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Industry 4.0 in Central and Eastern Europe: Is Romania Ready to Embrace the Fourth Industrial Revolution?

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Abstract. *This research paper analyses the opportunities for the possible implementation of the latest technological innovations in the Romanian manufacturing industry. The latest trends in technology can be summed up by the term "Industry 4.0", or the "Fourth Industrial Revolution", which brings unprecedented levels of automation, thanks to recent breakthroughs in Artificial Intelligence (A.I.), robotics and much more. However, manufacturing sectors are not created equally and some are more susceptible to implementing new technologies than others. The industrial situation in Eastern and Central Europe is highly debated and complex. During the Cold War, most of the Warsaw Pact and COMECON countries were characterized, economically speaking, by rapid industrialization, be it heavy or light industry. This is also the case in Romania, as it saw an increase in industrial output during the communist era. After the dissolution of the Soviet Union and the collapse of the collectivist ideology, some manufacturing sectors collapsed, while new ones appeared, the case of deindustrialization in Central and Eastern Europe still being under scrutiny, as the industrial output has been more stable than we tend to believe. However, a shift did occur, especially in Romania. Following the transition to a market economy, industrial output suffered a metamorphosis, exchanging some sectors (such as the textile one) for new ones (such as the automotive one, following an increase in foreign direct investments from the West). These shifts in the manufacturing sector have an advantage in the unfolding context, as the new industries (such as auto-manufacturing) are more inclined to adopt Industry 4.0. These factors, in combination with the recent trend of reshoring, are prone to positively influence the future economic environment of Romania.*

Keywords: Fourth Industrial Revolution, industry, reshoring, Romania, Central and Eastern Europe, European Union

Introduction

The "Fourth Industrial Revolution" concept is becoming more and more relevant, especially when debating its effects on the global economic landscape. The term "Industry 4.0" was coined by the economist Klaus Schwab and referred to the recent breakthroughs in technology that, due to further innovation, can positively affect the way we perceive manufacturing, whilst the "4.0" paradigm can exert influence upon many other aspects of social, political, cultural or ecological existence (Jora and Iacob, 2022), to be foresighted rather than simply forecasted (Curaj et al., 2020). However, manufacturing remains a/the key element in this transformational setup, as the newer trends in technology have a direct use on industry and its output and productivity. This is why debating the readiness to implement the latest technologies in Central and Eastern Europe (CEE) is relevant, especially when we consider the historical side of their respective industrial sectors.

In this paper, I propose a thorough analysis of the countries that have experienced "coerced" industrialization during the Cold War, as members of the socialist bloc (Warsaw Pact and COMECON), followed by a debated de-industrialization after the collapse of the collectivist ideology and the rapid transition to a market economy as well as integration into the European

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Union. Furthermore, it is essential to mention the economic gap between these countries and their western counterparts, the European Union functioning as a homogenizing factor. Therefore, the paper will explore the industrial environment and evolution in Romania, Bulgaria, Hungary, Poland, the Czech Republic and Slovakia, as well as the economic potential of implementing the Fourth Industrial Revolution in their manufacturing sectors. Moreover, the research will conclude by offering a hopefully clearer picture of Romania's place in the economic world of Industry 4.0.

Literature review

The risks and opportunities following the proliferation of the newest trend in technology are as widely debated and discussed as well as the situation in Central and Eastern Europe. The research paper "The Fourth Industrial Revolution: Shaping a New Era" (Philbeck and Davis, 2018) mentions, in a brief manner, the importance of Industry 4.0, characterized by the rapid exchange of information, succeeding the informational revolution of the past decades (Third Industrial Revolution). It is here that we find the most influential trends in technology, such as Artificial Intelligence, the Internet of Things, machine-learning algorithms and the mix between digital and biological. The paper also gives a holistic approach as it manages to explain the history of the past industrial revolutions.

Moreover, the paper entitled "Challenges and impacts of the digital transformation of society in the social sphere" (Komarčević et al., 2017) stresses the possible effects of the Fourth Industrial Revolution on humans, be they consumers or workers. Here we find dilemmas such as the increase in inequality, the emergence of a new class, that of "digital workers", instability regarding the labor market as new jobs emerge while old ones become obsolete and an increase in the surveillance targeting the workers. The paper also brings into discussion the case of Serbia and its challenges and opportunities regarding innovation in the digital age and the European initiatives such as digitization of the public sector and promoting investments in order to spread and incentivize innovation.

Naudé, Surdej and Cameron (2019) are successfully sketching a larger picture regarding industrialization, deindustrialization and the place of Industry 4.0 in post-communist European countries. The focus is being put on the shift which occurred in CEE regarding manufacturing, as foreign direct investments (FDI) after 1990 brought new opportunities alongside free-market reforms. These factors meant the collapse of unproductive and inefficient sectors while allowing others to prosper and grow. The authors also reflect on the opportunities for these countries to adopt the latest technological trends, but also their readiness.

Methodology

This paper's aim is to study the opportunities of the Fourth Industrial Revolution in the context of Central and Eastern European Countries (CEECs) while also focusing on Romania and its readiness for it. For this study, I've proposed both a qualitative and a quantitative approach, encompassing a critical analysis of the relevant literature focusing on the key concepts (such as the current technology trends), as well as the relevant statistics (such as economic indicators, graphical interpretations, etc.) which represent arguments in the debate whether Romania is ready to embrace the Fourth Industrial Revolution and whether the new technologies will transform its economy from a macroeconomic point of view as well as of the place of Industry 4.0 in the Central and Eastern European post-communist landscape.

The case of Central and Eastern Europe

This paper focuses on the six countries that experienced "coerced" industrialization during the Cold War, given they were communist countries closely aligned with the Soviet Union (but not part of), and members of the Warsaw Pact and COMECON. Furthermore, the six chosen countries (Poland, Czech Republic, Slovakia, Hungary, Bulgaria and Romania, with a focus on the latter) have in common the accession to the western organizations, such as NATO and the European Union, the latter being of much more importance, considering the economic context of Industry 4.0.

The selected countries experienced rapid industrialization during the Cold War as it was a critical part of the planned economy, centered on Moscow. The best way to understand the phenomenon of industrialization is to analyze the share of industry in a country's Gross Domestic Product. In the case of Romania, the share of industry in GDP was 26.4% in 1965, 35.5% in 1970 and 39.8% in 1975 (Kopsidis and Ivanov, 2017).

However, the fallacies of the planned economy (due to the inability of economic calculation) rose. The Romanian economy was focusing at that time on the heavy and chemical industry, with most of the operations relying on intensive energy consumption, represented by oil imports from the Middle East. Moreover, the industry was severely unproductive in terms of labor, having an average of 1,480 workers per industrial enterprise, with the USSR having 712 and West Germany 149. Furthermore, the rising oil prices during the 1970s and the (ideological) refusal to move to less-energy-dependent activities (such as the tertiary sector, that of services) confirmed the collapse that the industry would suffer after the regime change in 1989 (Kopsidis and Ivanov, 2017).

It should be noted that these unproductive traits represented consequences of a broader ideological mindset behind the mere central planning, not a solely economic one, although the latter was condemned to severely unfavorable results due to the absence of a free and functional market. On this note, the rest of the CEECs found themselves in similar situations, especially when referring to the industrialization of the 1950s, 60s and 70s.

A key moment when discussing the industrial environment in CEE is the collapse of the communist regimes in 1989 and the early 1990s. Following this event, the Eastern bloc has rapidly embraced free-market reforms, as well as democratic ones. These reforms brought unprecedented levels of economic growth and development, but, on the other hand, caused a period of readjustment, especially when referring to the manufacturing sector. Given the fallacies of the planned economy, most of the industry found itself to be unprofitable in a capitalist business environment and it was forced to close doors. This process, although cathartic, managed to "scrub" the economic landscape of the post-Eastern bloc, giving way to profitable businesses while closing the enterprises built upon ideological dogmas, rather than free economic thinking and business planning.

The liberalization of these economies brought a more open trade policy, facilitating imports, as well as encouraging foreign direct investments and privatization. All these factors further confirmed the uncompetitiveness of some industries. Therefore, a process of deindustrialization followed, which can be interpreted as an adjustment to a more efficient economic model, that of a free-market capitalist (and competitive) environment (Naudé, Surdej and Cameron, 2019).

This readjustment can be best observed in Figure 1, industry value added to the GDP in Romania dropping from 45.88% in 1990, during the collapse of the communist regime, to a minimum of 26.89% in 2020, due to the COVID-19 pandemic.

The readjustment period, although necessary in the long run, proved otherwise in the short run. In the post-Soviet countries, the average poverty headcount exceeded 50% of the population

in 1993/1995, Romania being the only non-Soviet post-communist country to have a similar percentage. Furthermore, the GINI coefficient (measuring income distribution, higher the value meaning higher inequality in a given society) rose from 0.15 to 0.4 in Romania during the first half of the decade following the collapse of the collectivist ideology (Tøndel, 2001).

The inflow of FDI in the post-communist world rose after 1990, with democratization and liberalization being key factors behind this, CEE accounting for 67% of FDI inflows in the post-communist environment, Poland being the biggest receiver with approximately 20 billion USD in 1994-1998, while Romania attracted just under 5 billion USD in FDI (Figure 2), the main country-sources being The Netherlands, Germany and France (Tøndel, 2001).

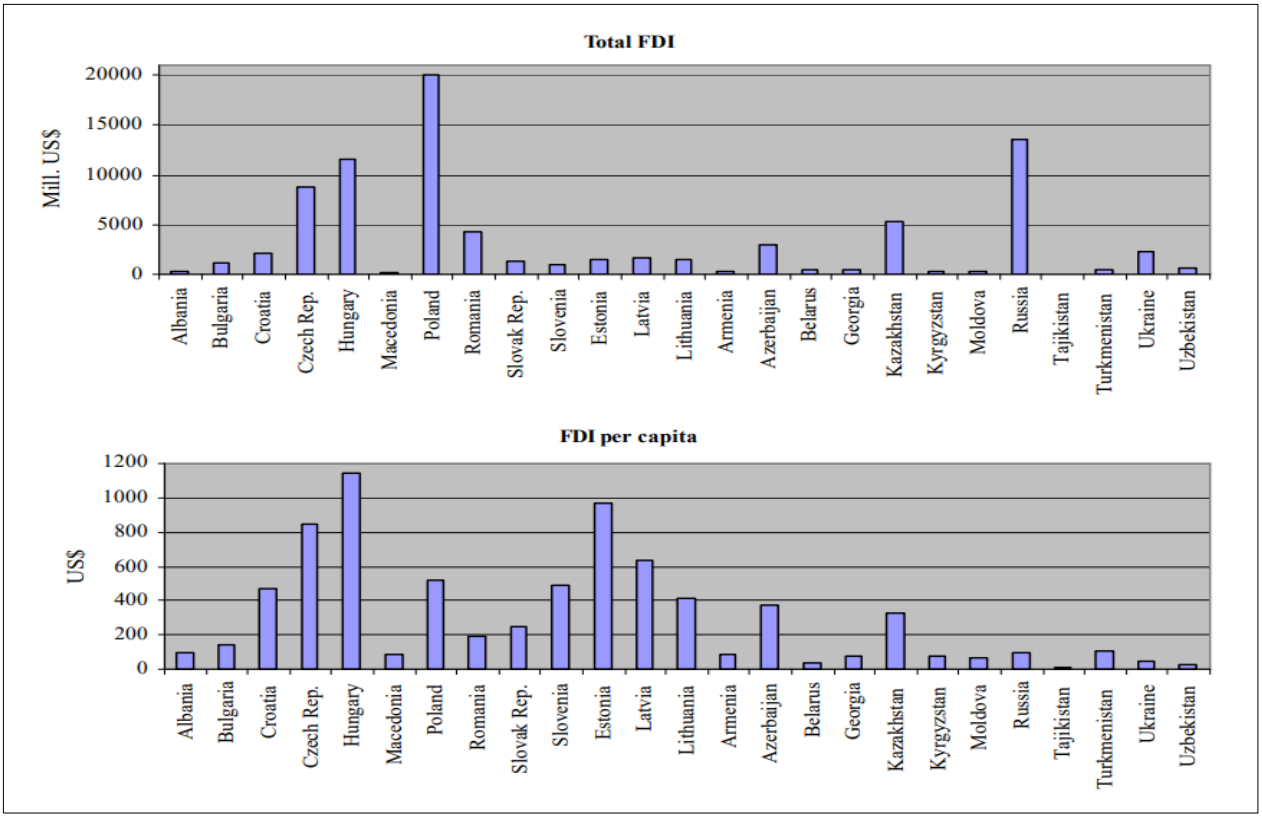


Figure 1. Value added by industry as a percentage of Gross Domestic Product in Romania

Source: The Global Economy (2022).

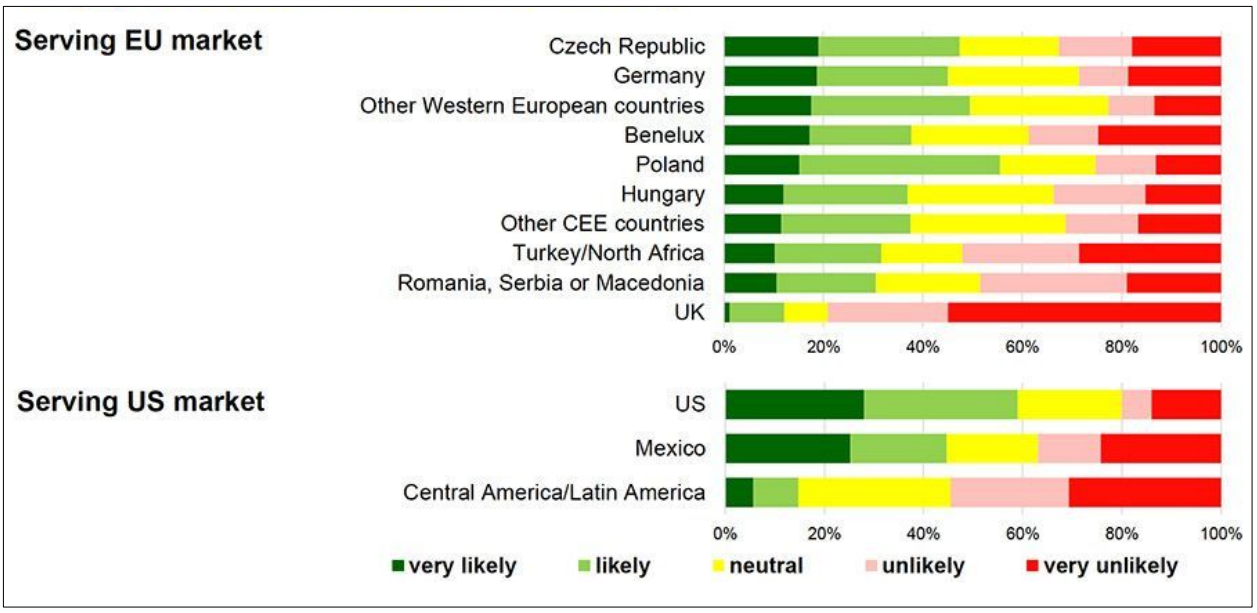


Figure 2. Dispersion of Foreign Direct Investments in post-communist countries in 1994-1998
Source: Tøndel (2001).

The change in the manufacturing landscape of Central and Eastern Europe

As mentioned above, CEE followed a period of readjustment after the collapse of the communist regimes. Economic and political reforms paved the way for a new model of economic thinking, that of free-market capitalism, focused, this time, on decentralized competition rather than central planning. The fallacies of a planned economy focused on ideological dogmas meant that most of the previous state-owned enterprises were no longer profitable. As privatizations and foreign direct investments made their way to the Eastern Bloc, more industries were forced to close their doors or implement major structural changes in order to reach sustainable figures.

One of the most iconic examples of the shift of industry, done with financial investments coming from the West, is the case of the state-owned Czech auto manufacturer Skoda. After the collapse of the Czechoslovakian communist regime, its government chose the German industry giant Volkswagen to collaborate with Skoda. This produced an inflow of capital, as well as innovation and restructuring in order to boost the enterprises' productivity and competitiveness. This example is vital in understanding the shift in manufacturing in CEE because these innovations in Skoda positively affected a whole range of Czech firms, especially local suppliers for the auto industry. All these factors led to even more FDI funneling into the Czech economy, including greenfield investments, rapidly changing the economic landscape of the country as a whole, making the period of readjustment last less than in other countries, such as Romania (Tøndel, 2001). It can be argued that Romania had a similar story, that of the local auto manufacturer Dacia, which was eventually privatized and acquired by Renault, although the difference is that the process of privatizing Skoda and partnering with Volkswagen precedes the case of Dacia-Renault by almost a decade.

The period of readjustment and change in manufacturing in CEE is essential to discuss due to its ramifications in the present day and the opportunities of Industry 4.0. To further understand the period, it is imperative to discuss the changes and shifts in the Romanian industry (Table 1.), following the liberalization after 1989.

Table 1. Industrial production in Romania by activities, as percentage (1990-2005)

Activities (divisions CAEN)	1990	1995	2000	2005
Industry, total	100	100	100	100
Manufacturing industry	85,8	80,5	79,4	80,6
Food and beverages	14,4	16,3	16,1	13,9
Tobacco products	0,5	0,5	1,5	1,4
Textile products	6,8	3,2	2,1	2,1
Clothing articles	3,6	2,6	3,3	3,3
Leather goods and footwear	1,9	1,5	1,3	1,5
Wood and wooden products manufacturing (except furniture)	1,6	1,9	2,5	4,0
Pulp, paper and paper products	1,2	1,2	1,2	0,8
Publishing houses, polygraphy and recording reproducible registrations	0,3	1,1	1,3	1,4
Crude oil processing, coal coking and nuclear fuel treatment	6,9	7,7	10,1	12,0
Chemical substances and products	7,3	8,7	7,0	4,8
Rubber and plastic products	2,6	2,1	1,7	2,5
Manufacturing of construction materials and other products of non metallic minerals	3,5	3,8	3,3	3,2
Metallurgy	8,5	10,4	11,4	9,3
Metallic constructions and metal products	4,1	2,8	2,5	3,3
Machinery and equipment (except electrical and optical equipment)	9,3	5,8	3,6	3,1
IT and office means	0,5	0,2	0,2	0,3
Electric machinery and appliances	2,5	2,0	1,9	2,6
Radio, TV and communications equipment and apparatus	0,8	0,9	0,7	0,4
Medical, precision, optical, and watch-making instruments and apparatus	1,1	0,4	0,4	0,5
Means of road transport	3,7	3,0	2,5	4,6
Means of transport non included in road transport	2,3	1,5	1,9	2,0
Furniture and other industrial activities non elsewhere classified	2,2	2,6	2,3	2,5
Waste recovering	0,2	0,3	0,6	1,1

Source: Author's work with data collected from Russu C. (2008).

Judging by the data collected, we can assess the transformation that occurred in the Romanian manufacturing sector, in the period of readjustment. We can observe that electric machinery and appliances increased by 4%, means of road transport (which includes the auto manufacturing sector) by 24.3% and crude oil processing, coal coking and nuclear fuel treatment

by a staggering 73.9% (Russu, 2008). On the other hand, some activities' share decreased, for example, textile products; pulp, paper and paper products; leather goods and footwear; metallic construction and metal products; clothing articles; chemical substances and products; radio, TV and communications equipment and apparatus (Russu, 2008).

The change can also be seen in Table 2, as the employment share in industry decreased, for example, in Romania, with 17.2%. These restructuring efforts were done so that the new manufacturing environment, with the help of FDI, can compete with its western, more competitive and productive counterparts.

Table 2. Employment share in Bulgaria, Romania, Poland, Slovakia, Czech Republic and Hungary (1989 compared with 2000)

	Employment share in industry (%)		Reduction (%)
Country	**1989**	**2000**	
Bulgaria	45.2	28.3	−16.9
Romania	43.4	26.2	−17.2
Poland	36.9	30.8	−6.1
Slovakia	44.9	37.3	−7.6
Czech Republic	44.7	39.5	−5.2
Hungary	35	33.7	−1.3

Source: Author's work with data collected from Kopsidis and Ivanov (2017).

These figures, however, show the total employment change. As seen in Table 1, some sectors expanded, while others contracted. One of the best examples is the comparison between the textile industries, which contracted considerably, and the auto manufacturing sector, which managed to attract investments and expand. Furthermore, the latter is responsible for an increase in people employed in the industry, while the former is responsible for a decrease. The shift meant a move from low-skilled labor to mid and high-skilled labor (Naudé, Surdej and Cameron, 2019). The further increase and turn in industrial activities and output are best described by the total cars and commercial vehicles produced in Romania. In 1999, the total number of vehicles produced was 106.897 units (International Organization of Motor Vehicle Manufacturers, 1999), while in 2019 it was 490.412 units (International Organization of Motor Vehicle Manufacturers, 2019).

The changes in industrial activity in CEE and especially in Romania are essential in order to understand the opportunities of the Fourth Industrial Revolution. As mentioned in the beginning, Industry 4.0 brings unprecedented levels of automation and connectedness which can further increase industrial output and the way we perceive production as a whole. The exciting aspect which justifies the research based on changes in the industry is that not all sectors are created equally. Therefore not all can adopt and enjoy the future capacities of technological innovation. Therefore, the economies of CEE suffered changes which may bring future economic benefits due to the proliferation of Industry 4.0. For example, the textile industry, which suffered losses in terms of the actual labor force as well as share in total industrial output, represents a sector which cannot adopt the future technological trend as well as others, therefore losing productivity and competitiveness in comparison with others (Naudé, Surdej and Cameron, 2019).

On the other hand, as we have seen above, some industries prospered, enjoying an increase in the share of industrial output as well as in the actual labor force employed, given the influx of FDI. One of the main actors here is the aforementioned auto manufacturing industry. Contrary to the declining textile sector, the auto manufacturing industry is highly regarded as being a source of innovation and it is highly susceptible to be further influenced by the future increase in automation brought by the Fourth Industrial Revolution (Naudé, Surdej and Cameron, 2019). Therefore, we can assume that the period of industrial readjustment following the collapse of planned economies in CEE caused a shift from industry sectors which cannot rely considerably on further future automation, to new sources of innovation which can directly prosper by easily adopting the powers of Industry 4.0. Moreover, it is imperative to mention that the overall change in the manufacturing landscape in CEEC cannot be easily labeled as deindustrialization, but more of a readjustment, most of the output having been recovered and transformed to be productive, competitive and on par with its western counterparts, even more so with prospects of integrating the technological aspects of next industrial revolution.

The prospects of adopting Industry 4.0

The change in the manufacturing landscape of CEE (adjustment and reindustrialization) is not the only variable when discussing the possibility of adopting Industry 4.0 in their economies. The situation regarding manufacturing and the future adoption of Industry 4.0 CEE holds another set of risks and opportunities, that of offshoring and reshoring.

The process of offshoring is defined as a movement of industrial capacities from the origin, which is an industrialized and developed economy, such as Germany, to another destination, which is in most cases a country with significantly reduced economic development (i.e. a developing nation), with reduced labor costs, the main objective being that of reducing the overall costs regarding production (O'Leary, 2020). On the other hand, reshoring is the process of returning a part of or all of the production to the country of origin, or close to it (nearshoring), in an effort for the production to be closer to the other elements such as the actual customers, the research and development departments, marketing and sales departments and so on, all these factors evening out the difference regarding higher wages in labor, with developed countries having higher overall wages and standards than developing ones, thus increasing the overall costs (Kenton, 2019).

In recent years there have been job losses in this region due to offshoring, however, the locations responsible for relocation were other CEE economies with lower wages (such as Slovakia), or even countries from Western Europe (Naudé, Surdej and Cameron, 2019).

The processes of reshoring and nearshoring are becoming more relevant, especially when we think of the recent disruption in global supply chains during the Covid-19 pandemic. These processes have advantages (such as the close proximity to consumers, being less dependent on supply chain disruptions, and being closer to the management and control operations), but also disadvantages (such as the probability of having higher costs, but also the larger distance between production and raw materials). There are relevant examples regarding reshoring such as Universal Plastics moving its production from China to the United States in 2014 due to quality issues but also the cost-effectiveness of the production in the country of origin due to automation and technological innovation. The same can be said about Motorcar Parts of America from Los Angeles, which invested in a facility in Mexico in order to be closer to the supply chain and benefit from lower costs regarding labor as well as trading, given the U.S.-Mexico-Canada Trade Agreement (Reinsch et al., 2021).

With all this in mind, we can assume that the CEECs possess an advantage regarding the possibility of reshoring or nearshoring, being in close proximity to the markets of the final products, as well as the research and development, control and management operations of the western companies, as well as lower labor costs while enjoying a skilled workforce, not to mention the readjusted manufacturing landscape aforementioned which can accompany the technological improvements in automation, all these factors being of great importance in the context of the recent disruptions in the global supply chains following the outbreak of the Covid-19 pandemic. On the other hand, even if the prospects show great opportunities for CEE, Romania is not highly regarded as a potential site for reshoring/nearshoring. As we can see in Figure 3, countries like the Czech Republic, Germany, Poland, Hungary and other states from Western Europe have a higher chance of benefiting from these processes, even with CEECs having lower labor costs.

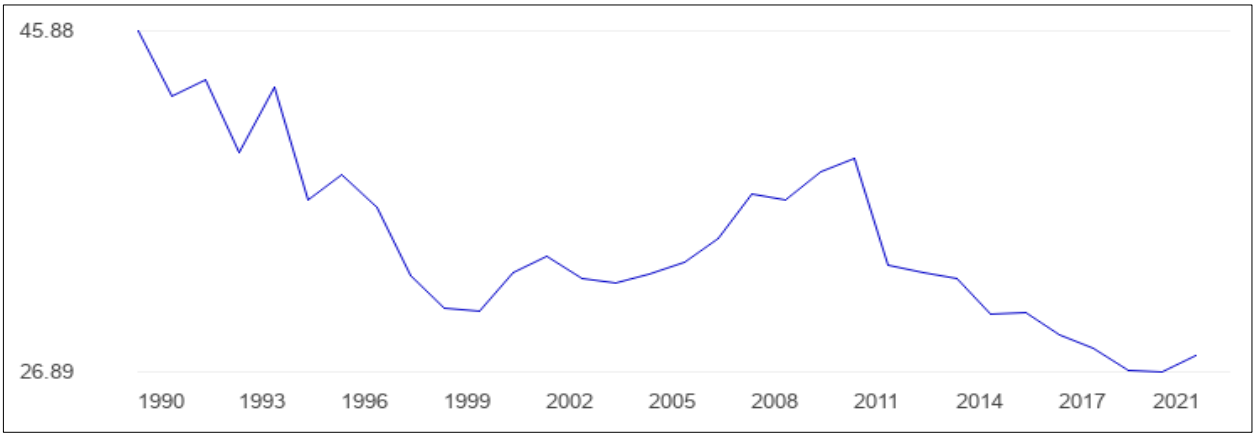


Figure 3. Locations considered for reshoring serving the EU market and US market in 2022
Source: Consultancy.eu (2022).

In the case of Romania, industrial readjustment, highly skilled labor force and lower labor costs, as well as proximity to the countries of origin for the world's manufacturers represent advantages for reshoring/nearshoring, procedures which can further increase investments in technology to further adopt the economic prospects of Industry 4.0. However, as seen in Figure 3, Romania is not a preferred destination. These processes represent just another side of FDI and Romania's ability to attract them.

The reasons why Romania is not highly considered a destination for investments which may bring unprecedented levels of automation are complex, but some are easier to point out. Factors such as infrastructure, political stability, the presence of raw materials as well as taxes, government duties as well as regulations can pose risks when regarding a country's ability to attract FDI (Haudi, Wijoyo and Cahyono, 2021).

In the context of FDI, reshoring/nearshoring and Industry 4.0, a key element is the digital readiness of the labor force. Table 3 offers a sight of the situation in Romania compared with other CEE countries, having the lowest technological competencies (0.63), a lower density regarding robotics (0,20), with the Czech Republic having the highest with 2,17, an average cyber security index (0,585), a good digital competitiveness ranking (47) while having a low tax rate for digital businesses (6,62%).

Table 3. Technological competencies in Central and Eastern European Countries

Country	I-Com Industry 4.0 Index Score 2017 [Highest = best]	Effective Average Tax Rate on Digital Business, 2017 (%) [Lowest = best]	Ranking on Digital Competitiveness Ranking, 2018 (of 63) [Lowest = best]	Global Cybersecurity Index Score, 2017 [Highest = best]	Density of Industrial Robots in 2015 [Highest = best]	Technological Competencies Composite Normalised Score [Highest = best]
Bulgaria	64	9,52	43	579	0,07	0.65
Czechia	78	7,48	33	609	2,17	0.93
Hungary	68	-6,85	46	534	1,11	0.76
Poland	66	12,63	36	622	0,51	0.73
Romania	53	6,62	47	585	0,20	0.63
Slovakia	77	15,09	50	362	1,93	0.74

Source: Author's work with data collected from Naudé, Surdej and Cameron (2019).

Results and discussions

This paper's aim is to further research the readiness, opportunities and risks regarding Industry 4.0 in Central and Eastern Europe, with a focus on Romania. As mentioned above, these countries, which were not part of the Soviet Union, but fell under its communist umbrella of economic planning experienced significant changes regarding their manufacturing sectors. Abrupt and deficient industrialization followed by an unstable and disruptive readjustment to free market and competitive standards and a shift to more Industry-4.0-friendly sectors are promising factors for the future. However, some nations from the same category are inclined to attract more FDI represented by reshoring/nearshoring operations which can increase the level of automation in manufacturing, thus leading to these economies embracing the Fourth Industrial Revolution.

Supply chain disruptions and cost-reducing innovation could change the economic industrial landscape of CEE. On the other hand, these countries need to dedicate resources in order to benefit from it. The uncertainty of the global markets due to geopolitical factors combined with the challenges of relocating production facilities are still important variables when debating the prospects of CEECs, reshoring, FDI and Industry 4.0 as a whole. Nonetheless, it becomes imperative for these nations, especially Romania, to focus on attracting this economic potential responsible for future economic development which may negatively influence the development gap still present on the European continent, between East and West.

Conclusion

To conclude, new levels of automation and connectedness are prone to change the way we perceive production as a whole. From AI and IoT to advanced robotics, all these technologies could bring substantial economic advantages to the countries ready to embrace them.

The situation in Central and Eastern Europe is promising, high-skilled yet low-cost labor, part of the European Union, in proximity to the markets and with a healthier manufacturing landscape than 30 years ago, these countries can attract more investments from the West, taking advantage of supply chain disruption to further bring production to the "periphery of Europe".

However, the place of Romania is still uncertain, as its population and infrastructure don't possess the necessary prerequisites for embracing Industry 4.0. With all this in mind, Romania should focus on education, digital education to be precise, as well as attracting capital, and encouraging entrepreneurship and innovation in its own borders in order to capitalize on its aforementioned geographical, demographic and economic advantages.

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