DIGITAL SKILLS AS AN IMPETUS FOR THE ACCELERATION OF ECONOMIC DIGITALIZATION: EU PERSPECTIVE

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Abstract

Digitalization, which gained momentum peculiarly after the invention of the Internet, has had a profound impact on the shape of the economy. It has changed the way of doing business and the labor market structure (Peetz, 2019). This change has brought the rise of automatized business processes and public services which aim to eliminate human manual work but at the same time cannot be realized without humans as a main component of information and communication technology (ICT). In order to fully leverage the positive effects of human capital in digitization, individuals must possess essential digital skills. This paper highlights the importance of citizens' ICT skills for the acceleration of the digital economy, therefore the empirical analysis conducted examines the impact of different levels of digital skills on the digitalization of the economy. Additionally, the paper investigates whether the way individuals acquire digital skills differs between highly digitalized European Union (EU) economies and other parts of the Union. In this paper, secondary data sourced from Eurostat was used. To address the research questions, the pooled ordinary least squares (OLS) and least-square dummy variable (LSDV) models were utilized as well as the t-test. The findings of the study reveal a positive impact of digital skills on the digitalization of the economy. Furthermore, significant differences in the ways citizens acquire digital skills in most digitalized economies of the EU are uncovered.

Keywords: Digital Economy, Digital Skills, European Union, Ways of Acquiring Digital Skills

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1. INTRODUCTION

Digitalization, which generally refers to a process of using information technology to transform data into information, has had a significant impact on the shape of the economy in several ways. Over the past few decades, the use of digital technology has become increasingly widespread in all areas of personal life, business processes, education, and government. Its impact is likely to continue as technology continues to evolve and new digital platforms and services emerge. The evolution of information and communication technology (ICT) has demonstrated a positive impact on economic growth (Bahrini & Qaffas, 2019; Solomon & van Klyton, 2020; Olczyk & Kuc-Czarnecka, 2022). The effects of economic digitalization increase as the quality of ICT components, among other human digital skills, improve. In order to fully reap the benefits of a higher level of digitalization, individuals need to have the necessary ICT skills (Langthaler & Bazafkan, 2020), therefore determining the ways in which digital skills can be obtained and at what level they should be to fully use the advantages of their benefits are important questions that require further research.

Literature states that the metamorphosis of advancement to digital economics requires people with ICT skills to utilize them in day-to-day activities in order to consume digital goods and services, as well as knowledge workers to drive more new digital processes or to adapt to the new changes brought about by economic digitalization (Feijao et al., 2021). Many authors found a positive impact of human capital on economic digitalization (Grigorescu et al., 2020; Cirillo et al., 2020). With the intention to analyze the impact of human capital and digitization on the well-being of the citizens of eleven Central Eastern European countries, Grigorescu et al. (2020) found a positive effect of the number of ICT workers within a country's economy. A positive effect of human capital on firm digitalization captured by the adoption of new technology in Italian firms is found also by Cirillo et al. (2020). However, despite the acknowledged significance of digital skills and their impact on the economy, several factors can prevent individuals from acquiring and achieving higher levels of these skills.

Digital skills differ in different countries due to varying levels of ICT infrastructure development. This can result in certain vulnerable groups of society, being excluded from the benefits of digitalization (Salemink et al., 2017). Focussing on the development of digital skills from an early age is proven to be an advantage (Marsh, 2016). Therefore, given the importance of early exposure to digital technologies, many countries have begun to set agendas to increase the use of ICT in both businesses and government processes. In this regard, the EU has developed a range of policies and initiatives (Europe 2020, 2030 Digital Compass: The European Way for the Digital Decade) to boost digital skills among the workforce as drivers of digital processes, such as ICT specialists, as well as among individuals as a consumer or user of these digital processes in day-to-day activities. The EU has set a target to ensure that at least 80% of its citizens have basic digital skills by 2030. Data shows significant differences in digitalization levels among EU countries, as reflected in the Digital Economy and Society Index (DESI). According to the latest DESI report (https://digital-agenda-data.eu/), Romania, Greece, and Bulgaria have the lowest digitalization level, while the highest stands for Nordic countries such as Denmark, Finland, and Sweden. Moreover, according to already mentioned data the level of possession of digital skills among EU countries has a gap of approximately 20% for the already mentioned group of countries. For example, in 2020, only 25% of individuals in Romania reported having at least basic digital skills, while in Denmark, this figure was 68%. This represents a significant gap of approximately 20% between the two countries. Important statistics on the level of development of digital skills of citizens within the EU are provided by Varenia et al. (2021) who show the passive behavior of EU citizens in obtaining the digital skills necessary to ensure information security.

The dilemma we raise in this paper is whether countries should invest more in empowering the citizens with digital skills, or expressed differently, is there an urgent need to create a digitally literate society? This paper emphasizes the importance of citizens' ICT skills for the acceleration of the digital economy. This is important because we are approaching an era in which, as Byundyugova et al. (2021) state people will not be able to think of themselves outside the digital space. However, this study has some limitations considering that it does not take into consideration the social, economic, and political factors of the specific country or region as was suggested by Dutta (2018).

Referring to the existing literature, there is no doubt that digital skills have a positive impact on the economy, but there is limited research on the specific impact of the level and acquisition of these skills on the acceleration of the digital economy. For this purpose, this paper aims to answer two posed research questions:

RQ1: Does the level of digital skills impact the digitalization of the economy?

RQ2: Does the way individuals acquire digital skills differ in economies with different levels of digitalization?

Facts and conclusions for this paper will be important for European countries with lower levels of economic digitalization, as well as for other non-EU countries which ought to reveal the best ways to accelerate the equipment of the citizens with digital skills, as well as to develop strategies as an impetus for digital transformation.

The remainder of this paper is structured as follows. Section 2 presents a review of the relevant literature with a special focus on digital skills. Section 3 presents the data used and specifies the empirical model utilized. Section 4 presents the empirical results, while Section 5 consists of conclusions.

2. LITERATURE REVIEW

Digitalization, which gained momentum peculiarly after the invention of the Internet, has had a profound impact on the shape of the economy. It changed the way of doing business and the labor market structure (Peetz, 2019). This change has brought the rise of automatized business processes and public services. The transformation of traditional economic activity to a digital one started earlier but the use of ICT is boosted even more by the COVID-19 pandemic (Alhassan & Adam, 2021) which has promoted new business models focused on new technologies.

During the literature review of the relationship between the digitalization of the economy and digital skills, we encountered several challenges in this field, including disagreements in the measurement of the digitization of the economy, as well as the essential level of digital skills required for this process. Most of the authors used a single ICT component to capture economic digitalization, such as Internet usage (Bahrini & Qaffas, 2019), while some others rely on indexes, such as Networked Readiness Index (NRI) and ICT Development Index (IDI) (Grigorescu et al., 2020). Recently, to capture the digitalization of the economy the EU proposed an index called the Digital Economy and Society Index (DESI). DESI is a composite index that is used by the European Commission for the assessment of digital development in EU member countries. This index incorporates five main dimensions: connectivity, human capital, use of the Internet, integration of digital technology and digital public services. With the staging of this index, numerous authors started to use it as an indicator to capture the digitalization of the economy (Česnauskė, 2019; Kwilinski et al., 2020; Olczyk & Kuc-Czarnecka, 2022). Although these indexes attempt to include all areas of digitization, they still are subject to criticism. In their paper, Olczyk and Kuc-Czarnecka (2022) evaluate whether the DESI structure captures the digitalization of society and economies, therefore based on their findings they propose to reduce the set of variables and, moreover, to change the weighting scheme.

As noted earlier, to attain the positive effects of human capital in digitization, individuals must possess the necessary digital skills. What these skills are and how to obtain them remains a topic for research. During the literature review, we perceived the main challenges related to digital skills, which we summarize in three directions: how to define digital skills, how to measure them, and how digital skills are acquired.

Literature shows that digital skill is not a single dimension, therefore, it is expressed in several ways starting from basic to advanced. Disagreement on the definition of digital skills exists widely among researchers. One argument is that it happens because society and digitalization are in constant change (Eynon, 2020). Another issue is that depending on the function we want to perform, in some cases, it is not enough to have only technical skills for the reason that a combination of competencies is required. Moreover, it is necessary to distinguish skills needed by a knowledge worker from those of an individual's ability to use ICT for day-to-day activities. In this context, referring to the views of van Laar et al. (2017) the concepts being used to describe the skills needed by a knowledge worker in a digital environment necessary for the 21st century are not only technical. In this regard, they find that in addition to technical skills, there are also some other skills that are fostered through the usage of ICT. They list information management, communication, collaboration, creativity, critical thinking, and problem-solving skills. While their findings are relevant for the determination of the specific digital skills required for knowledge workers, it remains to be investigated what skills should households or individuals have in order to perform day-to-day activities in a digital environment.

Depending on the activity to be performed, in some studies, even Internet skills, such as web-used skills are considered to be enough to capture digital skills. Internet skill is one dimension of digital skills used broadly in the literature (Bunz et al., 2007; Hargittai & Hsieh, 2012). However, due to the criticism that Internet skill captures only one dimension of digital skills, different authors and organizations have started to include more dimensions in the definition of digital skills. The European Commission split digital skills into basic, above basic, basic software skills and ICT specialists. It measures these skills in four dimensions: information, communication, problem-solving, and software for content creation (Eurostat, n.d.). On the other hand, the Organisation for Economic Co-operation and Development (OECD, 2020) states that to expand digitalization in society, citizens must have a combination of well-founded cognitive and problem-solving skills.

Regardless of how we define digital skills, individuals possess them at different levels, so, another challenge is to find the boundary between basic digital skills and above basic digital skills, since the same individual may have basic skills for some digital activities while advances for some others (van Deursen & van Dijk, 2014). On the other side, Alhassan and Adam (2021) minimize the importance of the division of digital skills into basic and advanced, instead of this they refer to skills as "sequential", "simultaneity", and "requiring path abstraction". By "sequential" they mean that skills are contingent and linked in a particular order to successfully reach a digital goal; while "simultaneous" refers to the way in which achieving a single digital end goal usually requires a wide range of skills of different levels of difficulty at the same time. Moreover, there is another skill required to reach the goal and it is the "human" dimension of abstract thinking which breaks down a goal into concrete activity. Digital skills are treated as sequential and compound also by van Deursen et al. (2017) therefore they consider that sequential deprivation has effects on economic outcomes. In addition, the division of ICT users based on the activity to be performed is also done by Ferrari (2013). In the paper aiming to contribute to the better understanding and development of the digital competence of people in Europe, the authors define three proficiency levels such as foundation, intermediate and advanced. The first two groups enable the use of ICT for work, leisure, learning, and communication, while the last one is needed to ensure more efficient and effective performance and to enhance innovation within different types of organizations. Moreover, they identify five areas of digital competence: information, communication, content-creation, safety, and problem solving. Additionally, some authors do not treat digital skills separately from technology that is why they use the term digital capital. Human digital capital faces some barriers in using the technology, which researchers refer to as the digital divide. In this context, Ragnedda (2018) identifies three levels of the digital divide starting from Internet access, and effective use of the Internet, and ending to the third level by grouping people that are not able to transform the online experience into something concrete and tangible. This division makes evident that it is not enough to just have digital skills but it is necessary to use them effectively so that they affect the growth of the digital economy.

Another challenge ascertained during our literature review is the digital skills measurement. This problem becomes more evident when we consider the diverse nature of digital skills. Literature highlights that those digital skills are not only technical but also abstract. Regardless of the disagreement in the definition of digital skills, the literature shows few ways of measuring them. One way of measuring it is by self-assessment surveys where the respondents had to assess their ability to perform some tasks. However, as with almost all assessments, the self-assessment surveys have some shortcomings. In this regard, Kaarakainen et al. (2018) criticize self-assessments because people tend to overrate or underrate their own levels of competence. Unlike others, mentioned authors use a performance-based approach to assess ICT skills. On the other hand, Alhassan and Adam (2021) argue that self-assessment surveys have advantages as they are easy to manage and can be used for cross-country comparisons, but at the same time they have a main disadvantage because it does not measure the skill directly but it uses a proxy for it. To overcome this pointed-out disadvantage, they use the approach of qualitative observation and interviews. Although a direct evaluation method, it can also be criticized for the sample size, representation, and high costs.

Assuming that we overcome the disagreements among researchers on the digital skills definition and measurement, another challenge in the digitalization field becomes evident: the way digital skills are acquired. Digital skills can be acquired through either a formal or informal learning process. However, besides other distinctions, there are demographic differences in the way of acquiring ICT skills, which may hinder the attainment of digital skills. In light of this, Sandhu et al. (2013) analyze elders' experience of the ICT learning process and find that for this category face-to-face support is needed. Moreover, they list numerous barriers to the acquisition of ICT skills by older people, among others lack of confidence. In this regard, Wicht et al. (2021) emphasize that the skills of using ICT are not simultaneous, therefore the use of ICT at work and in everyday life is a fundamental element in maintaining and improving digital skills. Hence, using a German large-scale survey authors manage to conclude that adults mainly acquire ICT skills through informal learning processes. They consider informal learning processes the application of ICT tools in the workplace and everyday life. Treating this issue, Eynon (2020) affirms that "social practice is not a 'one-off' event. It is part of a process of learning that is taking place throughout life" (p. 157). Here we come to lifelong learning which reveals that even if digital skills are acquired through education, there must be government support programs to keep the population up to date with the changes in digitalization.

Scientific literature, as well as practice, shows that nowadays traditional-manual business processes are being transformed into digital ones, therefore the users of digital technologies need to have the appropriate digital skills to fully benefit from these new opportunities (Helsper & Reisdorf, 2016). By users, it is meant the internal users (employees within business processes) and external users (individuals as economic agents). According to Cirillo et al. (2020), there is a positive association between the adoption of new production technologies within the business processes and employees' skills measured by education attainment levels and on-the-job training. Changes in current business processes can affect large numbers of older employees whose employers need additional funds to train and prepare them for the new way of doing the job. As Peetz (2019) notes, digitalization reduces the demand for low-skilled workers and increases the demand for employees equipped with competencies such as data analytics and security. Moreover, Deming and Noray (2018) argue that science, technology, engineering, and math (STEM) are introducing new job skills and that STEM employees themselves have a lower return on experience due to the changing nature of their job. These findings reveal that there is a new generation with high ICT skills competing in the labor market and worsening the situation of older ones.

The situation is worsening even more for some users of ICT, especially those who acquired digital skills informally, considering that while developing new digitized services, developers often overlook the complexity of process performance by end-users (Adelé & Dionisio, 2020) overcoming the difference in how users have acquired ICT skills. The new digitalized services may be easier to be used by end-users with ICT skills obtained through formal education compared to those with ICT skills informally obtained by self-study. This brings another constraint in society: the digitally excluded vulnerable groups (Byundyugova et al., 2021; Ragnedda et al., 2020). In this regard, by reviewing the literature, Byundyugova et al. (2021) reveal the focus of states on the development of digital literacy among young people through formal ways such as schools, colleges, and universities, while they conclude that there are no training programs aimed at middle-aged people. Furthermore, Ragnedda et al. (2020) develop a Digital Capital Index and investigate its interrelation with five variables such as income, age, gender, educational level, and living area. They find inequalities among people regarding these variables. Specifically, people with higher income, younger in age, living in an urban area, and with higher educational levels are more likely to possess digital capital than others. These conclusions signal governments where they should focus to provide the population with digital skills.

3. RESEARCH METHODOLOGY

3.1. Empirical data

This paper relies on secondary data. To capture economic digitalization the DESI 2016–2018 index editions were used. Data for DESI are obtained from the EU digital agenda (https://digital-agenda-data.eu/). Regarding the level of digital skills obtained in other ways than those of education, we used DESI individual indicators such as at least basic digital skills and above basic digital skills. Additionally, we aimed to see the impact of the part of the population that can obtain digital skills through formal education, therefore we used two variables for which the data are sourced from Eurostat. These variables are STEM and ICT employees.

Additionally, taking into account that this paper specifically focuses on the exploration of the ways individuals acquire digital skills, we have utilized the data obtained from Eurostat, respectively the database "Way of Obtaining ICT

Skills". This database contains data on the percentage of individuals obtaining digital skills in various ways. For this study, we have specifically analyzed the data from 2018 due to changes in the survey questionnaire.

3.2. Model specification

The data used in this paper are panel data. These data are short panels because we have 54 observations (n = 54) which is greater than the number of time periods *t* (here 3). The dataset consists of a fixed panel, meaning the *n* is observed for each period *t*. Our panel data do not suffer from entities and time period inconsistency.

To answer the research questions, we utilized pooled ordinary least squares (OLS) as well as the least-square dummy variable (LSDV) model. Pooled OLS is a statistical method used for analyzing panel data. The assumptions of pooled OLS are linearity, homoscedasticity, non-autocorrelation, no multicollinearity, and normality of residuals (Park, 2011).

Additionally, the LSDV model is applied in order to control whether there is a difference between two groups of countries, i.e., those belonging to Central Europe compared to the Central Eastern European Countries (CEECs), for this reason, a dummy variable was introduced in the model. We run the pooled OLS model as follows:

$$Y_{it} = \alpha + \beta_1 X_{it} + \varepsilon_{it}(u_i = 0) \quad (1)$$

The dependent variable Y represents the economic digitalization which is captured by DESI, i represents the country, while t stands for the time period. X represents the independent variables related to digital skills, as well as variables related to ICT infrastructure. The functional form of OLS is presented below:

$$desi_{it} = \alpha + \beta_1 DBs_{it} + \beta_2 DAs_{it} + \beta_3 STEM_{it} + \beta_4 ICTemp_{it} + \beta_5 Broadbandpriceindex_{it} + \varepsilon_{it} \quad (2)$$

While the functional form of LSDV is:

$$desi_{it} = \alpha + \beta_1 DBs_{it} + \beta_2 DAs_{it} + \beta_3 STEM_{it} + \beta_4 ICTemp_{it} + \beta_5 Broadbandpriceindex_{it} + \beta_6 DummyCEE_{it} + \varepsilon_{it} \quad (3)$$

Being aware of the complex digital ecosystem, the model takes into account variables intending to capture the digital skills, whether obtained in formal or informal ways, as well as variables trying to capture the ICT infrastructure, respectively connectivity, of a specific country. As for the latter, we used the Broadband price index which measures the prices of representative baskets of fixed, mobile, and converged broadband offers.

In Table 1, a more detailed description of each variable is given.

Table 1. Variable description

Variable	*Meaning*
DESI	DESI is a composite index that is used by the European Commission for the assessment of digital development in EU member countries. This index incorporates five main dimensions: connectivity, human capital, use of the Internet, integration of digital technology and digital public services.
DBs	At least basic skills (Word processing).
DAs	Above basic (advanced spreadsheet skills).
STEM	Graduates in tertiary education, in science, math, computing, engineering, manufacturing, construction, by sex — per 1000 of the population aged 20–29.
ICTemp	Percentage of the ICT personnel in total employment.
Broadbandpriceindex	The price index which measures the prices of representative baskets of fixed, mobile, and converged broadband offers.

A brief analysis of the DESI progress from year to year, for the period of 2016–2021 across all EU countries, shows an annual increase of approximately 3%. Delving into further analysis of the DESI, we reveal interesting information. For more analysis, we utilized the median of DESI subcomponents to categorize the countries into two groups. Countries that stand above the median value for the period of 2016–2018 for the following indicators: social networks, banking, shopping, availability of latest technologies, firm-level technology absorption, and eGovernment users, are Belgium, Denmark, Finland, Luxembourg, the Netherlands, and Sweden. While the countries that stand above the median value for the period of 2016–2018 for the human indicators, respectively the digital skills such as at least basic skills (Word processing), above basic (advanced spreadsheet skills), at least basic software (coding), telecommunication employee FTEs, and ICT graduates are Denmark, Estonia, Finland, and Luxembourg.

4. RESEARCH RESULTS

4.1. The level of digital skills impact on the digitalization of the economy

Hereof we present the outcomes of the aforementioned models. The following findings demonstrate that the pooled OLS model fits the data well, with an F-test at the significance of 0.01 level and with an R^2 of 0.60. These results stay stable in the LSDV model, respectively 0.01 level for the F-test and 0.59 for the R^2.

Table 2. Empirical models results

Explanatory variable	*Pooled OLS*	*LSDV-Model 1*
DBs	0.10663*	0.10915*
DAs	0.27452***	0.27075**
STEM	0.33720**	0.33355**
ICTemp	4.9148***	4.8761***
Broadbandpriceindex	0.4860**	0.4818**
DummyCEE		-0.00075
_cons	-0.047923	-0.04477
Country/Observations	54	54
Time	2016–2018	2016–2018
Adj R^2	0.5989	0.5904
F-test for the model	16.82***	13.73***
F-test of the joint significance of the dummy		0.01

*Note: ***, **, and * denote significance at 1%, 5%, and 10% levels, respectively.*

Based on the pooled OLS outcomes, as expected, all the variables have positive signs and turn out to be significant. Results suggest that while both basic and advanced digital skills have a significant impact on the digitalization of the economy, respectively a 0.1 level of significance for basic skills and 0.01 for advanced ones, the impact of advanced skills is relatively stronger than that of basic skills. Moreover, the results show that variables capturing digital skills obtained through specialized education, such as STEM, contribute to ICT advancement and have a positive and significant impact. The variable *STEM* is significant at 0.05 level, indicating that countries with a higher level of education focused on STEM have more digitalized economies. This finding is also supported by the results of the variable *ICTemp* with a positive and significant impact of 0.01 level. Our findings are in line with Grigorescu et al. (2020) who find a positive connection between the digitalization of the economy and human capital in eleven Central and Eastern European Countries (CEECs).

It is important to check whether OLS assumptions hold in the data. Violations of these assumptions can lead to biased and inconsistent estimates and undermine the validity of the results. Techniques such as tests for homoscedasticity and autocorrelation and tests for normality can be used to diagnose violations of the assumptions. In Table 3, the results of these tests are presented.

Table 3. OLS assumption tests outcomes

Variance inflation factor (VIF) for multicollinearity	*Mean VIF = 1.53*
Breusch–Pagan test for heteroskedasticity	p = 0.0761
Durbin–Watson test for autocorrelation	1.495
Shapiro–Wilk test for normal data	p = 0.31141

The Breusch–Pagan test outcome shows a p-value of 0.0761 which is greater than the significance level of 0.05, so we fail to reject the null hypothesis (H_0) that the variance of the residuals is constant (i.e., homoscedastic), and conclude that there is no evidence of heteroscedasticity in the residuals. Moreover, the VIF which tests for multicollinearity shows an outcome of 1.53 indicating that multicollinearity, in this case, is not a problem as the literature specifies that a VIF value of 5 or greater is often used as a threshold to indicate significant multicollinearity. The outcome of the Durbin–Watson test for autocorrelation shows that we have no problems with autocorrelation as the value of this test is 1.495. A test statistic value between 1.5 and 2.5 is considered acceptable, while values outside this range indicate a potential problem with autocorrelation. Furthermore, the outcome of the test for the normality of residuals shows a p-value of 0.31141 which is greater than the significance level of 0.05, so we conclude that the residuals are normally distributed.

Important results are also derived from the LSDV model. The variable of basic skills remains positive and significant at 0.1 level, while the variable expressing advanced skills remains positive but loses a level of significance, from 0.01 to 0.05. The *STEM* and *ICTemp* variables remain unchanged in terms of positivity and significance level. The additional dummy variable intended to examine the differences between two groups of countries categorized based on the region they belong to shows a negative and insignificant impact.

The negative sign reveals that countries belonging to Central Eastern Europe have lower levels of DESI index compared to their counterparts in Central Europe, although this is not a significant difference. Moreover, we run the F-test of the joint significance of the dummy to test whether the dummy variable is significantly associated with economic digitalization. The result turns out to be statistically insignificant. A similar finding is shown by Česnauskė (2019) who show that Latvia and Lithuania as part of the Baltic Countries are below the average of the EU figures regarding the dimension of human capital as an important component of the digital economy (Grigorescu, 2020).

4.2. The analysis of the ways of obtaining ICT skills

The literature presented in Section 2 pointed out that the digital divide is impacted by several factors, as well there are many ways that individuals may obtain digital skills. The ways of obtaining ICT skills can be divided into three main groups: through education or digitally literate, on-the-job training paid or organized by an employer, and self-training. The three groups provide different levels of skills. Digitally literate have the advanced skills which enable the advancement of the digital economy by using and inventing new technologies and processes. On-the-job training enables employees to use new technologies in their workplace but also to use other digital devices not directly related to their workplace. Self-training is conducted to be able to keep or find a job and to use digital devices in day-to-day activities.

To delve into the relationship between economic digitalization and the ways of acquiring digital skills, initially, we tested the level of correlation between DESI and the different ways of obtaining digital skills.

Table 4. Correlation results

Correlating parameters	*1*	*2*	*3*	*4*	*5*	*6*	*7*
***1** DESI*	1.0000						
***2** Free online training*	0.4656	1.0000					
***3** Training paid by themselves*	0.5280	0.2570	1.0000				
***4** Free training provided by public programs*	0.6344	0.4669	0.5159	1.0000			
***5** Training paid or provided by the employer*	0.7644	0.6615	0.5945	0.7205	1.0000		
***6** On-the-job training*	0.7081	0.7478	0.3330	0.6822	0.9006	1.0000	
***7** Graduates in tertiary education, in science, math, computing, engineering, manufacturing, construction*	0.1514	0.1916	-0.0898	0.2355	0.0556	0.1556	1.0000

The results reveal that the DESI presents a fairly strong positive correlation with training paid or provided by the employer (r = 0.7644) and on-the-job training (r = 0.7081), a moderate correlation with free training provided by public programs (r = 0.6344), while a week correlation with training paid by themselves (r = 0.5280) and free online training (r = 0.4654).

In the following, we tested whether the ways individuals acquire digital skills differ among EU countries. We use Eurostat data on the way individuals obtain digital skills. It is worth mentioning that the ways of the acquisition of digital skills are numerous, but here we are going to analyze only those ways for which the data are available. Analyzing the database on the ways of obtaining digital skills across the EU 27 countries, we reveal that individuals are more likely to pursue digital skills training when it is offered free of charge. We see that on-the-job training and free online training are mostly used ways. Upskilling and reskilling are two necessary steps to be taken by employers for their current employees. The data also reveal that in the EU the third most used way of obtaining ICT skills is the training paid for or provided by the employer. This is widely used in Finland, Norway, and Iceland, followed by Luxemburg, the Netherlands, and Sweden.

Further, to test if there are statistically significant differences in the mean between countries with different DESI and the way individuals get digital skills, we applied a two-group mean compassion test. To divide countries into two groups, the median of the DESI was used. The coding is done as follows: 1 for those with DESI greater than the median (0.43) and 0 otherwise.

Two-sample t-test for comparing two means was calculated by the formula:

$$t = \frac{\bar{X}_1 - \bar{X}_2}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \quad (4)$$

where, $\bar{X}_1$ and $\bar{X}_2$ are the means of the two samples, s_1^2 and s_2^2 are the standard deviations of the respective samples, while n_1 and n_2 represent the sample sizes. The null hypothesis (H_0) of the t-test is:

$$H_0: \mu_1 = \mu_2 \quad (5)$$

The data were tested for normal distribution using the two-group variance-comparison test in STATA. After visually inspecting the scatter plot, outliers were detected and subsequently removed from the dataset *r*, consequently, the number of groups varies while testing for different variables that represent different ways of obtaining digital skills.

Regarding the research question at hand, we present the outcomes of the test conducted to determine whether disparities in the way of acquiring digital skills exist among two groups of countries.

Table 5. Two-group mean comparison test results for digital skills acquired through self-training

Skill type	*Group*	*Obs.*	*Mean*	*Std. Err.*	*Std. Dev.*	*Hypothesis testing*
Self-study-free online training	0	14	8	0.9944903	3.721042	*Ha*: diff < 0; Pr(T < t) = 0.0044 *Ha*: diff! = 0; Pr(|T| > |t|) = 0.0088 *Ha*: diff > 0; Pr(T > t) = 0.9956
	1	11	11.63636	0.6643209	2.203303	
Self-study-training paid for by themselves	0	14	1.714286	0.2206029	0.8254203	*Ha*: diff < 0; Pr(T < t) = 0.0069 *Ha*: diff! = 0; Pr(|T| > |t|) = 0.0138 *Ha*: diff > 0; Pr(T > t) = 0.9931
	1	11	3.090909	0.5126499	1.700267	
Training provided by public programs or organizations	0	14	2.285714	0.3043381	1.138729	*Ha*: diff < 0; Pr(T < t) = 0.0071 *Ha*: diff! = 0; Pr(|T| > |t|) = 0.0142 *Ha*: diff > 0; Pr(T > t) = 0.9929
	1	10	3.6	0.4	1.264911	

T-test results reveal significant differences, with the determined 95% confidence interval, between two groups of countries in the following ways of obtaining digital skills: for self-study-free online training, the mean difference is t(df) = 3.636, for self-study-training paid by themselves the mean difference is t(df) = 1.376, while for training provided by public programs or organizations, the mean difference is t(df) = 1.314. The results define that citizens who belong to more digitized economies (those coded with 1) have a higher average attendance rate of individually undertaken training to obtain digital skills.

Table 6. Two-group mean comparison test results for digital skills acquired through on-the-job training

Skill type	*Group*	*Obs.*	*Mean*	*Std. Err.*	*Std. Dev.*	*Hypothesis testing*
Training paid or provided by the employer	0	15	5.133333	0.8444027	3.270357	*Ha*: diff < 0; Pr(T < t) = 0.0006 *Ha*: diff! = 0; Pr(|T| > |t|) = 0.0013 *Ha*: diff > 0; Pr(T > t) = 0.9994
	1	11	10.36364	1.215601	4.031693	
On-the-job training	0	15	7.06667	0.8699571	3.369239	*Ha*: diff < 0; Pr(T < t) = 0.0010 *Ha*: diff! = 0; Pr(|T| > |t|) = 0.0020 *Ha*: diff > 0; Pr(T > t) = 0.9990
	1	10	12.2	1.245436	3.938415	

Significant differences have also been found in the ways of digital skills acquisition through training paid or provided by the employer and on-the-job training. The results prove that citizens of more digitalized economies (those coded with 1) have a higher average attendance rate with a significant difference in mean between the two groups, t(df) = 5.23, for training paid or provided by the employer, while the difference between the two groups for on-the-job training undertaken to obtain digital skills is t(df) = 5.13. A similar finding is provided by Machuga (2020) who confirms the positive correlation between the percentage of people attending training paid or provided by the employer and the level of cloud computing usage in EU companies.

Table 7. Two-group mean comparison test results for digital skills acquired through education or digitally literate

Skill type	*Group*	*Obs.*	*Mean*	*Std. Err.*	*Std. Dev.*	*Hypothesis testing*
Graduates in tertiary education, in science, math., computing, engineering, manufacturing, and construction	0	15	35.333	2.448842	9.484323	*Ha*: diff < 0; Pr(T < t) = 0.3555 *Ha*: diff! = 0; Pr(|T| > |t|) = 0.7110 *Ha*: diff > 0; Pr(T > t) = 0.6445
	1	10	36.8	3.072458	9.715966	

Whereas the t-test results prove that there are no significant differences in the means regarding the way of obtaining digital skills through being graduates in tertiary education, in science, math, computing, engineering, manufacturing, and construction as the results show an insignificant difference in mean, t(df) = 1.46, between groups. This demonstrates that all EU countries are paying added attention to digital education. In this regard, Alhassan and Adam (2021) mentioned the fact that ICT specializations prepared by the national education system of the Euro area countries showed a significant increase in the period 2013–2018. Our findings indicate that policymakers across all EU countries recognize the importance of skills gained through the national education systems, which contribute to the acceleration of the digital economy.

5. CONCLUSION

The main objective of this paper is to advocate for the critical role of the human factor in the digitalization ecosystem. Having adequate digital skills is considered an urgent need in the 21st century (van Laar et al., 2017). However, the dilemma that confronts policymakers and stakeholders is whether countries should allocate more resources to enhance the empowering of their citizens with digital skills.

In this paper, initially, through a literature review, we highlighted that there is still no consensus regarding the definition and measurement of digital skills, as well we noted that the digital divide is a concern that needs to be addressed. Considering the importance of digital skills in today's era, we undertook a data-driven study, exemplifying the importance of citizens' digital skills by running two empirical models. The results showed a positive and significant impact of digital skills on the digitalization level. Specifically, both basic and advanced digital skills were found to be significant predictors of the level of the DESI. Additionally, a positive impact was found for digital skills obtained in other forms, especially those through education. Overall, these findings suggest that allocating more resources to digital skills development can contribute to the acceleration of the digital economy.

To further explore effective strategies of digital skills acquisition, we conducted a t-test analysis and found that countries with higher DESI scores exhibit greater rates of citizens who have the incitive for self-training. It seems that these countries have implemented comprehensive public training programs and have cultivated companies that invest more to empower their employees with digital skills.

In summary, our findings indicate that citizens of more digitalized economies have a higher rate of engagement in both individually undertaken training and on-the-job training to obtain digital skills. Based on the results, this paper concludes that having digitally literate people is crucial for achieving rapid digitalization of the economy, therefore it should be noted that to achieve faster digitization of the economy, training programs should be made available to all individuals that do not have the opportunity to be digitally literate.

As previously noted, the main limitations of this paper consist of the nontreatments of the social, economic, and political factors of the specific country or region that contribute to the DESI score. As a result, we recommend that future researchers interested in this area of study investigate these factors in greater detail.

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