

THE IMPACT OF THE STANDARD OF LIVING ON DIGITAL PERFORMANCE IN THE EUROPEAN UNION

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Abstract

The Digital Economy and Society Index can be considered a complex indicator that measures the digital performance of the European Union. This indicator has undergone some methodological changes, precisely to be permanently aligned with the European Union's development strategies but especially with technological development. The aim of the paper is to highlight the impact of the standard of living and its components on digital performance at the level of the European Union. Moreover, the paper will analyse the current state of digital performance at the level of the European Union. The results can serve as a policymaking tool to facilitate the implementation of the digitalisation project at the European level.

In this article, hierarchical clustering was used to define groups of countries from the perspective of digitalisation. Ward's algorithm determined four homogeneous clusters that were presented in the analysis. This approach serves as a hypothesis to test the correlation between digital performance and living standards. Thus, with the help of the linear correlation coefficient, a strong positive relationship was identified between the Human Development Index and the Digital Economy and Society Index. Moreover, at the level of the Human Development Index components, it was identified that individual well-being and education correlate linearly with the Digital Economy and Society Index; therefore, the analysis was completed with a multiple regression to verify this dependence. The last part of the case study is represented by the classic linear regression model, which confirms the hypothesis that living standards influence digital performance.

Keywords: Digital Economy and Society Index, Human Development Index, Hierarchical classification, Linear regression

JEL Classification: O11, O15, F63

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1. Introduction

Thanks to the advent of technology, the economy has reconfigured itself, becoming a digital ecosystem. The digital economy has developed as a result of the identification of the immediate benefits that technology can have on the economic environment. The economy must adapt to the dynamics of technology development. This aspect does nothing but encourages the business environment to compete. The competition to win the consumer takes place mostly at the level of technology, because in the digital economy innovation is the key to success (Mirolyubova, et al., 2020). The digital economy requires the existence of an infrastructure that supports the needs of technology, easy access to technology, adequate education on the use of technology, and a legislative package that protects users.

In the European Union, the digitalisation of the economy was approached differently by the member states. The COVID-19 pandemic may be the best example that has revealed the level of digital technology. Thus, the less developed states from the point of view of digitalisation were the most strongly affected from an economic and social point of view, because the activities that could be carried out remotely were either not possible to carry out, or were carried out much more difficult (Ionescu, et al., 2021) (United Nations, 2021) (Nayyar, 2022). Therefore, during the pandemic, the global poverty rate increased from 7.8% to 9.1% (World Economic Forum, 2021). This large-scale negative event highlighted that digitalisation can reduce the social and economic impact that possible biological and natural disasters can have on people.

The context presented above is just an example of a situation where digitalisation would have been beneficial. It is essential to analyse the levers through which digital performance would be improved. Thus, the work carried out aims to analyse how digital performance can be influenced by the standard of living of a country, in a period of socioeconomic calm. Standard of living was chosen as a determinant of digital performance because, according to Maslow's pyramid of needs, people first satisfy their basic needs in order to be able to satisfy other less critical needs later. In this case, the basic needs of society can be viewed from the perspective of standard of living.

Therefore, the first part of this paper presents an overview of digital performance indicators and their relationship to macroeconomic indicators from specialized literature. The second section of this article presents the components of digital performance indexes, standards of living indexes, and two composite indexes used for quantitative analysis. The Digital Economy and Society Index (DESI) is a digital performance index used and calculated by the European Commission, with the aim of permanently monitoring the level of digitalisation of states in order to formulate economic and social policies. The Human Development Index (HDI) was used to measure standard of living. The third section describes the results of Ward's hierarchical clustering algorithm, used to identify which are the main groups of states from a digital perspective and how each cluster can be described from the perspective of the index that

creates the DESI. Quantitative analysis is continued with a simple linear regression model, which indicates the impact of the HDI on DESI. In this section, a multiple regression model was also created to highlight the impact of expected years of schooling and gross national income per capita on DESI. The last part of the paper discusses the results of the quantitative analysis and presents the main conclusions.

2. Literature review

The European Commission has established a methodology for calculating an indicator used to measure digital performance (Jordanoski & Nielsen, 2021) (Osmanbegovic & Piric, 2019). This concept is theorized in the Digital Single Market project, where the main advantages of technology to the economy are also described (Bănescu, et al., 2022b). This approach by the European Commission aims at three main dimensions: consumer and business access to goods and services; regulating the online market in order to maintain fair competition and ensure the protection of user data; maximising growth potential for the digital economy (European Commission, 2020a). In accordance with the above, a composite index was calculated of the main digital performance indicators (European Commission, 2020b). The Digital Economy and Society Index is calculated for the first time based on five categories of digital performance indices, whose weighting level differs according to their importance (European Commission, 2018). In the mathematical formula of the DESI, the components "Connectivity" and "Human capital" have a weight of 25%, each, "Integration of digital technology" has an importance of 20%, and the index categories describing "Usage of Internet services" and "Digital public services" have a weight of 15% each (European Commission, 2018). There are studies in which the first two dimensions are considered independent and the other three show a certain degree of dependence (Bánhidi, et al., 2020). It was also shown that indicators related to Internet services and those related to digital public services do not add value to the DESI index, and in the same study it was specified that the pillar related to connectivity is the most important (Olczyk & Kuc-Czarnecka, 2022). Some researchers have even tried to recalculate the composite index, by eliminating redundant indicators or by reducing dimensionality (Bruno, et al., 2023).

Since the first definition of the DESI index, the European Commission has undergone a series of structural changes, becoming the main standard for monitoring the digitalization of the economy. In the last revision of the index, the dimension "Usage of Internet services" was removed, which was considered redundant, but other subdivisions were also updated because technology is advancing rapidly, which also produces an imbalance in economic theory. The version used in the case study contains only four of the original five subdivisions: Connectivity, Human Capital, Integration of Digital Technologies, and Digital Public Services.

The DESI index is a representative indicator of digital performance and can affect all sectors of the economy, but can also be influenced by the economic and social development of

the states. The DESI index has been seen by some researchers as a lever to reduce differences between rich and poor states (Olczyk & Kuc-Czarnecka, 2022). In other words, technology in general has as major objectives: reducing extreme poverty, reducing infant mortality, developing sustainable agriculture, promoting decent work, and universal literacy (United Nations, 2020). In addition, some researchers have shown that DESI is positively influenced by the consumption index, but also negatively by the unemployment rate (Stavytskyy, et al., 2020). In other words, digitalisation positively influences economic growth (Myovella, et al., 2020).

Digital performance, as we stated previously, is influenced by economic and social factors. For example, mobile Internet connectivity is influenced by social conditions, residential environment, education, age, but also gender (World Economic Forum, 2022). In 2020, the coverage gap for mobile broadband worldwide was only 6% and the usage gap for mobile broadband was 43% (World Economic Forum, 2022), indicating that although the technological infrastructure exists, people do not have the financial opportunity to access it (Doreen, 2021) (Fusiek, 2022). According to some studies, digitalization is also influenced by people's ability to use technologies (Al Buainain, et al., 2023), and lack of digital ability will only lead to companies' investments in technology becoming unprofitable expenses (Chamorro-Premuzic, 2021). Education is among the most important elements of technology development and adoption of digitalisation, as it trains innovation skills (Ramirez-Robles, et al., 2022). Education opens up man's willingness to use technology because it develops the cognitive skills necessary to understand technologies (Pappas, et al., 2019). In addition, in order to integrate digitalization into the education system, teachers need to be trained in digitalization to prepare human capital for the era of digitalization (World Bank, 2022).

3. Data and methodology

The DESI index and its components are used in the paper to analyse the level of development of the digital economy at the European level. DESI is a composite index that takes values from 0 to 100 and combines four important pillars to describe digitalisation: connectivity, human capital, integration of digital technologies, and digital public services. According to the last methodology analysed, the components of the index had the same level of weighting as in Equation (1). In turn, the components of the DESI index have values between 0 and 100, which are also composite indices. The digital performance indicator used in the analysis is measured in the period 2016-2021 and at the level of the European Union (European Commission, 2020).

$$\text{DESI} = 0.25 * \text{Connectivity} + 0.25 * \text{Human Capital} + 0.25 * \text{Digital Technology Integration} + 0.25 * \text{Digital Public Services} \quad (1)$$

The second part of the analysis uses the European Union human development index distribution, available in the 2019 Human Development Report (United Nations Development Programme, 2022). This indicator measures the standard of living of a state, which can have values between 0 and 1 and is the geometric mean of three main dimensions: longevity, measured by life expectancy at birth; education, measured by the expected number of years of schooling, and the average number of years of schooling; material well-being measured by GNI per capita.

The Ward unsupervised learning algorithm was used in the article. The algorithm is one of hierarchical clustering and involves building increasingly larger groups. More precisely, the algorithm starts from all entities included in the method and calculates the distances between each two entities. Thus, the first step will merge the entities between which the Ward distance is minimal. The formula to calculate the distance between two entities is shown in equation (2), where p_A and p_B represent the weights of the groups of entities, and $d^2(g_A, g_B)$ illustrates the square of the Euclidean distance between the centres of gravity of each entity (Boboc, 2007).

$$\delta(A, B) = \frac{p_A p_B}{p_A + p_B} d^2(g_A, g_B) \quad (2)$$

The first iteration of the algorithm will determine the fusion of at least two entities, for which, in the second iteration, equation (2) will change. The square of the Euclidean distance between the centre of gravity of an entity and the centre of gravity of a group of entities will be calculated. For this calculation to be possible, first calculate the centre of gravity of the group obtained after the first iteration by means of relation (3) (Boboc, 2007).

$$g_{AB} = \frac{p_A g_A + p_B g_B}{p_A + p_B} \quad (3)$$

The algorithm is repeated until all entities merge into one group. Of course, not all entities are meant to be in a category. As a result, to select an optimal clustering level, the step where the largest inertia loss occurs is evaluated. The lower the level, the more statistically homogeneous the groups. The Ward clustering method is based on the principle of minimising variability within groups and maximising variability between groups (Boboc, 2007). The clusters obtained in the end must be as homogeneous as possible inside and as heterogeneous as possible between them. Choosing the optimal level of clustering can also be determined graphically by means of the dendrogram. In the case study, the data were processed using IBM SPSS Statistics software.

The second algorithm used is linear regression. The model is represented by equation (4) and involves an explained variable (y) and an explanatory variable (x_1). The economic utility is found in the explanation of the β parameters, estimated first by the least squares method.

$$y = \beta_0 + \beta_1 * x_1 + \varepsilon \quad (4)$$

In addition, the multivariate linear regression will be used, which, unlike the previous one, includes several explanatory variables. Thus, equation (4) becomes equation (5), where

$X_1, X_2, \dots, X_k$ are explanatory variables, Y is the explained variable, and ε is the error term that indicates the influence of other factors on Y .

$$f(x_1, x_2, \dots, x_k) = \beta_0 + \beta_1 * x_1 + \beta_2 * x_2 + \dots + \beta_k * x_k + \varepsilon \quad (5)$$

Equation (5) can be written in matrix form, as in equation (6), where n represents the number of observations in the sample and k represents the number of explanatory variables.

$$Y = X * B + E \Leftrightarrow \begin{pmatrix} y_1 \\ y_2 \\ \vdots \\ y_n \end{pmatrix} = \begin{pmatrix} 1 & x_{11} & \dots & x_{1k} \\ 1 & x_{21} & \dots & x_{2k} \\ \vdots & \vdots & \dots & \vdots \\ 1 & x_{n1} & \dots & x_{nk} \end{pmatrix} * \begin{pmatrix} \beta_0 \\ \beta_1 \\ \vdots \\ \beta_k \end{pmatrix} + \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \vdots \\ \varepsilon_n \end{pmatrix} \quad (6)$$

Estimation of the β parameters can be made with the help of the least squares method, which involves the minimisation of the squares of the deviations (Voineagu, et al., 2007).

The relevance of the model is checked by calculating the Fisher test (F), which indicates that the parameters are significantly different from 0, and by calculating the Student's test (t) to validate the coefficients. To confirm the economic utility, the Gauss-Markov assumptions are also tested: linearity, no autocorrelation of the residuals, homoscedasticity of the residuals, and normality of the residuals. The linearity hypothesis assumes that the model equation has a linear form, as shown in Equation (5). Homoscedasticity represents the constancy of variance of the residuals and can be checked using the White test or the Glejser test. The hypothesis of normality indicates that the residuals of the regression model follow a normal distribution with mean 0 and variance σ_ε^2 . Checking the autocorrelation of residuals means identifying the existence of a correlation between random perturbations of statistical units and can be done either with the correlogram or with the Durbin-Watson and Breusch-Godfrey statistical tests. In the case of the multivariate logistic regression model, the hypothesis of multicollinearity of the explanatory variables is also verified. Multicollinearity means the existence of a linear correlation between the explanatory variables and can be identified by several methods: the calculation of the correlation matrix applied to the explanatory variables, the graphic representation of the variables, Klein's criterion, the auxiliary regression, or the variance inflation factor. If one of the hypothesis is violated, the model must either be adjusted, or some variables will be replaced, in order to validate the assumptions (Voineagu, et al., 2007).

4. Results

The first remark to be made concerns the evolution of digitalisation. It can be seen in figure no. 1 that during the period 2016-2019, the digital economy has an annual growth of approximately 7-8% and between 2019 and 2021, the annual growth will reach 13%.

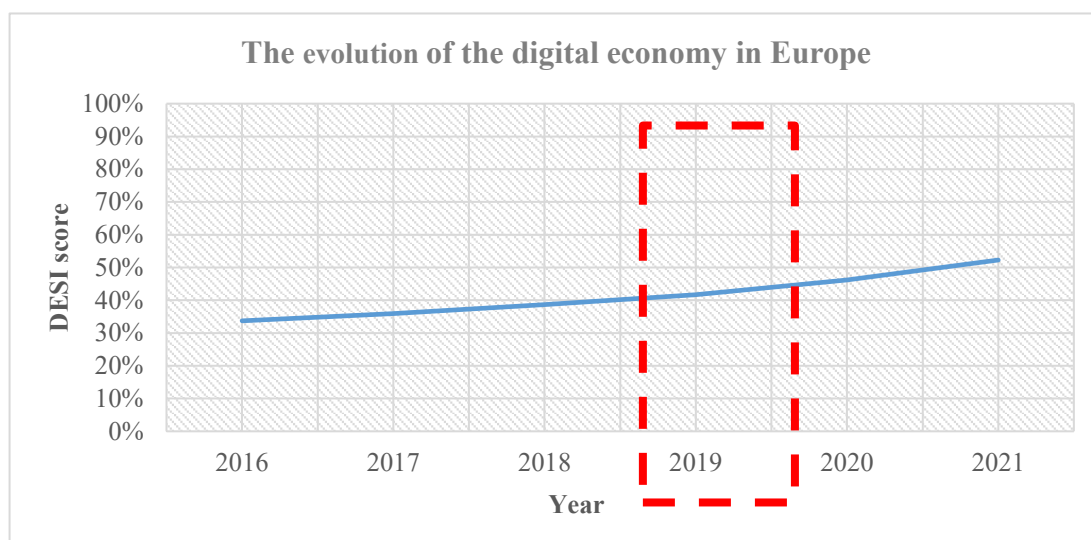


Figure no. 1: The Evolution of the Digital Economy in Europe

Source: Produced by the authors in Microsoft Office Excel using data from the European Commission (European Commission, 2022a)

The turning point of 2019 may be associated with the outbreak of the COVID-19 pandemic, as home isolation measures led to forced digitalisation. Thus, it is observed that during only 6 years, the digital economy of the European Union has grown by approximately 55%.

However, the analysis focused on the values of the index from 2021, distributed at the level of each state in the European Union. According to the distribution highlighted in figure no. 2, it can be seen that the first positions in terms of digitalisation are occupied by the Nordic states and at the opposite pole by the Balkan states. What cannot be precisely defined are groups of states with similar characteristics.

Moreover, figure no. 2 reveals the fact that in the most developed states, from the perspective of digitalisation, the components of the DESI index are approximately equal. As technology develops, it is integrated into the economy, introduced into labour training, and integrated into public services. The balance between the four components is lost as the value of the indicator decreases.

According to the descriptive statistics calculated in table no. 1, the scores of the digital performance index at the European Union level have values between 30.58% and 69.60%, which shows that Romania, which is the last ranked country, is more than 2 times less developed than Finland.

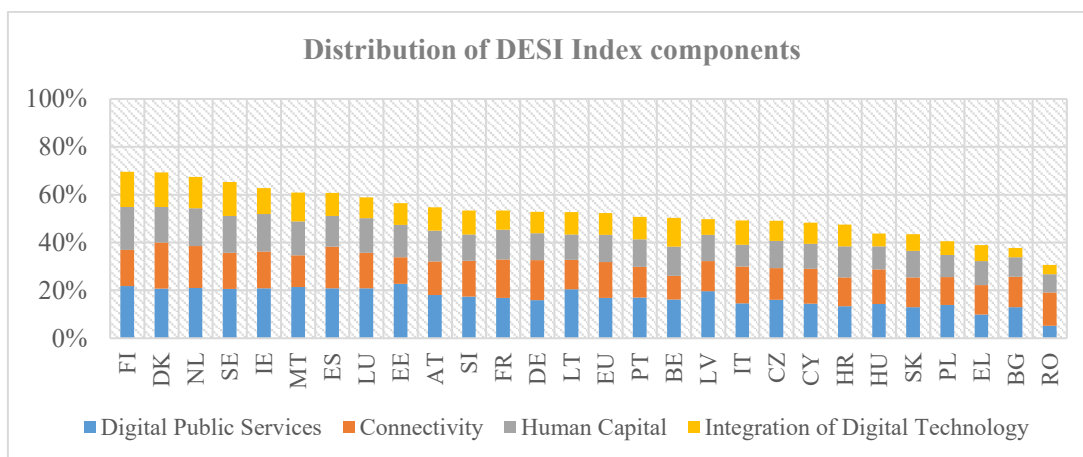


Figure no. Error! No text of specified style in document.: The territorial distribution of the components of the DESI index in the European Union, in the year 2021

Source: Produced by the authors in Microsoft Office Excel using European Commission data (European Commission, 2022a)

Table no. 1: Descriptive statistics of the DESI and its components

Descriptive Statistics	Maximum	Minimum	Skewness	Kurtosis	Median	Mean
DESI	69.60%	30.58%	-0.10	-0.25	52.71%	52.53%
Digital Public Services	22.79%	5.26%	-0.87	0.86	16.98%	17.05%
Connectivity	19.27%	9.96%	0.40	0.04	14.12%	14.12%
Human Capital	17.85%	7.73%	0.35	-0.32	11.49%	12.11%
Integration of Digital Technology	14.77%	3.79%	0.09	-0.24	9.18%	9.24%

Source: Performed by the authors in Microsoft Office Excel using European Commission data (European Commission, 2022a)

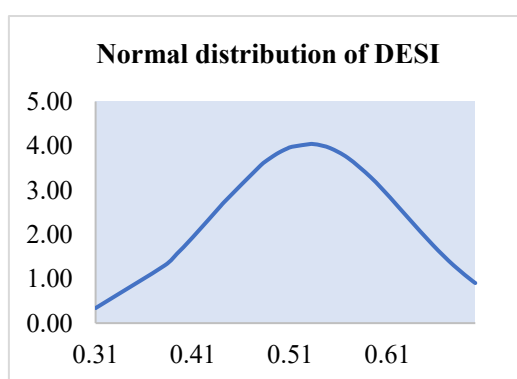


Figure no. 3: Normal distribution of DESI

Source: Performed by the authors in Microsoft Office Excel using European Commission data (European Commission, 2022a)

The difference between the mean and the median, but also the negative skewness and kurtosis coefficients, shows that the distribution of the DESI is skewed to the right (has more high values), but also slightly flatter than the normal distribution. The shape of the index distribution can be seen in figure no. 3.

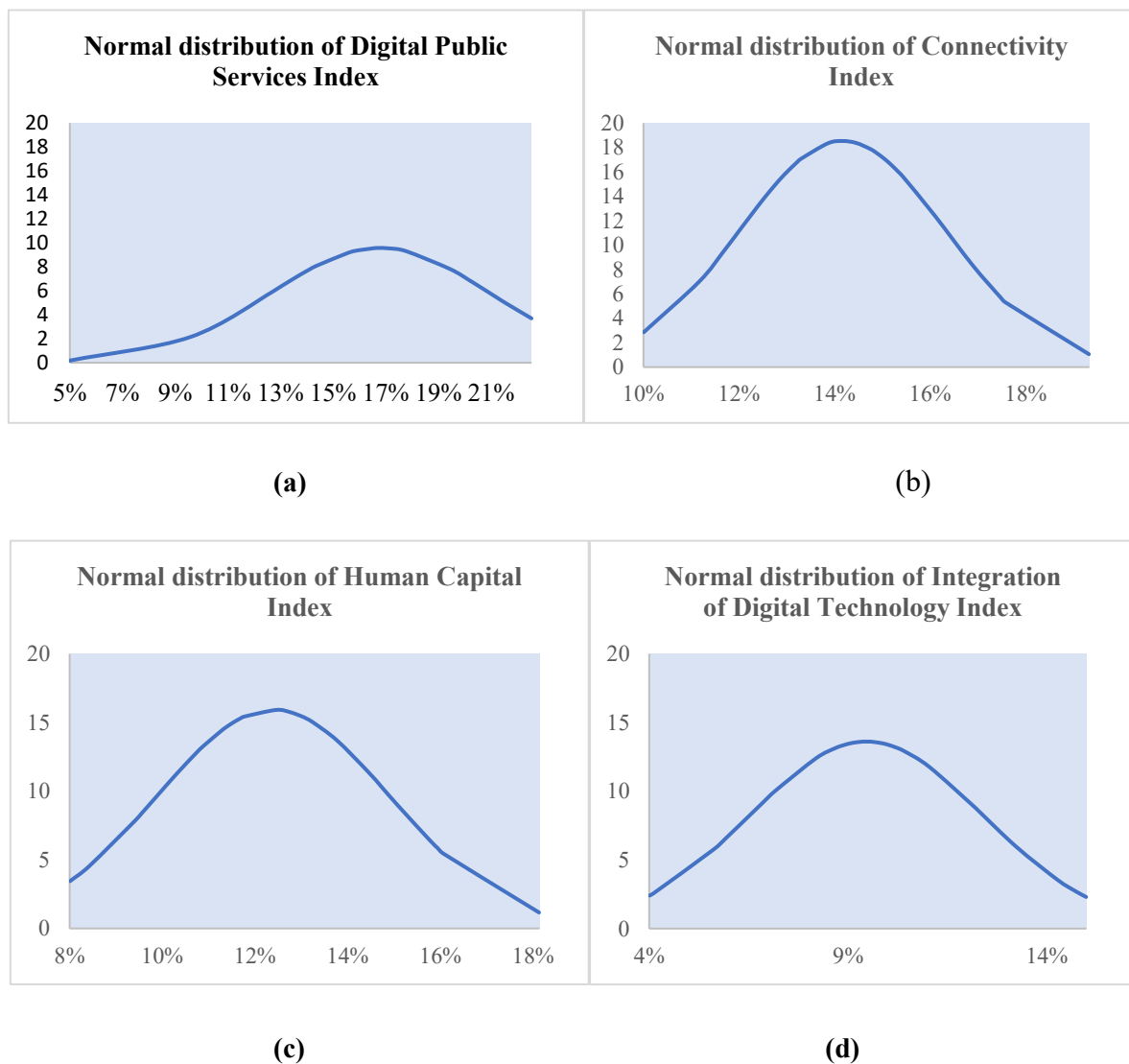


Figure no. 4: Normal distribution of the components of the DESI

Source: Produced by the authors in Microsoft Office Excel using European Commission data (European Commission, 2022a)

In table no.1, the descriptive indicators are calculated for the components of the digital performance index, in order to analyse their distribution as well. Thus, it can be seen that the digital public services index has the highest maximum value within the DESI index. Thus, according to figure no. 4 (a) and calculated skewness coefficient values, the existence of rather high values of the indicator is confirmed. The digital public service index has the most

unbalanced distribution, an aspect that can be highlighted by the larger difference between the average and the median, but also by the large difference between the best performing state and the least performing one.

The connectivity index is the second most important quantitative index in the DESI calculation. In figure no. 4 (b), there is a slight tilt to the left, but the skewness of the distribution is very close to the normal distribution (Kurtosis=0.04). The connectivity indicator has the smallest difference in value between the state with the highest performance in terms of connection to digital technology and the less digitalised state, which shows that this strategic topic has been approached almost similarly in all states of the European Union.

Human capital seems to be the second component for which the interest of the European states was almost similar (the difference between maximum and minimum is the second largest). In figure no. 4 (c), the distribution of the human capital index can be observed, which is slightly skewed to the left (Skewness=0.35) and is slightly flatter than the normal distribution (Kurtosis=-0.32). This means that lower values in the distribution predominate and extreme values are less represented.

The integration of digital technology index is the weakest represented at the level of the European Union. It seems that the European average of this indicator is 9.24%. From the point of view of symmetry, the distribution of the indicator is close to the normal one. Furthermore, the skewness of the distribution indicates a slight deviation from the normal, which is slightly more skewed.

It can be said that the component elements of the digital performance index are represented in different proportions at the level of the European Union, having distributions with different characteristics. Thus, to identify the similarity between the states, starting from these indicators, the hierarchical clustering analysis will be used.

4.1. Hierarchical clustering

In order to cluster the member states of the European Union into homogeneous groups from the point of view of digitalisation of the economy and society, the Ward algorithm will be used. The algorithm will use the indicator values for the year 2021, which were calculated in the year 2022.

Starting from the results of applying the Ward algorithm to the database containing the values of the DESI index components of the 27 states introduced in the analyse, we obtained four homogeneous groups of states. In figure no. 5, it can be seen that the optimal grouping level is 5, because after this level an exponential loss of inertia is observed.

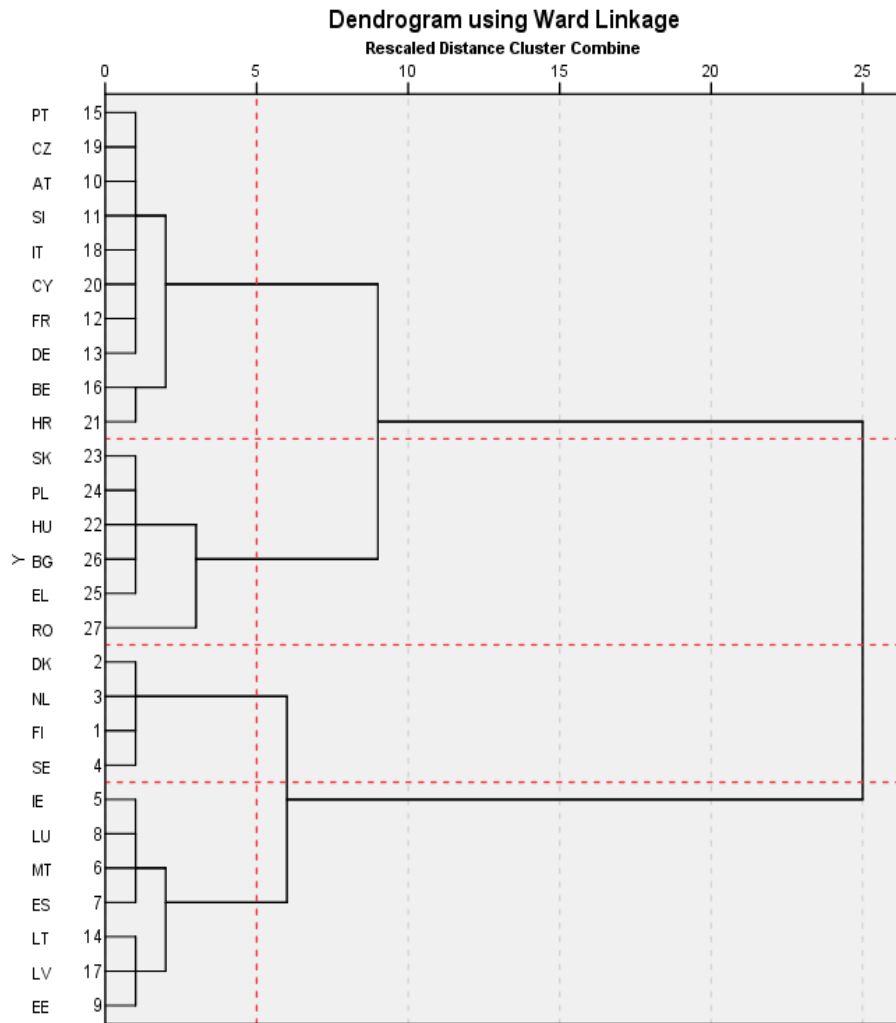


Figure no. 5: Dendrogram of the Ward algorithm for the clustering of European Union states

Source: Performed by the authors in IBM SPSS Statistics using European Commission data (European Commission, 2022a)

Thus, at the level of the European Union, we can differentiate four major homogeneous groups from the point of view of the digitalisation of the economy and society. The first group of states is represented by Sweden, Finland, the Netherlands, and Denmark. In table no. 2, it can be seen that the largest proportion of the digitalisation index is represented by the digitalisation component of public services. The second important component is represented by the Connectivity index and which does not differ significantly from the human capital index. The smallest weight in the calculation of the DESI composite index for cluster 1 is the integration of digital technologies. This group of states is the most balanced in terms of the contribution of the four components.

Table no. 2: Mean index values for each cluster

Mean values	Digital Public Services	Connectivity	Human Capital	Integration of Digital Technology
CLUSTER 1	21.07%	16.75%	15.98%	14.09%
CLUSTER 2	21.00%	13.84%	13.17%	9.45%
CLUSTER 3	15.98%	14.00%	11.51%	9.47%
CLUSTER 4	11.56%	12.89%	9.30%	5.40%

Source: Performed by the authors in Microsoft Office Excel using data from the European Commission (European Commission, 2022a)

The second cluster is represented by the countries Estonia, Latvia, Lithuania, Spain, Malta, Luxembourg, and Ireland. Within this group of states, a high level of digitalisation of public services is observed (table no. 2). The connectivity index and the human capital index are balanced in proportion to the DESI index, as in the previous cluster (table no. 2). However, the level of integration of digital technology indicates an almost halved performance compared to the previous group of states.

Cluster three is composed of Croatia, Belgium, Germany, France, Cyprus, Italy, Slovenia, Austria, Czech Republic, and Portugal. The average values within the group reflect a balanced weighting of the importance of the components of the DESI composite index. However, they cannot be compared with the states in the first cluster, because in absolute terms a poorer performance is observed (table no. 2).

The last cluster brings together the states of Romania, Greece, Bulgaria, Hungary, Poland, and Slovakia. This cluster is slightly atypical compared to the previous ones because the connectivity component is the most important in digitally performance (table no. 2). Moreover, an unbalanced proportion can be observed between the four indicators that creates DESI index (table no. 2).

The grouping of the European Union states (figure no. 6), from the perspective of the digitalization of the economy and society, can also be associated with the level of human development. It can be seen that the fourth cluster is represented by former communist states, where human development started from a much lower level after 1989, compared to the rest of the states.

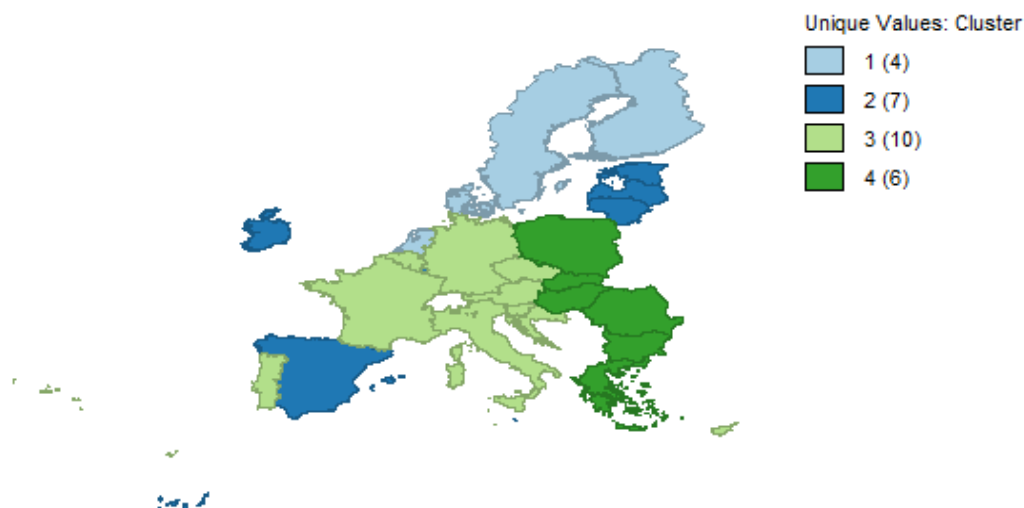


Figure no. 6: Grouping of the European Union states according to the digitalisation of the economy and society

Source: Performed by the authors in GeoDa Software using the results obtained in IBM SPSS Statistics

If we analyse the correlation between the Human Development Index and the Digital Economy and Society Index at the level of 2019, it is found that there is a strong direct dependence between the two indicators (figure no. 7). This aspect can also be verified by calculating the Pearson correlation coefficient, whose statistically significant value of approximately 0.75 supports the previous statement.

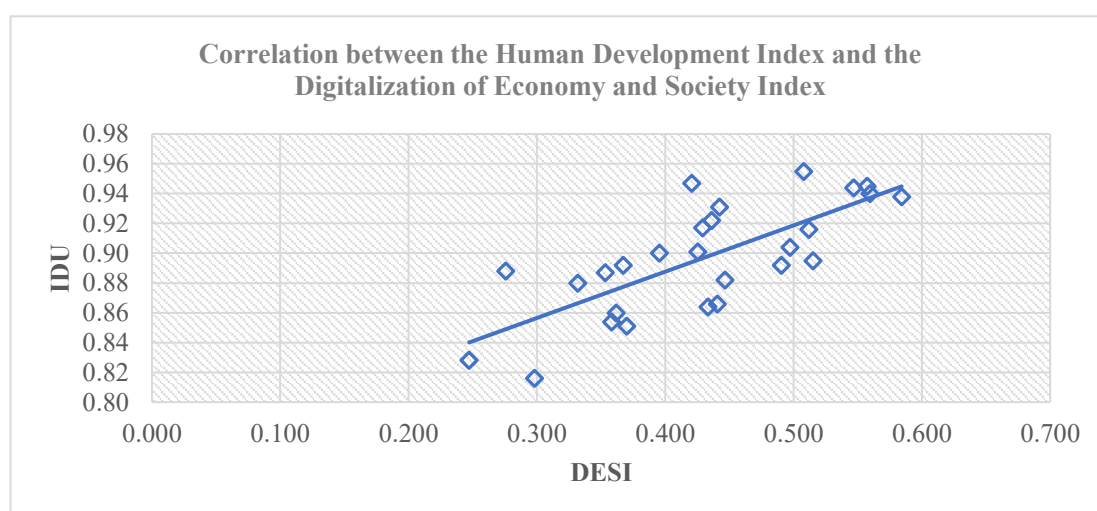


Figure no. 7: Correlation between the Human Development Index and the Digital Economy and Society Index, in 2019, in the European Union

Source: Performed by the authors in Microsoft Office Excel using data provided by UNDP (UNDP, 2020) and European Commission (European Commission, 2022a)

This may mean on the one hand, that digital performance is based on the standard of living of each state. The standard of living is also a composite index, bringing together life expectancy, level of education, and social well-being. The correlation between the two indicators analysed at the European Union level shows that digital performance cannot be manifested in an economy where basic needs are not met.

Table no. 3: Pearson linear correlation between DESI and HDI components

Variables (HDI and Components)	Correlation coefficient between DESI and corresponding variable	p-value
Human Development Index (HDI)	0.747	0.0000
Life expectancy at birth (LE)	0.491	0.0092
Expected number of years of schooling (ENYS)	0.600	0.0009
Average years of schooling (AYS)	0.316	0.1083
Gross national income per capita (GNI)	0.685	0.0000

Source: Performed by the authors in Microsoft Office Excel using data provided by UNDP (UNDP, 2020) and European Commission (European Commission, 2022a)

In table no. 3, it can be seen that DESI correlates directly and significantly, especially with the expected number of years of schooling (p-value 0.0009) and with gross national income per capita (p-value 0.00008). It is also natural that this correlation exists, since an increase in the education index causes an increase in the quality of human capital, which is one of the components of the DESI index. On the other hand, education could increase the probability of digital literacy of the population. However, the average years of schooling show a rather weak correlation with digital performance and are significant only if the correlation is accepted at a significance level of 10%. On another note, the gross national income per capita (GNI per capita) is also important in the expansion of digital performance. The correlation analysis reveals a significant and direct correlation of the DESI index with life expectancy at birth (p-value 0.0092).

4.2. Linear Regression

A simple linear regression model was used to identify the impact of standard of living on the digital performance indicator. In 2019, the level of the DESI index is observed to be explained in a proportion of approximately 55.9% by the regression model. The F-statistic test indicates that the model is statistically significant at a 95% confidence level. Furthermore, the t-statistic test shows that the coefficient of the Human Development Index is highly significant, which means that it influences the evolution of DESI.

Table no. 4: Summary output of the regression model

Variable	Coefficient	Std. Error	t-Statistic	P-value
HDI	1.7969	0.3195	5.6237	0.0000
C	-1.1817	0.2868	-4.1203	0.0004
R-squared	0.5585	F-statistic		31.6255
Adjusted R-squared	0.5408	Prob(F-statistic)		0.0000

Source: Performed by the authors in Eviews 8 using data provided by UNDP (UNDP, 2020) and European Commission (European Commission, 2022a)

However, for the model to be statistically valid, it is necessary to test the validity of the hypothesis of the classical linear regression model. The linearity assumption is satisfied, since the model equation has a linear form, as in equation (7).

$$\widehat{DESI} = -1.1817 + 1.7969 * HDI \quad (7)$$

The White test was used to check the homoscedasticity of the residuals. In table no.5 it can be seen that the residuals are homoscedastic. The third hypothesis to be tested is that of checking the autocorrelation of the residuals and for which the Breusch-Godfrey test will be used. In table no. 5, it is observed that the probability of the Chi-square test is much higher than the 5% significance level, which means that the residuals of the model are not correlated. The last hypothesis tested in the case of the estimated model is that of checking the normality of the random residuals. Thus, to make the decision, the Jarque-Bera test is calculated, whose null hypothesis states that the residuals are normally distributed. In table no.5 it can be seen that the Jarque-Bera test probability is 0.5389, much higher than the 5% significance level. Therefore, there is insufficient statistical evidence to reject the hypothesis that the residuals are normally distributed.

Table no. 5: Testing the assumptions of the simple regression model

Model Assumption	Test	Test statistic	p-value
Homoscedasticity	White	0.4954	0.5266
No autocorrelation	Breusch-Godfrey	2.1844	0.3355
Normality	Jarque-Bera	1.2362	0.5389

Source: Performed by the authors in Eviews 8 using data provided by UNDP (UNDP, 2020) and European Commission (European Commission, 2022a)

By confirming all hypothesis regarding the residuals of the model, it can be said that the model has economic utility. Thus, equation (7) shows that if HDI increases by one unit, DESI can increase by 1.7969.

Previously, we noticed that the DESI index also correlates with the components of the Human Development Index, so the question arises of the individual impact that the four indicators could have on the DESI.

Table no. 6: Summary output of the multiple regression model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ENYS_2019	0.0185	0.0093	1.9964	0.0584
GNI_2019	0.0030	0.0015	1.9383	0.0655
LE_2019	0.0023	0.0084	0.2723	0.7879
AYS_2019	0.0107	0.0162	0.6573	0.5178
C	-0.3216	0.7099	-0.4530	0.6550
R-squared	0.5843	F-statistic		7.7322
Adjusted R-squared	0.5088	Prob(F-statistic)		0.0005

Source: Performed by the authors in Eviews 8 using data provided by UNDP (UNDP, 2020) and European Commission (European Commission, 2022a)

Although the F-statistic indicates a valid model, it cannot be omitted that life expectancy at birth (LE_2019) and average years of schooling (AYS_2019) are not statistically significant (table no. 6). Thus, an optimal decision would be to eliminate the two from the model estimation.

Table no. 7: Summary output of the adjusted multiple regression model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ENYS_2019	0.0197	0.0080	2.4516	0.0219
GNI_2019	0.0036	0.0001	3.4896	0.0019
C	-0.0519	0.1212	-0.4280	0.6724
R-squared	0.5753	F-statistic		16.2554
Adjusted R-squared	0.5399	Prob(F-statistic)		0.0000

Source: Performed by the authors in Eviews 8 using data provided by UNDP (UNDP, 2020) and European Commission (European Commission, 2022a)

In this case, the model is statistically significant and the coefficients of the regressors are also significant. Thus, the digital performance is explained by the expected number of years of schooling and the gross national income to the extent of 57.53% (table no. 7). In order to accept its validity, the multiple regression model must verify the hypotheses of linearity, homoscedasticity, no autocorrelation, normality and multicollinearity.

$$\widehat{DESI} = -0.0519 + 0.0036 * x_1 + 0.0197 * x_2 + \varepsilon \quad (8)$$

The linearity is satisfied because the estimated model has the linear form shown in equation (8). The White test shows that the residuals are homoscedastic because the probability of test F is greater than the significance level of 5% (table no. 8). According to the probability of the Breusch–Godfrey test, the null hypothesis that the residuals are not correlated cannot be rejected (table no.8). Moreover, the Jarque-Bera test confirms that residuals follow a normal distribution (table no. 8).

Finally, the model must not show multicollinearity. This means that the variable "Expected years of schooling" should not correlate with the variable "Gross national income". To verify this hypothesis, the Klein criterion and the variance inflation factor criterion will be applied.

Table no. 8: Testing the assumptions of the multiple regression model

Model Assumption	Test	Value	p-value
Homoscedasticity	White	1.5003	0.2364
Nonautocorrelation	Breusch-Godfrey	2.5932	0.2735
Normality	Jarque-Bera	0.3203	0.8519

Source: Performed by the authors in Eviews 8 using data provided by UNDP (UNDP, 2020) and European Commission (European Commission, 2022a)

Table no. 9: Results for testing the no multicollinearity assumption of the regression model

Indicator	Value
Correlation coefficient (ENYS and GNI)	0.4508
t-statistic	2.5255
p-value	0.0183
Variance Inflation Factor (VIF)	1.2551

Source: Performed by the authors in Eviews 8 using data provided by UNDP (UNDP, 2020) and European Commission (European Commission, 2022a)

It is observed that there is a significant correlation between the two explanatory variables, but according to Klein's criterion, if the coefficient of determination of the model (R-squared) is greater than the square of the correlation coefficient of the explanatory variables, then it can be said that the explanatory variables are not they are not strongly correlated. Within the estimated model $R_y^2 = 0.5843 > r_{EYS_{2019}, GNI_{PC_{2019}}}^2 = 0.2032$, which means that the model is not affected by multicollinearity (table no. 9). The inflation factor criterion will also be applied to strengthen the decision made. We can see in table no.9 that the VIF value=1.2551 indicates the existence of low-level multicollinearity.

The application of the multiple regression model revealed the existence of a direct positive influence of the expected number of years of schooling, but also of the national income per capita, on the DESI index.

5. Discussion

The first part of the quantitative analysis aimed to identify the level of digitalisation of the European Union. To achieve this objective, the Digital Economy and Society Index was used for the year 2021, because the digital economy had to accelerate due to the COVID-19 pandemic. However, large differences in development are observed between the 27 states analysed. The four clusters obtained after the application of the Ward algorithm divide the European Union according to the digital performance they have. Digital performance means connecting with technology resources, the ability of human capital to use it, and the integration of technology into business and public services.

The composition of each cluster led to the idea of researching a new hypothesis, namely, whether the standard of living has any influence on digital performance. The ideas specified in

the literature section focus mostly on the influence of technology on the economy and society. However, there is also research, which also talks about what technology needs to develop, namely, human capital to develop and use it and the financial situation to access the technology. Thus, the comment in the Introduction of the pyramid of needs is not accidental at all. In the first phase, we used a simple regression model through which we indicated the direct impact of the Human Development Index on the Digital Economy and Society Index. Later, we also researched the individual influence of the components of the standard of living on digital performance. The results showed that only the expected number of years of schooling and the gross national income per capita have a significant impact. This result demonstrates ideas more or less supported by other works (World Economic Forum, 2022) (Ramirez-Robles, et al., 2022). The fact that most research highlight the effects of digitalisation on society and the economy provides an opportunity for thorough research on the influence of the economy and society on digitalisation.

6. Conclusions

The digitalisation of the economy and society can be measured with the help of the DESI index, which provides important information on connectivity, human capital, the integration of digital technology in business, and the digitalisation of public services. More specifically, the DESI index measures the digital performance of a state in the European Union. In this paper, the EU countries are grouped into four clusters from the perspective of digitalisation. The best performing states identified are those in northern Europe, followed by the Baltic States, Spain, Malta, Luxembourg and Ireland. The third cluster focused on Central and Western Europe, with South-East European states the least developed from a digitalisation perspective.

This grouping is not accidental, as was shown further by the analysis that the standard of living is correlated with the level of digitalisation of the European Union. At a more granular level, a particular correlation is observed between DESI and GNI per capita, i.e., the increase in individual well-being can influence the level of digitalisation. An equally significant correlation was also noted between DESI and ENYS, as education can have a major impact on a state's digital performance. The paper concludes by highlighting the positive linear impact that HDI and its components have on DESI.

This paper is of particular economic importance, as it proposes a direction not widely exploited in relation to the evolution of technology. If most research analyses the positive and negative impact that technology has on society and the economy, the bi-directional relationship will also need to be explored. The article draws attention to the fact that technology could not survive in a poor society where the standard of living does not allow for the luxury of technology. This is a scientific call to address the basic problems of society first so that society and the economy can enjoy the fruits of technology. However, the limitations of the paper relate in particular to the availability of the DESI index, which only has values for 2016-2021. Still,

this limitation must also be overcome in the following analyses. A future research proposal could be to analyse digitalisation in poor states compared to rich ones. Such an analysis could rather be carried out at the global level. It is also possible to analyse how digitalisation has evolved in states where a guaranteed minimum income has been introduced with the aim of fighting poverty.

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