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EDUCATION, EMPLOYMENT AND SOCIAL DEVELOPMENT AS KEY MEASURES OF DIGITALISATION ROLE IN LABOUR FORCE DEVELOPMENT IN EU

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In the paper, we investigate the differences between EU countries in the adoption of digitalisation in the context of the labour force. We used the authors' index of digitalisation as a proxy to control for labour force adjustment to technological progress and human capital development. Our focus is on three main pillars affecting digitalisation: the number of students in the field of information and communication technologies, the degree of use of advanced technology at workstations, and online community groups focused on digitisation and improvement of digital skills. The results suggest EU countries are diversified in terms of the labour force's development under digitalisation. The ranking in the index turned out to be significant in showing two different groups of countries. Finland, Malta and Ireland are top-ranking countries, while the United Kingdom's index result is distant from other developed EU nations, what is confirmed by its Digital Economy and Society Index (DESI) and Global Innovation Index (GII) rank. The scores for less developed countries are low, however, the dynamics in the number of CS&IT students indicate advances in digitisation and its positive influence on labour development. The study uses data for the period of 2012–2018. In contrast to the DESI and GII measures, we used human and social development and digital use at work as pillars in the entire group of EU countries to highlight social and economic fields determining digitalisation's development.

Keywords: digitalisation, labour, work conditions, education, Internet forum

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1. INTRODUCTION

Influenced by the digitalisation process, education systems, professions and jobs adapt to the requirements of technological progress. In countries in the EU digitalisation has radically different dynamics. It is well-known that capital input, public policy, and research and development of ICT lead to efficiency gains. It is rather a revolutionary than an evolutionary phenomenon, because existing solutions are radically replaced with new ones. This results in a challenge for public programs and the content of education and training.

Monitoring differences between countries and analysing the progress of digitalisation and the related industrial revolution 4.0 is the subject of many research papers. Nevertheless, little is known about the characteristics of the digitalisation process with a focus on labour force operation. This state of knowledge is in stark contrast to empirical analyses on digitalisation and innovativeness with a broad focus on institutions, infrastructure, business strategy, and human capital, which are recognized as crucial factors to advance digitalisation in an economy (Schultz, 1961; Becker, 1962).

This vast empirical literature also shows that the majority of EU member states are in the first phase of digitalisation, with a scarcity of digital solutions implemented at workstations, and social development far from discussions on digital solutions. (Lundvall, 1992; Lundvall, Johnson, 1994; Smith, 2002, 6).

The main aim of this paper is to identify differences between EU countries in digitalisation's role in labour force development. The analysis contributes to the empirical literature by providing country-level evidence on the determinants of digitalisation processes on the labour market. Our approach builds on earlier studies that focus on aggregate indexes of data using composite models of digitalisation factors (*Measuring*..., 2002; *Regional*..., 2002). In our index digitalisation responds to the social and economic variables of education, work and social activity. In the study, we used a unique database on CS&IT faculties and Internet forums. The study uses data for the period of 2012–2018. This period results from the commencement of the implementation of the Digital Agenda for Europe initiative (2010) and the observed developing digitalisation in EU economies with higher and lower levels of development. The availability of data also spoke in favour of the choice of the period of 2012–2018.

Our two hypotheses concern questions as to what extent does the index explain the differences in the status of digitalisation. On the one hand, digitalisation in countries refers to the State and private sector partnership being the accelerator of technological progress and human capital development, while on the other, it is negatively related to the level of digitalisation.

Concerning education, we control for the range of countries to account for the possible scope of study faculties accessible in English for CS&IT studies. We expect that with countries and their high schools offering a wider range of faculties, more students with skills adjusted to the labour market will emerge, which leads to productivity growth (index number 1). We also identify the intensity of computer and Internet use at work (at least once a week) (index number 2). A higher level of these applications will increase manufacturing capacity, in the form of increasing productivity and quality (Vujanovic, Lewis, 2017), which will indisputably affect labour force conditions (Pupillo, 2018). We also control the intensity of social movement in informal training to account for the possible effects of participation in a global knowledge network (index number 3).

The remainder of the paper is organised as follows. Section 2 surveys the relevant literature. Section 3 presents the datasets and method used in the study. In section 4 we present the discussion on the results obtained from index calculation. Section 5 concludes the paper.

2. LITERATURE REVIEW

Digitalisation among the EU countries is somewhat uneven. The Internet, artificial intelligence and Big Data affect all types of work in enterprises, public institutions, the non-governmental sector and individuals' behaviour. The process of digitalisation introduces changes to mechanisms of the labour market, which include a demand for particular qualifications, changes in mode and work conditions. Frey and Osborne and other researchers argue that computing power and the potential of automation will eliminate almost half of current jobs in the US, young professionals will have to change their profession about six times (Frey, Osborn, 2013; Frey, 2016; Jung 2019. For workers, digitalisation means movement between sectors and the necessity of adopting a life-long-learning model, for managers – constant education during their work period. Re-skilling on a massive scale is a difficult process, however, imagine a classic BMW engineer who by training is to become a big data analyst (Schafer, Muster, Owczarek, 2017, 15–16). Eliminating the demand for routine and cognitive work, digitisation causes changes in the content of work of many professions. (Dworak et al., 2014, 11–35) A permanently growing demand for work is focused only on selected categories of skills, which strongly polarizes the labour market. In addition, globalisation, increasing productivity and wages are accompanied by aging and a decline in the population (Goos, Manning, Salomons, 2014, 2509–2526).

Digitalisation is identified as a set of values leading to the optimization of the growth of the economy and includes applications that support the manufacturing process (Milošević et al., 2018, 861–880). Digitisation mobilizes the implementation of innovative business models and work modes like new sales platforms such as Airbnb and Uber, while challenging a country's law system (Nadim, Schreyer, 2016, 4–27; Świątkowski, 2019, 11–18). Digitalisation brought about free media supported by Big Data, activities like crowdsourcing, and its manifestations like agile management. Without a network system in society and machine communication, innovation and research, the development of a country would have been ultimately stifled. Moreover, digitalisation boosts effectiveness and leads to productivity growth more in intensive than extensive development (Meijers, 2014; Roller, Waverman, 2001, 909–923; Czernich et al., 2011). To continue this claim and look into this phenomenon lets focus on digitalisation from the point of view of two components: automation and the “economy motive” (Eichhorst, Rinne, 2017; Bartkiewicz, Czerwonka, Pamuła, 2020). The first component concerns the existence of infrastructure such as robots or algorithms that override the working routine performed so far by people. It follows the prospect of higher productivity-induced technology that displaces the work routine, by describing, on the one hand, “technological unemployment” and, on the second hand, the fact that artificial intelligence (AI) creates jobs, helps people work better and can be used to retrain workers in more effective ways (Eichhorst and Rinne, 2017; Rappers et al., 2018; Yeung et al., 2018, 1271–1273; Laskowska-Rutkowska, 2020). The second component of digitalisation refers to the “economy motive” and is addressed to the new business and economy model, which includes online services and a virtual extended reality. The reference to this digitising component can be found in the study of Deakin and Markou, who claim that due to digitalisation and the improvement of business models it is possible to achieve fast growth in productivity through education focused on e-skills and social media on a massive scale (2018).

In relation to the studies above, this paper is an attempt to define some of the differences in the digital economy performance of EU countries. In the present literature, the level of digitalisation of the economy is measured by GDP or public and private outlays (Degryse, 2017; Billon, Marco, Lera-Lopez, 2009, 596–610). With reference to these meters, Meijers’ research shows a correlation between the GDP’s growth rate and service sector expenditures, education quality, economic stability in highly developed countries (2014, 137–163). In highly developed countries the GDP serves as the best indicator of digitalisation and it seems that ICT outlays along with a decreasing cost of the Internet drive up creation and the spread of new ideas and strengthen the position of these areas in digitalisation. Nevertheless, in these countries the costs of Internet-based services are higher than in other countries and negatively affect the adoption of ICT, inhibiting the implementation of technological solutions (Degryse, 2017). The conclusion from these studies is a strong correlation between indexes of digitalisation and changes in GDP and a weak correlation to national income. Moreover, some authors focus on an aggregated index of digitalisation meters (Corrocher, Ordanini, 2002, 9–19; Vicente, Lopez, 2006). The composite index procedure is proposed by Hanafizadeh. His construct uses two components: infrastructure resource and access facilitation (2019, 1–37). Researchers measure digitalisation also by public and private investments in ICTs and their implementation in various sectors of the economy (Corrocher, Ordanini, 2002, 9–19). The Milošević multidimensional indicator (Milošević et al., 2018, 861–880) is based on meters of companies and households such as the use of the Internet to operate businesses and households, and the use of cloud mobile services. The author calculates the weights of these components, basing on the Pearson correlation ratio between the indicator and particular variable values. A slightly different formula is suggested by the Centre for Data Innovation, which rates countries using 5 sub-indexes, such as data access, key technologies, technology development for business, work and education quality (Wallace, Castro, 2017; Majumdar, Banerji, Chakrabarti, 2018, 1247–1255).

Analyses of digitalisation based on composite indexes are also performed by European and global institutions and include the Digital Economy and Society Index (DESI), Global Innovation Index (GII), Bloomberg Innovation Index (BII), Composite Science and Technology Innovation Index (CII), and World Development Indicators (WDI).

Research on the composition of the index is necessary because digitalisation is a multidimensional phenomenon and it is difficult to define its universal measure. The index meters proposed here cover three dimensions: education, employment and Internet communication. Some EU countries are more focused on education strategy reforms (European Commission, 2016), including the examination of skills policies that could help improve productivity and inclusiveness (Vandenberghe, Demmou, Frohde, 2017). In this way those countries actively use all the benefits of digitalisation. Finally it calls for meters that encourage **information** and **communication technology** (**ICT**) upskilling. In the last decades research shows that the **ICT** education programs significantly increase **students'** likelihood of obtaining a job offer in the labour market and the wage they were offered (Kuvat, 2019; Lu, Song, 2020). Moreover, the aspect of ICT students is also incorporated through research on entrepreneurship tendencies.

Enterprises will be able to maintain their global competitiveness if they introduce digitisation solutions into their daily practice, which is at a minimum the use of a computer and the Internet at work, at least once a week. This has triggered a change in the set of **skills** that are required from workers (Galor, 2005, 171–293). Heeks focuses on the labour force differences between EU countries and innovation policy which are interrelated with infrastructure development and the spread of advanced technology (Heeks, 2010, 625). Digital transformation impacts labour markets with a varying effect on the high- and low-skilled workers. This is reflected by changes in productivity and wage inequality (Monnig, Maier, Zika, 2019). European countries range from high performing (North and Western Europe) to low performing (South and South-eastern Europe). For some countries, low levels of adaptability of the workforce can pose an important obstacle for future growth and development, what is reflected in a study by Jandric and Randelovic (2018).

The growing importance of digitisation contributed to the development of remote communication needs and an increased interest in upgrading knowledge competences (Nadim, Schreyer, 2016). Each Internet service aims to promote information exchange among people who share common interests, activities, or goods. Internet users have consolidated their place in the field of technology and digitisation by running permanent forums as discussion platforms. As stated by Carlsson and Stankiewicz (1991), the purpose of a technological innovation system is to provide connections among various parts of the system. The use of the Internet as a measure to analyse the differences in digitisation on a country level has been applied by Myovella (Myovella, Karacuka, Haucap, 2020) and Milošević (Milošević et al., 2018), who included the percentage of all individuals who have accessed the internet in the last three months, or a percentage of households with internet access. Number of Internet forums related to “technology” in capital cities reflects the commitment to digitalisation. This channel of Internet communication is first of all developed in the capital cities where the urban population operates in a highly advanced digital infrastructure.

The proposed index’s formula is complementary to the other meters mainly based on the input – output scheme in the economic context and we firmly believe that a three dimensional index has potential as an attempt to measure the digitalisation of EU countries.

3. METHODOLOGY

Measuring the digital phenomenon, according to the cited research papers, is therefore difficult and complex. It can be considered multifaceted, because it is present not only in the economic, but the social area as well. In this paper the measurement of digitalisation was carried out by using one general index formula, covering three areas: educational, professional and social development, represented by three sub-indices (see Table 1).

The adoption of such a content allowed us to illustrate and compare areas of digitalisation and its intensity in every EU country. In this way digitalisation had been identified in different life stages of present generations, from education to the professional life phase. It also refers to the human capital factor that represents a state of knowledge and skills, use of equipment and software, and activity resulting from the need to learn by doing, exchange and interaction, as well as shared expectations.

The first area – education (index 1) is represented by a percentage of tertiary students who study Computer Science & Information Technology (CS&IT). Ranking countries based on this index has allowed us to determine the level of openness and attractiveness of the international universities and indirectly also indicates the depth of interest in teaching information and communication technology development. Index 1 assesses the potential of digitalisation in shaping the current human capital and future resources. The professional activity area (index 2) as the interim rate, represents the number of employees, who at least once a week use a computer or the Internet. The number of jobs where ICT is used is one of the most widely used measures of digitalisation and demonstrates the level of commitment of the advanced technology in manufacturing processes, increases in productivity and the quality of production. The social life area (index 3) is multifaceted and focuses on the examination of the digital selection within a social community. It is illustrated by the number of Internet forums registered in capitals of countries. A high number of groups can be evidence of expansive knowledge and entrepreneurship of inhabitants and represents a high interest in the subject of digitalisation that integrates participants in a discussion around many different issues. Which results in a knowledge spill over and innovators mobilisation. All three raw data indexes (also called sub-indexes) were converted to comparable values through data standardisation on a scale from 0 to 10.

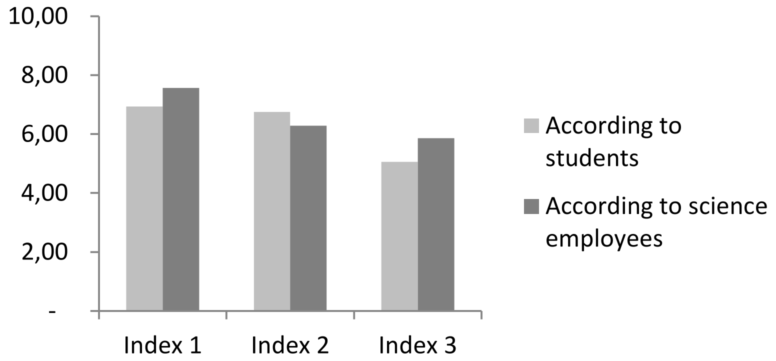

Fig. 1. Comparison of sub-indexes' weights as evaluated by scientists and students in the survey. Own elaboration

Table 1. Sub-indexes used in this survey

Sub-Index	Description	Source
Index 1 Weight = 7,3 (out of 10)	Percentage of tertiary students who study Computer Science & Information Technology (CS&IT) in every country	Eurostat
Index 2 Weight = 6,5 (out of 10)	Percentage of employees from private sector companies with at least 10 employees, who at least once a week use a computer and the Internet	European Commission (digital-agenda-data.eu)
Index 3 Weight = 5,5 (out of 10)	Number of Internet forums related to "technology" in capitals of analysed countries (per 10 thousand residents of these capitals)	www.meetup.com
Additional Index 4 (not used in the overall index)	Number of English Master's degree studies in Computer Science & Information Technology compared with the number of tertiary students in EU countries (per 10 thousand students).	MasterPortal (www.mastersportal.eu) Eurostat

Own elaboration.

The sub-indicators were individually standardised and varied by weights from 0 to 10 (see Figure 1), and were rated in a survey among science employees and Master's degree students (in total 30 respondents). These weight levels regulate the importance of the indexes. Although particular areas seem to be equally important to each other, the study discusses the obtained weights in the next stages of analysis.

The evaluation of countries contains a set of ranges (see Table 2) and, according to these ranks, countries were grouped into 2 groups and classified as highly or poorly developed in terms of digitalisation's advancement in labour force development.

4. EMPIRICAL DATA AND ANALYSIS

The degree of digitalisation, as a derivative of the areas of education, employment and social development, is the result of many factors and processes that have been taking place in Europe for about 30 years and in the Silicon Valley have started even earlier (Kuciński, 2016, 83–99). The diversity of digitalisation in the EU is represented by a general index as weighted by 3 sub-indexes. Our results show that countries were divided into two groups but the results of cluster analysis show even four separate groups (see: Fig. 2). As for the ranking, three countries (Finland, Malta, Ireland) achieved the top position in digitalisation. Finland obtained 7.66, Malta – 6.74 and Ireland – 6.21 points (out of 10). They are followed by Sweden, the Netherlands, Denmark, Belgium, Germany, Luxemburg, Estonia, France, and the United Kington. The remaining sixteen EU countries in the second group are far behind with a 3.94 index rate as the highest one achieved.

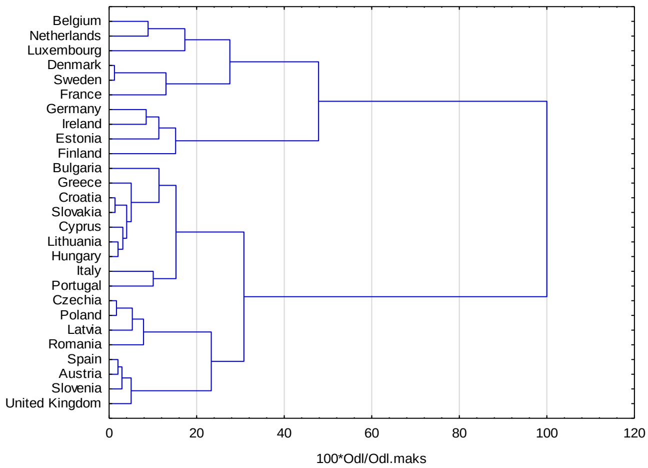

Fig. 2. Similarity of EU 28 countries in terms of digital indicators based on cluster analysis performed using the Ward method. Own calculations

The higher-scoring group encompasses member states progressing in digitalisation in education, employment and social active learning. Finland and Estonia are examples (with index 1 values of 10.0 and 8.76 respectively) of high development in the area of education for new jobs with the use of digitisation. For Belgium, Malta and the Netherlands the general index's level is mostly determined by the number of Internet forums (index 3 equals 10.0 10,0 and 7.53 respectively), which shows the society's inclination to educate themselves and provide assistance to those interested in data processing and expanding knowledge outside the formal education. The lower-scoring group (17 countries), where total indexes range from 3.08 to 3.84 refers to the early stage of digitalisation and has a lot of catching up to do. Quite better are Slovenia, Austria, Spain, Latvia and Czechia. Sub-index number 3 stayed below one in 8 countries, although it stays at a much lower level than in the group of the top-scoring countries.

Table 2. Ranking of EU countries according to the general and partial indexes of digitalisation

Country	Index 1	Index 2	Index 3	General Index	Country	Index 1	Index 2	Index 3	General Index
Finland	10.00	9.16	2.77	7.66	Spain	4.20	4.86	1.20	3.57
Malta	7.11	3.58	10.00	6.74	Latvia	5.66	3.37	0.62	3.45
Ireland	7.52	5.39	5.43	6.21	Czechia	4.49	3.12	1.18	3.09
Sweden	3.78	10.00	3.89	5.91	Romania	6.05	1.20	0.76	2.91
Netherlands	2.22	8.67	7.53	5.9	Poland	4.14	2.61	1.31	2.82
Denmark	3.75	9.92	3.44	5.74	Croatia	3.32	3.58	0.88	2.71
Belgium	1.90	6.42	10.00	5.73	Slovakia	3.42	3.07	0.84	2.57
Germany	6.62	6.32	2.57	5.36	Hungary	2.74	2.72	1.15	2.28
Luxembourg	5.43	3.75	7.04	5.32	Lithuania	2.38	3.28	0.80	2.23
Estonia	8.76	4.13	1.27	5.07	Cyprus	2.69	3.22	0.00	2.10
France	1.67	6.91	4.20	4.15	Greece	2.23	2.02	1.28	1.89
United Kingdom	3.61	6.69	1.60	4.07	Portugal	0.82	1.96	3.16	1.87
Slovenia	3.92	5.26	2.03	3.84	Italy	0.00	4.11	0.16	1.43
Austria	4.03	5.60	1.05	3.71	Bulgaria	2.81	0.00	0.62	1.24

Source: own calculations, https://ec.europa.eu/digital-single-market/en/desi.

The role of digitalisation monitored by our general index is partly supplementary to the Digital Economy and Society Index (DESI) (https://www.k2base.re.kr/costii/ en/countryProfile.do, data access 30.12.2019), a composite of 6 components focused on social, business and infrastructural aspects of EU member states and the Global Innovation Index, GII (https://www.globalinnovationindex.org/gii-2019-report) which contains five pillars: institutions, human capital and research, infrastructure, market sophistication, and business sophistication for 130 countries. These indexes, being complementary, follow a similar order with some exception (see Table 3).

Table 3. Comparison of DESI and GII indexes in EU countries*

1	Finland	DESI:	1	GII:	7	15	Spain	DESI:	11	GII:	28
2	Malta	DESI:	10	GII:	26	16	Latvia	DESI:	17	GII:	34
3	Ireland	DESI:	7	GII:	10	17	Czechia	DESI:	18	GII:	27
4	Sweden	DESI:	2	GII:	3	18	Romania	DESI:	27	GII:	49
5	Netherlands	DESI:	3	GII:	2	19	Poland	DESI:	25	GII:	39
6	Denmark	DESI:	4	GII:	8	20	Croatia	DESI:	20	GII:	41
7	Belgium	DESI:	9	GII:	25	21	Slovakia	DESI:	21	GII:	36
8	Germany	DESI:	12	GII:	9	22	Hungary	DESI:	23	GII:	33
9	Luxembourg	DESI:	6	GII:	15	23	Lithuania	DESI:	14	GII:	40
10	Estonia	DESI:	8	GII:	24	24	Cyprus	DESI:	22	GII:	29
11	France	DESI:	15	GII:	16	25	Greece	DESI:	26	GII:	42
12	United Kingdom	DESI:	5	GII:	4	26	Portugal	DESI:	19	GII:	32
13	Slovenia	DESI:	16	GII:	30	27	Italy	DESI:	24	GII:	31
14	Austria	DESI:	13	GII:	21	28	Bulgaria	DESI:	28	GII:	37
* The order of countries is according to our digitalisation index.											

Own elaboration based on https://www.k2base.re.kr/costii/en/countryProfile.do, https://www. global innovationindex.org/gii-2019-report, data access.

The degree of digitalisation in EU countries, and especially in Finland, stems directly from the high use of technology in the workplace environment based on ICT knowledge, which translates to building company value and its best place in the production value chain. Finland gets first rank in the DESI and 7th in the GII. It also declares 46.2% knowledge-intensive employment and jobs, which positions it at the 10th position in the world (https://tcdata360.worldbank.org/indicators, 2.10.2019). Malta, in spite of its low ICT-intensive employment (index 2: 3.58), exploits its wide potential of openness to the global market, and attracts a high amount of CS&IT students, what corresponds to a score of 10 for the number of Internet forums (index 3). Nevertheless DESI and GII pillars like generic top-level domains, a very high level of entrepreneurship and global R&D companies set Malta in the 10th position in the EU and 26th in the world. These explain the moderate implementation of labour digitalisation in Malta creating a competitive knowledge-intensive labour force. The third position in our total index rank for Ireland complies with the 7th position in the DESI ranking and the 10th score in the GII, what demonstrates intensive knowledge absorption and diffusion in Ireland.

Our results confirmed the status of these three countries as leaders in digitalisation focused on human capital development.

Subsequent indexes' investigations also confirm the results for Denmark, the Netherlands, and Sweden (equivalent to the 4–6 positions, see Table 2) (Wallace, Castro, 2017). The United Kingdom reaches only the 12th position, which is determined by the low number of tertiary students and Internet forums (see Table 2, Table 4), although the DESI places the United Kingdom in 5th and the GII in 4th position.

Table 4. Indexes of dynamics for tertiary students in EU countries for the 2012–2017 period

Country	**Whole period dynamics (2012=100)**	**Average yearly dynamics**	**Country**	**Whole period dynamics (2012=100)**	**Average yearly dynamics**
Romania	469.23	167.42	Italy	107.14	102.33
Lithuania	186.36	116.84	Slovenia	104.65	101.53
Luxembourg	151.35	110.92	Austria	104.35	101.07
Latvia	134.78	107.75	Spain	104.26	101.05
Poland	127.50	106.26	France	103.70	101.22
Belgium	120.69	104.81	Croatia	102.56	100.85
Portugal	116.67	105.27	Finland	98.91	99.64
Germany	115.25	103.61	Denmark	97.78	99.44
Netherlands	114.81	N.A.	Malta	97.18	99.05
Estonia	114.47	103.44	Hungary	94.74	98.21
Slovakia	113.89	104.43	Ireland	91.14	91.14
United Kingdom	113.16	104.21	Czechia	87.50	95.65
Bulgaria	112.50	104.00	Cyprus	80.00	92.83
Sweden	110.00	103.23	Greece	64.71	89.69

Own calculations based on Eurostat: Distribution of students enrolled at tertiary education levels by sex and field of education (educ_uoe_enrt04) (12.03.2019).

In turn, France and Germany's rank is four positions higher when measured by our index than by the DESI. Nevertheless according to the Roland Berger Report, the ranks for France (7) and Germany (8) confirm our index's results (Rappers et al., 2018, 8). These positions result from the fact that the DESI and GII measure the results of artificial intelligence strategy aimed at creating a human-machine relation which is outside the scope of our index. Hansen and others state that it is indisputably the result of a long term strategy taken up by highly developed countries in the last decade (Hansen, Norup, 2017, 851–860; Dumitru, 2016, 133–144; Yampolskiy, 2020).

Our investigation on the labour force oriented index is in line with the level of public and private R&D outlays. The public budget for R&D in Germany and France stands for on average 2% of the GDP and in total in Germany 69% comes from the private sector while 68% in The United Kingdom. Finland and Ireland, which are highly ranked, spend about 1% of the GDP on R&D. In contrast, Estonia (10th position in the general index rank) reaches 1.5% of the GDP on R&D expenditures, but 40% of public outlays for R&D is devoted to higher education and it's in 8th position in the DESI.

The index for Estonia presented in this paper supports the identification of emerging countries in terms of their achievements in labour development. Estonia is utilizing its current employment position of skilful human capital even if its innovations take the form of adopting imported technology developed elsewhere (bloomberg.com/graphics/2015-innovative-countries). Countries rated at the top of the index set the development and provision of education and training as a priority. It is addressed to the needs of emerging jobs in the ICT sector. This is a priority in these countries due to increasing rates of unemployment and, on the other hand, hard-to-fill vacancies for ICT jobs for which there is a strong demand. Moreover, ten years ago many countries attempted to channel young jobseekers towards ICT jobs by developing programs through multi-stakeholder partnerships such as the like "IT Academy program" in Estonia; the "ITMB Degree" in the UK; the "Get Qualified" scheme in Malta; and the "Level 8 Conversion program" in Ireland. Finland, Malta, and Ireland have made major efforts in "on-the-job" and "just-in-time learning" (Gereis, 2014; Korte, 2007).

Countries ranked below 4.07 have a lower but growing number of tertiary CS&IT students (see Table 4). In 2012–2017 in Romania the growth has increased by 369.23%, in Poland, Lithuania and Portugal – 43.5% (see: Table 3). However, in order to increase e-skills multi-stakeholder partnerships are needed (Korte, 2007). The Roland Berger Report states that low index countries have a positive impact, but not to the extent achievable if they were running programs at an institutional level under favourable framework conditions and with the continuous support of governments. The Report suggests that it is a priority to reinforce staff education in a country and also to strengthen fiscal incentives to attract and retain employees in start-ups, which will achieve stable and homogenous conditions for the economic activity of start-ups in the EU's cities (Rappers et al., 2018, 28; Kuciński, 2016, 83–99). The low score in the index suggests a need for improvement in the environment and general assistance of young companies in terms of legal, financial and social conditions (Tominc et al., 2018, 25–33; Kuciński, 2016; Stasiulis, 2017, 217–226).

A country's status in the era of Economy 4.0 is explained by the International Labor Organization's (ILO) classification of countries in which a complete production value chain is located, which is exemplified by models of speed factories and countries that provide supplementary functions, e.g. back office, remaining in a medium economic growth mode (Nübler, 2016). Our findings support the ILO distinction but the question remains of how will the forms of labour and the market evolve in these countries in the context of skills and qualification requirements, price regulation and the jobs model. Countries with a lower price of labour in the EU experience the growth of new job models, such as ICT-based mobile work, voucher based work, portfolio work, crowd employment, collaborative employment, interim management. These types of jobs disconnect the classic components of work, such as place, time of work and salary. This phenomenon is commonly observed in Middle Eastern EU member states (*The new forms*…, 2019, 59–122; Owczarek, 2018, 15–21). The most advanced forms like crowd employment and the existence of back office businesses suggest that low index countries have become the area of many factors influence. That is why monitoring our index focused on labour force status lets us compare countries driven by changes in digitalisation's role. The index ranking shows diversity arising from digitisation in the areas of IT education, interest among students and candidates, and vocational and social networking. This diversity arises in the context of legal and organizational changes which stimulate interest in digitalisation in the social and economic spheres induced by the autostimulation market development or by an intentional policy framework.

Public and private R&D outlays refer to index measures. In countries with a high level of private sector activity, the stimulation of the labour force's interest in digitalisation is visible by a high rank in the index. Moreover, a high percent of R&D outlays in relation to the GDP refers to the scale of digital development and is also reflected by the index.

Countries which implemented a labour development policy are currently better prepared for handling the problem of ICT workers' scarcity. Their economies, having high student interest in CS&IT faculties and their societies interested in informal digital knowledge, have the potential to upgrade the productivity of employment.

By using this digitalisation index we can contribute to knowledge on the labour force's social development and the use of digital technology on a country level. To assess differences we recommend applying our index and interpreting the ranking according to the education infrastructure and skills dimensions.

5. CONCLUSION

In this paper we have taken up an investigation into the differences in the digitalisation of EU member states along with the United Kingdom. To examine from a significant distance we used a special index, composed of three indexes. We explore a country-level dataset compiled from a variety of sources. In contrast to the

European Union's DESI and Global Innovation Index (GII), our dataset covers social and economic factors focused on labour development and digital skills.

The empirical findings concerning the division of countries into 2 groups occurred mostly naturally. Ireland, Malta and Finland are ranked at the top and will develop digitisation solutions faster than other countries. Estonia joined the group of countries of the developed world, while the second group of 17 countries – dominated by the less developed ones – include some better developed countries: the United Kingdom, Italy and Austria.

Some EU countries have taken action to intervene in the process of digitisation, and their effects are shown in part by their position in the index rank. In the group of top ranked countries, the United Kingdom and Italy were not included because of a relatively low percentage of students studying CS&IT and a low number of Internet forums established in their capitals. In Italy, the results are extremely weak, but still slightly higher than in Poland, which belongs to one of the lagging EU countries in terms of the labour force's potential and is also not in the top ten countries in terms of education and employment in the ICT area. In Poland and other countries of CEE, current positive changes allow us to predict that in the next decades, the level of technological advancement should advance the competitiveness of the economy (Weber, 2017, 22–27). These changes are shown by the number of CS&IT students. We can expect that these countries will no longer adapt achievements but create their own technologies, what reinforces labour productivity.

The higher the public and private outlays for R&D and partner program actions, the better result in index rank we observe. The human capital of the labour force became a key resource for business because the efficiency largely derives from qualities and skills. Their sophistication is increasing along with the process of digitalisation.

The research confronts the results of the DESI or GII. As a result we observe a moderate linkage between our own index and the DESI or GII in the first highly ranked group of countries. Ireland and Germany ranked higher in our index, while the United Kingdom ranked much lower, which means better development of infrastructure and policy support than human and the society's engagement in digitalisation. These empirical findings are of practical importance as they show a measure of the roots of digitalisation where the object is labour force activity and contribute to a wider composite of the mentioned indexes.

One can note that our approach has some shortcomings. We have concentrated on a limited set of pillars. There is scarcity of information available on index composites with a similar structure of variables being focused on education, digital skills at work and social development by participation in Internet forums. The most significant drawback is a lack of supplementary dimensions for digitalisation measures placed in the DESI and GII, but our intention was to build a supplementary measure of digitalisation with a focus on labour force development. We hope to look into digitalisation investigations as a part of further research.

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EDUKACJA, ZATRUDNIENIE I ROZWÓJ SPOŁECZNY JAKO KLUCZOWE MIARY ROLI CYFRYZACJI W ROZWOJU ZASOBÓW LUDZKICH UE

Streszczenie

W artykule zbadano różnice między krajami UE pod względem zaawansowania procesu cyfryzacji w obszarach edukacji studentów, pracy i aktywności społecznej w sieci. Wykorzystano autorski wskaźnik cyfryzacji jako narzędzie do zbadania dostosowania zasobu pracy do postępu technologicznego i rozwoju kapitału ludzkiego. Skoncentrowano się na trzech głównych filarach mających wpływ na digitalizację. Są to: liczba studentów w dziedzinie technologii informacyjno-komunikacyjnych, poziom wykorzystania zaawansowanych technologii na stanowiskach pracy oraz grupy społeczne *online* skupione na digitalizacji i doskonaleniu umiejętności cyfrowych. Wyniki świadczą o tym, że kraje UE są zdywersyfikowane pod względem rozwoju siły roboczej w ramach cyfryzacji. Wartości indeksów okazały się wystarczające, aby wskazać dwie grupy krajów. Finlandia, Malta i Irlandia są państwami czołowymi, w wyniku czego wskaźnik Zjednoczonego Królestwa jest daleki od wartości dla rozwiniętych krajów UE, co potwierdza również wskaźnik DESI i globalny wskaźnik innowacji. Indeks dla słabiej rozwiniętych krajów jest niski, jednak dynamika liczby studentów CS&IT świadczy o postępie w zakresie cyfryzacji i o jej wpływie na rozwój zasobu pracy. W badaniu wykorzystano dane z lat 2012–2018. W przeciwieństwie do miar DESI i GII podkreślono aspekt rozwoju indywidualnego i społecznego oraz wykorzystania technologii cyfrowych środowiska pracy w całej grupie krajów UE, by naświetlić społeczne i gospodarcze aspekty determinujące rozwój cyfryzacji.

Słowa kluczowe: praca, forum internetowe, warunki pracy, cyfryzacja, edukacja