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THE INVESTMENT ON HUMAN CAPITAL, AND ITS CONNECTION TO THE FOURTH INDUSTRIAL REVOLUTION. THE CASE OF ROMANIA

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The Fourth Industrial Revolution is based on different pillars such as connectivity, smart initiative in human capital (especially in education), integrative digital technology, and digitisation of public services. We will present some key facts about foreign direct investment (FDI) and human capital in Romania, connected to some characteristics of the Fourth Industrial Revolution. This will allow us to do further research related to the connection between FDI, human capital, and the Fourth Industrial Revolution.

The starting point of the present paper is the idea that human capital and investment in human capital, particularly in education, are considered key determinants of economic growth, and their development can be connected to the Fourth Industrial Revolution.

The study analyses two economic growth factors: FDI and human capital; the latter is analysed from the perspective of two components – a) health and skills of the workforce, and b) the quantity and quality of education –, taking into account indicators that define the human factor from the perspective of the Fourth Industrial Revolution. A composite index is calculated to highlight the level of development of our country, as well as Romania's place in the EU, regarding the two components of the human capital referred to above.

Keywords: fourth industrial revolution, education, human capital, foreign direct investment, economic growth, competitiveness.

La Quarta rivoluzione industriale si basa su diversi pilastri, quali la connettività, l'adozione di tecnologie cosiddette "smart" a livello di capitale umano (soprattutto nell'ambito dell'istruzione), l'adozione di tecnologie digitali integrative, e la digitalizzazione dei sevizi pubblici. Il saggio fornisce alcuni dati chiave relativamente agli investimenti diretti esteri (IDE) e al capitale umano in Romania, in relazione ad alcune caratteristiche della Quarta rivoluzione industriale. Ciò consente di approfondire la ricerca per quanto concerne la relazione esistente tra gli IDE, il capitale umano e la Quarta rivoluzione industriale.

Il presente contributo parte dall'idea secondo la quale il capitale umano e gli investimenti in capitale umano, con particolare riferimento al settore dell'istruzione, vadano considerati come fattori chiave della crescita economica, e che il loro sviluppo possa essere collegato alla Quarta rivoluzione industriale.

Lo studio analizza quindi due fattori di crescita economica: gli IDE e il capitale umano. Quest'ultimo viene analizzato considerando due componenti – a) la salute e il livello delle competenze della forza lavoro, e b) la quantità e qualità dell'istruzione –, esaminando gli indicatori che definiscono il fattore umano dal punto di vista della Quarta rivoluzione industriale. Si calcola così un indice composito con l'obiettivo di delineare il livello di sviluppo del Paese, nonché il posto che occupa la Romania all'interno dell'UE, relativamente alle due componenti del capitale umano selezionate.

Parole chiave: Quarta rivoluzione industriale, istruzione, capitale umano, investimenti diretti esteri, crescita economica, competitività.

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1. Introduction

The Fourth Industrial Revolution (Industry 4.0) is a modernisation of the industry, and refers to how technologies such as artificial intelligence (AI), autonomous vehicles, and the Internet of Things (IoT) merge with the physical lives of people. With the launch of the Industry 4.0 programme, Romania, as is the case with other European States, is in the initial period of the Fourth Industrial Revolution. The use and development of these technologies are currently only at an early stage, considering the full potential that they can have once fully implemented.

The tendency towards greater automation will have an impact on the competences of human capital. The new competences in the field of information technology and data analysis will be the basis for defining the set of basic skills needed for the jobs, while the importance of cognitive skills will increase. The digitisation will result in a restructuring of the workforce, which will also have an effect on the employment rate.

Industry 4.0 will also have an impact on foreign direct investment (FDI). Innovation, knowledge, and education are criteria that determine location decisions in relation to FDI. The regions and countries that have managed to maintain a skilled, trained, qualified, and educated workforce and to support science and research will be more innovative and will grow more, increasing their attractiveness.

In the first part of the study, we present some theoretical considerations regarding human capital and FDI as factors determining the growth and economic development of a country, as well as a brief overview of the main factors determining the decision to locate a plant in a particular area. We then analyse the characteristics of the Fourth Industrial Revolution, and the effects that the advanced technologies specific to Industry 4.0 can have on the competences of human capital and on FDI.

In the second part, we provide an analysis of FDI and human capital in Romania. We calculate a ranking of EU Member States based on the indicators of human capital, education, and health, which are characteristic of the Fourth Industrial Revolution.

2. Literature review

2.1. Human capital and FDI: factors of economic growth

The literature on theories related to the analysis of human capital as a factor of economic growth is rapidly increasing (Barro, 1991; Barro and Lee 2010; Mankiw *et al.*, 1992; Sala-i-Martin, 1996; Bils and Klenow, 2009; Keller and Poutvaara, 2005; Lee and Kim, 2009). The test of the importance and impact of human capital on economic growth was carried out with the help of inter-country regressions.

Through an empirical approach, Barro and Lee (2010) establish that the impact of schooling rates on GDP could be negative, but the average number of years of study had a significant positive effect on macroeconomic outcomes. On the other hand, Richard (2006) shows that there is more economic growth in countries where the higher-education system is well developed, and Tsai *et al.* (2010) find that the number of researchers per capita and of scientific articles per capita are indicators that reflect economic growth.

Mincer (1958) and Becker (1962 and 2007) focused more on the study of the relationships between human capital and labour incomes, more precisely on the changes in people's income depending on the level of education of individuals. Mincer (1958, p. 282)

emphasised the role of human capital in economic growth. He defined human capital "as a stock of skills and knowledge", because it does not only involve investment in education but also investment in health.

Eicher (1990) considers education as the main factor of economic development. He shows that "education increases the productivity of the one who is trained", and considers it to be "the whole of the productive capacities of an individual (or a group), including its operative skills in the broadest sense: general or specific knowledge, savoir-faire, experience […]" (Eicher, 1990, p. 9).

At the *macroeconomic* level, investing in education produces profits, i.e. productivity. Productivity is the economic value of what is achieved by a worker (or any form of capital). High productivity stimulates economic growth, which brings us greater economic benefits. A more educated workforce increases productivity locally, which implies an increase in the price of land (Rauch, 1993, p. 386).

Nowadays, in the new era of knowledge and information, human capital is incorporated into the notion of "intellectual capital", because the technical knowledge of individuals can generate a series of externalities that result in technological progress and economic growth.

A number of studies have considered how the interaction between human capital and FDI affect economic growth. Lipsey (2000) demonstrated the crucial impact on growth, of the interaction between FDI and the level of education. In a study of 11 developing countries in East Asia and South America, Zhang (2001) demonstrated that FDI, trade liberalisation, export orientation, and human capital have significant effects on economic growth.

Sang-Do Park (2018) studies the effect of FDI, human capital, and R&D on the development of the Chinese economy between 1991 and 2015. Based on the theory of endogenous growth, the study demonstrates their importance for sustained economic growth, their interactions being established as the main variables affecting growth (GDP).

Regarding the factors that influence FDI, the literature places particular emphasis on *innovation*, *knowledge*, *education*, *research*, and *technological development*. In particular, innovation, knowledge, and education are criteria determining the decision to locate FDI. The regions and countries that have managed to maintain a skilled, trained, and educated workforce and to support science and research will be more innovative and will grow more, increasing their attractiveness (Petrakos, 2008, p. 36-37). A specialised workforce has a distinctive place in the theories that are based on innovation and knowledge. A significant contribution in this regard was also made by Capello (2011) and Capello and Nijkamp (2009) in their regional studies. According to them, education, research, and technological development contribute to diminishing the differences between regions by equalising the productivity in the territory due to the spatial mobility of the production factors (Antonescu, 2013, p. 25).

In addition to the fundamental factors that determine multinational companies' expansion strategies and their decision to locate in a particular country (i.e. the existence of large and dynamic potential markets, and the possibility of reducing costs), there are other complementary factors that influence companies' location choice.

The main factors affecting the decision to invest are:

– economic and political stability, commercial policy (the existence of tariff or non-tariff barriers), fiscal policy (income and profit taxation), privatisation policy (the

commitment demonstrated by the authorities regarding private property, through the direct or indirect sale of some assets to foreign investors), and institutional quality; conversely, corruption acts as a barrier to the entry of multinational corporations into the market (Ciobanu, 2015);
– workforce qualification, the cost of labour, the availability of a local labour force, as well as of a skilled and well-trained labour force, and the availability of adequate infrastructure (Ciobanu, 2015);
– a large market (to exploit economies of scale) (Charkrabarti, 2001);
– the market absorption capacity for the goods and services of foreign companies (expressed by the level of GDP and GDP per capita, as well as by the GDP growth rate) (Artige and Nicolini, 2006);
– other factors: market integration, transport costs (Antonescu, 2012), qualification of labour force (Carlino, 1979; Faini, 1984; Fingleton and McCombie, 1998), and the level of risk, which may discourage investments (Günther and Kristalova, 2016).

2.2. The Fourth Industrial Revolution and its effects on human capital and FDI

The advanced technologies specific to the Fourth Industrial Revolution are: IoT, data processing, and, more recently, cloud manufacturing, additive manufacturing, augmented reality, big data, autonomous robots, process simulation, and vertical and horizontal systems integration (Schwab, 2018).

In the near future, it will be imperative for organisations to have the right people who are familiar with cloud technology, data analysis, or robotics. Present business leaders point out that today's workforce does not have enough digital skills. The tendency towards greater automation will cause companies to give up on low-skilled workers who perform simple, repetitive tasks. Some authors believe that unskilled and semi-skilled workers will be the most affected (Flynn *et al.*, 2017), a theory that creates fear of job loss (Sciutti *et al.*, 2018). The digitisation will determine a restructuring of the workforce, which will also affect the employment rate.

At the same time, the increasing use of software, connectivity, and analyses will raise the demand for employees with skills in software development and IT technologies, such as mechatronics experts with software skills (Shamim *et al.*, 2016; Bonekamp and Sure, 2015). This transformation of competences is one of the key challenges: the improvement of these competences will enable employees to face the challenges and needs of the Fourth Industrial Revolution. Offering internships to increase the digital knowledge of the workforce can help in this process (Digital Journal, 2018). In addressing the insufficient human capital, all relevant parties must be involved in the retraining and upskilling of employees to fight against the growth of unemployment, and the lack of talent (Kusmin *et al.*, 2017).

This persistent technological progress will lead to the point where machines and computers will perform tasks as well as, or maybe even better than, workers do (Bonekamp and Sure, 2015). It is essential to ensure the creation of more jobs than those that will disappear (Pereira and Romero, 2017). According to the World Economic Forum's (WEF) estimates, over 75 million jobs will be lost over the next four years due to firms' transition to automation, while 133 million new jobs will appear: a new division of labour between people and cars. The leading technologies – robots and AI – will produce changes in the structure of work, and a new division of labour between workers and machines.

Other authors believe that the adoption of Industry 4.0 will increase employment in the coming years. The demand for employees in the manufacturing sector could grow even more, but different skills will be needed. The workforce in the future will have to have new skills in the field of IT and data analysis, and the importance of cognitive skills will increase. They will be the basis for defining the set of basic skills needed for the jobs. Although Industry 4.0 completely changes the human capital requirements, new business models will be capable of changing the current workplaces with smart machines and new employment opportunities (Rajnai and Kocsis, 2017).

Hecklau *et al.* (2016, p. 2) define competences as the set of skills, knowledge, attitudes, and motivations that an individual needs in order to cope with the tasks and challenges related to jobs efficiently. Four main categories of competences are identified: technical skills (job-related knowledge and skills); methodological competences (skills and abilities for general problem solving and decision making); social skills (all skills and abilities, as well as the attitude towards cooperation and communication with others), and personal skills (including an individual's social values, motivations, and attitudes). Qualification is the process of developing the necessary set of skills through training and education.

Industry 4.0 creates many new opportunities for companies, as well as challenges in this process of automation and digitisation. According to some authors, it will have an impact on the location as well as the extent of FDI, as the need for global flows of FDI, and FDI location characteristics are likely to change (De Beule and Nauwelaerts, 2018). Companies will have to reconsider the criteria used in the decision-making process regarding the location of investments in foreign countries. One of these factors is the cost of labour. While some studies show that it is the skills of the workforce, and not the wages, that matter for the location of FDI (Overseas Development Institute, 1997), many others show that higher wages discourage FDI, and lower labour costs attract FDI from developed economies. Finally, according to the FDI Intelligence Report (2018), Industry 4.0 can blur the distinction between developing and developed countries, making the benefits of inexpensive labour in developing countries less relevant; companies will prefer to invest in the nearer, more developed countries. Digitalisation is an essential concept around which the decision to locate FDI will be built. The low cost of labour will become a less important factor, while the highly qualified human capital will become more important and, perhaps, even the determinant factor of FDI.

The Global Competitiveness Report 2018 presents a Global Competitiveness Index 4.0. This index includes four categories of factors influencing the country productivity at this stage of the new technological changes determined by Industry 4.0. These factors are organised into 12 pillars: enabling environment: a) institutions; b) infrastructure; c) ICT adoption; and d) macroeconomic stability; human capital: e) health; and f) skills; markets: g) product market, h) labour market, i) financial system, and j) market size; and innovation ecosystem: k) business dynamism; and l) innovation capability.

Human capital consists of two components: health (healthy life expectancy) and skills (the general level of skills of the workforce, and the quantity and quality of education). Health is considered as a state of complete physical, mental, and social well-being, not just as the absence of diseases or disabilities; education refers to the skills that people must develop in the era of the Fourth Industrial Revolution. These two components will be used in our analysis.

3. FDI and human capital in Romania

The first part of the Romanian case study analyses quantitatively and qualitatively FDI in Romania. The data and information used help to establish the position and performance of Romania in attracting FDI and to highlight their effects on the economy of the country. The period of analysis is 2010 to 2017. The data are taken from the website of the National Institute of Statistics, the National Bank of Romania, the World Bank, and the World Robotics Report 2018 by the International Federation of Robotics (IFR).

In the second part of the case study, a composite index was calculated to highlight the level of development of the country, as well as its position in the European hierarchy for the two components of human capital (health and education). Depending on the availability of Eurostat data, we have selected indicators that define the human capital factor from the perspective of the new industrial revolution. The health component (the fifth pillar of the Global Competitiveness Index 4.0) highlights healthy life expectancy, and skills (the sixth pillar) the level of workforce, as well as the quantity and quality of education.

3.1. FDI in Romania

Romania encompasses a set of attractive factors for FDI, of which we mention: the strategic geographical position, a large market, and low labour costs; conversely, an inert legislative framework, the lack of measures aimed at attracting investors, and the political instability of recent years are among the reasons why Romania is not today a pole of FDI in Europe and in the region. Regarding the business environment, there are substantial differences between EU Member States as well as within them (at regional or local level). The place of member countries in the global ranking on the attractiveness of the business environment is presented in table 1.

Of EU Member States, seven are in the top 20: Denmark, Ireland, Germany (in 2017), Estonia, Finland, Sweden, and the United Kingdom. Romania climbed 37 positions in the global ranking on the attractiveness of the business environment, from the 73rd place in 2014 to the 36th place in 2017. This performance was due to lowering taxes for companies, improving the way of paying taxes through electronic systems, facilitating the execution of contracts, and improving the whole process. However, in 2019 it lost 16 positions, falling back to 52nd in the world ranking. Although the attractiveness of the business environment has improved in Romania in the last years compared with 2014, FDI flows have not experienced a significant increase during the same period, which indicates that the reforms regarding the business environment, education, the labour market, and infrastructure should continue.

In 2008, the improvement of the institutional and legislative framework under the auspices of the accession to the EU, the increase in terms of privatisations, and global economic expansion sustained investors' optimism. At that time, Poland and Romania had clearly distanced themselves as top investors' preferred states (Horobeț and Popovici, 2017). In 2009, the attractiveness of Romania fell sharply, in the context of the national economic and political turmoil and of the effects of the global financial crisis, which were beginning to be felt also in the region. FDI fell to one third of the level reached the previous year. The worst year was 2011, when FDI fell below one fifth of the level reached in 2008.

Table 1. The attractiveness of the business environment

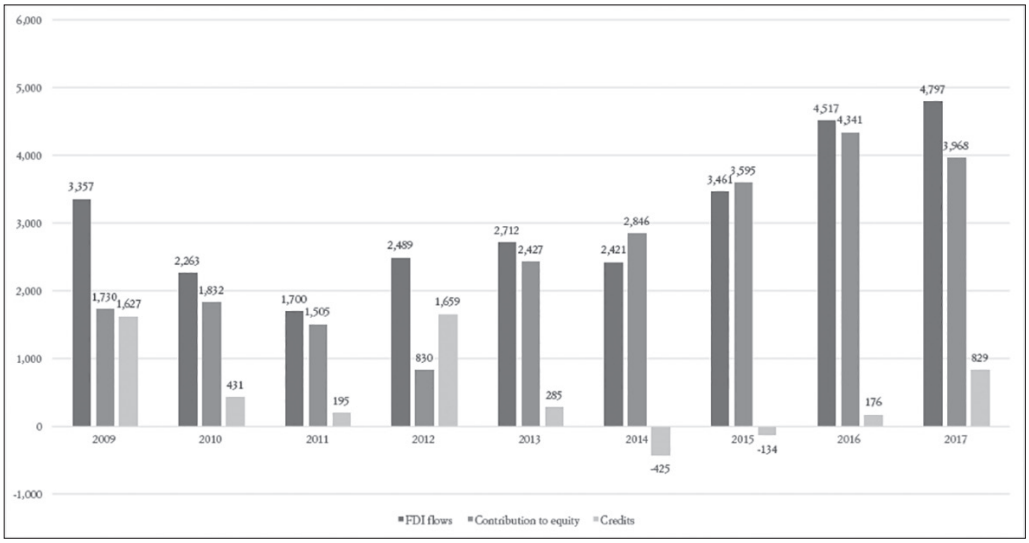
Rank	2010	2011	2014	2017	2019	2017 versus 2014	2019 versus 2017
Belgium	22	25	36	42	45	–6	–3
Bulgaria	51	51	58	39	59	+19	–20
Czechia	82	63	75	27	35	+48	–8
Denmark	6	6	5	3	3	+2	0
Germany	21	22	21	17	24	+4	–7
Estonia	17	17	22	12	16	+10	–4
Ireland	8	9	15	18	23	–3	–5
Greece	97	109	72	61	72	+11	–11
Spain	48	49	52	32	30	+20	+2
France	28	26	38	29	32	+9	–3
Croatia	89	84	89	43	58	+46	–15
Italy	76	80	65	50	51	+15	–1
Cyprus	35	37	39	45	57	–6	–12
Latvia	27	24	24	14	19	+10	–5
Lithuania	26	23	17	21	14	–4	+7
Luxembourg	42	45	60	59	66	+1	–7
Hungary	52	46	54	41	53	+13	–12
Malta	–	–	103	76	84	+27	–8
Netherlands	29	30	28	28	36	0	–8
Austria	31	32	30	19	26	+11	–7
Poland	73	70	45	24	33	+21	–9
Portugal	33	31	31	25	34	+6	–9
Romania	54	56	73	36	52	+37	–16
Slovenia	43	42	33	30	40	+3	–10
Slovakia	40	42	49	33	42	+16	–9
Finland	11	13	12	13	17	–1	–4
Sweden	18	14	14	9	12	+5	–3
United Kingdom	4	4	10	7	9	+3	–2

Source: World Bank, Doing Business 2013-2019.

Since 2011, net FDI started to increase again, to reach 4.79 billion euro in 2017. Investment in equities of foreign companies in Romania made up the largest part of FDI, the remaining being net credits received from the foreign direct investors. In 2014 and 2015, the latter recorded a negative value of 425 million euro and 134 million euro,[1] respectively.

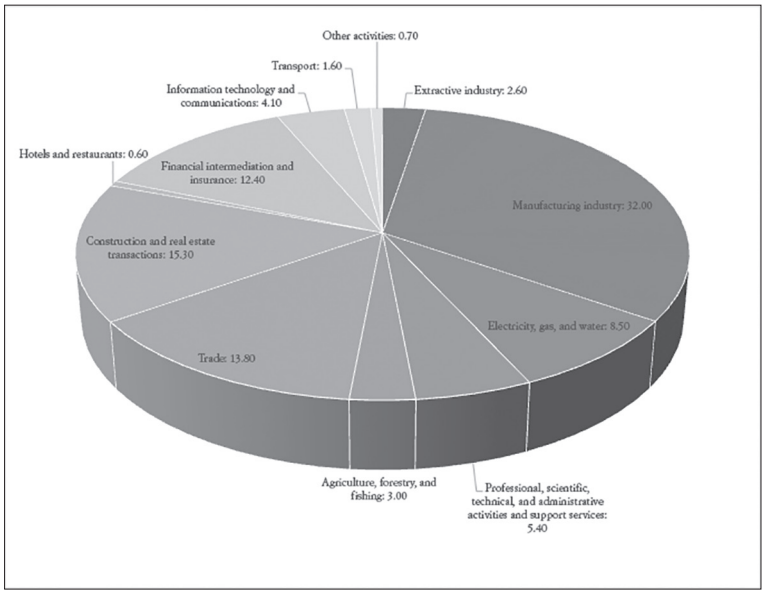
[1] The negative value of the parent subsidiary's net credit is the net result of the loans and repayments made between the two.

Figure 1. FDI flows in Romania between 2009 and 2017 (in million euro)



Source: figure based on the data from www.bnro.ro.

Figure 2. Breakdown of net FDI (main economic activities)



Source: figure based on the data from www.bnro.ro.

The FDI stock in Romania registered an increase during the period under examination. Although growing, Romania had the second-lowest FDI stock in the region after Bulgaria, extremely low when compared with Czechia, Poland, and Hungary (Horobeț and Popovici, 2017), one of the reasons being that the privatisations were carried out at a faster pace in these countries, thus attracting more FDI.

From the point of view of the destination (figure 2), net FDI went mainly to the manufacturing industry (32% of the total). Within this industry, the best-represented activities are the transport industry, oil processing, chemicals, rubber and plastics, and metallurgy. Electricity, gas, and water attracted 8.5% of net FDI, while other activities that have attracted significant FDI are construction and real estate (15.3%), trade (13.8%), and financial intermediation and insurance (12.4%).

Table 2. Distribution of net FDI by country of origin (year-end)

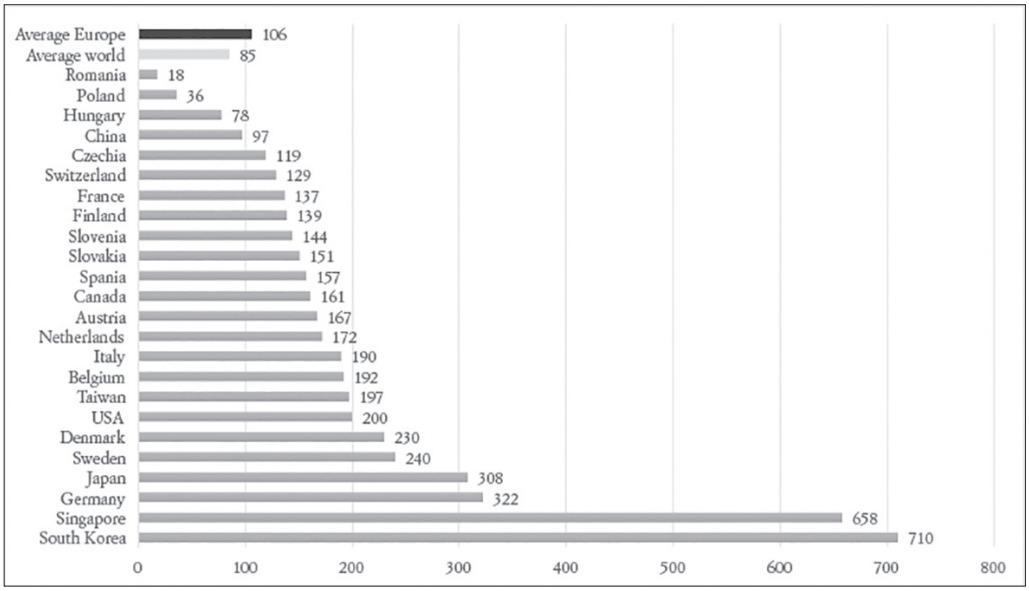
		2017		2014	
		Million euro	Percentage in total	Million euro	Percentage in total
	Total FDI	75,851	100	60,198	100
1	Netherlands	19,638	25.9	14,224	23.6
2	Germany	9,704	12.8	7,482	12.4
3	Austria	9,575	12.6	9,694	16.1
4	Italy	4,739	6.2	2,776	4.6
5	France	4,731	6.2	4,199	6.8
6	Cyprus	4,647	6.1	4,274	7.1
7	Luxembourg	3,543	4.7	2,150	3.6
8	Switzerland	3,144	4.1	2,151	3.6
9	Greece	1,723	2.3	1,644	2.7
10	Belgium	1,584	2.1	1,281	2.1

Source: www.bnr.ro (FDI in Romania in 2017 and 2014).

The Netherlands is by far the largest foreign investor in Romania, accounting for 25.9% of total FDI as at 31 December 2017. Germany (12.8%), Austria (12.6%), Italy (6.2%), and France (6.2%) account for another 37.8%.

It should be noted that Germany – the main supporter of the Industry 4.0 strategy, and the world leader in the number of robots in the industry in this field – is one of the largest investors in Romania. Despite Romania's still small number of robots installed, many German companies already have state-of-the-art technology in the production facilities in Romania (figure 3).

Figure 3. Number of installed industrial robots per 10,000 employees in the manufacturing industry (2017)



Source: based on IFR's World Robotics Report 2018 data.

According to IFR's 2018 report, Germany ranks third in the world in this field, with 322 robots per 10,000 employees, and first in the EU, having over 200 robots more than the EU average. It is followed by Sweden and Denmark, which have, respectively, 240 and 230 robots in the industry. In Romania in 2017, the number of robots in the industry increased to 18 robots per 10,000 workers, up 63.63% compared with 2014. However, it is noted that Romania is far from the EU average, with a gap of 88 robots. Romania is also at a considerable distance from the countries in the region. Poland features a double density compared with Romania, i.e. 36 robots per 10,000 employees in the industry, whereas Hungary, Czechia, and Slovakia boast far higher values (i.e. 78, 119, and 151 robots, respectively).

3.2. Human capital and its connection to the Fourth Industrial Revolution

Starting from the consideration that human capital is an essential factor for economic growth and development, and one of the engines of economic development, we start the analysis by calculating the composite index that would highlight Romania's place in the EU, taking into account its economic performance.

To obtain the multi-criteria ranking of EU Member States, we used the *method of relative distances*. The method of relative distances is a multidimensional instrument of measurement of differences (disparities), a method that quantifies the relative distances between the countries included in the analysis for all the analysed variables, then added together into a single synthetic value. The general formulation is:

$$D_{ri} = \sqrt[m]{\prod_{i=1}^{m} \frac{X_{ij}}{X_{\max j}}}$$

where: D_{ri} is the multi-criteria distance of each territorial unit in relation to the best performing territorial unit for the variable (indicator) j; X_{ij} is the value of indicator j in the territorial unit i; and X_{maxj} is the value of indicator j in the territorial unit that records its highest value.

This method is widely used to carry out territorial comparisons, and allows for the simultaneous use of several economic indicators, providing a more complex image of the territorial units analysed, as well as a multi-criteria classification of them. In order to have a common basis of assessment, we use the relationship as modified by Zizi Goschin *et al.* (2007), where the best performance of variable j (X_{maxj}) is replaced by the average value of the variable j at EU level (EU-28).

The formula for the indicator is then:

$$D_{ri} = \sqrt[m]{\prod_{i=1}^{m} \frac{X_{ij}}{\bar{X}_j}}$$

where: X_{ij} is the value of indicator j in the country i; and $\bar{X}_j$ is the average value of indicator j at EU level.

In the following, we use the synthetic indicator to analyse two aspects of the development of Romania in relation to the EU average: relative competitiveness (or development) and human capital.

The three indicators selected to assess relative competitiveness were: GDP per capita, labour productivity, and the employment rate. Thus, we obtain the following relationship:

$$Dri\_competitiveness = \sqrt[3]{\frac{X_{i\_GDP/capita}}{\bar{X}_{\_GDP/capita\_EU28}} * \frac{X_{i\_LW}}{\bar{X}_{\_LW\_EU28}} * \frac{X_{i\_OL}}{\bar{X}_{\_OL\_EU28}}}$$

Equation 1
where:

$X_{i\_GDP/capita}$ = GDP per capita in country I;

X_{i_LW} = labour productivity in country I;

X_{i_OL} = employment rate in country I;

$\bar{X}_{\_GDP/capita\_EU28}$ = GDP per capita at EU level (EU-28 average);

$\bar{X}_{\_LW\_EU28}$ = labour productivity at EU level (EU-28 average);

$\bar{X}_{\_OL\_EU28}$ = employment rate at EU level (EU-28 average).

The higher the composite index (relative to the EU average, Dri>1), the better the country's performance on the selected indicators, and the higher its level of development. A value of the index below 1 is characteristic of less developed countries.

The same method is used in the analysis of human capital for both its components: health and skills. The first variable is proxied by two measures: life expectancy at birth, and the number of healthy life years at birth:

$$Dri\_Health = \sqrt{\frac{X_{i\_Life\ expectancy}}{\bar{X}_{\_Life\ expectancy\_EU28}} * \frac{X_{i\_Healthy\ life\ years}}{\bar{X}_{\_Healthy\ life\ years\_EU28}}}$$

Equation 2
where:

$X_{i\_Life\ expectancy}$ = life expectancy at birth in country I;

$X_{i\_Healthy\ life\ years}$ = number of healthy life years at birth in country I;

$\bar{X}_{\_Life\ expectancy\_EU28}$ = life expectancy at birth at EU level (EU-28 average);

$\bar{X}_{\_Healthy\ life\ years\_EU28}$ = number of healthy life years at birth at EU level (EU-28 average).

The skills variable is proxied by the following indicators: 15 to 64-year-old active population with tertiary education (levels 5-8) as a share in total active population; 15 to 64-year-old employed persons with tertiary education (levels 5-8) as a share in total employed; persons with tertiary education employed in science and technology, as a share in active population; adult participation in learning (25 to 64-year-olds); employed ICT specialists as a share in total employment; and employment in technology and knowledge-intensive sectors with tertiary education as a share in total employment.

$$Dri_{Skills} = \sqrt[7]{\frac{X_{i_{AP}}}{\bar{X}_{AP\_EU28}} * \frac{X_{i_{EP}}}{\bar{X}_{EP\_EU28}} * \frac{X_{i\ P\_ST}}{\bar{X}_{P\_ST\_EU28}} * \frac{X_{i_{Ad\ P}}}{\bar{X}_{Ad\ P\_EU28}} * \frac{X_{i_{E\_ICT}}}{\bar{X}_{E\_ICT\_EU28}} * \frac{X_{i\ E\_ITC\_TE}}{\bar{X}_{E\_ITC\_TE\_EU28}} * \frac{X_{i\ E\_TK}}{\bar{X}_{E\_TK\_EU28}}}$$

Equation 3
where:

$X_{i_{AP}}, \bar{X}_{AP\_EU28}$ = share of active persons (15 to 64-year-olds) with tertiary education (levels 5-8) in country I and at EU level (EU-28 average);

$X_{i_{EP}}, \bar{X}_{EP\_EU28}$ = share of employed persons (15 to 64-year-olds) with tertiary education (levels 5-8) in country I and at EU level (EU-28 average);

$X_{i\ P\_ST}, \bar{X}_{P\_ST\_EU28}$ = persons with tertiary education employed in science and technology (percentage of active population) in country I and at EU level (EU-28 average);

$X_{i_{Adult\ P}}, \bar{X}_{Adult\ P\_EU28}$ = adult participation in learning (25 to 64-year-olds) in country I and at EU level (EU28 average);

$X_{i_{E\_ICT}}, \bar{X}_{E\_ICT\_EU28}$ = employed ICT specialists (percentage of total employed) in country I and at EU level (EU-28 average);

$X_{i\ E\_ITC\_TE}, \bar{X}_{E\_ITC\_TE\_EU28}$ = employed ICT specialists with tertiary education in country I and at EU level (EU-28 average);

$X_{i\ E\_TK}, \bar{X}_{E\_TK\_EU28}$ = employment in technology and knowledge-intensive sectors at national level, with tertiary education (percentage of total employment) in country I and at EU level (EU-28 average).

Below we show the results for the three indices. The composite index of economic competitiveness of EU Member States for the period 2010-2017 is presented in table 3.

Luxembourg is significantly detached from the other countries, recording performances of 60% (2010) and 68% (2014) above the EU average. It is followed by Ireland, which is consistently above the average by more than 20%, scoring 51% more than the EU average in 2017. Nine other countries (Belgium, Denmark, Germany, France, the Netherlands, Austria, Finland, Sweden, and the United Kingdom) reported higher-than-average performances, though not exceeding 20%.

At the bottom of the ranking is Bulgaria, with an index between 0.55 and 0.60, which represents a difference of over 40% compared with the EU average. The relative deviation from the total level of the indicator (maximum/minimum) is of 108% in 2010 (given by the difference between the maximum value of the index, 1.63 in Luxembourg, and its minimum value, 0.55 in Bulgaria), and of 100% in 2017, respectively. Among the countries having index deviations superior to 30% of the EU average is Romania, whose index has values between 0.63 and 0.70. The only year when Romania had a deviation inferior to 30% of the EU average is 2017, when the index registered the value of 0.73, i.e. a 27% deviation.

Most countries records differences between 20% and 30%. The increases registered by the countries with the best performances led to an increase of the EU average, resulting in a decrease of the composite index in other countries.

Table 3. Composite index of economic competitiveness

	2010	2011	2012	2013	2014	2015	2016	2017
EU-28	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Belgium	1.16	1.15	1.16	1.15	1.15	1.14	1.13	1.13
Bulgaria	0.56	0.56	0.57	0.56	0.58	0.58	0.59	0.61
Czechia	0.87	0.87	0.87	0.88	0.90	0.91	0.91	0.93
Denmark	1.18	1.17	1.17	1.18	1.17	1.17	1.16	1.17
Germany	1.11	1.13	1.13	1.13	1.14	1.13	1.13	1.12
Estonia	0.77	0.81	0.83	0.84	0.85	0.84	0.85	0.86
Ireland	1.21	1.21	1.22	1.22	1.25	1.50	1.48	1.52
Greece	0.89	0.82	0.79	0.78	0.78	0.77	0.76	0.76
Spain	0.96	0.94	0.93	0.92	0.93	0.93	0.94	0.94
France	1.03	1.03	1.08	1.08	1.07	1.07	1.06	1.05
Croatia	0.71	0.71	0.72	0.72	0.71	0.71	0.72	0.73
Italy	1.02	1.01	1.00	0.98	0.96	0.96	0.97	0.96
Cyprus	1.00	0.97	0.94	0.89	0.87	0.88	0.89	0.89
Latvia	0.66	0.70	0.72	0.73	0.75	0.75	0.75	0.78
Lithuania	0.72	0.77	0.80	0.82	0.83	0.83	0.83	0.85
Luxembourg	1.63	1.65	1.64	1.64	1.68	1.66	1.64	1.61
Hungary	0.74	0.75	0.75	0.77	0.78	0.78	0.77	0.77
Malta	0.89	0.88	0.89	0.90	0.93	0.96	0.97	0.98
Netherlands	1.20	1.19	1.19	1.20	1.17	1.17	1.15	1.15
Austria	1.16	1.17	1.19	1.19	1.18	1.17	1.17	1.16
Poland	0.74	0.76	0.78	0.78	0.78	0.79	0.79	0.80
Portugal	0.88	0.84	0.82	0.84	0.84	0.84	0.84	0.84
Romania	0.63	0.64	0.66	0.66	0.67	0.68	0.70	0.73
Slovenia	0.88	0.88	0.87	0.87	0.87	0.87	0.87	0.89
Slovakia	0.84	0.83	0.84	0.85	0.85	0.85	0.85	0.85
Finland	1.12	1.12	1.11	1.10	1.08	1.07	1.07	1.07
Sweden	1.20	1.21	1.21	1.19	1.18	1.19	1.17	1.16
United Kingdom	1.06	1.05	1.06	1.07	1.07	1.07	1.05	1.05

Source: own calculations based on Eurostat data.

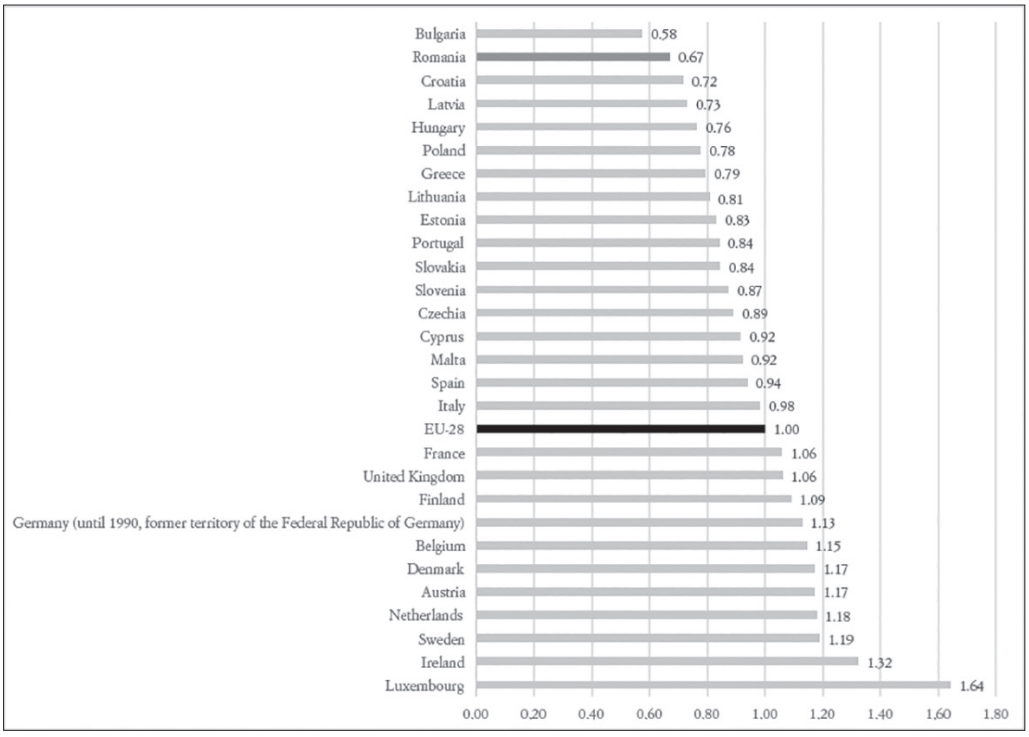
Based on the size of the composite index, one can establish a hierarchy of EU Member States, by calculating an average of the indices of each country, for the period 2010-2017 (figure 4).

At the top of the list, Luxembourg and Ireland are significantly detached from the followers. At the bottom of the ranking, we find the eastern countries (with the exception of Greece and Portugal), with Bulgaria (0.58) and Romania (0.67) 30% below the average.

The relative deviation from the total level of the indicator (maximum/minimum) in the period 2010-2017 is 106%. Of the 28 EU Member States, 17 have lower performances

than the EU average: two States with a deviation of more than 30% compared with the average (Bulgaria and Romania), five countries with a deviation between 20% and 30% (Croatia, Latvia, Hungary, Poland, and Greece), six countries with a deviation between 10% and 20% (Lithuania, Estonia, Portugal, Slovakia, Slovenia, and Czechia) and only four with a deviation below 10% from the average (Cyprus, Malta, Spain, and Italy).

Figure 4. Ranking of EU Member States based on the composite index of development for the period 2010-2017



Source: own calculations based on Eurostat data.

Human capital is analysed through the two components: health (healthy life expectancy) and skills (the general level of skills of the workforce, and the quantity and quality of education).

It is known that a high level of health is a key element of the human capital of each country, contributing to its competitiveness vis-à-vis other countries. Healthy people are more productive and creative, have greater physical and mental capacity, and tend to invest more in education as life expectancy increases. The composite health indices for the period 2010-2017 are presented in table 4. As indicated above, the index uses two indicators: life expectancy at birth, and healthy life years at birth, both in absolute value.

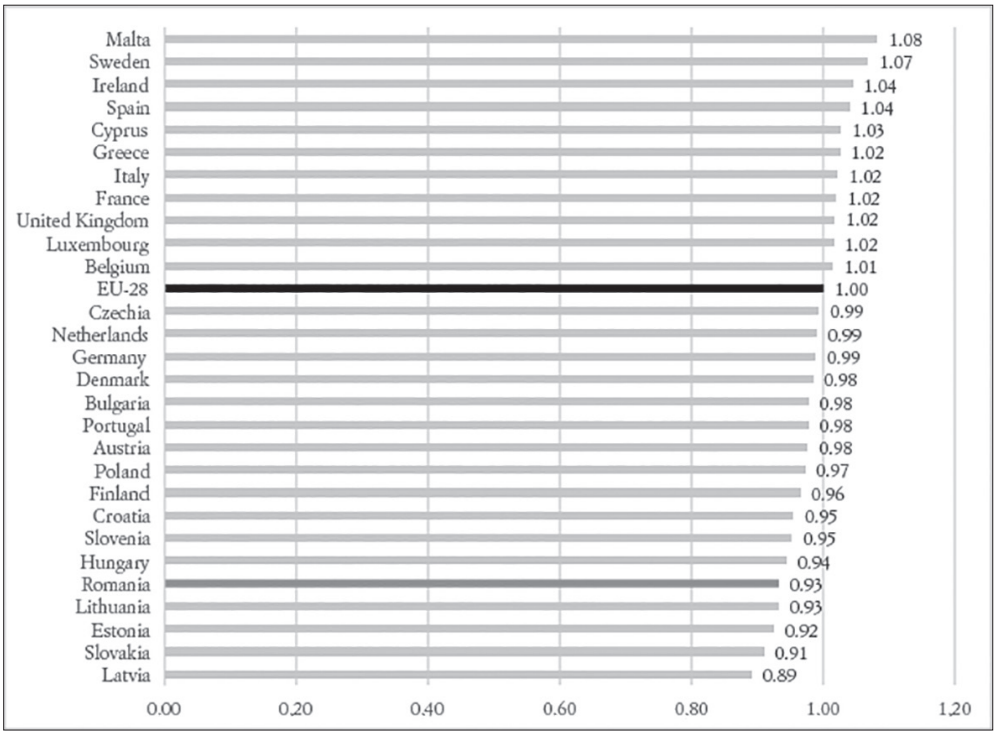
Table 4. Health composite index

Year	2010	2011	2012	2013	2014	2015	2016	2017
EU-28	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Belgium	1.01	1.02	1.02	1.02	1.02	1.01	1.00	1.00
Bulgaria	0.98	0.98	0.98	0.99	0.98	0.97	0.98	0.97
Czechia	1.00	0.99	1.00	1.00	1.01	0.99	0.98	0.97
Denmark	0.99	0.99	0.99	0.99	0.99	0.97	0.97	0.97
Germany	0.97	0.97	0.97	0.97	0.96	1.03	1.02	1.02
Estonia	0.93	0.93	0.92	0.93	0.92	0.92	0.92	0.92
Ireland	1.04	1.05	1.05	1.05	1.05	1.04	1.04	1.05
Greece	1.04	1.04	1.03	1.03	1.03	1.01	1.01	1.01
Spain	1.03	1.04	1.04	1.04	1.04	1.02	1.03	1.06
France	1.02	1.02	1.02	1.03	1.03	1.02	1.01	1.01
Croatia	0.95	0.97	0.99	0.96	0.96	0.93	0.94	0.93
Italy	1.02	1.02	1.01	1.01	1.02	1.01	1.04	1.03
Cyprus	1.03	1.00	1.02	1.04	1.05	1.01	1.04	1.02
Latvia	0.90	0.90	0.92	0.89	0.89	0.88	0.88	0.86
Lithuania	0.94	0.94	0.94	0.94	0.95	0.91	0.91	0.92
Luxembourg	1.03	1.04	1.04	1.02	1.03	1.00	0.98	0.97
Hungary	0.93	0.94	0.95	0.95	0.95	0.94	0.94	0.94
Malta	1.08	1.07	1.08	1.09	1.10	1.09	1.07	1.08
Netherlands	1.00	1.00	1.00	0.99	1.00	0.98	0.98	0.97
Austria	0.99	0.99	1.00	0.99	0.97	0.96	0.95	0.95
Poland	0.96	0.97	0.97	0.97	0.98	0.97	0.97	0.97
Portugal	0.97	0.98	1.02	1.01	0.96	0.95	0.96	0.96
Romania	0.92	0.93	0.93	0.94	0.94	0.94	0.93	0.93
Slovenia	0.93	0.93	0.95	0.98	0.98	0.96	0.96	0.93
Slovakia	0.89	0.89	0.90	0.92	0.92	0.91	0.92	0.91
Finland	0.97	0.97	0.96	0.97	0.97	0.96	0.96	0.95
Sweden	1.05	1.05	1.05	1.05	1.10	1.09	1.08	1.08
United Kingdom	1.03	1.03	1.03	1.03	1.02	1.01	1.00	0.99

Source: own calculations based on Eurostat data.

In the case of this index, the discrepancies between countries are not as significant as in the case of the composite index of economic competitiveness, the discrepancies being between ± 10%. Malta records the highest value of the index (between 1.069 in 2011, and 1.099 in 2014), followed by Sweden, Ireland, Spain, and Cyprus, which record values high and above the EU average for both indicators entering the composite index. At the bottom, we find Latvia, with a deviation between 10% and 20% compared with the EU average, followed by Slovakia, Estonia, Lithuania, Romania, and Hungary.

Figure 5. Ranking of EU Member States based on the health composite index of human capital for the period 2010-2017



Source: own calculations based on Eurostat data.

It should be noted that six of the EU Member States that recorded the best economic performance are also at the top of the health ranking (Sweden, Ireland, France, the United Kingdom, Luxembourg, and Belgium). Conversely, Southern European countries, with a relatively good health ranking (Malta, Spain, Greece, and Italy), recorded lower economic performance than the EU average.

Focusing on Romania, despite advances in the health status of the population – as a result of the introduction of new medical treatments, the improvement of technology, the modernisation of the medical system, the access to medical information, and the development of private health services –, the indicator still places the country at the bottom of the ranking in Europe. There are gaps and inequalities characterising the rural-urban divide, as well as between the different regions of the country. These gaps are determined primarily by access to health services and their quality, but also by numerous socio-demographic indicators. There is an evolution of both indicators, life expectancy at birth (from 73 to 75 years), and healthy life years at birth (from 57 to 59 years). The increase in lifespan is due to the decrease in mortality at young ages, i.e. where the dependency on the average lifespan is higher. Combined with the decline in the birth rate, it leads to demographic ageing and to the consequent increase in the old-age dependency ratio, i.e. the number of older people that the active persons must support.

In addition to health, education is an essential investment in human capital, because of its effects on labour productivity (since it makes individuals more productive) and on individual well-being. The wealth of a nation is primarily due to the level of education of its population, as well as to its health status. Thus, education has a decisive role in the formation of "human capital" and in determining the individual's chance from an economic point of view; it "represents the essence of human capital, its importance being superior to the components associated with the state of health" (Woodhall, 2001, pp. 6951-6952). In table 5, we present the skills composite index, derived by equation 3.

Table 5. Skills composite index

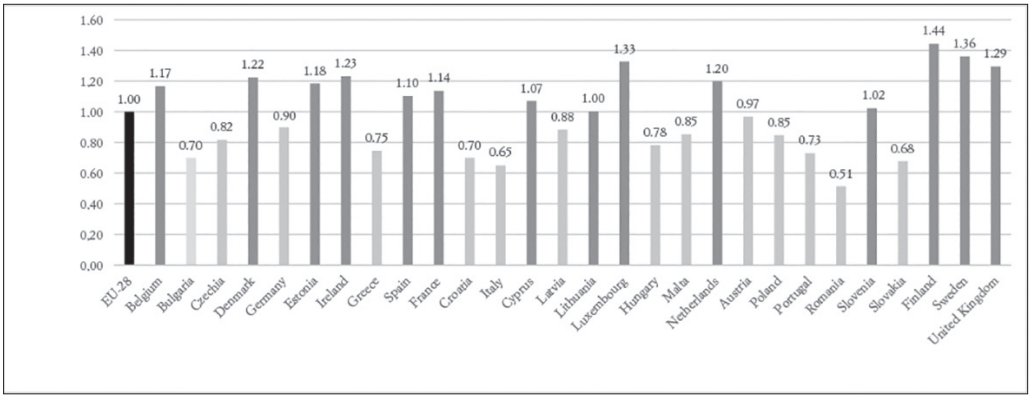
	2010	2011	2012	2013	2014	2015	2016	2017	2018
EU-28	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Belgium	1.21	1.19	1.19	1.14	1.16	1.13	1.12	1.19	1.17
Bulgaria	0.66	0.68	0.67	0.70	0.71	0.72	0.73	0.70	0.73
Czechia	0.79	0.84	0.84	0.83	0.82	0.81	0.80	0.82	0.80
Denmark	1.27	1.27	1.27	1.21	1.22	1.22	1.18	1.20	1.16
Germany	0.93	0.92	0.95	0.91	0.88	0.88	0.88	0.88	0.86
Estonia	1.20	1.19	1.21	1.16	1.12	1.15	1.19	1.21	1.24
Ireland	1.19	1.29	1.29	1.25	1.20	1.18	1.17	1.24	1.27
Greece	0.73	0.74	0.76	0.76	0.72	0.71	0.74	0.78	0.79
Spain	1.14	1.16	1.13	1.12	1.11	1.05	1.06	1.07	1.08
France	0.98	1.01	1.01	1.19	1.19	1.21	1.22	1.20	1.21
Croatia	0.69	0.68	0.68	0.68	0.71	0.71	0.71	0.69	0.73
Italy	0.64	0.63	0.64	0.63	0.66	0.65	0.66	0.67	0.67
Cyprus	1.07	1.11	1.13	1.07	1.07	1.05	1.03	1.04	1.05
Latvia	0.87	0.90	0.91	0.90	0.84	0.87	0.91	0.92	0.84
Lithuania	1.00	1.03	1.00	0.97	0.94	1.00	1.02	1.03	1.03
Luxembourg	1.34	1.36	1.40	1.36	1.42	1.32	1.25	1.15	1.34
Hungary	0.76	0.76	0.77	0.76	0.76	0.85	0.80	0.79	0.78
Malta	0.78	0.82	0.84	0.82	0.85	0.85	0.84	0.91	0.96
Netherlands	1.23	1.22	1.21	1.19	1.19	1.20	1.18	1.18	1.20
Austria	0.86	0.83	0.83	0.82	1.06	1.07	1.08	1.10	1.07
Poland	0.88	0.84	0.85	0.84	0.84	0.82	0.82	0.84	0.89
Portugal	0.60	0.68	0.70	0.69	0.78	0.78	0.79	0.77	0.78
Romania	0.50	0.54	0.52	0.53	0.51	0.52	0.52	0.51	0.48
Slovenia	1.03	1.07	1.04	1.00	1.00	1.01	1.00	1.05	1.01
Slovakia	0.69	0.73	0.68	0.65	0.66	0.66	0.65	0.68	0.71
Finland	1.47	1.47	1.46	1.43	1.44	1.45	1.42	1.43	1.43
Sweden	1.36	1.36	1.36	1.33	1.35	1.36	1.37	1.39	1.38
United Kingdom	1.38	1.34	1.34	1.29	1.29	1.28	1.26	1.25	1.23

Source: own calculations based on Eurostat data.

Regarding the skills indicator, at the top we find Finland (between 1.4178 and 1.4693), Sweden (between 1.3281 and 1.3900), Luxembourg (between 1.2507 and 1.4238), and the United Kingdom (between 1.2291 and 1.3792). These four countries maintain their position throughout the period, with deviations of more than 30% compared with the EU average. Sweden, Luxembourg, and the United Kingdom perform better than the EU average in all the three indices. At the bottom of the ranking is Romania, with a composite index between 0.48 and 0.53, corresponding to half the EU average. It records the lowest values in five out of the six indicators considered in the determination of the skills composite index (the exception being employed ICT specialists as a share of total employment). The skills of the population need to be updated to obtain a better-trained workforce. Romania's low score, also in terms of participation of the population aged between six and 29 years at all levels of education, depends on a wide range of factors: the age structure of the population, legal requirements regarding the beginning and end of compulsory education, the duration of education cycles, and the availability of educational resources. Besides increasing participation in education, one of the major challenges for the Romanian economy is to improve the quality of teaching and to offer young people the digital and cognitive skills required by the economy of the future. Efforts should be carried on to improve the quality of higher education, to increase the number of students, and to match the skills supplied with the demands of the labour market.

Synthesising the results obtained over the whole period under analysis, we can see the position of the countries, and the size of the differences from the EU average (figure 6).

Figure 6. Ranking of EU Member States based on the skills composite index of human capital for the period 2010-2017



Source: own calculations based on Eurostat data.

The countries that stand out significantly are Finland (1.44), Sweden (1.36), Luxembourg (1.33), and the United Kingdom (1.29). At the bottom of the ranking is Romania (0.51), with a 49% deviation from the EU average, Italy (0.65), Bulgaria and Croatia (0.70), Portugal (0.73), Greece (0.75), and Hungary (0.78).

The relative deviation from the total level of the indicator (maximum/minimum) in the period 2010-2017 is 93%. Of the 28 EU Member States, 14 are performing below the EU average: a country with a deviation of more than 40% from the average (Romania), two countries with a deviation between 30% and 40% (Slovakia and Italy), five countries with a deviation between 20% and 30% (Bulgaria, Croatia, Portugal, Greece, and Hungary), four countries with a deviation between 10% and 20% (Czechia, Latvia, Malta, and Poland), and only two countries with a deviation below 10% from the average (Germany and Austria).

4. Conclusions

Romania, as is the case with the other EU countries, is in the process of transition to the new digital industrial reality, in full swing throughout the world. Although Romania has some strengths that it can exploit, namely the existence of a high-performance IT sector, with skills in areas essential to Industry 4.0, and the existence of very high-performance internet infrastructure, it is not yet ready to cope with all the changes that will follow.

Romania has a low level of highly qualified workforce in the IT field compared with other EU countries. It ranks last in the EU as to the skills indicator. The skills of the population need to be updated to have a better-trained workforce. There is the need for qualification of human capital in line with the new technological trends, developing skills, training, and education.

From the present study, we can conclude that the countries that have invested over time in the education system, which is at the top of the ranking in the skills index, are the ones that have the best economic performance. The degree of training and education of the population, and its level of professional, technical, scientific, and general knowledge affect the productivity of work, the quality of products and services, and the quality of social and human relations. Training, education, and development of human personality are the most productive and efficient economic and social investments in the medium and long term.

Besides increasing participation in education, one of the most significant challenges for the Romanian economy is to improve the quality of teaching and to offer young people digital and cognitive skills required by the economy of the future. Efforts should be carried on to improve the quality of higher education, to increase the number of students, and to match the demands of the labour market. Education embeds skills and competences in the labour force.

The qualification of the labour force is also an important factor in FDI. The companies will reconsider the criteria used in the decision-making process regarding the location of investments in foreign countries. Qualified, specialised, and experienced personnel is needed, especially when investing in high-technology sectors.

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