Behavioral patterns of European countries from the triple perspective of tertiary education, labour market and digitalization

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Abstract

Multicriterial characterization of European countries from the triple point of view of tertiary education, digitalization, and the situation in the labor market for young people and for those with higher education is essential for understanding and adapting to changes in the contemporary economy and society. The main objective of the research is to identify patterns of behavior among European countries from a three-dimensional perspective, that combines tertiary education, digitalization, and the situation in the labor market for individuals with higher education and young people. This represents the novelty of the work, aiming to fill the information gap in the specialized literature in this regard. To achieve this objective, a unique selection of indicators was utilized to form main components, which subsequently served as criteria for clustering EU member countries. The constructed patterns enabled the identification of strengths and weaknesses, as well as the recommendation of necessary measures to address vulnerabilities, which may be of interest to decision-makers in mitigating the inequalities between country-groups and in optimizing the level of indicators within the groups.

Keywords

Tertiary education, Labour market, Digitalization, Principal Component Analysis, Cluster analysis.

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Introduction

Multicriteria characterization of European countries regarding tertiary education, digitalization, and the labor market situation of young people and highly-educated people is essential for understanding and adapting to changes in the contemporary economy and society. It can provide guidance for educational and labor policies, contributing to sustainable development and long-term competitiveness of European countries. Technological advancements, such as automation and artificial intelligence, have a significant impact on labor demand and skill requirements. Accurately characterizing this shift in the labor market is crucial for understanding sought-after skills and sectors facing major changes. Thus, higher education institutions should be able to respond to these changes, by adapting their educational offerings to match the needs of the digital labor market. Digitalization can lead to profound transformations in certain sectors, potentially causing structural unemployment in some cases. In this context, characterizing European countries should consider retraining initiatives and lifelong learning programs to support workers in adapting to changing skill demands and prevent social and professional exclusion. As evident from the recent health pandemic, improving digital skills may be necessary for streamlining and flexibilizing the labor market, correlated with higher salaries (Piroșcă et al., 2021). On the other hand, higher levels of education and more visible research outcomes are factors that can drive improvement and stimulate the

digital economy (Răileanu-Szeles and Simionescu, 2020). Specialized studies have indicated the difficulty in capturing the dimension of digital workforce, as well as their influence and the impact of digitalization on labor market changes (Charles et al., 2022), while existing studies on the impact of digitalization on the labor market situation have not reached a common denominator (Crisan, et al., 2023). Additionally, as revealed by the review of specialized literature, there are few studies providing a characterization of European countries from the triple perspective of tertiary education, digitalization, and the labor market, outlining behavioral patterns, and this work aims to address the information gap in this regard.

Thus, the main objective of the research is to identify patterns of behavior among European countries from a three-dimensional perspective that combines tertiary education, digitalization, and the labor market situation of individuals with higher education and young people. To achieve this objective, a selection of indicators was utilized as the basis for forming main components, which subsequently represented the criteria for clustering EU member countries.

This paper comprises four sections as follows: the first section analyzes the main results of the relevant specialized studies, the second section presents the dataset and methodology applied to it, the third section reveals the main findings of the conducted analysis and discusses them, while the fourth section synthesizes the main conclusions and proposes a series of economic and social policy measures to mitigate inter-regional disparities regarding the triple dimension of education, digitalization, and the labor market.

1. Review of the scientific literature

One of the existing directions of study in the specialized literature is the connection between the labor market and digitalization. Shibata (2023) analyzes the main transformations in the labor market of Portugal under the impact of the COVID-19 pandemic, highlighting the importance that this pandemic has given to the digitalization process. He has shown that young people, those with lower education levels, and those working in non-digital fields experienced a more dramatic decrease in employment during the pandemic than other groups of employees, and that jobs requiring digital skills have become increasingly prevalent. Pichler and Stehrer (2021) analyze the impact of ICT skills on individuals' labor market mobility patterns, especially in transitions from one job to another, from employment to unemployment or vice versa, in 9 EU member countries and the UK. Their results indicate that individuals with strong ICT skills have more opportunities and, therefore, not only change jobs more frequently but also have fewer chances of facing unemployment, and holding ICT skills can help individuals exit unemployment and secure jobs in medium and high digital sectors. Similar results have been obtained by Pirzada (2013), Kee et al. (2023), or Picatoste et al. (2018). Crisan et al. (2023) examine the diversity among EU member states regarding the digitalization of the labor market and identify patterns for EU countries in the context of the post-COVID-19 pandemic. The authors used indicators reflecting the specificities of each country's labor market, in terms of digitalization level and the impact of the COVID-19 pandemic on each country. Piroșcă et al. (2021) analyze the advantages and disadvantages that the digitalization process can bring to the labor market situation. On one hand, the authors show that digitalization exacerbates some existing labor market issues, such as low wages, job insecurity, stress, or long-term unemployment. However, the fault does not lie with the technology itself, the authors argue, but with the way social and economic policies are applied, and these policies should be used to protect employees' rights and ensure proper remuneration, as digitalization also has numerous advantages, requiring increased adaptability of the workforce to change, improvement of digital skills, and flexible thinking. And, as mentioned by Acemoglu and Restrepo (2018) and Atkinson and Wu (2017), although digitalization can lead to the loss, elimination of routine jobs, it can also generate the creation of new ones, thus ensuring a balance in the long run. Charles et al. (2022) believe that digitalization has fundamentally changed the organization and conduct of work, the skill requirements needed to perform job duties, employment relationships, the social protection system, and job quality. However, digitalization can also pose the risk of exacerbating imbalances, inequalities between social groups or countries. For example, certain disadvantaged groups such as women or ethnic minorities have lower digital skills, and some lower-income countries do not have the resources necessary to keep up with digitalization compared to more developed, higher-income countries.

Another aspect explored in specialized studies is the correlation between education and digitalization. Thus, Langthaler and Bazafkan (2020) have shown that digitalization has led to an acceleration of the transformation of education systems worldwide, generating educational innovations that have the potential to improve cognitive and analytical skills, as well as creativity and autonomous learning. However, there are also some risks, such as deepening the digital divide, increasing educational and social inequalities, and fragmenting public education systems to the benefit of the private sector. Rosak-Szyrocka et al. (2023) study the relationship between digitalization and education systems in European countries, taking into

account the particularly diverse and multifaceted nature of the digitalization process. Digitalization (through the integration of modern technologies, the use of the internet, and digital public services) can be a key factor in enhancing the innovation capacity of higher education and expanding the use of cutting-edge learning technologies in their curriculum, ultimately stimulating student achievements and improving their skills.

A third category of studies correlates the education system, the labor market situation of various social categories, and the digitization process. For instance, Hetmańczyk (2023) is one of the authors who combine all three aspects in his studies, which we aim to reference in this paper. He analyzes the impact of digitization on the labor market and education in Poland, concluding that digital transformation must ensure the diversification and modernization of local economies and limit the negative effects on the labor market. The author mentions the role of intellectual capital in the development of the information society and knowledge-based economy, the increase in competency levels and skills in using ICT techniques, the development of high-quality digital services - essential factors in stimulating social and economic development and minimizing the marginalization of those at risk of digital exclusion. Shuangshuang, Zhu, Mughal, et al. (2023) focus their analysis on the impact of digitization and education on the situation of women in the labor market in BRICS countries. Thus, the authors indicate the existence of a positive correlation between digitization and the employment situation of women in the labor market, with key factors ensuring a long-term relationship being education and GDP. Wolbers (2007) focuses his analysis on another group - young people, studying the differences between European countries regarding youth unemployment and the quality of their jobs. The author identifies a series of transnational models for integrating young graduates into the labor market from 11 European countries, analyzing the speed, quality, and stability of the entry process into the labor market. The author explains the heterogeneity among these models through national differences in labor protection legislation, the specific nature of the education system, and the macroeconomic conditions of socio-economic development in these countries.

2. Data and methodology

The selection of variables included in the analysis was carried out following a review of specialized literature, considering their relevance and their power of synthetic characterization of the three pillars pursued: tertiary education system, labor market, and digitization. All variables are numerical, continuous, measured on a ratio scale, and all are expressed in percentages or coefficients, ensuring comparability between countries. All ten variables were recorded for the 27 EU member countries, for the last available year (generally 2022 or 2021), their values being collected from the Eurostat database. A brief presentation of these variables can be found in Table No. 1.

Table no. 1. List of selected statistical variables

Name of statistical variable	Measurement unit	Data source/online code
Public educational expenditure – tertiary education	% of EU-level	Eurostat/educ_uoe_fine02
Graduates in tertiary education	% of EU-level	Eurostat/educ_uoe_grad01
Share of mobile students from abroad enrolled in tertiary education	%	Eurostat/educ_uoe_mobs03
Ratio of pupils and students to teachers and academic staff in tertiary education	Rate	Eurostat/educ_uoe_perp04
Employment rate of tertiary educated (16-64)	%	Eurostat/lfsa_ergaed
Employment rates of young people not in education and training (18-34)	%	Eurostat/edat_lfse_24
Level of internet access – households	% of households	Eurostat/tin00134
Internet use by individuals (last 3 months)	% of individuals	Eurostat/tin00028
Individuals who have basic or above basic overall digital skills	% of individuals	Eurostat/tepsr_sp410
Individuals using the internet for doing an online course	% of individuals	Eurostat/tin00103

Source: authors' selection

Based on the studies in the specialized literature, the following research hypothesis has been formulated in line with the main objective of the work:

H1: *European countries exhibit significantly different patterns of behavior regarding the labor market, digitalization, and tertiary education*.

The analysis is carried out in two stages: in the first stage, the dataset was synthesized based on Principal Component Analysis, resulting in three complex variables. The adequacy of applying the PCA method was tested using Kaiser-Meyer-Olkin statistics and Bartlett's test, and based on Eigenvalues analysis and the

Scree Plot, the number of relevant principal components was identified to retain an acceptable degree of variation from the initial dataset. In the second stage of the analysis, the obtained complex variables were used as clustering criteria for European countries, aiming to identify patterns or behaviors, highlighting strengths and weaknesses, and recommending necessary measures to address vulnerabilities. The number of clusters was identified by applying the Hierarchical cluster method (Ward Linkage), then the grouping of EU member countries was conducted using the K-Means Non-Hierarchical Cluster Method.

3. Results and discussions

In the first stage of the analysis, the dataset underwent principal component analysis (PCA) to reduce it to a linear combination of original variables that retain a substantial portion of the initial information (principal components) (Greenacre et al., 2022). The Kaiser-Meyer-Olkin (KMO) statistic value is 0.69, higher than 0.6, and the Bartlett's test indicates that the correlation matrix is not an identity matrix, suggesting that the data are suitable for PCA (Table no. 2). Three principal components were retained, for which Eigenvalues are greater than 1, with the three components explaining 76.41% of the variation in the initial dataset (43.16% for the first component, 20.05% for the second component, and 13.2% for the third component).

Table no. 2. KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.690
Bartlett's Test of Sphericity	Approx. Chi-Square	170.482
	df	45
	Sig.	.000

Source: authors' contribution, based on Eurostat data

Component 1 is determined by indicators characterizing access to electronic resources and their usage, as well as the digital skills of users (Household Internet access, Individual Internet usage in the last 3 months, Proportion of individuals taking online courses, Proportion of individuals with basic or above basic digital skills). This component could be named the **Digital Component**. All variables are strongly and positively correlated with this component (correlation coefficients between 0.791 – 0.899).

Component 2 contains indicators characterizing two aspects: the employment of young people and of those with tertiary education in the labor market (Employment rate of tertiary-educated individuals, Employment rate of young people), as well as certain facets of the education system, such as international visibility (Proportion of international students enrolled in tertiary education) or participation in education (Student to teacher ratio and academic staff in tertiary education). This component could be named the **Education-Labor Market Correlation Component**. All included variables are fairly strongly and positively correlated with this component, except for the student-to-teacher ratio, which has an inverse correlation with Component 2.

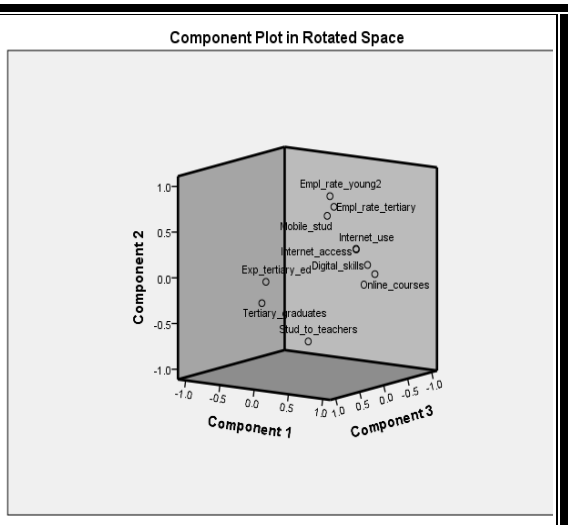
Component 3 consists of indicators characterizing, on one hand, financial efforts (Expenditure on tertiary education), and on the other hand, the outcomes of the educational system (Number of tertiary education graduates). This component can be named the **Tertiary Education Component**, and it is highly strong and directly correlated with the subordinate variables (Table no. 3).

In the next stage of the analysis, the three principal components are transformed into multiple clustering criteria for EU member countries, aiming to identify groups of countries with common characteristics based on these criteria, but also with significant differences among them.

To establish the appropriate number of clusters, the Hierarchical cluster method (Ward Linkage) was first applied, resulting in a total of 4 clusters (Figure no. 1).

Table no. 3. Rotated Component Matrix[a] and Component Plot in Rotated Space

	Component		
	1	2	3
Exp_tertiary_ed	.060	.051	.951
Tertiary_graduates	.000	-.188	.950
Online_courses	.899	.066	-.120
Digital_skills	.875	.181	-.001
Internet_use	.809	.364	.141
Internet_access	.791	.366	.117
Empl_rate_young2	.255	.856	-.104
Empl_rate_tertiary	.345	.755	-.059
Stud_to_teachers	-.105	-.779	-.166
Mobile_stud	.138	.613	-.214



Source: authors' processing results

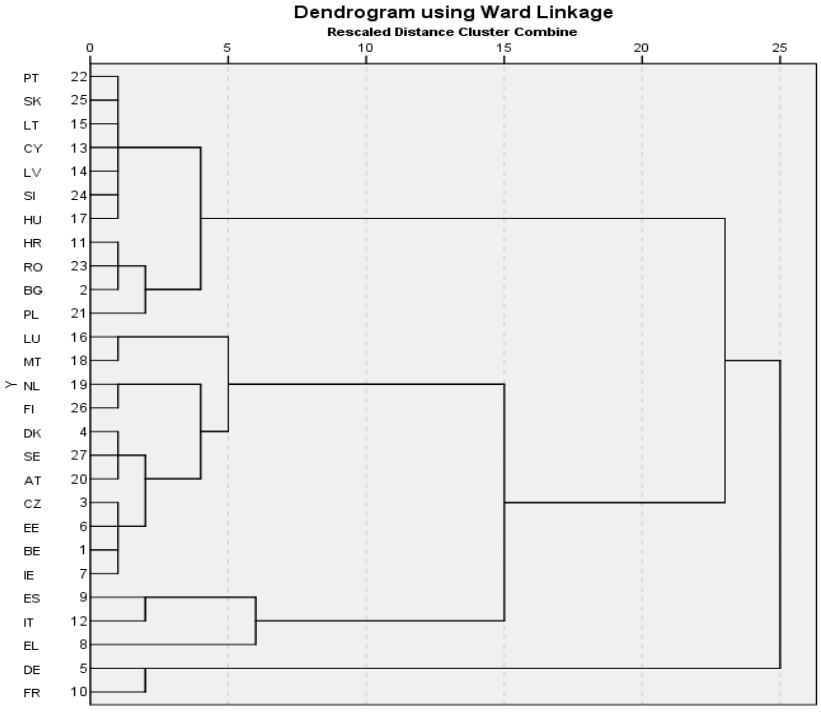


Figure no. 1. Dendrogram

Source: authors' processing results

Based on the determined number of clusters, the K-Means Non-Hierarchical Cluster Method was then applied (Table no. 4, Figure no. 2).

Table no. 4. Final Cluster Centers

	Cluster			
	1	2	3	4
Factor score 1 for analysis 1	-.46559	-.86789	-.23274	.91195
Factor score 2 for analysis 1	.42648	.11744	-2.54139	.24483
Factor score 3 for analysis 1	2.96679	-.37330	.03105	-.15745

Source: authors' processing results

Thus, the four clusters that define, at the same time, four patterns of behavior of European countries in terms of tertiary education, youth and highly skilled employment, and digitalization, are:

Cluster 1, consisting of two EU countries with strong economies, true engines of the European economy (France, Germany), is distinguished by the highest level of the tertiary education component (Component 3). These countries have recorded the highest expenditures on tertiary education (a cluster-level average of 22.41% of the EU total), the highest share of tertiary education graduates (17.78% of the EU total), and the lowest number of students relative to teaching staff, indicating a high number of employees in the academic field. The countries in this cluster hold the second-best position among the indicators within Component 2 (Education-Labor Market Correlation) and Component 1 (Digital Component), with high rates of employment among the tertiary-educated population and youth, as well as high levels of internet access, internet usage, digital skills, and online course participation.

Cluster 2, composed of countries with emerging economies, in the process of development, originating from the former socialist bloc (BG, HR, CY, LV, LT, HU, PL, PT, RO, SI, SK), has the lowest level of indicators within Component 3 (Tertiary Education), with the lowest level of expenditure on tertiary education (less than 1%, on average, of the EU total) and the lowest number of tertiary education graduates (only 1.87% of the EU total). Regarding the digital and education-labor market correlation components, countries in this cluster have among the lowest indicator values.

Cluster 3 consists of Southern European countries (Italy and Greece), which share the common trait of having the most unfavorable position under numerous aspects of digitalization (the lowest proportion of households with internet access and internet usage), as well as education-labor market correlation (lowest employment rates among youth and tertiary-educated individuals, lowest proportion of foreign students attending courses in these countries, highest student-to-teacher ratio). However, these countries rank second-most favorably regarding the tertiary education component, in terms of the proportion of public expenditure on tertiary education and the number of tertiary education graduates relative to the EU total.

Cluster 4 generally consists of developed EU countries, among which Nordic countries stand out, with a recognized efficiency of the tertiary education system (BE, CZ, DK, EE, IE, ES, LU, MT, NL, AT, FI, SE). These countries have the highest level of the digital and education-labor market correlation components, but record more modest levels of the tertiary education component in terms of expenditure on tertiary education and the number of tertiary education graduates.

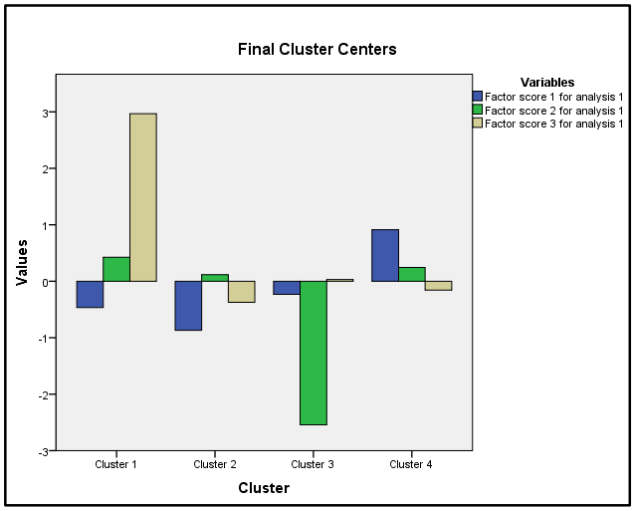


Figure no. 2. Final Cluster Centers
Source: authors' processing results

At the same time, the ANOVA table (Table no. 5) shows that all three components had a significant contribution to the creation of the four clusters (for all principal components, the minimum level of significance Sig. being below 0.05).

Table no. 5. ANOVA

	Cluster		Error		F	Sig.
	Mean Square	df	Mean Square	df		
Factor score 1 for analysis 1	6.269	3	.313	23	20.046	.000
Factor score 2 for analysis 1	4.717	3	.515	23	9.158	.000
Factor score 3 for analysis 1	6.479	3	.285	23	22.701	.000

Source: authors' processing results

Conclusions

The analysis applied in this study allowed the identification of patterns of behavior among European countries from a triple perspective: tertiary education, youth and highly educated employment on the labor market, and digitalization. Based on the selection of relevant statistical indicators characterizing the three pillars, the strengths and weaknesses of each behavioral model were highlighted, followed by recommendations for addressing the identified vulnerabilities. The main patterns of behavior among European countries identified are as follows:

- The first pattern of behavior belongs to European countries with developed economies, such as Germany and France, which recognize and support the importance of higher education through high public spending, attracting a significant number of young people to tertiary education, and stimulating the employment of academic staff in this field. At the same time, measures to support and encourage citizens to continue their education by accessing online courses and facilitating access to digital education can be taken in these countries.
- A second pattern of behavior is observed in countries with emerging economies, former socialist countries that had centralized economies, which have the lowest share of public spending on tertiary education in total EU spending, as well as the lowest share of tertiary education graduates in the total EU. The level of indicators characterizing the other two principal components (the digital component and the correlation of tertiary education with the labor market) is relatively low, necessitating some improvement measures to enhance the attractiveness of higher education, both from the perspective of participants and that of teaching staff, investments, and international visibility.
- A third pattern of behavior is found in Southern European countries, Italy and Greece, characterized by the lowest levels of internet usage and access to the internet by households, as well as low rates of employment among young people and the educated population. In these countries, measures are needed to facilitate and optimize digital infrastructure, population access to electronic resources, and to stimulate the employment of highly educated youth, commensurate with their level of education. At the same time, these countries must leverage the advantages of their tertiary education system for greater international visibility, as they have the lowest proportions of foreign students studying in these countries.
- A fourth pattern of behavior is characteristic of developed European countries, including numerous Northern European countries, where the education system has proven its efficiency and value over time, being particularly attractive to many students from other countries who come in large numbers to attend universities here. They are highly digitized countries, some of which - such as Malta, Sweden, or Ireland - have among the highest proportions of the ICT sector in GDP. Moreover, highly educated young people have a good employment situation, with these countries

already implementing programs to encourage the employment of young people and highly qualified individuals in positions where they can leverage their skills.

- One of the limitations of the current analysis is that it captures a static, cross-sectional picture of the situation in European countries regarding the labor market, digitalization, and tertiary education, coupled with the issue of the availability of the most recent data for all EU member states. This analysis can be further expanded and refined in the future by identifying even more relevant indicators that characterize these and other socio-economic realities in European countries, with a focus on the use of artificial intelligence and its impact on the labor market situation.

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