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By Septimiu Szabo

Abstract

The brief provides an analysis on the progress made by the Visegrád Four countries in their transition to Industry 4.0, a concept encompassing new digital technologies like automation and robotisation, 3D printing, machine learning or artificial intelligence. As their share of manufacturing to GDP has been historically high, the economies and the workforce of these four countries are likely to be impacted by the technological disruption expected to take place in the coming decades. The automotive industry, one of the trademarks of the Visegrád economy, is the most advanced in the transition, having started to replace some of the more predictable manual and routine labour tasks with industrial robots. Other dimensions of the Industry 4.0 are less advanced and need particular attention. Most domestic firms lag behind in the integration of new technologies and do not have a clear vision in terms of their digital transformation. The level of advanced digital skills among the workforce is also rather low and the prevalence of digital public services remains limited. Also in the light of the economic recovery following the COVID-19 pandemic, various policies can support the digital transition, including by investing in cross-cutting technologies, facilitating access to risk financing to innovative firms and promoting entrepreneurship.

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Introduction

This brief provides an overview on the transition to Industry 4.0 in the Visegrád countries (V4). It starts with an overview of the industry-intensive economies of the V4 (Czechia, Hungary, Poland and Slovakia) that may be impacted by significant technological changes in the near future. It continues by assessing the level of industrial robotisation compared with older Member States. It also describes the efforts and shortfalls in other areas of the Industry 4.0 transition. Finally, it details a couple of policies that can ease the transition and allow the countries to take advantage of the upcoming technological disruptions.

Industry 4.0 foresees a new economic transformation, bringing both opportunities and threats. It provides a new approach to manufacturing by fully linking the physical work with the digital world, automatising processes and allowing machines to work independent of human touch. While still rather expensive to roll out, Industry 4.0 promises to improve optimisation and productivity across the board. According to Tractica Research, by 2025, revenue generated by the robot industry is expected to reach around $250 billion, five times more than in 2018. Furthermore, there is an increasing divergence between the increasing labour costs and the decreasing robot prices, as seen in the USA in the last three decades (McKinsey, 2017b). Still, the analyses on the impact of automation on jobs provide mixed results. While some suggested that the effect is limited, as the losses in manufacturing are compensated in other sectors (Dauth et al., 2017 for Germany), others found a significant impact on employment and/ or on wages (Acemoglu and Restrepo, 2017 for the US; Chiacchio et al, 2018 for six EU countries). While some studies suggest value chains may also be shortened or disrupted (McKinsey, 2017c and 2019), other reports suggest that the impact of technological change on trade and global value chains is likely to be positive (World Bank, 2020). Literature also suggests that any potential technological disruption may proceed at a slower pace than generally assumed in the available analyses and at different speeds across industries and countries (Leitner and Stehrer, 2019).

Industry 4.0 is expected to have a significant impact on employment. Jobs of the future will require a moderate level of digital skills and strong non-cognitive skills (the type of skills that cannot yet be adopted by artificial intelligence technologies). The changes will mostly favour the highly skilled, while people working in predictable physical jobs will need significant reskilling programmes. Capital cities focusing more on services will be less affected than the regions which depend on manufacturing, agriculture or mining. Also, most automatable jobs are in the lower and middle income quartiles which could also lead to an increase in inequality. Domestic SMEs will be much more affected than the large foreign-owned enterprises that have the available capital to invest in new technologies.

The V4 will be particularly impacted by the new industrial revolution. Recent studies (McKinsey, 2018) suggest that the share of jobs likely to be automated in the V4 is higher than the EU average ([1]). This is due to the significant share of the manufacturing sector in GDP and the high degree of predictable physical work involved therein. The number of deployed robots ([2]) is already relatively high and new installations will continue. On the other hand, the V4 countries still lag behind in many other aspects of the transition and may struggle to remain globally competitive in the longer-term.

The V4 economies depend heavily on manufacturing and FDI.

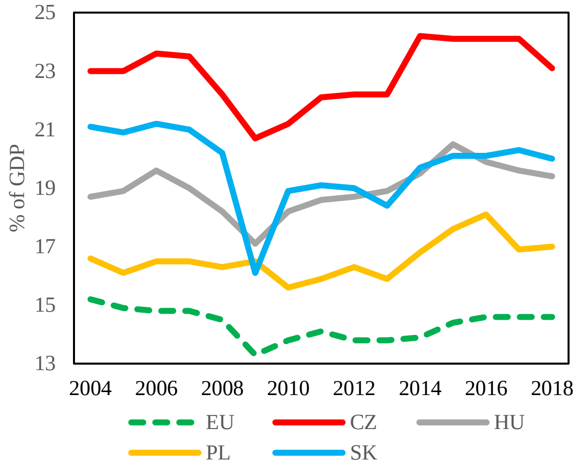
V4 economies are dependent on manufacturing and sensitive to the business cycle. Compared to the EU average (14.6%), the share of manufacturing to GDP is significantly higher in the V4 (Graph 1). With 23.1% in 2018, Czechia had the second highest share in the EU, after Ireland. The sector was particularly sensitive to the economic downturn in 2009 in Czechia, Slovakia and Hungary. In Slovakia, the share dropped from above 20% to 16% in 2009, below the level of Poland. This reiterates the deep level of integration into the global value chains.

([1]) The cut-off date for this Brief is the end of 2018. Thus, the referenced EU averages include 28 countries and the data does not cover the impact of the COVID-19 pandemic.

([2]) The word robot was first introduced in the 1920s by the Czech writer Karel Čapek, from the Slavic word 'robota', or forced labourer in the feudal system.

Transportation and machines are the main exports of the V4, accounting for 38% in Poland and around 60% in the other three countries. Cars and vehicle parts and the top exports in each of the four countries (from 9.5% in Poland to 27% in Slovakia).

Graph 1: **Share of manufacturing in GDP (%)**



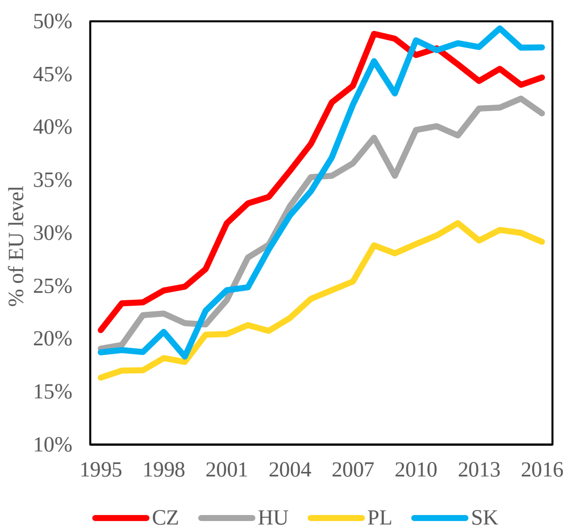
Source: Eurostat.

The sector remains dependent on foreign investment and integration into global value chains. All four countries have large shares of FDI, due to their close proximity to Western Europe and favourable conditions offered by the authorities to multinational enterprises. In manufacturing, the share of FDI to GDP has remained around 30% in all four countries since the early 2000s. The automotive sector is almost fully foreign-owned, as the major car manufacturers have also brought with them foreign-owned suppliers. With a couple of notable exceptions, most domestic suppliers are embedded only in lower levels of supply chains (Szabo, 2019). On the other hand, export-oriented companies working in higher levels of the global supply chains are mostly foreign-owned and highly concentrated in certain regions (Buti and Szekely, 2019). Nonetheless, FDI has been a significant vector of convergence for all these countries since the late 1990s (Szabo and Duran, forthcoming).

The automotive industry has a significant contribution to value-added and employment. One fifth of the cars produced in the EU are coming from the V4. In relation to the size of the economy, the automotive industry is much more important in V4 (to a less degree in Poland) than in the EU as a whole and any disruptions in the sector disproportionally affect the economies of these countries (Polish Economic Institute, 2019). Since 2004, annual car production in V4 has increased significantly from 1.4 million to 3.5 million. Including indirect employment, the V4 automotive industry employs around 1.5 million people.

Investment increased significantly but focused mostly on physical capital. Whereas gross fixed capital formation (GFCF) in the EU increased by 16% between 2010 and 2018, in the V4 it grew by 24%, most notably in Hungary (+34%) and Slovakia (+32%). Particularly important was the increase in investment in equipment, which grew by around 37% since 2010, significantly above the rates seen in Germany (+23%), France (+21%) or Italy (+4%). Currently, Czechia, Slovakia and Hungary have the highest shares of equipment investment to GDP (between 8 and 11%, compared to an EU average of around 7%). On the other hand, excluding Czechia (18.9% of non-residential GFCF), investment in ICT equipment and software and databases remains low in Slovakia (6.3%) and Hungary (8.6%).

Graph 2: **Labour productivity in € per hour worked in manufacturing as % of EU level**



Source: own calculation based on JRC 2019 Predict data.

Labour productivity in manufacturing has increased. Since 2004, labour productivity ([3]) in manufacturing almost doubled in all countries (120% increase in Slovakia). Currently, Czechia, Slovakia and Hungary are roughly at the same level

([3]) calculated as Gross Value Added per hour worked.

of productivity (almost 50% of the EU average). Poland, which focuses less on the automotive industry, follows behind (30% of the EU average). The gap remains significant also when assessing output-based labour productivity in manufacturing.

There is a continuous gap in Total Factor Productivity (TFP). Between 1997 and 2014 the TFP gap in manufacturing between Czechia and Germany shrank from 44% to 35%. This is in part due to a low contribution of ICT capital investment to productivity in all four countries. Compared to other sectors of the economy, manufacturing has one of the smallest gap in TFP. In other sectors (accommodation, transportation, agriculture) the gap remains above 50% (IMF, 2018 and EU Klems).

Industry 4.0 may bring certain long-term employment challenges

A large share of jobs in the V4 have the potential to be automatable. The automation potential of jobs is defined by the work activities that can be automated and performed by machines, by adapting currently available technologies. Various studies provide different estimates but a majority suggest that the V4 countries will be particularly affected by the future technological changes. McKinsey (2018) finds that the automation potential of the V4 countries is on average 5% higher than the EU and US averages, but in line with the global average ([4]). The difference is more pronounced in the automotive industry where jobs such as production worker (82% potential degree of automation) and machine feeder (74%) are particularly at risk. The OECD (2019) also notes that the prevalence of jobs at risk of automation in Eastern Europe is higher than average. PricewaterhouseCoopers (2019) finds a similar share of jobs at potential high risk of automation across Slovakia, Hungary and Czechia (40 to 45%), with Poland further behind (35%). They divide the transition into three phases: the algorithm wave (early 2020s); the augmentation wave (2025); and the autonomy wave (2030+) ([5]). Most of the transformation is expected to occur in the final phases, with workers in manufacturing particularly affected by the third wave. In Hungary, 1 million jobs could already be transformed by 2030, as almost 50% of work hours could be automated (McKinsey, 2018). According to Nedelkoska and Quintini (2018), 64% of jobs in Slovakia, 50% of jobs in Poland and 47% of jobs in Czechia have a significant or high likelihood of automation. Lordan (2018) puts figures as high as 70% in Czechia and 60% in Slovakia and Hungary. All these indications are mostly due to the larger share of manufacturing in the economy and the differences in the job content within nominally similar industries and occupations.

Current education and training systems do not appear fully prepared to support the coming technological changes. In the PISA scores issued by the OECD (2018), only Poland has improved its scores in reading mathematics and science between 2006 and 2018. The other three countries witnessed a worsening of all their scores (except Czechia in reading), with Slovakia particularly problematic in science and reading (ranked 41st in both areas among the 78 analysed countries). Slovakia also suffers from significant regional socio-economic disparities in educational outcomes. Spending on education as a share of GDP is in line with the EU average (apart from Slovakia) but lower than in the frontier Nordic countries. The teaching profession is less prestigious than in other countries, with salaries lower than in jobs of similar skill levels and with limited career development and continuous training possibilities. Adult learning is also low in some of the countries. According to the 2018 OECD PIAAC results, 24% of all adults in Poland showed low numeracy skills, compared to 13% in Czechia or Slovakia and 18% in Hungary. 19% showed low literacy skills in Poland and Hungary (12% in the other two countries).

Future transformation favours services over manufacturing in the labour market. Cedefop projections of future employment growth by 2030

([4]) The study puts the EU automation potential at 44% compared to 43% in the USA, 49% in Poland and Hungary, and 51% in Czechia. The global average is at 49% (counting 52 countries encompassing 80% of all global jobs).

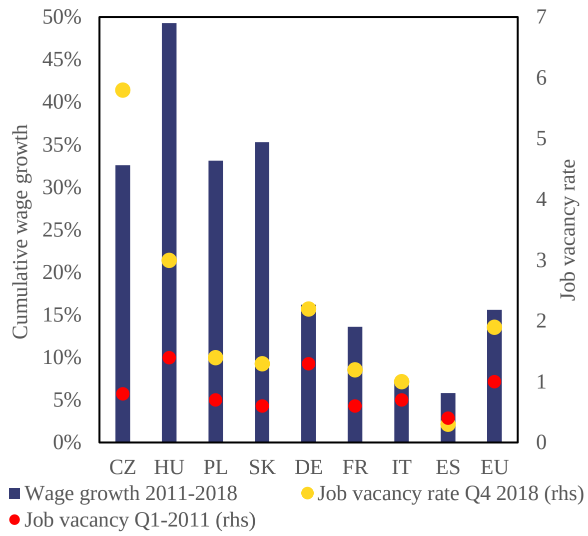
([5]) The algorithm wave foresees automation of simple computational tasks; the augmentation wave foresees the dynamic interaction with technology for support and decision making; the autonomy wave foresees the automation of physical labour/ manual dexterity in dynamic real-world situations that require responsive actions.

suggest that demand will focus more on administrative, professional or ICT services and less on manufacturing and production. Agriculture and mining will also be affected in Hungary and Poland, as the demand for professional services may skyrocket. Hungary will see less demand for jobs in the accommodation and food sector but will require much more workforce in the financial sector. Due to the ageing of population, demand for jobs in healthcare will also increase significantly. The transformation may predominantly affect the low- and medium-skilled, require ring significant investment in reskilling parts of the workforce.

The number of ICT graduates in the V4 remains low and there is a large gender gap in the profession. Between 3 and 4% of all graduates are graduating in ICT subjects, i.e. a below-average percentage of ICT specialists in total employment (1 pp below the EU average). The number of female ICT specialists, in particular, is among the lowest in the EU – below 1% of female employment, compared to 2.3% in Estonia and 1.4% at EU level. As a result, only around 10% of all software programmers are women, creating a significant gender gap in the sector. Thus, in 2018, almost 80% of Czech firms and 60% of Hungarian and Slovak firms looking to hire specialists in this field reported major difficulties in recruitment. There seems to be an increase in the number of universities offering artificial intelligence programmes, particularly in Poland and Hungary, but the human resources teaching science and technology remains low (Eurostat and JRC).

Population ageing will create further incentives for automation. The old age dependency ratio (the ratio of the population over 65 and the population between 15-64) is expected to increase significantly across the region. While the EU average is expected to grow from 30 in 2018 to 55 in 2060, in Poland and Slovakia it is expected to go from below 25 to around 62. Czechia and Hungary are somewhat more in line with the EU average. In the next three decades, the median age of the population is expected to grow by around 10 years in both Poland and Slovakia and by around 5 years in Czechia and Hungary (only 4 years in EU). As of 2040, the median age in Poland (48.8) and in Slovakia (48.6) will be above the EU average (46.7) and by 2100, projections suggest that Slovakia may have one of the oldest population in the EU (a median age of 51 compared to 48.7 in EU). In the longer term, population is expected to remain somewhat constant in Czechia but significantly decrease in the other three countries. By 2100, the total population in V4 is expected to have decreased by around 15 million people (from the current 64 million), out of which 10 million in Poland alone (Eurostat population projections based on 2018 data). In a no-policy change scenario, this may put a significant burden on the labour market in these three countries and push further the need for investments in automation.

Graph 3: **Wage growth and job vacancy rate in the manufacturing sector between 2011 and 2018**



Source: Eurostat.

Note: Job vacancy rate = (number of job vacancies) / (number of occupied posts + number of job vacancies). Nominal wage growth using national currencies. The figures are not adjusted for currency depreciation.

Employment indicators improved significantly between 2011 and 2018. While the EU employment rate grew by 4.7 percentage points (pps) between 2010 and 2018, in Poland and Slovakia it increased by 8 pps, in Czechia by 9.5 pps and in Hungary by 14.5 pps. This led to increasing labour shortages, particularly in manufacturing. At the end of 2018, there were around 155,000 vacant jobs in manufacturing in the V4 (171,000 in Germany). Czechia (85,000) accounted for more than half of all vacant jobs. Since 2010, unemployment rates have decreased significantly, reaching record lows in all countries, varying from 2.2% in Czechia to 6.5% in

Slovakia. Employment rates have also gone up since 2010, ranging between 72% in Poland and 80% in Czechia, close or above the EU average (73%). Nonetheless, the COVID-19 pandemic is expected to have an impact on the labour market and halt some of these decade-long improvements.

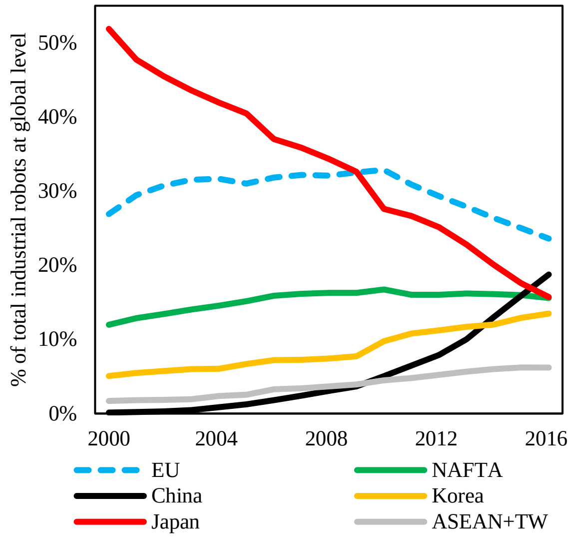
The acute labour shortages have led to significant wage increases. While at the EU level nominal wages and salaries have grown by around 15% since 2011, in the V4 the increase has reached between 33% in Czechia and 50% in Hungary (Graph 3). In 2018 the average hourly wage in the V4 manufacturing sector varied between €7.4 in Poland and €9.1 in Czechia, compared to €24.8 in the euro area. In general, if wage growth constantly outpaces productivity growth, export competitiveness may be affected in the longer term.

Robotisation in manufacturing has been steadily increasing

The EU may soon lose its seat as leader in terms of global robot share... While it continues to be the world leader in terms of deployment of industrial robots, its global share has been shrinking since 2010 when it had a third of the global stock. The decrease is due to a speedy robotisation process in the Asian countries, particularly China but also South Korea, the ASEAN countries and Taiwan. China in particular has moved from an insignificant global share in the early 2000s, to almost 20% of global share. The EU and Japan are the only major regions that have been losing market share in the last decade (Graph 4). By contrast, the USA together with its NAFTA partners has kept a steady pace. According to the latest data from the International Federation of Robotics, in 2018 there was a total shipment of 422,000 robots, out of which 36% were delivered to Chinese companies. They also forecast that by 2022 the number of annual shipments may reach almost 600,000.

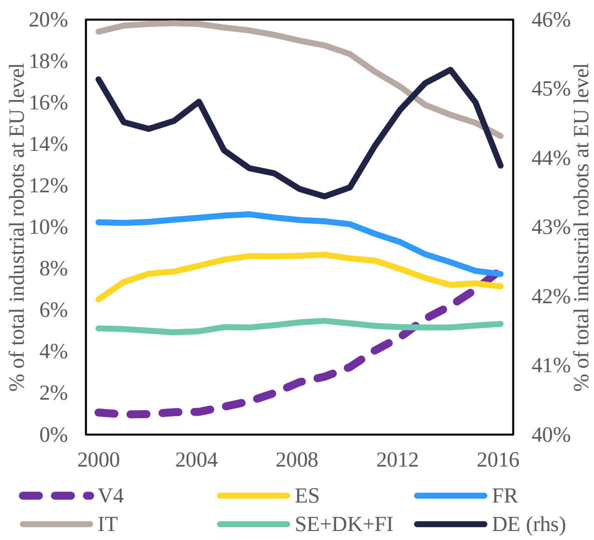
But the V4 region has a different trend and has seen a steady increase in the stock of industrial robots. Since 2000, the V4 have continuously increased the number of installed robots whereas in countries like France, Italy and Spain it mostly stagnated (Graph 5). Germany has kept its share stable since 2000, accounting for around 45% of all industrial robots in the EU and a 10% global share. From a global perspective, the V4 has followed a similar trend to other catching-up economies that focus intensively on manufacturing, such as Thailand or Mexico. Within the V4, the growth is mostly driven by Czechia which installed almost 40% of the industrial robots, followed by Poland with around one quarter of the total. Hungary and Slovakia contribute equally to a third of the total. Since 2010, all four countries have at least tripled their stock, with Hungary increasing almost six-fold.

Graph 4: **Share of total global industrial robots**



Source: own calculation based on IFR data.

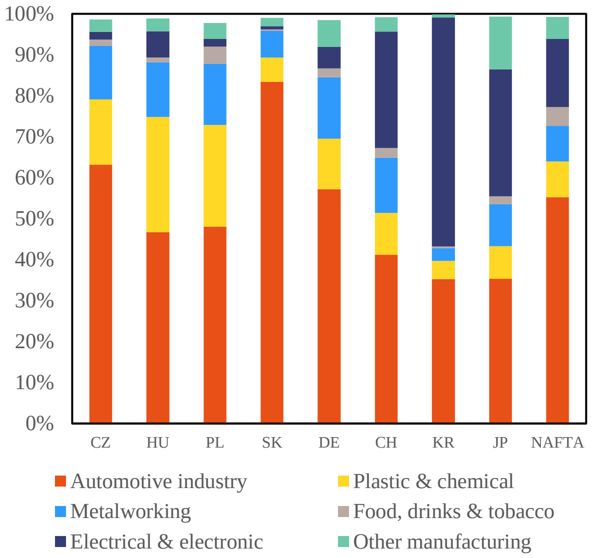
Graph 5. **Share of total industrial robots in the EU**



Source: own calculation based on IFR data.

However, more than half of all industrial robots installed in V4 are used in car manufacturing. In Slovakia, the share of robots in car manufacturing reaches almost 80% (see Graph 6), compared to 30% at a global level. Hungary and Poland also have a significant share in the manufacturing of plastic and metal products (above 25%). The distribution does not differ much from Germany, particularly in Czechia. However, the mix is quite different in Asian countries which focus much more on the electrical and electronic sector (50% of all industrial robots in South Korea). In V4, only Hungary has a more significant share of robots in that sector (6% in 2016). The use of robots in education and R&D in the V4 is quite low. In 2016, there were a total of 200 industrial robots used for R&D, mostly in Poland (86) and Czechia (64), compared to 1,734 in Germany. Finally, when looking at tasks required from the robots, data shows that almost half (47%) of all industrial robots in the V4 are used for handling operation and machine tending, while 30% are used for welding and soldering.

Graph 6: **Distribution of industrial robots by sector**

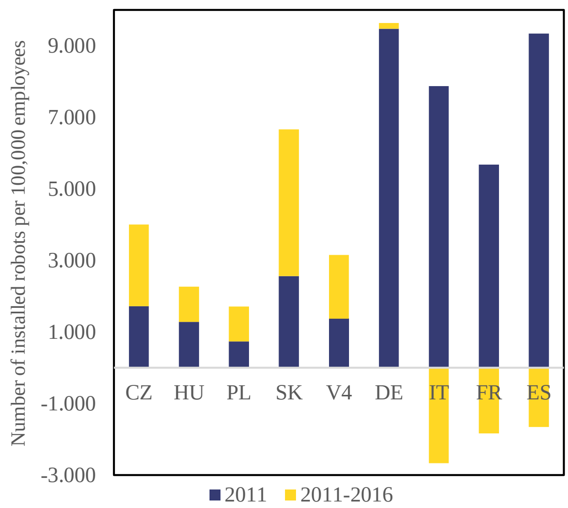


Source: own calculation based on IFR data.

Note: Figures exclude the unspecified sectors. The difference to 100% includes all other NUTS-2 sectors.

Despite the increase in nominal numbers, robot density in manufacturing remains rather low (6). At 65 industrial robots installed per 100,000 employees in manufacturing (2016 data from IFR for number of robots and Eurostat for number of employees), the V4 lags behind Germany (224), Spain (163), Italy (156) or France (101). This is mostly due to the low density seen in Poland (34), as figures in Czechia (105) and especially in Slovakia (137) are much higher. However, compared to 2011, the situation has progressed significantly in all four countries. When looking only at car manufacturing, the robot density in V4 reached 3,150 in 2016, in line with the figures in the France, but significantly below Italy (5,200), Spain (7,700) or Germany (9,600). It remains particularly low in Poland (1,700). Compared to 2011, the V4 has seen a robust increase, compared to a stagnation in Germany, or a decrease in France, Italy or Spain (Graph 7). Slovakia stands out in this regard, increasing from around 2,500 in 2011 to almost 7,000 in 2016, above the levels seen in France. According to the recent 2019 World Robotics report, robot density in manufacturing reached 135 in Czechia and 165 in Slovakia, above the European average of 114 but still significantly behind Germany (338), or, among peer countries, Slovenia (174).

Graph 7: **Robot density in car manufacturing**



Source: own calculation based on IFR and Eurostat data.

Robotisation in manufacturing did not come at the expense of employment. Despite the 175% increase in the number of robots in the automotive industry, employment in the sector has also increased by around 20% since 2011 (and by 38% in Hungary). In comparison, employment in the German automotive industry grew by around 8%, whereas the number or robots increased by 10%.

(6) This Economic Brief uses different figures for the number of employees in manufacturing (EU Klems), compared to the International Federation of Robotics.

However, as mentioned before, some studies suggest that in the longer term, automation and robotisation can have a significant negative impact on employment. Robotisation may have helped the V4 productivity as some studies found a positive relationship between robotisation and productivity (European Commission, 2018; Jungmittag and Pesole; 2019). Hungary has the highest productivity in the sector among the V4, reaching 51% of the EU average in 2016, followed by Czechia (48%) and Slovakia (45%). Poland, on the other hand, remains only at only 20% of the EU average. Hungary and Slovakia did a lot of catch-up since the EU accession (more than 10 pps) while Czechia had a significant decrease since the financial crisis (11 pps drop between 2009 and 2016).

Transition to other dimensions of Industry 4.0 is less spectacular

Apart from robotisation in manufacturing, digital transformation in the V4 is still low. In the latest Digital Transformation Scoreboard issued by the European Commission ([7]), only Czechia features above the EU average. The scoreboard looks into the deployment of various components of Industry 4.0 such as mobile and cloud technologies, Internet of Things, cybersecurity and artificial intelligence, big data or 3D printing. Digital infrastructure remains underdeveloped in Poland and there is a significant lack of digital skills in Hungary and Slovakia. The countries are also lagging behind in the European Commission's Digital Economy and Society Index. In the 2019 rankings, the four countries are ranked 18th (Czechia), 21st (Slovakia), 23rd (Hungary) and 25th (Poland). Compared to the 2014 Index, all four countries are worse off, each dropping one position in the rankings, and continue to remain below the EU average. In comparison, the Baltic countries are ranked much higher - between the 8th (Estonia) and the 17th place (Latvia). The digitisation of public services is low throughout the region, as only 50% of the population uses e-government, compared to over 80% in the Baltic countries.

The V4 had a mixed evolution in terms of global digital competitiveness. In the 2019 rankings of World Digital Competitiveness, published by the IMD World Competitiveness Center, the V4 are ranked 33rd (Poland), 37th (Czechia), 43rd (Hungary) and 47th (Slovakia) among 63 upper-middle- and high-income countries. Compared to 2015, Poland and Hungary progressed in the rankings, while Czechia and Slovakia were downgraded. The countries excel in different areas: scientific concentration and business agility (Poland), talent and capital (Czechia) or technological and regulatory frameworks (Hungary). On the other hand, they suffer from business agility and talent (Slovakia and Hungary), regulatory framework (Slovakia, Poland and Czechia), adaptive attitudes (Hungary and Czechia), or training and education (Slovakia, Hungary and Czechia). Apart from Czechia, all countries are lagging in terms of future readiness.

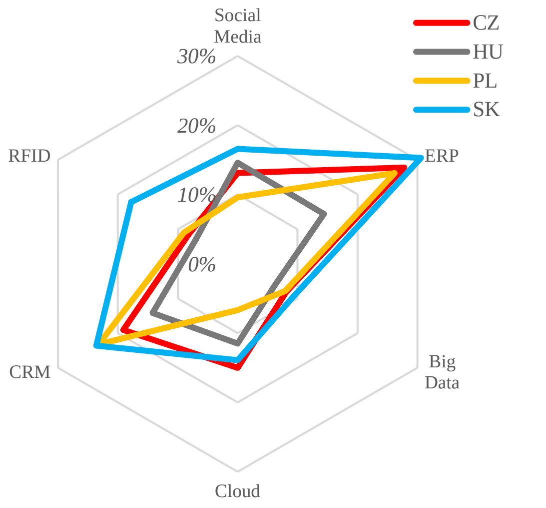
The adoption of new technologies among local firms varies significantly. Less than 7% of all V4 firms use big data analytics, compared to 12% at the EU level. Deployment of cloud computing is also quite low in Poland and Hungary (Graph 8). Business digitalisation and the use of e-commerce is relatively high only in Czechia, but Hungary and Poland are among the worst performers in the EU. Almost a quarter of all Czech SMEs sell online, compared to only 10 to 12% of all firms in the other three countries. As a result, around 18% of the turnover reported by the Czech SMEs comes from e-Commerce, one of the highest rates at the EU level.

Digital skills need improvement. Apart from Slovakia, all countries perform below the EU average in terms of advanced digital skills. In Poland, in particular, only 20% of individuals had above basic overall digital skills in 2017. Almost a quarter of Czech, Hungarian and Polish people have low or no overall digital skills. This translates into a rather low use of internet services. Some more recent data, however, shows that at least in the cases of Czechia and Slovakia, the rate of individuals who carried out trainings in 2018 to improve their digital skills was above the EU average, particularly in self-studying. However, OECD data shows also that less

([7]) The objective of the Digital Transformation Scoreboard (DTS) is to monitor the transformation of existing industry and enterprises. In particular, the scoreboard adopts national indicators to monitor digital transformation in Europe with a geographic focus and from a macro perspective.

than 20% of low skilled employees in Slovakia receive firm-based training, compared to around 40% in Czechia (almost 80% in the Scandinavian countries). In addition, only 40% of the medium skilled in Slovakia and Poland get training, compared to 60% in Czechia (OECD 2015 data).

Graph 8: **Use of new technologies among V4 firms**



Source: OECD and European Commission.

Note: Graph shows the share of firms using a specific technology out of all firms with 10+ employees. RFID = radio-frequency identification; CRM = Customer relationship management; ERP = Enterprise resource planning; Cloud = Cloud computing.

The number of Industry 4.0 patent applications from V4 remains low but it has been increasing. According to the European Patent Office (2017), between 1990 and 2016, the V4 countries submitted 164 patent applications for Industry 4.0 industries, representing around 1.2% of all EU applications. Almost 70% of these applications in the V4 were submitted after 2011. Slovakia scores particularly low in this area, with only 4 applications, compared to 33 in Czechia, 41 in Hungary and 86 in Poland. As a comparison, Estonia has submitted 21, Israel submitted 520, while Korea submitted around 3,800, close to the number seen in Germany. In total, around 30% of all applications were submitted from the EU, mostly from Germany and France.

There are various encouraging local initiatives that can be scaled-up. Due to agglomeration effects, most developments take place in the V4 capital cities. Companies in Prague are world leaders in cybersecurity, Warsaw is known for marketing automation technologies, while Budapest excels in scaleups. According to a Forbes (2018) article, Prague could become the city with the most Bitcoin-accepting vendors in the world. Bratislava is also witnessing some developments but proximity to Vienna seems to hinder some of its potential, particularly regarding the capacity to retain highly skilled employees. Regional hubs are also contributing to the Industry 4.0 transition. Brno, in South Moravia, has become a technological hub, focusing on microscopy, nanotechnology or biotechnology. Poznan, a city in between Warsaw and Berlin, is also developing its information industries, being focused particularly on IT and business services. Krakow is hub for technologies such as beacon solutions and the Internet of Things. There are currently 10 frontier research centres on artificial intelligence in the V4 (5 in Poland) but most regions in the V4 are ranked low or very low at the EU level in terms of frontier research.

V4 citizens welcome digital transformation processes but care for privacy and cybersecurity. In a 2017 Commission Special Eurobarometer poll, most V4 respondents said that digital technologies have a positive impact on the economy (ranging from 75% in Hungary to 85% in Poland) or on their quality of life (varying from 66% in Czechia to 79% in Poland). Surprisingly, they were more sceptical towards the use of robots and artificial intelligence, particularly in Hungary, where only 53% of respondents had a positive view (69% in Poland and 63% in Czechia and Slovakia). Hungarian citizens seem very concerned about privacy and security when using e-government services. While only 5% of the Czechs that did not submit forms online cited these reasons, they were invoked in 40% of the cases in Hungary (OECD, 2018). For similar security and privacy reasons, there seems to be also a reluctance to buy online in Hungary – almost 50% compared to 5% or below in Czechia or Poland. While firms in Czechia and Slovakia are doing rather well in defining a digital security policy (30% to 40% of all firms have one), Poland and Hungary are lagging behind (only 10%). The V4 and particularly Slovakia are also ranked low in the International Telecommunication Union's Global Cybersecurity Index (2017).

Public policies can ease the transition

Implementing some of the EU's country-specific recommendations can ease the transition to Industry 4.0 in the V4. In 2020, all V4 countries were recommended to focus investments on the digital transition. Czechia was recommended to focus in particular on developing high-capacity digital infrastructure and technologies, to foster digital skills and digital learning and to ensure access to finance for innovative firms. Hungary was recommended to focus investments on the research and innovation framework and on the digital infrastructure for schools. Poland was recommended to further promote the digital transformation of companies and public administration and to focus investments on digital infrastructure. Slovakia was recommended to strengthen digital skills and to close the digital infrastructure gaps. The Commission's 2020 country reports complement these recommendations, looking more in depth into the artificial intelligence sector in Czechia, the automation potential in Slovakia or the digital transformation of Hungary.

There is a large scope to increase domestic research and innovation. The V4 countries are at most moderate innovators according to the 2019 European Innovation Scoreboard. Apart from Czechia that ranks in the middle, the other three countries are at the bottom of the rankings. Public funding for research and innovation in ICT is very low. The V4 contributes with only 4% to the overall EU public funding for research in ICT and with 7% to the EU funding for ICT research in industrial production and technology. While the allocations doubled in Poland, Hungary and Czechia since 2006, in Slovakia they actually dropped. Currently, most innovation in the V4 is generated by foreign-owned firms. As expected, productivity is lower for smaller, mostly domestic firms. Nonetheless, ownership accounts for only a share of the productivity gap. While accounting for more than half of all employment, smaller firms are less productive and focus less on automation and robotisation.

The V4 Governments are rolling out Industry 4.0 related strategies and action plans. All V4 governments adhered to the European Artificial Intelligence (AI) Strategy launched in 2018 and the High-Level Expert Group on AI, and joined the new European AI Alliance. In addition, the V4 signed a declaration on economic cooperation with a focus on the transition to Industry 4.0 and issues such as cybersecurity or 5G infrastructures. Czechia issued its National AI Strategy in 2019, a document produced in collaboration with the private sector and academia that aims to make the country a leading AI hub in the next decade. The Polish government also prepared its AI strategy, focusing on issues such as AI R&D, digital public services and infrastructure. Hungary created a new AI Coalition composed of more than 70 Hungarian and international firms, universities and public bodies, which is being tasked to prepare the national AI Strategy. Slovakia included its national AI-related policies as part of the broader digitalisation strategy unveiled in 2019.

Venture capital investment in new technologies is extremely low. It varies from 0.002% in Slovakia to 0.008% of GDP in Hungary (OECD 2017 data). This is, however, in line with the EU trend where venture capital in general is very low compared to the US, Israel, Canada or South Korea. Out of the €7.7 billion raised in 2018 in the EU, the V4 only received €124 million, out of which 70 million were raised in Hungary (only €4 million in Slovakia).

Until the private sector is mobilised, EU funding can help the V4 countries foster further digital innovation. There are various funding opportunities for extending the digital infrastructure and the digitisation of the public sector. In the European Commission's proposals to establish the InvestEU and Digital Europe programmes, the development and deployment of digital technologies and services are listed among the eligible areas, with topics like artificial intelligence, cybersecurity, supercomputers, cybersecurity, Internet of Things, blockchain and advanced digital skills. Other programmes like Connecting Europe Facility or Horizon Europe can also provide funding for digital infrastructure and frontier research in new technologies. The European Commission recently presented a new long-term industrial policy strategy, with a perspective to 2030 and beyond, that supports the ecological and digital transition and upholds fair competition. The recently proposed Recovery Package of the European Commission also puts the digital transition at the forefront of the EU's economic recovery path.

Conclusions

The V4 countries are not fully prepared for the Industry 4.0 transition. As the four countries had lower labour costs compared to older Member States, there was less pressure to make a full transition. Consequently, leaving aside the foreign-controlled automotive industry, the V4 countries are less prepared for the transition than many of their Western European peers. Nonetheless, as all are continuing to converge and in light of the economic recovery following the COVID-19 pandemic, pressures will inherently increase. Further technological changes in the domestic economy can improve long-term productivity and global competitiveness, while also specialising the workforce. Depending on the rate of adoption, McKinsey (2017a) finds that automation can boost annual productivity by 0.8 to 1.4%. Nonetheless, the impact on Industry 4.0 on employment and wages remains to be seen in the longer term.

Certain tailored public policies can ease the technological transition in the V4. As mentioned in the Commission's country-specific recommendations, these can include the improvement of the domestic research and innovation ecosystem, the increased use of new technologies, an extended digital infrastructure, support for risk-financing and tailored investments in education and reskilling, particularly for digital skills. A strong R&D base, combined with opportunities for risk financing is critical for the development of technological innovation. Various tax breaks for investments in automation and artificial intelligence could also be considered in well-justified cases that are in line with the national and EU legislation. As private financing remains rather low, authorities can make better use of EU funding and financial instruments.

More research in this area is encouraged to assess the real impact of Industry 4.0. One the one hand, a quicker transition can help countries face the demographic challenge ahead, both in view of the declining labour force and in terms of the needs of the ageing population. On the other hand, it will require the V4 countries to make an effort to adjust their education and training systems to allow the population to acquire the necessary skills to face the change and reap the benefits. In sectors where a significant number of tasks may be replaced by machines, there will be an urgent need to reallocate and reskill workers. Public-sector cooperation with academia and the private sector could help to assess in more detail the magnitude of the changes in each subsector and address it accordingly.

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