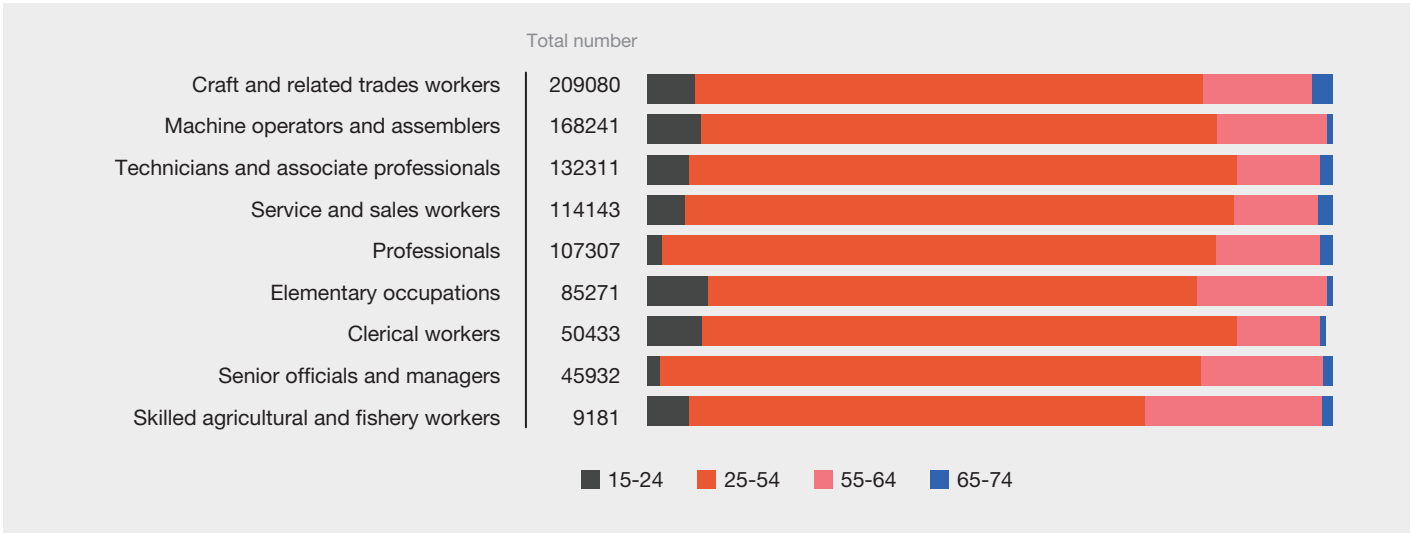
4. Type of workers

FIGURE 4.1 – Share of jobs at potential high risk of automation by age across occupations



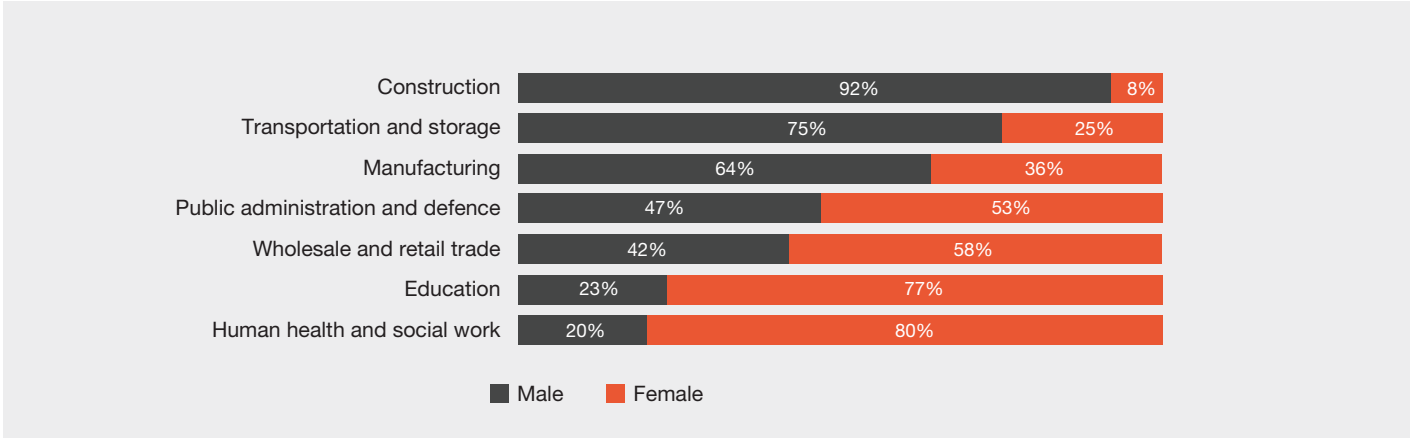
Source: PwC analysis

FIGURE 4.2 – Share of jobs at potential high risk of automation by age across occupations



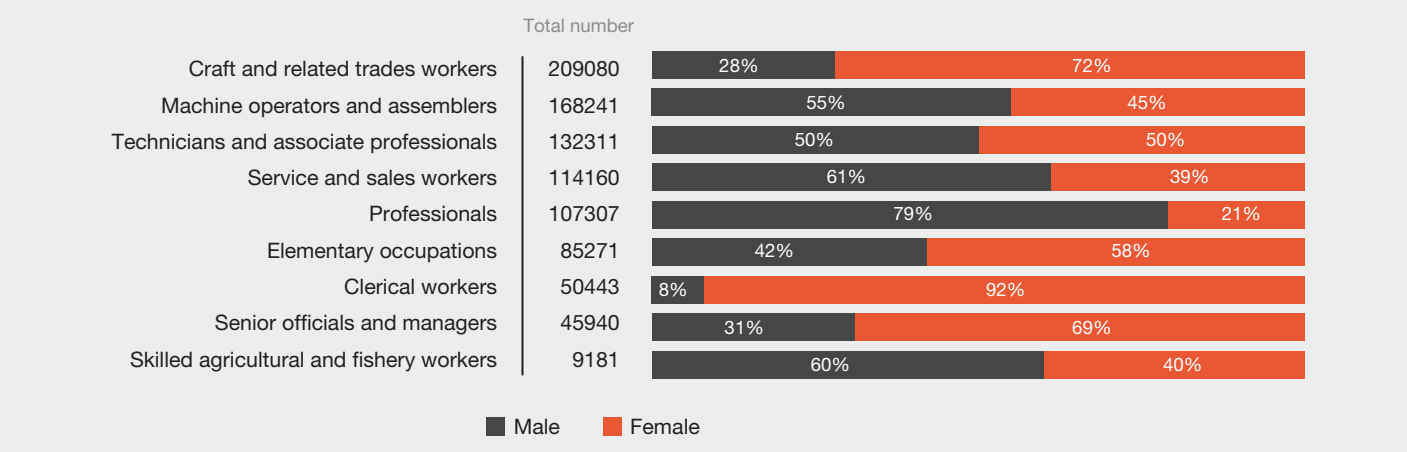
Source: PwC analysis

FIGURE 4.3 – Share of jobs at potential high risk of automation by gender in the top 7 industries



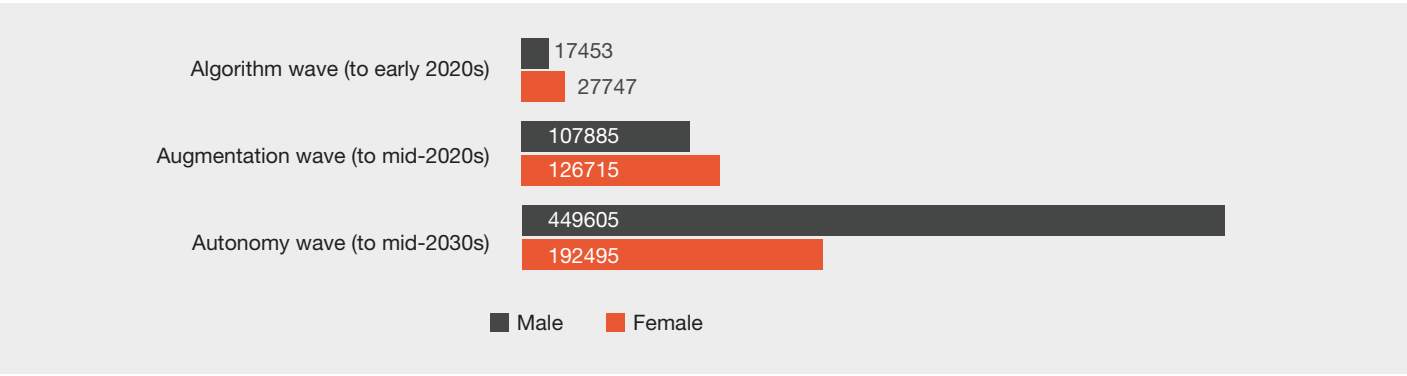
Source: PwC analysis

FIGURE 4.4 – Share of jobs at potential high risk of automation by gender across occupations



Source: PwC analysis

FIGURE 4.5 – Share of jobs at potential high risk of automation across waves



Source: PwC analysis

5. Conclusion

The following table sums up our findings of the most threatened industries, occupations and types of workers across the three waves of automation.

TABLE 5.1 – Analysis results

Hungarian labour market	(Chapter 2) **Industry analysis**	(Chapter 3) **Occupation analysis**	(Chapter 4) **Type of worker analysis**
Algorithm wave (2020s)	• Financial • Human health and social work • Accommodation and food service • Agriculture	• Professionals • Technicians	• Young generation (15-24) • Female workers with high education level
Augmentation wave (2025)	• Education • Wholesale and retail trade • Public administration and defence • Administrative and support service	• Professionals • Technicians • Service and sales workers	• Young (15-24) and middle aged (25-54) employees • Female workers with high education level
Autonomy wave (2030s)	• Manufacturing • Transportation and storage • Construction	• Craft workers • Machine operators	• Middle (25-54) and older (54-65) generation of employees • Male workers with low and medium education level

Source: PwC analysis

Acknowledgement of contributions:

We acknowledge the valuable contribution of the Hungarian AI Coalition and the 4 international master students: Réka Ostorházi, Josefin Styve, Hai Anh Leova and Daniel Claro from CEMS Program of Corvinus University of Budapest to the drafting of the *How will AI impact the Hungarian labour market?* report.

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