Digital skill types and economic performance in the EU27 region, 2020–2021

Trang L. Q. Tran
Károly Ihrig Doctoral School of Management and Business, University of Debrecen, Debrecen, Hungary
E-mail: lam.tran@econ.unideb.hu

Miklós Herdon
Károly Ihrig Doctoral School of Management and Business, University of Debrecen, Debrecen Hungary
E-mail: herdon.miklos@econ.unideb.hu

Thich D. Phan
Hantos Elemér Doctoral School of Business, University of Miskolc, Miskolc, Hungary
E-mail: sttpd@uni-miskolc.hu

Tuan M. Nguyen
University of Economics and Business, Vietnam National University- Hanoi, Hanoi, Vietnam
E-mail: ngtuan@vnu.edu.vn

Keywords:
human capital, digitalization, e-skills, GDP, correlation, clusters

In the era of Industry 4.0, enterprises and economies are increasingly investing in digital tools and resources, which allow them to create competitive advantages to improve business efficiency and sustainable development. Among these, digital skills of individuals and the role of information and communication technology (ICT) specialists are pivotal to the success of digital transformation. In contrast, capital sources, such as intangible, tangible, or human, also affect the effectiveness of the digital transformation process of enterprises. In this study, the authors processed secondary data from the Statistical office of the European Union (EUROSTAT) and the Network Readiness Index to investigate the relationship between the digital skills of the labour workforce and economic development, and the relationship between IT specialists and ICT development. Using correlation and hierarchical cluster analyses, this study shows that almost all indicators of digital skills strongly and positively correlate with economic development in the European Union countries (EU27), except for the most basic level of online information and data literacy skills. Moreover, this study found a strong correlation between deploying ICT specialists and ICT development levels. ICT specialists were classified into five groups, based on certain indicators, using hierarchical cluster analysis. In the conclusion, the authors emphasised the importance of digital skills and ICT specialists in developing policies for digital transformation in Europe.

Introduction

Over the past few decades, the development of digital technologies has profoundly transformed organisations and societies. Global digitalisation has exponentially widened the horizon of services like never before (Bhutani–Paliwal 2015). The adoption of new technologies, such as big data, artificial intelligence, and blockchain, is pervasive across all sectors, and is playing an increasingly important role in economies. Its impact poses direct and significant challenges for traditional enterprises (Henriette et al. 2015). The goal of digitalisation is for companies to increase their competitiveness and catch up with established digital organisations without disruption (Vial 2019). Therefore, "pre-digital" companies believe that digitalisation, including transforming processes, capabilities, and business models, is very important (Arias-Pérez et al. 2021). The digital transformation process combines many technological elements that support decision-making and benefit organisations. During the last decade, the business world has witnessed various high-tech companies dominating their markets more rapidly.

Although the benefits of digital transformation are evident, more than two-thirds of digital transformation initiatives have been unsuccessful (Tabrizi et al. 2019). Even the banking sector implements digital transformation cautiously; consequently the level of digitalisation in traditional banks is still moderate (Tran et al. 2022). The inability to reap the benefits of digital transformation is not a problem of technology but of human resources. It is a fact that employees are uncertain about digital transformation (Tabrizi et al. 2019); some of them even worry about being replaced during the process. To enable sustainable digital transformation in this age of digitalisation, the issue of human skills must be prioritised for development. For example, solving business problems requires greater reliance on analytical skills from employees (Vial 2019). In a report by the OECD on digital skills, the growth and popularity of ICT demands new skills from workers (OECD 2016). Notably, nearly 50% of the adult population does not meet the skills required to work in a digital environment (OECD 2016). Therefore, improving employees' digital skills will benefit businesses, in particular, and the entire economy, in general.

Technology cannot completely replace humans; however, when it develops, human capacity must be enhanced to control and use it (Sima et al. 2020). Therefore, digitalising the economy and developing human capital will ultimately increase population welfare (Grigorescu et al. 2021, Ramdhan 2021) as well as the country's reputation (Fernández-Crehuet et al. 2019). Especially during the Covid-19 pandemic, when companies and society have to switch to a "new normal", enterprises and economies must accelerate digital transformation because of its benefits and relevance (Nagy–Veresné Somosi 2022). Therefore, during this transformation and even after the covid-pandemic recovery, developing human capital will become urgent and more important than human resource automation (World Economic Forum 2020). Although research on digitalisation and digital human resource management is

growing rapidly (Strohmeier 2020), most previous studies have focused on how digital technology affects human capital.

As digital technology spreads across the economy to all sectors and the number of jobs increases, digital skills have become an essential element of employability. Most importantly, companies and individuals possess sufficient digital skills to take full advantage of the economy and society. Therefore, it is necessary to collect data on the digital skills of the workforce. In 2011, the European Commission launched a project (DIGCOMP) to develop a Digital Competence Framework. The purpose of this project was to produce a framework for digital competence, with descriptors for all levels of learners. The European Commission has been monitoring the digital progress of Member States through Digital Economy and Society Index (DESI) reports, since 2014. To access human capital, the DESI report summarises data within a framework that identifies five competence areas: 1) information and data literacy skills, 2) communication and collaboration skills, 3) digital content creation skills, 4) safety skills, and 5) problem-solving skills. Furthermore, as of 2021, the dataset encompasses an additional indicator due to the Covid-19 pandemic (not included in the DESI), i.e., 6) Online Information and Communication skills.

Despite their relatively small share, the employment of ICT professionals has a significant impact on building the competitive potential of enterprises through their contribution to the production and use of digital technology. Different aspects of supply and demand influence the work motivation of ICT specialists. Some aspects are highlighted by statistics on the problems companies face in hiring ICT specialists and how they mitigate digital skills shortages, including: 1) percentage of enterprises employing ICT specialists; 2) percentage of enterprises trying to recruit ICT specialists; 3) percentage of enterprises training their ICT specialists; and 4) percentage of enterprises providing training to employees to develop ICT-related skills.

The main goal of this article is to study the impact and role of human capital on digital transformation in businesses in a rapidly developing digital economy. To address this goal, this study attempts to address the motivators and barriers of human capital that impact digitalisation in a firm. Based on theory and data analysis related to human capital factors, we clarify the relationship between human resource skills, qualifications, and capacity to develop the national economy and businesses. Accordingly, the questions to be answered in this study are as follows:

RQ1: What kind of relationship exists between the Digital skills of the workforce and Economic development?

To answer this question, we hypothesize that there is a positive correlation between:

- *H1a: The level of information and data literacy skills and gross domestic product (GDP)/capita.*
- *H1b: The level of communication and collaboration skills and GDP/capita.*
- *H1c: The level of digital content creation skills and GDP/capita.*

- *H1d: The level of safety skills and GDP/capita.*
- *H1e: The level of problem-solving skills and GDP/capita.*
- *H1f: Online Information and Communication skills and GDP/capita.*

RQ2: What kind of relationship exists between the employment of ICT specialists and the level of development of ICT?

To answer this question, we need to check whether there is a correlation between the percentage of enterprises:

- *H2a: employing ICT specialists and national Network Readiness Index (NRI).*
- *H2b: trying to recruit or recruiting ICT specialists and national NRI.*
- *H2c: training their ICT specialists and national NRI.*
- *H2d: providing training to employees to develop ICT-related skills and national NRI.*

Literature review

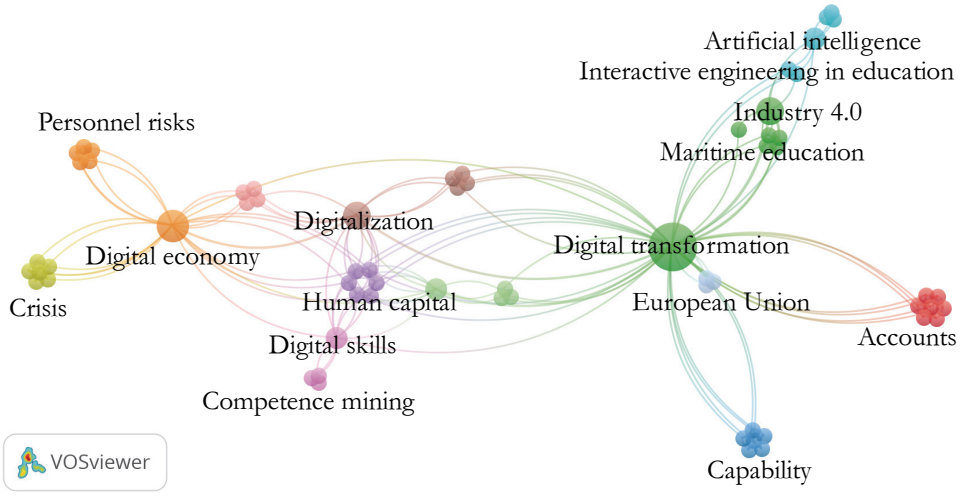
Through increasing usage, and developments in ICT infrastructure, digitalisation has created new ways of running businesses and performing daily activities (Huđek et al. 2019). Digitalisation and the use of digital technology deepen capital structure by creating digital capital, which has become the main production factor and has exponentially increased labour productivity. As ICT represents a special type of capital, companies and governments increase ICT investments to raise labour and total factor productivity. These investments complement or replace investments in other capital assets and increase the production capacity of ICT sectors and industries (Herdon–Csordás 2019). As machines perform human tasks, there has been widespread concern over the possible mass displacement of workers by robots. Nedelkoska–Quintini (2018) estimated that approximately 9% of US jobs would be at risk of automation, with this proportion ranging from 7% (for Finland) to 33% (for Slovakia). However, the proportion of jobs "at risk of automation" cannot be equated to the expected rate of job loss due to automation. As Arntz et al. (2016) emphasise, automation may not occur because of various economic or legal barriers, and workers may adapt to automation by taking up new tasks within their jobs. In digital transformation, technology creates a digital working environment in which the working method and the work completion evaluation criteria of each individual and department will be faster, more transparent, and more flexible. Moreover, the tasks are constantly updated, immediately providing a picture of the production and business activities; therefore, it will be very effective to maintain two-way cooperation between people and technology (Trenerry et al. 2021). Human capital is one of the most important factors in the development of organisations because it is the key to creating long-term competitive advantages, so-called distinctive competencies, and acquiring high adaptive qualities that allow adaptation to extremely volatile market conditions (Kelchevskaya et al. 2019). Ghi et al. (2022) investigate digital transformation as a mediating mechanism between human capital and firm

performance. The results demonstrate a positive relationship between human capital, digital transformation, and firm performance. Mazurchenko–Maršíková (2019) confirm the importance of digitalisation for human resources and the increasing demand for digital skills in recent years. Santoalha et al. (2021), in a study calling attention to the potential of digitalisation in the transition toward a greener economy, argue that E-skills negatively moderate the effect of relatedness on technological diversification. According to Manco-Chavez et al. (2020), there is a significant positive relationship between ICT integration and digital skills among students during the Covid-19 pandemic. Furthermore, the authors highlighted that the digital skills students acquire while using digital technologies for studying during this time make them more compatible and productive in the labour market. Among the five dimensions of the digital economy and society index, Bánhidi et al. (2020) find that the integration of digital technology has a causality relationship with the human resource dimension. Based on GDP per capita and digital skills in 28 countries in Europe, Bălăcescu et al. (2019) recognise the large gap between EU countries in terms of digital skills and emphasise that these skills play an important role in economic growth and social development. Using the European region's digital economy and society index, Imran et al. (2022) demonstrated the importance of human capital in economic development, finding that it has a stronger impact on sustainable development than the integration of digital technology.

For an overview of research related to human capital in the context of digitalisation, this study conducted a title, summary, and keyword search of the Scopus database using synonyms for 1) human capital, 2) digitalisation, 3) digital transformation, and 4) skills.

Figure 1

The main theme of human capital in digitalisation studies



Source: Authors' elaboration based on keywords collected from Scopus.

To ensure that the study considered recent literature, the author limited the search to English-language publications from 2018 till date. The article then used VOSviewer software to visualise the keywords appearing most frequently in the authors' research (shown in Figure 1). Accordingly, the results of the analysis show that all studies that mention human capital in digitalisation, recognise the important role of "digital skills", "capability", and "competences". In addition, studies show that growing technology and digitalisation will lead to "personnel risks" and "crisis". The growing uptake of advanced technology, accompanied by a growing skill shortage in the labour market, employee retraining, and upskilling, are important challenges faced by organisations.

In addition, the study manually searched for articles with many citations, that mentioned human capital in the digitalisation of enterprises (shown in Table 1). Prior studies have identified people as both, the biggest challenge for, and the main source of, digitalisation success.

Table 1

The barriers and drivers of human capital in digitalisation in enterprises

Authors	Barriers/Challenges	Drivers/Success factors
Börner et al. 2018		Soft skills such as communication, problem-solving, and creativity.
Field–Chan 2018	Work-related stress and well-being	
Kane et al. 2018	"Competency traps"	A growth mindset
Meske–Junglas 2021		Employees' expectations of autonomy, competence, and connectedness.
Molino et al. 2020		Resilience; Expectation of information and training opportunities
Oberländer et al. 2020		Digital competencies (knowledge, skills, and abilities)
Osmundsen 2020		Critical thinking, cognitive competencies (a willingness to learn and openness to change)
Töytäri et al. 2017	Internal barriers (culture, change of mindset, beliefs, identity)	
van Laar et al. 2020		Digital skills (Technical, information, communication, collaboration, critical thinking, creativity, and problem-solving skills)
Vogelsang et al. 2019	Missing skills (IT and process knowledge); Technical barriers; Individual barriers (fear of job loss, transparency, loss of control).	Employee qualifications; Adaptability

Kane et al. (2018) point out "competency traps" with employees, and Field–Chan (2018) mention that "work-related stress and wellbeing" are prisoners of their successes. Töytäri et al. (2017) report difficulties in changing people's mindsets and beliefs, while Vogelsang et al. (2019) focus on people's IT capabilities. In addition to the increasing demand for highly specialised skills (Chuang–Graham 2018), critical thinking (Osmundsen 2020), analytical and problem-solving skills (Börner et al. 2018), self-management, adaptability (Vogelsang et al. 2019), and resilience (Molino et al. 2020) are emphasised as the top skills required in today's workforce.

Similarly, van Laar et al. (2020) also pay attention to the determinants of human capital in the digital era. The following skills are evaluated: technical, information (Oberländer et al. 2020, Vogelsang et al. 2019), communication, creativity, problem-solving skills (Börner et al. 2018), and collaboration and critical thinking (Osmundsen 2020). In addition, the factors, "expectation" (Meske–Junglas 2021, Molino et al. 2020) and "open mindset" (Kane et al. 2018, Osmundsen 2020) of employees, also positively impact the success of digitalisation. Van der Velden–Bijlsma (2019) emphasise that skills and skill mismatches affect workers' productivity. Moreover, in a world where the task content of jobs is progressively de-routinised and changing faster than ever, while cognitive skills remain very important, there are signs that non-cognitive skills are also increasing rapidly (Morandini et al. 2020). Therefore, adjusting the level and type of skills supplied to changing labour market demands is crucial to overcome the challenges mentioned, and reap the benefits of digitalisation.

Materials and methods

Materials

In this study, the authors use data from EUROSTAT's last update in March 2022 [1], including comprehensive databases with survey results on the usage of information and communication technologies by enterprises (ENT2-2009-2021-v220315) and households/individuals (HH-2002-2021-v220325). In addition, the study also uses GDP per capita [2] and the network readiness index (NRI) [3] of Europe's 27 countries to determine the relationship between human capital variables, economic development, and ICT development level.

Table 2

List of variable names, codes, and dataset

Variable name	Variable code	Dataset
Overall digital skills	I_DSK2	ISOC_SK_DSKL_I21
Information and data literacy skills	I_DSK2_IL	ISOC_SK_DSKL_I21
Communication and collaboration skills	I_DSK2_CC	ISOC_SK_DSKL_I21
Digital content creation skills	I_DSK2_DCC	ISOC_SK_DSKL_I21
Safety skills	I_DSK2_SF	ISOC_SK_DSKL_I21
Problem-solving skills	I_DSK2_PS	ISOC_SK_DSKL_I21
Online information and communication skills	I_DSK2_IC_S	ISOC_SK_DSKL_I21
Enterprises employing ICT specialists	E_ITSP2	ISOC_SKE_ITSPEN2
Enterprises trying to recruit or recruiting ICT specialists	E_ITSPRCR2	ISOC_SKE_ITRCRN2
Enterprises training their ICT specialists	E_ITSPT2	ISOC_SKE_ITTN2
Enterprises providing training to employees to develop ICT-related skills	E_ITT2	ISOC_SKE_ITTN2

Source: Eurostat database.

Table 3

List of country names and codes

Country	Code	Country	Code	Country	Code	Country	Code
Austria	AT	Estonia	EE	Ireland	IE	Poland	PL
Belgium	BE	Greece	EL	Italy	IT	Portugal	PT
Bulgaria	BG	Spain	ES	Lithuania	LT	Romania	RO
Cyprus	CY	Finland	FI	Luxembourg	LU	Sweden	SE
Czechia	CZ	France	FR	Latvia	LV	Slovenia	SI
Germany	DE	Croatia	HR	Malta	MT	Slovakia	SK
Denmark	DK	Hungary	HU	Netherlands	NL		

Source: Eurostat database.

Methodology

The data were downloaded and transferred to R programming. As the study attempted to discover the relationship between digital skills and economic development, and between ICT experts and the digital economy, the Spearman rank correlation coefficient with a two-tailed p-value was examined to evaluate the relationship between the two variables. The properties of Spearman rank correlation, such as easy calculation and no sample assumption requirements, make it one of the most widely utilised approaches to determine the correlation between two variables (Dodge 2008). Spearman correlation is a type of Pearson correlation, which uses the data ranks instead of their original values (Kutner et al. 2005). Another advantage of

using Spearman's rank correlation is that it can be applied to both, linear and monotonic relationships, whereas Pearson allows us to determine only the linear association between two variables (Caruso–Cliff 1997). This study uses a two-part approach.

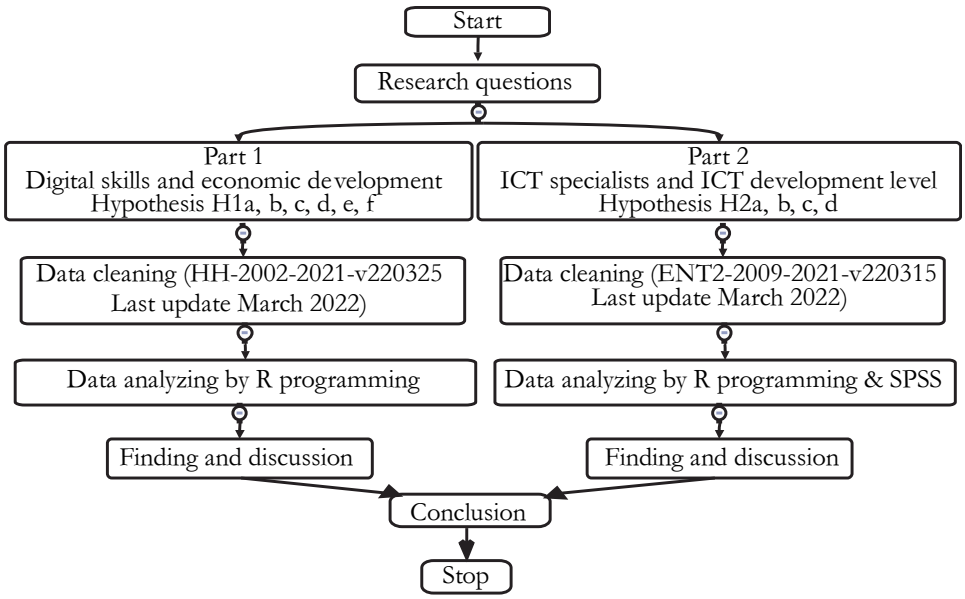
In the first part, we investigate the correlation between the indicators of digital skills of the workforce between the ages of 25 and 64, and GDP per capita in 27 European countries. To prepare the data for Spearman rank-correlation analysis, we rank the values of all variables, from the lowest to the largest. Moreover, the research divides the countries into four main groups, based on the indicators – overall digital skills above the basic level, and GDP per capita.

In the second part, we examine the correlation between the employment indicators of ICT specialists of all enterprises (employing 10 persons or more), excluding the financial sector, and the development of ICT through the Network Readiness Index, in 27 European countries. The original values of both variables were ranked before calculating the Spearman correlation. Next, we utilise SPSS with Hierarchical cluster analysis to classify countries, hierarchically, in recruitment, employment, and training of ICT specialists through the four variables mentioned above.

Finally, the study analyses and discusses the results. The research methodology and documentation of this study are shown in Figure 2.

Figure 2

Research workflow of analysing the relationship between the workforce's digital skills and economic and ICT development



Findings and discussion

Digital skills of the labour workforce

The first set of questions investigated the correlation between the indicators of digital skills and GDP per capita in 27 European countries. The results of the analysis are summarised in Table 4.

Table 4

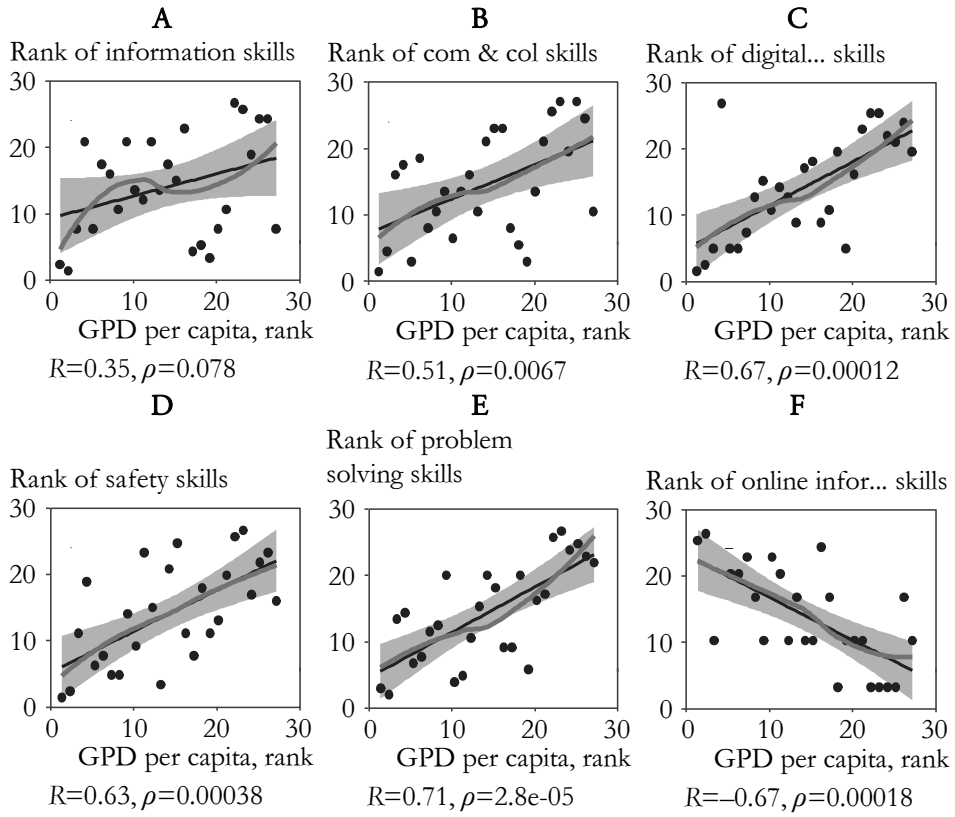
Correlation between digital skill indicators and GDP per capita

Variable code	Variable description	Measurement	Spearman correlation ρ (25)	Sig. (2-tailed) p-value	Result
I_DSK2_IL_AB	Information and data literacy skills above basic level	Percentage of individuals	0.35	0.078	Positive, insignificant
I_DSK2_CC_AB	Communication and collaboration skills above basic level	Percentage of individuals	0.51	0.0067	Positive, significant
I_DSK2_DCC_AB	Digital content creation skills above basic level	Percentage of individuals	0.67	0.00012	Positive, significant
I_DSK2_SF_AB	Safety skills above basic level	Percentage of individuals	0.63	0.00038	Positive, significant
I_DSK2_PS_AB	Problem-solving skills above basic level	Percentage of individuals	0.71	2.8e-05	Positive, significant
I_DSK2_IC_S	Online information and communication skills	Percentage of individuals	–0.67	0.00018	Negative, significant

Our analysis revealed that digital skills and most indicators have a significant positive correlation with GDP per capita (Figure 3). Except for Figure 3A, the other relationships between digital level and GDP per capita were found to be significant. The findings from Figure 3A shows that there is no significant correlation between the level of information skills and GDP per capita in the 27 European countries. Moreover, the correlations become stronger for more advanced digital skills, such as communication and collaboration, digital content creation, safety, and problem-solving skills. Nevertheless, two remarkable outcomes are observed.

Figure 3

Spearman correlation between the digital skill indicators and GDP/capita in EU27, 2021



First, these correlation analyses confirmed hypotheses H1 (b, c, d, e, f); however, H1a hypothesis was not fulfilled. There is a negative correlation between Online Information and Communication skills and GDP/capita indicators (H1f). At the basic level of digital skills (level of information skills), which relates to finding and searching the relevance of the information source and its content, the correlation with GDP per capita was positive but insignificant. This exemplifies that most countries in the EU27 have achieved a basic level of digital skills, regardless of their economic status. Thanks to the development of Internet access and smartphones, collecting and gathering information, surfing websites, and reading online news have become everyday habits in many countries. However, the study found that the correlation between online information and communication skills and GDP per capita was negative and statistically significant. This indicates that low digital skills are higher in less developed countries in the EU27. Furthermore, the monotonic relationship

between digital skills and economic development can be seen in Figures 3B, 3C, and 3E. Countries with low digital skills, such as communication and collaboration, digital content creation, and problem-solving skills have a stronger correlation with GDP per capita. These results are helpful for developing countries that are likely to achieve a larger increase in GDP per capita due to an increase in digital skills. Our study results are in line with previous research from Piroşcă et al. (2021) and Imran et al. (2022), which showed that in the European region, countries with higher digital proficiency and internet usage yield higher individual incomes and wages. Our results expand on deeper results from a study by Bălăcescu et al. (2019), which generally concluded that digital skills are likely to have a positive relationship with GDP per capita in the European region. Our result is in line with the findings of Alhendi et al. (2020), which emphasise the importance of education and training quality in developing the economy. Moreover, the results from this study provide more insight into conclusions from the World Economic Forum, which explains why a larger number of workers from countries with higher GDP per capita was able to work from home compared with those from low-developed economies, globally (World Economic Forum 2020).

Second, from the analysis, it can be further observed that developing countries in the EU mainly possess fundamental digital skills, in information and communications. On the other hand, countries with higher economic development have more advanced digital skills, including communication and collaboration, digital content creation, safety, and problem-solving skills. Among these, the correlation between digital skills and GDP per capita is strong for digital content creation, safety, and problem-solving skills. This finding further clarifies that the level of digital skills in Euro countries is strongly related to its stage of economic development.

Further specifying the groups of countries in the EU27 based on overall digital skills and GDP per capita, Figure 4 shows that there are four main groups.

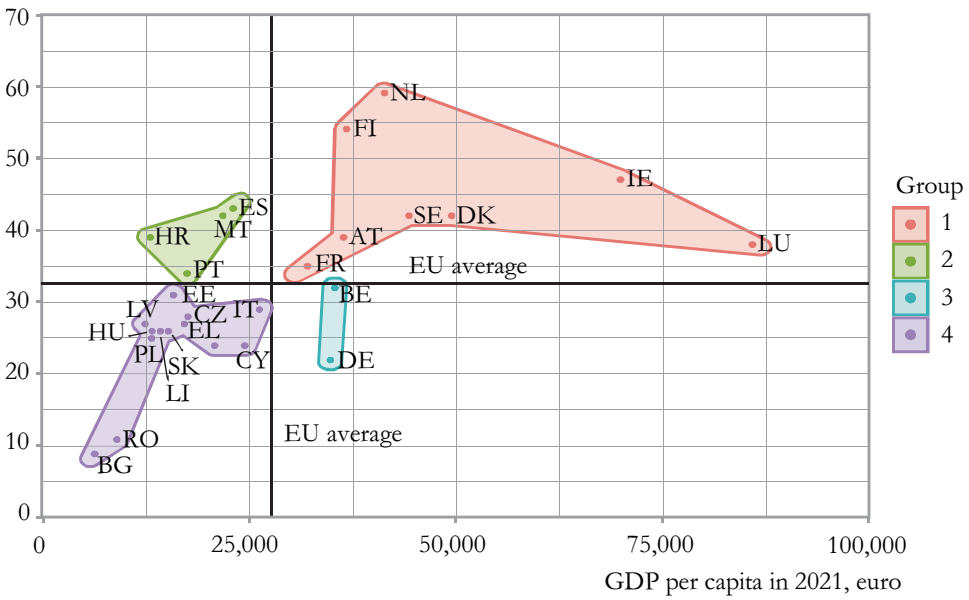
- Group 1: Higher digital skills – more developed countries include Luxembourg, Ireland, the Netherlands, Denmark, Sweden, Finland, Austria, and France. These are mainly the developed economies in Western Europe, which have achieved stable economic as well as digital skill development.
- Group 2: Higher digital skills – less-developed countries include Croatia, Portugal, Spain, and Malta. These countries have made much progress in digital development, despite their limited economic development compared to Group 1 countries. Therefore, countries in this group may provide the best reference for Group 4 in attempting to enhance digital skills. Moreover, higher levels of digital skills provide these countries with more competitive advantages in attracting outsourcing incentives for multinational companies.
- Group 3: Low digital skills – more developed country group includes Germany and Belgium. Although these countries have more developed economies, their digital skills are low. Germany and Belgium should consider their digital skills more seriously, because these are not in line with their economic power. In

particular, digital skills in Germany are at the lowest level, just above Bulgaria and Romania.

– Group 4: Low digital skills – less-developed countries include Estonia, Italy, Slovenia, Czechia, Hungary, Poland, Latvia, Greece, Slovakia, Romania, Bulgaria, Lithuania, and Cyprus. This is a group of transition countries in Central Europe. This group has the largest number of members and takes the most effort to catch up with other countries in the region. Central European countries, such as V4 and Northeast Europe, possess similar digital skills. However, Bulgaria and Romania lag far behind other regional countries.

Figure 4

Groups of EU27 based on digital skill indicators and GDP per capita in 2021



ICT specialists in enterprises

ICT specialist indicators at the enterprise level are significantly correlated with the 2020 Network Readiness Index. The results are summarised in Table 5.

Table 5

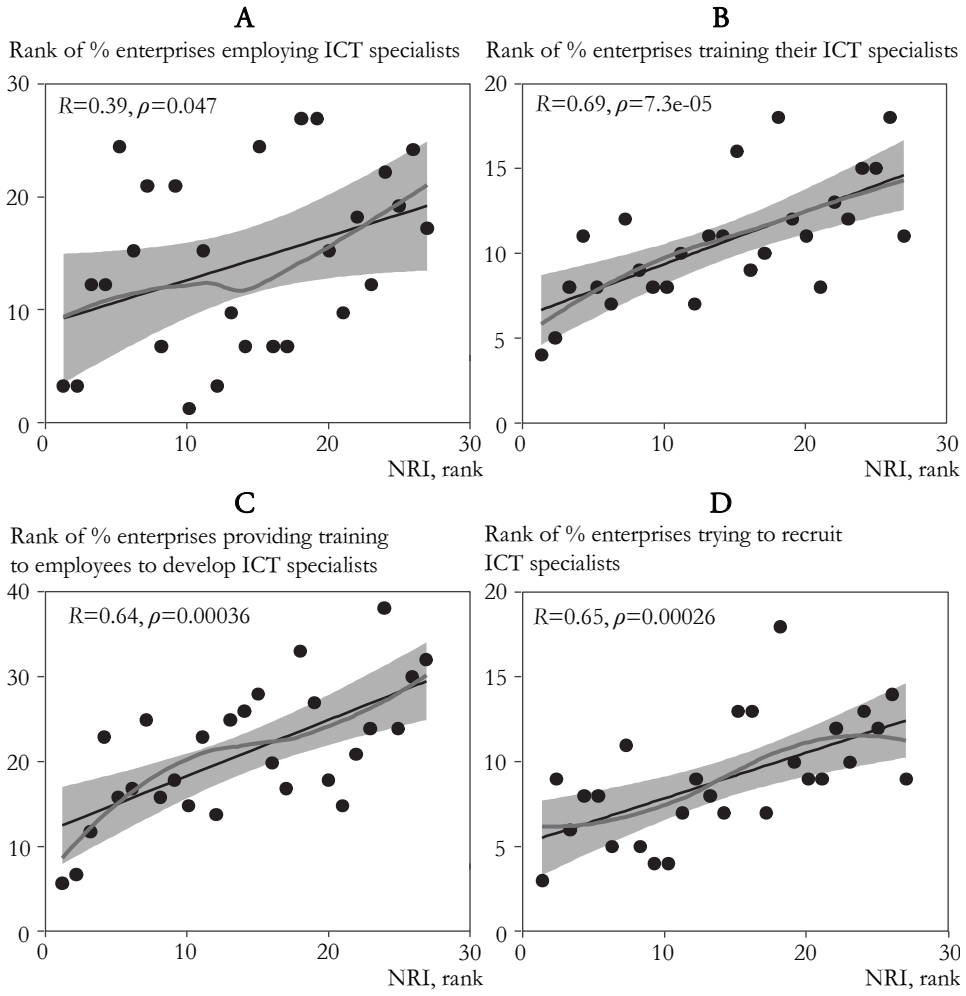
Correlation between the ICT specialists' indicators and NRI, 2020

Variable code	Variable description	Measurement	Spearman correlation ρ (25)	Sig. (2-tailed) p-value	Result
E_ITSP2	Enterprises employing ICT specialists	Percentage of enterprises	0.39	0.047	Positive, significant
E_ITSPRCR2	Enterprises trying to recruit or recruiting ICT specialists	Percentage of enterprises	0.65	0.00026	Positive, significant
E_ITSPT2	Enterprises training their ICT specialists	Percentage of enterprises	0.69	7.3e-05	Positive, significant
E_ITT2	Enterprises providing training to employees to develop ICT-related skills	Percentage of enterprises	0.64	0.00036	Positive, significant

Interestingly, not many differences were observed between the four sub-figures. Four indicators of ICT specialist employment have a significant positive correlation with NRI (shown in Figure 5). This shows that in countries with a higher level of ICT development, higher recruitment, employment, and training percentages enhance the ICT capacity of ICT specialists in companies. Unlike unskilled workers and workers with low and medium ICT skills, ICT specialists' labour market dynamics are characterised by rapid and sustained job growth, which can demonstrate resilience to the economic downturn. Therefore, although the proportion is not high, the influence of this group of workers on human capital, in particular, and the ICT development level in other countries is very significant. However, it could be seen that the correlation between the percentage of enterprises employing ICT specialists, and NRI 2020 is not clear, as the p-value is near 0.05. An acceptable reason for this finding is that employing ICT specialists is not deemed very important by many companies, because it is considered an external service (outsourcing). Figure 5 also shows a strong correlation between training ICT specialists or employees to develop ICT skills and digital economies. This means that countries are likely to achieve sustainable levels of digital economy, when enterprises develop their ICT experts. By contrast, deploying ICT experts shows a weak correlation with the NRI index. Meanwhile, trying to deploy ICT experts is likely to have a strong correlation as countries stand at low levels of digital economy; this relationship seems to reduce with the level of digital economy. This is because at high levels of digital economies, enterprises tend to develop or educate their ICT experts to maintain stable development or reduce their dependence on the high-skill labour market.

Figure 5

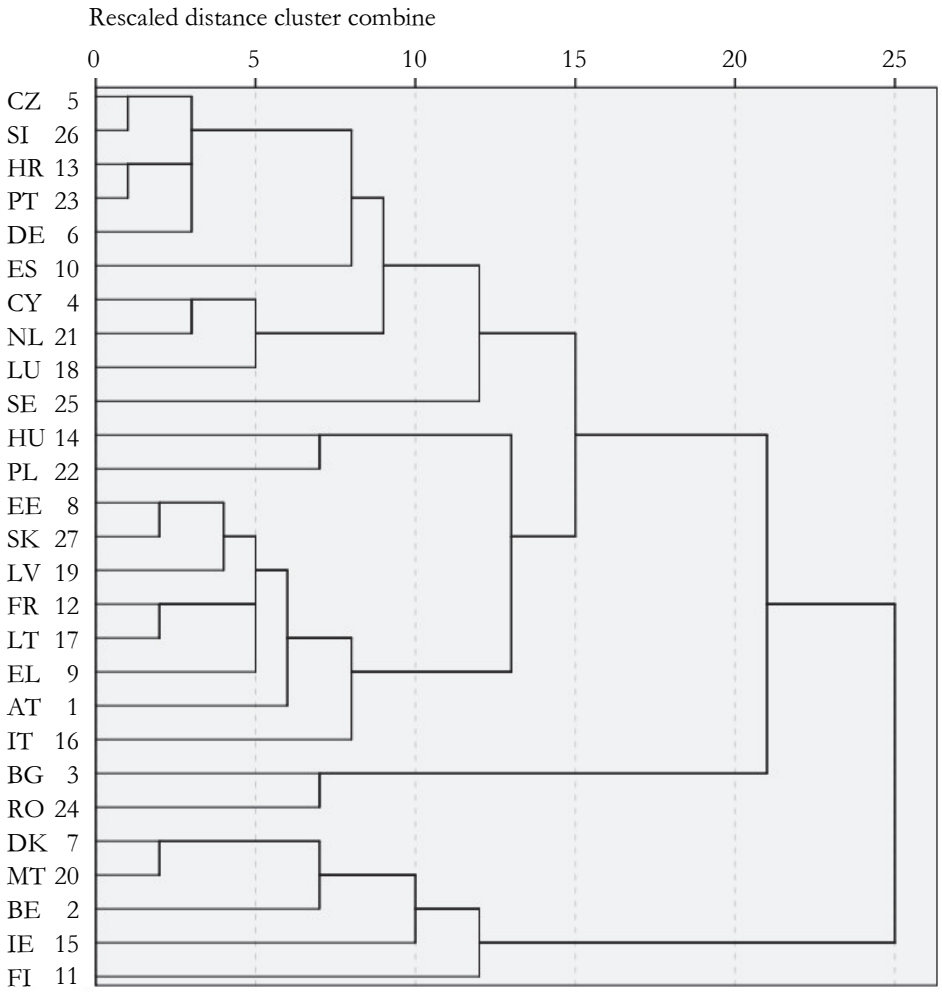
Spearman correlation between ICT specialist indicators and NRI, 2020



To group countries by the employment indicators of ICT specialists in enterprises, we selected the hierarchical cluster methodology because it can be supported with dendrogram visualisation and is an explicit demonstration of how distinct groups emerge as a result of creating clusters. The first result describes how close the data points are in a given cluster (Figure 6), and the second shows the number of different data points that can be divided into clusters (Table 6).

Figure 6

Dendrogram of clusters by ICT specialist indicators in enterprises in EU27 for 2020



In the first stage, the algorithm separates the two clusters, the countries with the highest employment of ICT specialists in the digital economy, including Denmark, Manta, Belgium, Ireland, and Finland, from the rest. In the second stage, the remaining countries continue to fall into two separate clusters, with Bulgaria and Romania exhibiting the lowest rates. Finally, in the subsequent stages, we can observe the spreading of clusters by decreasing the distance between the cluster centres. In other words, hierarchical cluster analysis provides more insight into identifying similar and consistent groups of countries regarding employment ICT specialists' indicators

based on Euclidean distance. Based on the structure of the data, we conclude that the EU27 countries fall into the five groups presented in Table 6:

- Group 1 (Cluster 2): Belgium, Denmark, Finland, Ireland, and Malta.
- Group 2 (Cluster 4): Cyprus, Czechia, Germany, Spain, Croatia, Luxembourg, the Netherlands, Portugal, Sweden, and Slovenia.
- Group 3 (Cluster 5): Hungary and Poland.
- Group 4 (Cluster 1): Austria, Estonia, Greece, France, Italy, Lithuania, Latvia, and Slovakia.
- Group 5 (Cluster 3): Bulgaria and Romania.

Table 6

Change in cluster membership

Case	Country	Cluster			
		5	4	3	2
BE	Belgium	2	2	2	2
DK	Denmark	2	2	2	2
FI	Finland	2	2	2	2
IE	Ireland	2	2	2	2
MT	Malta	2	2	2	2
CY	Cyprus	4	4	1	1
CZ	Czechia	4	4	1	1
DE	Germany	4	4	1	1
ES	Spain	4	4	1	1
HR	Croatia	4	4	1	1
LU	Luxembourg	4	4	1	1
NL	Netherland	4	4	1	1
PT	Portugal	4	4	1	1
SE	Sweden	4	4	1	1
SI	Slovenia	4	4	1	1
HU	Hungary	5	1	1	1
PL	Poland	5	1	1	1
AT	Austria	1	1	1	1
EE	Ireland	1	1	1	1
EL	Greece	1	1	1	1
FR	France	1	1	1	1
IT	Italy	1	1	1	1
LT	Lithuania	1	1	1	1
LV	Latvia	1	1	1	1
SK	Slovakia	1	1	1	1
BG	Bulgaria	3	3	3	1
RO	Romania	3	3	3	1

Conclusion

At present, the EU is beginning to implement projects toward achieving the goals of the 2021-2027 budget framework, which emphasise building up digital capacity and infrastructure and boosting advanced digital skills. Our research has important implications, including many practical contributions and policy suggestions for countries in the region. Based on the results of the literature review, data analysis, and discussion, this study synthesises the following conclusions:

First, human capital in the digital economy has a significant relationship with economic and ICT development. Compared to other regions of the world, the EU 27 is making multiple efforts to improve human resource performance for the digital economy and society. While the top EU countries (Denmark, Finland, Ireland) are leading in digital skills and employment of ICT specialists, countries, such as Romania and Bulgaria, are in a very modest position.

Second, the gap in human capital between the countries in the EU 27 is huge. At the individual level, this gap is a barrier to social participation and exacerbates existing socio-economic inequalities. Moreover, at the aggregate level, it can hinder further expansion of the digital economy and e-government, and the adoption of new technology in the business sector. Suggestions for policies: more attention should be paid to investment, development, and education to enhance digital skills, especially in Bulgaria, Romania, Cyprus, Hungary, Poland, Slovakia, Slovenia, and Germany, particularly those related to data management, which use new data management and digital tools at work.

Third, as digital technology spreads across economies, all sectors, and an increasing number of jobs, the digital skills of the labour workforce and the percentage of employment ICT specialists are becoming essential. Furthermore, the fact that its index can be broken down into different underlying variables, allows an assessment of digital skills for the EU workforce and complements further investigation of skill shortages. For an individual to be qualified to handle the requirements of work in the digital economy, digital skills synthesis must be above basic levels. The share of the EU labour force with basic or above basic digital skills was 31% in 2021, while the rate of the EU labour force with no, limited, narrow, and low digital skills was 37%, which means that more than one third of the EU labour force do not have sufficient digital skills to manage their work in the digital economy. To adjust to this situation, at the enterprise level, highly skilled workers are most productive if they are employed in jobs that fully utilise their skills. Creating these high-skilled jobs requires additional investments in fixed assets (such as machinery and equipment) and intangible assets (such as research, data, and software).

Fourth, digitalisation and the rapid advancement of digital technologies are unavoidable at the firm level. Enterprises must embrace digital and transformational technologies to remain competitive and viable. This will lead to increased concerns

among enterprises and workers about the future of work. Therefore, it is important to understand employees' perceptions and attitudes toward technological change and develop other strategies to enhance their digital capabilities. If employees perceive that a particular technology or system is useful for their job, will enhance their performance, and is easy to learn and use, they are more likely to accept it. Technology adoption and acceptance should be linked to resilience and training opportunities.

Finally, taking advantage of and developing the potential for human capital by enhancing digital capabilities, is the direction of enterprises in developed countries. This is a practical lesson for businesses in developing and undeveloped countries. To adapt to the digital transformation process and keep up with the trend of the digital economy, it is more necessary than ever to identify human capital indicators and pay attention to limited dimensions. Once employees' digital skills, cognition, and mindset capacity are enhanced, human capital will promote the digitalisation process in enterprises.

This broader investigation was influenced by the scope of the study. Further research is planned on the effect of the digital readiness of human resources on efficiency indicators at the national economic level. Further research can include sectoral analyses based on company data. Businesses operating in different size categories and industries have different capabilities and opportunities; therefore, the digital readiness of the workforce has different effects on company performance and efficiency.

REFERENCES

ALHENDI, O.–DÁVID, L. D.–FODOR, GY.–ADOL, G. F. C.–BALOGH, P. (2020): The impact of language and quality education on regional and economic development: a study of 99 countries *Regional Statistics* 11 (1): 42–57. https://doi.org/10.15196/RS110101

ARIAS-PÉREZ, J.–VELEZ-OCAMPO, J.–CEPEDA-CARDONA, J. (2021): Strategic orientation toward digitalization to improve innovation capability: why knowledge acquisition and exploitation through external embeddedness matter *Journal of Knowledge Management* 25 (5): 1319–1335. https://doi.org/10.1108/JKM-03-2020-0231

ARNTZ, M.–GREGORY, T.–ZIERAHN, U. (2016): The Risk of Automation for Jobs in OECD Countries: A Comparative Analysis *OECD Social, Employment and Migration Working Papers*, No. 189, OECD Publishing, Paris. https://doi.org/10.1787/5jlz9h56dvq7-en

BĂLĂCESCU, A.–ZAHARIA, M.–BADEA, D. N. (2019): Economic growth and digital skills: An overview on the Eu-28 country clusters *Annals - Economy Series* 6: 78–85.

BÁNHIDI, Z.–DOBOS, I.–NEMESLAKI, A. (2020): What the overall Digital Economy and Society Index reveals: A statistical analysis of the DESI EU28 dimensions *Regional Statistics* 10 (2): 42–62. https://doi.org/10.15196/RS100209

BHUTANI, S.–PALIWAL, Y. (2015): Digitalization: a step towards sustainable development *OIDA International Journal of Sustainable Development* 8 (12): 11–24.

BÖRNER, K.–SCRIVNER, O.–GALLANT, M.–MA, S.–LIU, X.–CHEWNING, K.–WU, L.–EVANS, J. A. (2018): Skill discrepancies between research, education, and jobs reveal the critical need to supply soft skills for the data economy *Proceedings of the National Academy of Sciences* 115 (50): 12630–12637. https://doi.org/10.1073/pnas.1804247115

CARUSO, J. C.–CLIFF, N. (1997): Empirical size, coverage, and power of confidence intervals for Spearman's rho. *Educational and psychological Measurement* 57 (4): 637–654. https://doi.org/10.1177/0013164497057004009

CHUANG, S.–GRAHAM, C. M. (2018): Embracing the sobering reality of technological influences on jobs, employment and human resource development: A systematic literature review *European Journal of Training and Development* 42 (7/8): 400–416. https://doi.org/10.1108/EJTD-03-2018-0030

DODGE, Y. (2008): *The concise encyclopedia of statistics* Springer Science & Business Media.

FERNÁNDEZ-CREHUET, J. M.–ROSALES-SALAS, J.–GALINDO BARRAGÁN, G. (2019): Construction and validation of an international reputation index: The European case *Regional Statistics* 9 (2): 105–130. https://doi.org/10.15196/RS090205

FIELD, J. C.–CHAN, X. W. (2018): Contemporary knowledge workers and the boundaryless work–life interface: Implications for the human resource management of the knowledge workforce *Frontiers in Psychology* 9: 2414. https://doi.org/10.3389/fpsyg.2018.02414

GHI, T. N.–NGUYEN, Q. T.–HUAN, N. Q.–NGUYEN, T. T. (2022): Human capital, digital transformation, and firm performance of startups in Vietnam *Management* 26 (1): 1–18. https://doi.org/10.2478/manment-2019-0081

GRIGORESCU, A.–PELINESCU, E.–ION, A. E.–DUTCAS, M. F. (2021): Human capital in digital economy: An empirical analysis of Central and Eastern European Countries from the European Union *Sustainability* 13 (4): 2020. https://doi.org/10.3390/su13042020

HENRIETTE, E.–FEKI, M.–BOUGHZALA, I. (2015): The shape of digital transformation: A systematic literature review *MCIS 2015 Proceedings*. Paper 10. http://aisel.aisnet.org/mcis2015/10

HERDON, M.–CSORDÁS, A. (2019): Changes in the relationship between ICT use and economic development in EU member states 2010-2016 *Applied Studies in Agribusiness and Commerce* 13 (1–2): 91–100. https://doi.org/10.19041/APSTRACT/2019/1-2/10

HUĐEK, I.–ŠIREC, K.–TOMINC, P. (2019): Digital skills in enterprises according to the European digital entrepreneurship sub-indices: Cross-country empirical evidence *Management: Journal of Contemporary Management Issues* 24 (2): 107–119. https://doi.org/10.30924/mjcmi.24.2.8

IMRAN, M.–LIU, X.–WANG, R.–SAUD, S.–ZHAO, Y.–KHAN, M. J. (2022): The Influence of Digital Economy and Society Index on Sustainable Development Indicators: The Case of European Union *Sustainability* 14 (18): 11130. https://doi.org/10.3390/su141811130

KANE, G. C.–PALMER, D.–PHILLIPS, A.–KIRON, D.–BUCKLEY, N. (2018): Coming of age digitally *MIT Sloan Management Review and Deloitte Insights* 59 (5): 1–10.

KELCHEVSKAYA, N. R.–SHIRINKINA, E. V.–STRIH, N. I. (2019): Evaluation of digital development of human capital of enterprises *Proceedings of the 2nd International Conference on Education Science and Social Development (ESSD 2019)*: 446–449. https://doi.org/10.2991/essd-19.2019.99

KUTNER, M. H.–NACHTSHEIM, C. J.–NETER, J.–LI, W. (2005): Inferences in regression and correlation analysis *Applied Linear Statistical Models (International Edition)*: 40–99.

MANCO-CHAVEZ, J. A.–URIBE-HERNANDEZ, Y. C.–BUENDIA-APARCANA, R.–VERTIZ-OSORES, J. J.–ISLA ALCOSER, S. D.–RENGIFO-LOZANO, R. A. (2020): Integration of ICTS and digital skills in times of the pandemic COVID-19 *International Journal of Higher Education* 9 (9): 11–20. https://doi.org/10.5430/ijhe.v9n9p11

MAZURCHENKO, A.–MARŠÍKOVÁ, K. (2019): Digitally-powered human resource management: Skills and roles in the digital era *Acta Informatica Pragensia* 8 (2): 72–87. https://doi.org/10.18267/j.aip.125

MESKE, C.–JUNGLAS, I. (2021): Investigating the elicitation of employees' support towards digital workplace transformation *Behaviour & Information Technology* 40 (11): 1120–1136. https://doi.org/10.1080/0144929X.2020.1742382

MOLINO, M.–CORTESE, C. G.–GHISLIERI, C. (2020): The promotion of technology acceptance and work engagement in industry 4.0: From personal resources to information and training. *International Journal of Environmental Research and Public Health* 17 (7): 2438. https://doi.org/10.3390/ijerph17072438

MORANDINI, M.–THUM-THYSEN, A.–VANDEPLAS, A. (2020): Facing the digital transformation: Are digital skills enough? *European Economy - Economic Briefs*: 054, Directorate General Economic and Financial Affairs (DG ECFIN), European Commission.

NAGY, S.–VERESNÉ SOMOSI, M. (2022): The relationship between social innovation and digital economy and society *Regional Statistics* 12 (2): 3–29. https://doi.org/10.15196/RS120202

NEDELKOSKA, L.–QUINTINI, G. (2018): Automation, skills use and training *OECD Social, Employment and Migration Working Papers*, No. 202, OECD Publishing, Paris. https://doi.org/10.1787/2e2f4eea-en

OBERLÄNDER, M.–BEINICKE, A.–BIPP, T. (2020): Digital competencies: A review of the literature and applications in the workplace *Computers & Education* 146: 103752. https://doi.org/10.1016/j.compedu.2019.103752

OSMUNDSEN, K. (2020): Competences for digital transformation: Insights from the Norwegian energy sector Paper presented at the *Proceedings of the 53rd Hawaii International Conference on System Sciences* pp. 4326–4335. https://doi.org/10.24251/HICSS.2020.529

PIROŞCĂ, G. I.–ŞERBAN-OPRESCU, G. L.–BADEA, L.–STANEF-PUICĂ, M. R.–VALDEBENITO, C. R. (2021): Digitalization and labor market – A perspective within the framework of pandemic crisis *Journal of Theoretical and Applied Electronic Commerce Research* 16 (7): 2843–2857. https://doi.org/10.3390/jtaer16070156

RAMDHAN, D. (2021): Impact of provincial human capital on TFP growth through the FDI channel: The case of Indonesian manufacturing industries *Regional Statistics* 11 (4): 28–51. https://doi.org/10.15196/RS110402

SANTOALHA, A.–CONSOLI, D.–CASTELLACCI, F. (2021): Digital skills, relatedness and green diversification: A study of European regions *Research Policy* 50 (9): 104340. https://doi.org/10.1016/j.respol.2021.104340

SIMA, V.–GHEORGHE, I. G.–SUBIĆ, J.–NANCU, D. (2020): Influences of the industry 4.0 revolution on the human capital development and consumer behavior: A systematic review *Sustainability* 12 (10): 4035. https://doi.org/10.3390/su12104035

STROHMEIER, S. (2020): Digital human resource management: A conceptual clarification *German Journal of Human Resource Management* 34 (3): 345–365. https://doi.org/10.1177/2397002220921131

TABRIZI, B.–LAM, E.–GIRARD, K.–IRVIN, V. (2019): Digital transformation is not about technology *Harvard Business Review* 13 (March): 1–6.

TÖYTÄRI, P.–TURUNEN, T.–KLEIN, M.–ELORANTA, V.–BIEHL, S.–RAJALA, R.–HAKANEN, E. (2017): Overcoming institutional and capability barriers to smart services *Proceedings of the 50th Hawaii International Conference on System Sciences* pp. 1642–1651. https://doi.org/10.24251/HICSS.2017.198

TRAN, L. Q. T.–PHAN, D. T.–HERDON, M.–KOVACS, L. (2022): Assessing the digital transformation in two banks: Case study in Hungary *AGRIS on-line Papers in Economics and Informatics* 14 (2): 121–134. https://doi.org/10.7160/aol.2022.140210

TRENERRY, B.–CHNG, S.–WANG, Y.–SUHAILA, Z. S.–LIM, S. S.–LU, H. Y.–OH, P. H. (2021): Preparing workplaces for digital transformation: an integrative review and framework of multi-level factors *Frontiers in Psychology* 12: 822. https://doi.org/10.3389/fpsyg.2021.620766

VAN DER VELDEN, R.–BIJLSMA, I. (2019): Effective skill: A new theoretical perspective on the relation between skills, skill use, mismatches, and wages *Oxford Economic Papers* 71 (1): 145–165. https://doi.org/10.1093/oep/gpy028

VAN LAAR, E.–VAN DEURSEN, A. J.–VAN DIJK, J. A.–DE HAAN, J. (2020): Determinants of 21st-century skills and 21st-century digital skills for workers: A systematic literature review *Sage Open* 10 (1): 2158244019900176. https://doi.org/10.1177/2158244019900176

VIAL, G. (2019): Understanding digital transformation: A review and a research agenda *The Journal of Strategic Information Systems* 28 (2): 118–144. https://doi.org/10.1016/j.jsis.2019.01.003

VOGELSANG, K.–LIERE-NETHELER, K.–PACKMOHR, S.–HOPPE, U. (2019): Barriers to digital transformation in manufacturing: development of a research agenda *Proceedings of the 52nd Hawaii International Conference on System Sciences* pp. 4937–4946. https://doi.org/10.24251/HICSS.2019.594

INTERNET SOURCES

OECD (2016): *Skills for a Digital World*
https://www.oecd.org/els/emp/Skills-for-a-Digital-World.pdf
(downloaded: September 2022)
WORLD ECONOMIC FORUM (2020): *The Future of Jobs Report 2020*.
https://www.weforum.org/reports/the-future-of-jobs-report-2020/
(downloaded: September 2022)

DATABASES/WEBSITES

[1] EUROSTAT Digital skills database:
https://ec.europa.eu/eurostat/web/digital-economy-and-society/data/database
(downloaded: March 2022)
[2] EUROSTAT Economy and Finance database:
https://ec.europa.eu/eurostat/web/main/data/database
(downloaded: March 2022)
[3] NRI Network Readiness Index 2020:
https://networkreadinessindex.org/
(downloaded: March 2022)