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Adaptation to Industry 4.0 in the Visegrád Group

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Abstract

Motivation: The concept of Industry 4.0 is widely recognised, since technological development is an inseparable factor of the modern organisations functioning. Due to this, the interest in the subject of the 4th industrial revolution has grown in recent years. However, far too little attention has been paid to the measurement of readiness and implementation of key attributes in Czechia, Hungary, Poland and Slovakia.
Aim: The major objective of this study was to investigate the adaptation to Industry 4.0 in the Visegrád Group. Consequently, in the theoretical part both a historical context and a description of the main components of Industry 4.0 was introduced, which was the basis for the evaluation of the V4 transition toward Industry 4.0 in the empirical section.
Materials and methods: Both quantitative (basic statistical analysis) and qualitative (critical analysis of the subject literature) methods were used in this investigation. The research data was drawn mainly from institutional reports and Eurostat database.
Results: The investigation indicated that the transition towards Industry 4.0 in V4 countries is less advanced than in other European regions and need particular attention. Despite the relatively good results achieved in the field of robotisation, especially in the foreign-owned automotive industry, in general the Group lags behind the majority of Western and Baltic countries in terms of already adapted technologies, innovations and digital skills.

Keywords: *Visegrád Group; V4; Industry 4.0; 4th industrial revolution; digitalisation*
JEL: *L50; O14; O33*

1. Introduction

Along with the social, economic and technological development, all the surrounding processes are becoming more and more interdependent which increases their complexity. Thus, a lot of emphasis is put on optimisation of the undertaken projects. Nowadays, stable and sustainable development depends on the ability to adapt to changing conditions, to take advantage of the opportunities that arise, as well as to react quickly to emerging crises, such as these caused by unprecedented events like Covid-19 pandemic. The indicated elements of efficient functioning in the dynamic environment are reflected in the rapidly spreading, global phenomenon — Industry 4.0. Changes resulting from Industry 4.0 sooner or later impact both all fields of economy and the citizens daily life. Countries that follow the trends set by the ever-evolving concept of Industry 4.0 will not only remain competitive but also attract workforce, the lack of which has already become a significant problem for many regions.

Although some research has been carried out on the features, challenges and implementation of Industry 4.0, there have been few empirical investigations into the characteristics of transition to Industry 4.0 in the Visegrád Group. Therefore, the objective of this research was to determine whether and to what extent the Visegrád countries have adapted to key aspects of the examined phenomenon. Due to limitations of space, this paper cannot provide a comprehensive review of all attributes related to Industry 4.0.

The overall structure of the study takes the form of five sections, including this introductory section. Section 2 of the article deals with the theoretical descriptive of the past industrial revolutions, as well as the definitions and characteristics of the main features of the Industry 4.0. Section 3 is concerned with the materials and methods used for this study. Section 4 presents the findings of the research, focusing on the themes that were mentioned in the theoretical part. Finally, Section 5 gives a brief summary.

2. Literature review

Industries have been expanded greatly in order to meet society's demands regarding the improvement of the quality of life (Olanders & Rosenvinge, 2018). Despite many differences in the pace of processes that have been taking place, resulting from the stage of maturity of the economy, its innovation's culture and investment opportunity, the perceptible trend of changes is clear (Ślusarczyk, 2018, pp. 232–248).

It is generally assumed that enterprises have sought to improve performance by adapting advanced production methods, mainly connected with operation practices and sophisticated manufacturing technologies (Pehrsson, 2020). Noticeable technological breakthroughs have been manifested in the so-called industrial revolutions that have triggered significant transitions in the organization and structure of production (Ślusarczyk, 2018, pp. 232–248). Until now four industrial revolution have been distinguished, including the recent one — the fourth industrial revolution, commonly known as Industry 4.0 (Lazanyi & Lambovska, 2020, pp. 100–113), marked by blurring the boundaries between people' and machines' work (Ślusarczyk, 2018, pp. 232–248).

2.1. Past industrial revolutions

The historical advance of manufacturing system technology concentrates on three complementary measurements, such as productivity, quality and cost (Chen, 2017, pp. 588–595). Nevertheless, the first two industrial revolutions focused rather on boosting productivity at the expense of the remaining aspects (Nhamo et al., 2020, pp. 315–337).

Although the term — industrial revolution — first appeared in France in the 1920s with regard to mechanisation of the cotton industry (Lazanyi & Lambovska, 2020, pp. 100–113), the first industrial revolution is said to have begun in the United Kingdom. It started in the second half of the 18th century and lasted till the mid 19th (Olanders & Rosenvinge, 2018). In that period of time a few vital inventions occurred in order to increase people's physical potential through machines' support in their manual labor. The main invention of the steam engine implemented by James Watt was the key factor that enabled the production of the first machines powered by steam. Due to this fact, the characterised period is considered as the launching of the machines and transportation industry (Lazanyi & Lambovska, 2020, pp. 100–113). Furthermore, analysed age involved the beginning of industrialisation, which manifested itself in adaptation of new technologies in the production processes (Brezis & Tsiddon, 1998, pp. 261–277). Indeed, the factory itself is stated as the major novelty (Kapás, 2008, pp. 15–33). The cottage industry was replaced with the production based on mechanical tools (Ślusarczyk, 2018, pp. 232–248), in which steam and water became the main driving forces and coal was the main fuel

(Lazanyi & Lambovska, 2020, pp. 100–113). The share of industry in the added value increased, as the population migrated from agriculture to industrialized areas. Despite tough living conditions in overcrowded cities, the standard of living improved with time. Moreover, this period is connected with the foundations of large enterprises (Beaudoin, 2000, pp. 7–13), as the small workshops and shops were replaced by bigger plants and department stores.

The prominent developments again came up in the second half of the 19th century which accounted for the second industrial revolution (Agarwal & Agarwal, 2017, pp. 1062–1066). In view of the role of applied science which led to efficiency and productivity increase, this period is known also as the scientific revolution (Amiti, 2001, pp. 149–172). The era was revolutionary due to the introduction of technologies associated mainly with production, just as in the previous period (Lazanyi & Lambovska, 2020, pp. 100–113). Steam was replaced with electricity (thanks to the invention of the light bulb by Thomas Edison), oil and the internal combustion engine that from now on became the new sources of energy. The two main products of the time were steel (invented by Henry Bessemer) and chemicals. In the first phase industries related with metallurgy, heavy engineering, chemistry, ship-building, food canning, power generation and armaments emerged, while the dominant sectors in the second half of the analyzed revolution were the automotive industry and refineries (Kapás, 2008, pp. 15–33). 1870 was a crucial year in terms of installing first assembly lines and pursuing labor diversification, which both contributed to significant development of mass production (Lazanyi & Lambovska, 2020, pp. 100–113). The term mass production stands for exploiting economies of scale through new technology usage that leads to both productivity increase and decrease in production costs (Amiti, 2001, pp. 149–172). The development had a positive impact on the mobility of workforce. The first serial production was introduced by Ford Motor Company. The American carmaker is also famous for the T-model — second industrial revolution's symbol (Lazanyi & Lambovska, 2020, pp. 100–113).

The presence of electricity gave rise to the inventions primarily based on electronic devices (Nasution, 2020). The third industrial revolution is dated to the middle of the 20th century. It is also commonly characterised as information technology, digital or computer-based revolution. In this period there were three stages which can be distinguished. The first phase referred to the introduction of the transistor and the computer, this stage was followed by biological engineering and microelectronics advancement, while the last phase was marked by popularisation of the Internet (Lazanyi & Lambovska, 2020, pp. 100–113). Advances in the field of electronics and computing enabled automatization and optimization of production processes (Ślusarczyk, 2018, pp. 232–248). Information and communication technology were the driving forces of that time. Knowledge became the key factor of economic and social life. As a consequence, the society transformed into the so-called information society (Lazanyi & Lambovska, 2020, pp. 100–113). New technologies based on information implicated plenty of changes in physical and social technologies. The most important change in the scope of social issues was the extension as well as globalisation of markets. Decrease in the cost of obtaining information and limitation of the trade barriers broadened competition. Additionally, new institutions in financial markets came up (Kapás, 2008, pp. 15–33). The number of expanded disciplines and innovative technologies that emerged in the third industry revolution were by far greater than in the previous ones, since it was the period of pushing the limits of not only science but also cognitive abilities (Lazanyi & Lambovska, 2020, pp. 100–113).

2.2. The 4th industrial revolution

The term Industry 4.0 was first introduced in 2011 in German in relation to the new idea of German economic policy (Atik & Ünlü, 2019, pp. 852–860). It occurred at the Hanover Trade Fair as the name of the new, common concept proposed by the representatives of the business, policy and science communities standing for strengthening the competitiveness of the industry (Rao & Prasad, 2018, pp. 145–159). The number 4.0 was to indicate the beginning of the fourth industrial revolution. In contrast to past revolutions, the 4th revolution was announced before it actually took place. There have been some critical opinions around the newly stated revolution, since the technology used in it has already existed during the previous one. Nevertheless, the concept of the fourth industrial revolution — Industry 4.0 — has spread dynamically and become a common phenomenon (Lazanyi & Lambovska, 2020, pp. 100–113). Similar ideas have appeared among different countries under the name of e.g. Smart Industry or Integrated Industry (Ślusarczyk, 2018, pp. 232–248).

Fourth industrial revolution is happening globally and simultaneously. A lot of countries have adopted this idea through national policy initiatives such as Industry Connected 4.0 in the USA, Manufacturing Innovation 3.0 in South Korea, Made In China 2025 & Internet Plus in China (Kiel et al., 2017, pp. 1–34), Industrie 4.0 in Germany, High Value Manufacturing Catapult in Great Britain, Produktion 2030 in Sweden, Alliance industrie du futur in France, Piano Industria 4.0 in Italy, Made Different in Belgium, Industria Conectada 4.0 in Spain, Plattform Industrie 4.0 in Austria (European Commission, 2018). Among Visegrád Group countries introduced policies are as follows: IPAR 4.0 National Technology Platform in Hungary, Initiative for Polish Industry 4.0 — The future Industry Platform in Poland, Průmysl 4.0 (Industry 4.0) in Czech Republic and Smart Industry in Slovakia. However, nearly half of the European's initiatives have been implemented since 2016 or later (European Commission, 2018).

2.3. Key features of Industry 4.0

A lot of authors and institutions have attempted to define the term "Industry 4.0". Lasi et al. (2014, pp. 239–242) claim that "Industry 4.0 describes the increasing digitisation and automation of the manufacturing environment, as well as the creation of digital value chains to enable communication between products, their environment and business partners". According to Lu (2017, pp. 1–10) "Industry 4.0 can be summarised as an integrated, adapted, optimised, service-oriented, and interoperable manufacturing process which correlates with algorithms, big data, and high technologies". Kamble et at. (2018b, pp. 107–119) define the Industry as "a range of technologies that enable the development and growth of value chains leading to reduced manufacturing times, and improved product quality and organisational performance". Though the name of the present revolution contains the word "industry", it also results in vast changes in remaining areas beyond the industrial sector. In fact, it affects the manufacturing, products, services, business model, work environment, skill development, market and the economy as a whole (Pereira & Romero, 2017, pp. 1206–1214). Industry 4.0 provides a new approach "by fully linking the physical work with the digital world, automated processes and allowing machines to work independent of human touch" (European Commission, 2020c). It indicates that Industry 4.0 is the revolution of trust — trust toward the decision of non-human entities (Lazanyi & Lambovska, 2020, pp. 100–113).

Industry 4.0 is based on various technological components, such as the cyber physical system (CPS), the Internet of Things (IoT), big data analytics, cloud computing, robotics, cybersecurity, artificial intelligence (AI) and other digital solutions applied among enterprises like customer relationship management (CRM), enterprise resource planning (ERP) or usage of e-commerce or social media. These technologies facilitate an improvement in adjustment of products to the different recipients' requirements. Additionally, the connection between devices, machines and components of the supply chain, linked together with shared information is to guarantee rapid modifications in production processes (Ślusarczyk, 2018, pp. 232–248).

Mentioned elements of Industry 4.0 often interpermeate and the net result is a combination of their collective use. CPS is a link of networking, computation and physical processes, where both computers and processes taking place monitor and control each other providing appropriate feedback (Lazanyi & Lambovska, 2020, pp. 100–113). The IoT is a network, which enables communication between devices and objects through wireless Internet infrastructure (Bajic et al., 2021, pp. 546–559). Big data analytics represents a practice based on massive volumes of data that can not be processed with the use of traditional methods (Lazanyi & Lambovska, 2020, pp. 100–113). This data is sourced from many devices and processed thanks to advanced analytical techniques such as data mining, that results in real-time decision making (Bajic et al., 2021, pp. 546–559). Cloud computing signifies storing and accessing data from the Internet without the need to use the computer's hard drive. Services like that have become an effective architecture to deliver large scale tasks (Atik & Ünlü, 2019, pp. 852–860). Robotics can be characterised as a system using industrial robots or robotic devices that work autonomously in order to function precisely in a cooperative and flexible way (Kamble et at., 2018a, pp. 408–425; Moktadir et at., 2018, pp. 730–741). In the wake of development of new, interconnected, smart solutions within machine resources that become smarter due to uninterruptible access to data, entire plants are also becoming smarter, which means more productive and less wasteful. The phenomenon of Smart Factory is said to be the pure power of Industry 4.0 (Siekelova & Podhorska, 2019). The basic systems to run action in today's smart factories are ERP as well as CRM. ERP may be defined as a general software which enables realising business activities like manufacturing, finance and logistic. Hence ERP is assumed to be a foundation of Industry 4.0 (Haddara & Elregal, 2015, pp. 721–728). CRM is a strategy of communication with customers. It focuses on collecting and managing information about customers which ought to result in better and longer relationships between company and clients. The new communication channel consisting of proper CRM applications linked with social media fulfills buyers needs and increases satisfactions (Dukić et al., 2017).

However, Industry 4.0 is not only a technological advancement but also human resource development that implies developing essential skills and knowledge (Schallock et al., 2018, pp. 27–32). Technological advancement of the 4th revolution requires a qualified and specialised workforce (Benešová & Tupa, 2017, pp. 2195–2202). The availability of appropriate capabilities among the country's current and future workforce greatly influences the successful transition to Industry 4.0 at the both micro and macro level. Additionally, it will be a key factor for innovation and competitiveness increase in organisations (Benešová & Tupa, 2017, pp. 2195–2202; Mavrikios et al., 2018, pp. 1–6). Technical and practical skills including technological, programming and digital ones will be essential in Industry 4.0 development (Maisiri et at., 2019, pp. 90–105). It is stated that ICT skills should be coupled with soft and collaborative capabilities such as creativity, proactive thinking, emotional intelligence and teamwork, as smart machines cannot apply neither common-sense reasoning nor empathy (Guszcza et at., 2017; Wilson & Daugherty, 2018). All things considered, in the era of the newest industrial revolution filled with sudden and impactful advances, life-long learning skills seem to be inevitable (Prifti et at., 2017).

3. Materials and methods

The major objective of the conducted research was to investigate readiness and adoption of Industry 4.0 in the Visegrád countries. Empirical analysis involved comparison of selected characteristic features — in the member countries — connected with the fourth industrial revolution which were presented in the Section 2 of this article.

A combination of quantitative and qualitative approaches was used in the comparative data analysis. Basic statistical analysis as well as critical analysis of the subject literature were used in the research. Data for this study were collected using both institutional reports and Internet databases. Main sources used in the assessment of the transition to Industry 4.0 are European Commission reports as well as Eurostat database.

4. Results

The Visegrád Group is notably impacted by the newest industrial revolution (European Commission, 2020c). Latest research shows that the percentage of jobs likely to be automated in the Group's member countries is higher than the European Union average (McKinsey & Company, 2018). This is due to the fact that V4 economies strongly rely on the manufacturing sector, which is based on schematic and routine physical work.

Compared to the EU average — 14.21%, the share of manufacturing to GDP is significantly higher in the Visegrád Group, which is demonstrated on Chart 1. In recent years Czechia has had the second highest share in the EU, after Ireland. This sector was in particular sensitive to the economic downturn in 2009 in Slovakia, Hungary and Czechia. This indicates the deep level of integration into the global value chains, as well as strong foreign investment dependency (European Commission, 2020c).

All member countries have large shares of FDI. Since the 2000s the share of FDI to GDP in manufacturing has fluctuated around 30% in V4. The automotive industry which has a prominent contribution to value-added and employment in V4 is almost fully foreign-owned. Since 2004 annual car production in the Group has increased from 1.4 to 3.5 million. Nowadays this industry in V4 employs around 1.5 million people and 20% of all cars produced in the EU come from the V4. As far as the size of economy is concerned, the automotive industry is much more important in the Visegrád Group than in the whole EU, so any disruptions in this sector have an incomparable impact on the economies of these countries (although to a less extend in Poland) (Polish Economic Institute, 2019).

Even though the EU global share of industrial robots has been shrinking since 2010 (mainly due to the increase of robotisation processes in China, South Korea and the ASEAN countries), robotisation in manufacturing has been steadily increasing in the V4 region since 2000. In comparison, the number of installed robots in other EU countries like Spain, Italy or France has been stagnating. Since 2010 Visegrád Group has at least tripled its robotic resources. Within V4, the growth is especially driven by Czechia (40% of all industrial robots in the Group), followed by Poland (25%). Hungary and Slovakia contribute equally to the total score (European Commission, 2020c; International Federation of Robotics, 2017).

However, around 60% of all industrial robots used in Visegrád Group are installed in car manufacturing. Slovakia is on the leading edge, where the share of robots connected to car manufacturing exceeds 80%, in Czechia 60%, in Poland and Hungary the share reaches 50%. A significant share of robots used in the manufacturing of plastic and metal products is noted in Hungary and Poland (around 25%). The third manufacturing sector in terms of the share of installed robots is metalworking. Generally the distribution of robots among different sectors observed in V4 is quite similar to that recorded in Germany, but it differs from the mixes in Asian countries (South Korea, Japan, China), where the electrical and electronic sectors form an essential part of the country's economy. Relatively the highest share of robots in mentioned areas was in Hungary (6%). Alas, in V4 the use of robots in R&D and education is low — in 2016 there were 200 industrial robots whereas 1734 in Germany (European Commission, 2020c; International Federation of Robotics, 2017).

In spite of visible increase in nominal numbers of installed robots, robot density in manufacturing lags behind other EU countries. In V4 there have been 65 industrial robots per 100000 employees in manufacturing, while in German 224, Spain 163, and France 101. This is mostly because of the significantly lower density in Poland (34), whereas Slovakia has the highest score among V4 — 137 (European Commission, 2020c; International Federation of Robotics, 2017).

A large share of jobs in the Visegrád Group is estimated to be automated mostly due to the large share of manufacturing in the economy. PricewaterhouseCoopers (2019) states that in Slovakia, Hungary and Czechia there is a similar share of jobs at potential high risk of automation (40 to 45%), and in Poland a bit lower (35%). These predictions of technological changes which favour services (administrative, ICT services) over manufacturing in the labor market do not mix with the current education system and current employment. For example, according to the latest Eurostat (2021c) data in Slovakia no more than 3.3% of all graduates were ICT graduates (in Poland 3.5%, in Hungary 4.3% and in Czechia 4.5%). Thus, in 2018 nearly 80% of Czech enterprises and 60% of Slovak and Hungarian firms reported difficulties in recruitment when looking for specialists in this field (European Commission, 2020c). Moreover, there is a large gender gap in the ICT profession. In V4 only around 10% of all employed ICT specialists are women (according to Eurostat (2021e) 14% in Poland, 13.1 in Slovakia, 9.7% in Czechia and 8.6% in Hungary). Furthermore, digital skills among society as a whole need improvement. All V4 countries in 2019 performed below the EU level with regard to more advanced digital skills. Compared to the EU average (31%), in Slovakia 27% of people had above basic overall digital skills, in Czechia 26%, in Hungary 25%, and the lowest percentage was noted in Poland — 21%. In terms of low digital skills the worst situation was reported in Poland again where 35% of society had low overall digital skills whereas the EU average was 29% (based on Eurostat (2021g)).

The usage of new technologies among domestic enterprises in V4 varies (Chart 2). The most popular technology adopted in V4 firms is social media (the highest score is noted in Czechia — 47%, the lowest in Poland — 37%). However, the Group has been still lagging behind the EU average (50%). In case of the less current technology — big data analytics — only about 7% of firms use it, while the EU level is 13%. As far as other technologies are concerned, Czechia stands out from the rest V4 countries with the adoption of both e-commerce and ERP, which at the same time exceeds the EU average. On the other hand Hungary significantly lags behind regarding the use of ERP and CRM.

According to European Innovation Scoreboard (European Commission, 2020b) the Visegrád Group should work on domestic research and innovation increase. All V4 countries belong to the third out of four performance groups — Moderate Innovators (after Innovation Leaders e.g. Denmark, Finland, Netherlands, Sweden and Strong Innovators e.g. Austria, Belgium, Estonia, France, Germany and Portugal). Although Czechia ranks in the middle of the ranking, Poland, Hungary and Slovakia are at the bottom of the list near the worst performance group — Modest Innovators — that includes Bulgaria and Romania. Furthermore, gross domestic expenditure on R&D remains low in V4. In Czechia it is 1.93% of GDP, Hungary 1.53%, Poland 1.21%, Slovakia 0.84%.

The V4 countries also lag behind in the European synthetic indicator of overall digital performance — Digital Economy and Society Index DESI (Chart 3), which is made up of 5 dimensions (connectivity, human capital, use of internet, integration of digital technology and digital public services). In the 2020 ranking that covers 28 countries (including the United Kingdom) the four countries are ranked as follows: 17th Czechia, 21st Hungary, 22nd Slovakia and 23rd Poland. In comparison, the Baltic countries are generally much higher in the 2020 ranking — Estonia 7th, Lithuania

14th, Latvia 18th and this region is distinguished by highly developed digital public services. While in V4 slightly over 50% of the population uses e-government, in Baltic countries the percentage fluctuates around 85%. Compared to the 2015 scores, the only country in V4 which improved its result was Hungary (one position change), while Czechia and Poland maintained the same level and Slovakia dropped two positions. The Visegrád Group continues to remain below the EU average in a holistic approach. According to the 2020 Index only Czechia features above the EU average in terms of integration of digital technology dimension, and as far as the connectivity dimension is concerned only Hungary in V4 significantly exceeds the EU level. The high Czech score in the 4th dimension results from the fact that this country ranks third in the EU when it comes to the percentage of enterprises selling online cross-border, and ranks second in the case of SMEs total turnover from e-commerce. Analysing the relatively high score in the 1st dimension in Hungary it should be mentioned this country ranks fourth in the aspect of percentage of households subscribing to fixed broadband of at least 100 Mbps, and ranks third when it comes to the percentage of spectrum assigned and ready for 5G within the so-called 5G pioneer bands (European Commission, 2020a).

The global digital competitiveness varies among the Visegrád Group. According to the 2020 ranking of World Digital Competitiveness which covers 64 countries, the V4 ranks as follows: Poland 32nd, Czechia 35th, Hungary 47th and Slovakia 50th. In comparison with the 2015 scores the progress was noted only in Poland while the remaining V4 countries were downgraded. The strengths of each region differ — Poland and Slovakia excel in technological framework and scientific concentration, Czechia stands out with business agility and talent, Hungary dominates only with advantageous technological framework. On the negative side, Poland suffers from average regulatory framework, Czechia's weak side is training and education, Hungary lags behind in adaptive attitudes and business agility, Slovakia suffers from poor regulatory framework and business agility (IMD World Competitiveness Center, 2020).

The most significant developments related to Industry 4.0 take place in capital cities, mainly due to the essential resources and agglomeration effects. These initiatives could be scaled-up on neighbouring areas in order to effectively use the already developed know-how. For example, Prague is commonly known for cybersecurity and Bitcoin solutions, Warsaw excels in marketing and Budapest is famous for scaleups. Bratislava due to close proximity to Vienna does not use its full potential, since highly skilled employees emigrate from the capital of Slovakia. However, developments take place in other cities too. Poznan strongly develops IT industries and business services, Krakow's enterprises concentrate on beacon solutions and IoT and Brno is famous for technologies like microscopy, nanotechnology or biotechnology (European Commission, 2020c).

There seems to be quite a large divergence among V4 societies regarding the impact of digitisation and automation on daily life. The 2017 Special Eurobarometer 460 (European Commission, 2017) shows the vast majority of the population in the Group thinks that recent digital technologies have a positive impact both on the economy (the highest percentage was noted in Poland — 88%, the lowest in Hungary 75%) and on their quality of life (the highest score again in Poland — 79%, the lowest in Czechia 66%). However, only Polish society (73%) ranked above EU average (71%) in terms of considering itself to be sufficiently skilled in the use of digital technology in daily life (among all EU countries the smallest percentage of people who felt skilled was in Hungary — 52%). Additionally, more than half of Hungarian and Slovakian considered themselves unskilled to use online public services, such as filing a tax declaration or applying for visa online, whereas 68% of Poles agreed to have the mentioned skills. Hungarians are also the most sceptical towards the use of robots and artificial intelligence among V4, where only 53% of respondents had a positive view while in Poland 69%, in Czechia 64%, in Slovakia 63%. There is a positive correlation between the awareness of artificial intelligence and attitude towards robots and artificial intelligence (Chart 4). Hungarian were the most reluctant to these technologies but they were also the least likely to have heard, read or seen anything about AI in V4.

5. Conclusion

The main goal of the current study was to reflect on the preparedness of the Visegrád Group to the changes linked to the 4th industrial revolution. The investigation has shown that the transition towards Industry 4.0 in V4 countries is less advanced than in other European regions and need particular attention.

Despite the relatively good results achieved in the field of robotisation, especially in the foreign-owned automotive industry, in general the Group lags behind the majority of Western and Baltic countries in terms of already adapted technologies, innovations and digital skills. The findings of this study suggest that the Czech Republic stands out from other V4 countries in many of the mentioned areas, although Poles seem to be the most open to changes and new technologies.

However, it is generally assumed that Covid-19 pandemic and the subsequent recovery will increase the pressure for further development of digital solutions. Consistent research and implementation of new technologies at the level of both private companies and state institutions are crucial to boost competitiveness in international markets. Also, unfavourable demographic position combined with the predictions of work automation should provide an incentive to make effective adjustments in the V4. The Visegrád Group should focus on the education and training system which will enable the present and future workforce to obtain the relevant and appropriate skills and knowledge.

Taking into account the fact that Industry 4.0 is constantly evolving and its solutions are tested in more and more new areas of the economy, further investigation in the field of integration of new technologies in V4 and in other European countries would be worthwhile.

References

Agarwal, H., & Agarwal, R. (2017). First industrial revolution and second industrial revolution: technological differences and the differences in banking and financing of the firms. *Saudi Journal of Humanities and Social Sciences*, 2(11), 1062–1066. https://doi.org/10.21276/sjhss.2017.2.11.7.

Amiti, M. (2001). Regional specialization and technological leapfrogging. *Journal of Regional Science*, 41(1), 149–172. https://doi.org/10.1111/0022-4146.00211.

Atik, H., & Ünlü, F. (2019). The measurement of industry 4.0 performance through Industry 4.0 Index: an empirical investigation for Turkey and European Countries. *Procedia Computer Science*, 158, 852–869. https://doi.org/10.1016/j.procs.2019.09.123.

Bajic, B., Rikalovic, A., Suzic, N., & Piuri, V. (2021). Industry 4.0 implementation challenges and opportunities: a managerial perspective. *IEEE Systems Journal*, 15(1), 546–559. https://doi.org/10.1109/jsyst.2020.3023041.

Beaudoin, S.M. (2000). Current debates in the study of the industrial revolution. *OAH Magazine of History*, 15(1), 7–13. https://doi.org/10.1093/maghis/15.1.7.

Benešová, A., & Tupa, J. (2017). Requirements for education and qualification of people in industry 4.0. *Procedia Manufacturing*, 11, 2195–2202. https://doi.org/10.1016/j.promfg.2017.07.366.

Brezis, E.S., & Tsiddon, D. (1998). Economic growth, leadership and capital flows: the leapfrogging effect. *Journal of International Trade and Economic Development*, 7(3), 261–277. https://doi.org/10.1080/09638199800000014.

Chen, Y. (2017). Integrated and intelligent manufacturing: perspectives and enablers. *Engineering*, 3(5), 588–595. https://doi.org/10.1016/j.eng.2017.04.009.

Dukić, B., Dugandžić, S., & Dukić, S. (2017). *Conceptual CRM application database model in the function of physical products distribution for known customer*. Proceedings of the 17th International Scientific Conference Business Logistics in Modern Management.

European Commission. (2017). *Special eurobarometer 460: attitudes towards the impact of digitisation and automation on daily life*. Retrieved 03.07.2021 from https://europa.eu/eurobarometer/surveys/detail/2160.

European Commission. (2018). *Digital transformation scoreboard 2018: EU businesses go digital: opportunities, outcomes and uptake*. Retrieved 04.05.2021 from https://op.europa.eu/en/publication-detail/-/publication/683fe365-408b-11e9-8d04-01aa75ed71a1.

European Commission. (2020a). *Digital Economy and Society Index (DESI) 2020: thematic chapter*. Retrieved 18.06.2021 from https://digital-strategy.ec.europa.eu/en/policies/desi.

European Commission. (2020b). *European innovation scoreboard 2020*. Retrieved 18.06.2021 from https://ec.europa.eu/docsroom/documents/42981.

European Commission. (2020c). *Transition to industry 4.0 in the Visegrád countries*. Retrieved 04.05.2021 from https://ec.europa.eu/info/publications/transition-industry-40-visegrad-countries_en.

Eurostat. (2021a). *Big data analysis*. Retrieved 18.05.2021 from https://ec.europa.eu/eurostat/data/database.

Eurostat. (2021b). *Cloud computing services*. Retrieved 18.05.2021 from https://ec.europa.eu/eurostat/data/database.

Eurostat. (2021c). *Distribution of graduates at education level and programme orientation by sex and field of education*. Retrieved 18.05.2021 from https://ec.europa.eu/eurostat/data/database.

Eurostat. (2021d). *E-commerce sales*. Retrieved 18.05.2021 from https://ec.europa.eu/eurostat/data/database.

Eurostat. (2021e). *Employed ICT specialists by sex*. Retrieved 18.05.2021 from https://ec.europa.eu/eurostat/data/database.

Eurostat. (2021f). *Enterprises using software solutions, like CRM to analyse information about clients for marketing purposes*. Retrieved 18.05.2021 from https://ec.europa.eu/eurostat/data/database.

Eurostat. (2021g). *Individuals' level of digital skills*. Retrieved 18.05.2021 from https://ec.europa.eu/eurostat/data/database.

Eurostat. (2021h). *Integration of internal processes*. Retrieved 18.05.2021 from https://ec.europa.eu/eurostat/data/database.

Eurostat. (2021i). *Social media use by type, internet advertising*. Retrieved 18.05.2021 from https://ec.europa.eu/eurostat/data/database.

Guszcza, J., Lewis, H., & Evans-Greenwood, P. (2017). *Cognitive collaboration: why humans and computers think better together*. Retrieved 18.05.2021 from https://www2.deloitte.com/us/en/insights/deloitte-review/issue-20/augmented-intelligence-human-computer-collaboration.html.

Haddara, M., & Elregal, A. (2015). The readiness of ERP systems for the factory of the future. *Procedia Computer Science*, 64, 721–728. https://doi.org/10.1016/j.procs.2015.08.598.

IMD World Competitiveness Center. (2020). *The IMD world digital competitiveness ranking 2020*. Retrieved 18.06.2021 from https://worldcompetitiveness.imd.org/rankings/digital.

International Federation of Robotics. (2017). *World robotics industrial robots and service robots 2017*. Retrieved 18.06.2021 from https://ifr.org.

Kamble, S.S., Gunasekaran, A., & Gawankar, S.A. (2018a). Sustainable industry 4.0 framework: a systematic literature review identifying the current trends and future perspectives. *Process Safety and Environmental Protection*, 117, 408–425. https://doi.org/10.1016/j.psep.2018.05.009.

Kamble, S.S., Gunasekaran, A., & Sharma, R. (2018b). Analysis of the driving and dependence power of barriers to adopt industry 4.0 in Indian manufacturing industry. *Computers in Industry*, 101, 107–119. https://doi.org/10.1016/j.compind.2018.06.004.

Kapás, J. (2008). Industrial revolutions and the evolution of the firm's organization: an historical perspective. *Journal of Innovation Economics & Management*, 2(2), 15–33. https://doi.org/10.3917/jie.002.0015.

Kiel, D., Müller, J.M., Arnold, Ch., & Voigt, K-I. (2017). Sustainable industrial value creation: benefits and challenges of industry 4.0. *International Journal of Innovation Management*, 21(8). https://doi.org/10.1142/s1363919617400151.

Lasi, H., Fettke, P., Kemper, H.G., Feld, T., & Hoffmann, M. (2014). Industry 4.0. *Business & Information Systems Engineering*, 6(4), 239–242. https://doi.org/10.1007/s12599-014-0334-4.

Lazanyi, K., & Lambovska, M. (2020). Readiness for industry 4.0 related changes: a case study of the Visegrad four. *Ekonomicko-manazerske Spektrum*, 14(2), 100–113. https://doi.org/10.26552/ems.2020.2.100-113.

Lu, Y. (2017). Industry 4.0: a survey on technologies, applications and open research issues. *Journal of Industrial Information Integration*, 6, 1–10. https://doi.org/10.1016/j.jii.2017.04.005.

Maisiri, W., Darwish, H., & van Dyk, L. (2019). An investigation of industry 4.0 skills requirements. *South African Journal of Industrial Engineering*, 30(3), 90–105. https://doi.org/10.7166/30-3-2230.

Mavrikios, D., Georgoulias, K., & Chryssolouris, G. (2018). The teaching factory paradigm: developments and outlook. *Procedia Manufacturing*, 23, 1–6. https://doi.org/10.1016/j.promfg.2018.04.029.

McKinsey & Company. (2018). *Transforming our jobs: automation in Hungary*. Retrieved 18.06.2021 from https://www.mckinsey.com/featured-insights/europe/transforming-our-jobs-automation-in-hungary.

Moktadir, A., Ali, S.M., Kusi-Sarpong, S., & Shaikh, A.A. (2018). Assessing challenges for implementing industry 4.0: implications for process safety and environmental protection. *Process Safety and Environmental Protection*, 117, 730–741. https://doi.org/10.1016/j.psep.2018.04.020.

Nasution, M.K.M. (2020). Industry 4.0. *IOP Conference Series: Materials Science and Engineering*, 1003, 012145, 1–10. https://doi.org/10.1088/1757-899X/1003/1/012145.

Nhamo, G., Nhemachena, C., & Nhamo, S. (2020). Using ICT indicators to measure readiness of countries to implement industry 4.0 and the SDGs. *Environmental Economics and Policy Studies*, 22(2), 315–337. https://doi.org/10.1007/s10018-019-00259-1.

Olanders, D., & Rosenvinge, M. (2018). *Industry 4.0: how can industry 4.0 create value in manufacturing companies* [Bachelor's thesis, KTH Royal Institute of Technology]. Retrieved 21.04.2021 from http://urn.kb.se/resolve?urn=urn:nbn:se:kth:diva-233809.

Pehrsson, A. (2020). *Industry 4.0: impact on manufacturing strategies and performance* [Bachelor's thesis, Linnaeus University]. Retrieved 21.04.2021 from http://urn.kb.se/resolve?urn=urn:nbn:se:lnu:diva-97129.

Pereira, A.C., & Romero, F. (2017). A review of the meanings and the implications of the industry 4.0 concept. *Procedia Manufacturing*, 13, 1206–1214. https://doi.org/10.1016/j.promfg.2017.09.032.

Polish Economic Institute. (2019). *The automotive industry in the Visegrad Group countries*. Retrieved 18.06.2021 form https://pie.net.pl/en/polska-i-kraje-cee-napedzaja-europejska-motoryzacje.

Prifti, L., Knigge, M., Kienegger, H. & Krcmar, H. (2017). *A competency Model for "Industrie 4.0" Employees*. Proceedings of the 13th International Conference on Wirtschaftsinformatik.

PricewaterhouseCoopers. (2019). *How will AI impact the Hungarian labour market*. Retrieved 18.06.2021 from https://www.pwc.com/hu/en/publications/assets/How-will-AI-impact-the-Hungarian-labour-market.pdf.

Rao, S.K., & Prasad, R. (2018). Impact of 5G technologies on industry 4.0. *Wireless Personal Communications*, 100(1), 145–159. https://doi.org/10.1007/s11277-018-5615-7.

Schallock, B., Rybski, C., Jochem, R. & Kohl, H. (2018). Learning factory for industry 4.0 to provide future skills beyond technical training. *Procedia Manufacturing*, 23, 27–32. https://doi.org/10.1016/j.promfg.2018.03.156.

Siekelova, A., & Podhorska, I. (2019). Earnings indicators under the condition of globalization. In T. Kliestik (Ed.), *Proceedings of the 19th international scientific conference globalization and its socio-economic consequences: sustainability in the global-knowledge economy*, 74, 1–7. https://doi.org/10.1051/shsconf/20207401031.

Ślusarczyk, B. (2018). Industry 4.0: are we ready. *Polish Journal of Management Studies*, 17(1), 232–248. https://doi.org/10.17512/pjms.2018.17.1.19.

The Global Economy. (2021). *Share of manufacturing in the European Union*. Retrieved 18.06.2021 from https://www.theglobaleconomy.com.

Wilson, J.H., & Daugherty, P.R. (2018). Collaborative intelligence: humans and AI are joining forces. *Harvard Business Review*, July–August, 114–123.

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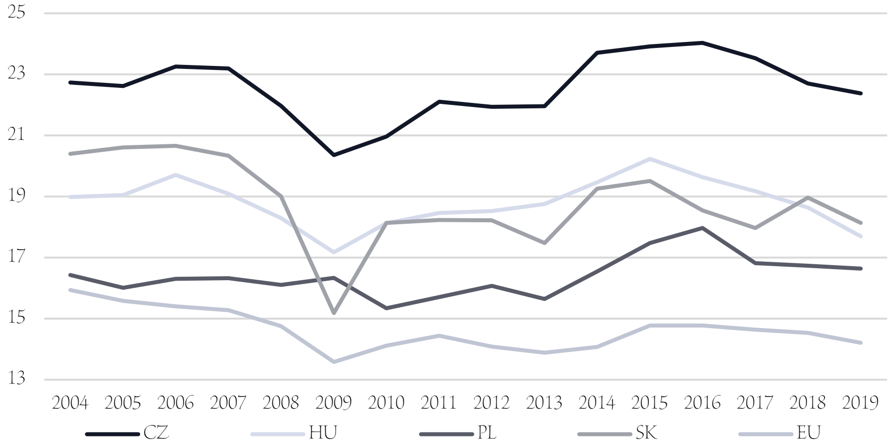
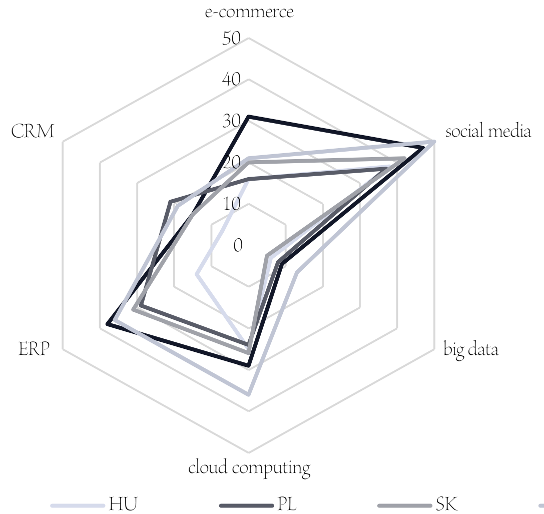
Appendix

Chart 1.
Share of manufacturing in GDP (%)



Source: Own preparation based on European Commission (2020c) and The Global Economy (2021).

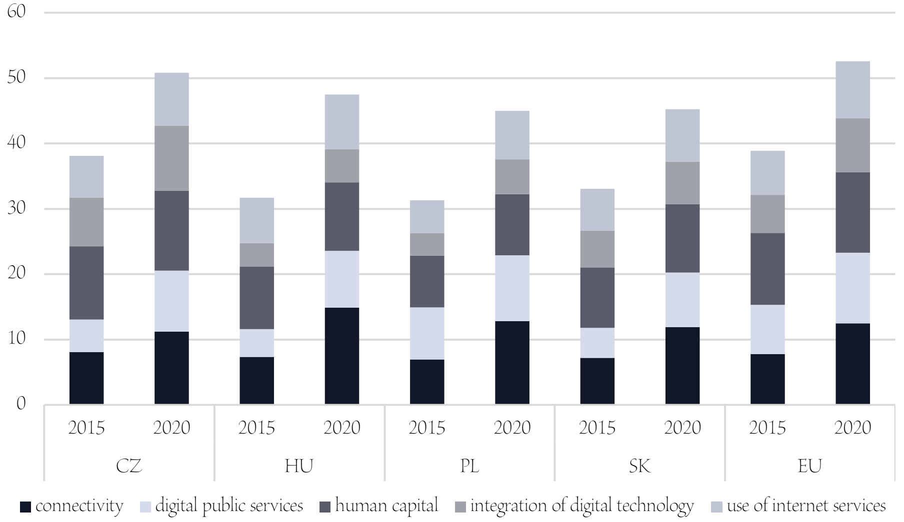
Chart 2.
V4 enterprises using new technologies



Notes:
Chart 2 presents the percentage of enterprises using selected technologies out of all enterprises (without financial sector) with 10 person employed or more.

Source: Own preparation based on Eurostat (2021a; 2021b; 2021d; 2021f; 2021h; 2021i).

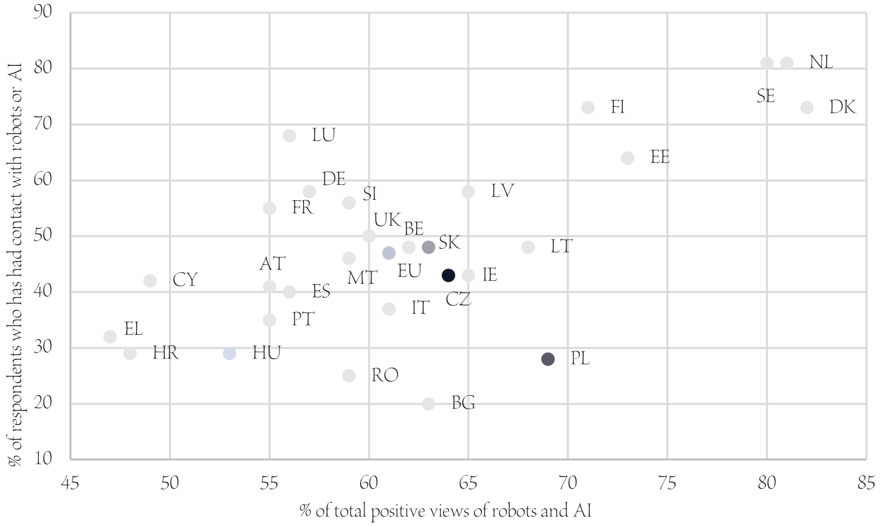
Chart 3.
Digital Economy and Society Index (DESI)



Notes:
Chart 3 presents the structure of DESI that is made up of 5 dimensions: connectivity (fixed broadband take-up, fixed broadband coverage, mobile broadband and broadband prices), human capital (internet user skills and advanced skills), use of internet (citizens' use of internet services and online transactions), integration of digital technology (business digitisation and e-commerce), digital public services (e-Government).

Source: Own preparation based on European Commission (2020a).

Chart 4.
Correlation between the awareness of AI and attitude towards robots and AI



Notes:

Chart 4 is made on the basis of two questions from the Special Eurobarometer poll (N=27 901). OX axis presents total "Positive" answers to the following question: "Generally speaking, do you have a very positive, fairly positive, fairly negative or very negative view of robots and artificial intelligence?", while OY axis shows total "Yes" answers to the question: "In the last 12 months, have you heard, read or seen anything about artificial intelligence?".

Source: Own preparation based on European Commission (2017).