

Shaping the digital labor market in the European Union

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Abstract. *Digitalization is currently transforming labor markets and the sustainable development of our society, as technologies are constantly worldwide integrated into everyday life and digitally skills are becoming a must on the labor market. Under such context, our paper aims to carry out a cluster analysis among the 27 EU member states to investigate how digitalization has shaped the EU labor market so far and to pinpoint the main similarities among the EU countries in terms of digitalization, economic development and sustainability. The resulting clusters may be used to characterise the EU economy in connection to the two fundamental social transitions that are currently taking place, digitalization and sustainability, with the aim of emphasizing the key features of the component countries. Using a set of relevant indicators, we were able to group the countries into 3 clusters and to differentiate between digitalized and sustainable economies and the least digitalized or with less sustainable economic developments countries.*

Keywords: digitalization, labor market, sustainability, cluster analysis.

JEL Classification: C38, E24.

1. Introduction

In 2020, the European Commission set out its vision for the digital transformation in strategy “Shaping Europe’s digital future” to deliver an inclusive use of technology that works for people and respects EU fundamental values. The *White Paper on Artificial Intelligence* and the *European data strategy* are the first two pillars of the new digital strategy of the EU. The EU's objective is to get Europe’s societies and economies back on the track of sustainable growth integrating the green transition and the digital transformation. Thus, the EU adopted the Next Generation EU recovery strategy to provide member states with the funds to make their economies more resilient. Crucially, it will ensure that these investments and reforms focus on the challenges related to the green and digital transitions.

In this context, our research aims to carry out a cluster analysis at the level of the 27 EU member states for the year 2022. The analysis focused on grouping the EU member states based on a series of indicators reflecting digitalization, economic development, and economic sustainability by considering the environmental impact. In terms of economic development, we gathered data on business enterprise expenditure on R&D (BERD), high-technology employment, labor cost, and net earnings. Regarding sustainability and environmental impact, we considered indicators reflecting CO2 emissions and renewable energy, while for digitalization, the Digital Economy and Society Index (DESI) was chosen. The digital economy plays a vital role in promoting sustainable development.

The cluster analysis allowed us to illustrate how the digitalization is currently shaping the EU labor market and to pinpoint the main similarities among the EU countries in terms of digitalization, economic development and sustainability. The structure of the paper is the following. Section 2 presents a brief literature review on how digitalization is currently influencing the labor market and the green and economic development, while section 3 describes the data and the methodological approach considered for the cluster analysis. The main findings of our investigation are discussed through Section 4, while the last section concludes.

2. Brief literature review

The Digital Economy and Society Indicators has been calculated at European level since 2014 and measures the evolution and development of the digital competitiveness of EU Member States through the performance of 5 indicators: internet connectivity, human capital (internet user skills and advanced skills), use of internet, integration of digital technology and digital public services.

Kovács et al. (2022) reviewed DESI's human capital individual indicators to identify critical areas that need to be addressed in the future to ensure that digital development is as broad-based as possible. After an analysis of the DESI overall index and its core dimensions, they concluded that in areas where convergence is not achieved, the EU's targets will not be met or will be in backlog in 2030. Obviously, convergence does not aim to make the member states homogeneous, especially in terms of digital skilled human capital. At the same time, clustering can help EU policymakers to provide guidance and support.

A study based on the survey conducted on European countries during the period 2018-2021 examines the relationship between human well-being and digital development and indicates that as the adoption and utilization of digital technologies increase, the quality of life also improves, and vice versa. At the same time during the COVID-19 pandemic while digitalization has progressed and positively affected the quality of life index, the overall well-being of individuals has been adversely affected (Laitsou and Xenakis, 2023).

Imran et al. (2022) investigated the influence of the digital economy and sustainable development on the promotion of sustainable development indicators across 28 EU countries (including the United Kingdom) and the results showed that the use of internet services followed by connectivity and human capital have an influence on the promotion of sustainable development growth indicators. Simultaneously, the integration of digital technology and digital public services has a limited significant impact on promoting sustainable development growth indicators.

He and Pérez Estébanez (2023) studied the impact of R&D investment intensity, human capital, patents, and brand value on the productivity of small and medium-sized firms in China. The analysis concerned 846 SMEs indicating that there is a positive impact of patents and brand value on business performance. Thus, it can be concluded that investments in research and innovation and highly educated personnel have a positive influence on productivity and competitiveness on the market.

Khan et al. have shown through the study conducted on Chinese companies listed on the stock exchange in the period 2000-2020 that a higher level of spending on R&D is correlated with a lower level of operating profit because R&D expenses reduce the operating profit. Therefore, firms lower their R&D spending and wait for further information to avoid financial loss and perform better. The findings of this study have substantial implications for policymakers, managers, and investors.

Following the Europe 2030 Agenda we can identify two major trends. One trend aims at a digital economy, and the other at the implementation of a "green deal" in the context of achieving the objectives of sustainable development. The future economic development of the EU is based on the use of digital technologies and artificial intelligence to protect the environment and the climate. Basically, using new technologies, the higher the level of digitization, the faster greenhouse gas emissions are reduced.

Kuzior et al. (2022) analyzed the level of influence of the digitization process on the volume of greenhouse gases per inhabitant among the EU states. The results obtained by applying the regression method and studying the Kuznets curve indicated that digitization is not the main factor in reducing greenhouse gas emissions. In practice, it is necessary to consider other factors such as regulatory policy, tax policy, investment policy, the culture of consumption, etc.

In another research Sultanova et al. (2022) aims to provide an empirical investigation of the relationship between the digital economy and renewable energy consumption and generation based on a panel data analysis of 25 European Union (EU) countries for the period 2017-2021. The results indicate that the growth of the digital economy positively influences the transition to clean energy. Simultaneously, while the relationship between

the digital economy and the transition to renewable energy sources is positive, the impact of urbanization, carbon emissions, and primary energy consumption on green energy in the EU is ambiguous.

Li et al. (2021) used global panel data of 190 countries from 2005 to 2016 to perform fixed-effects regression and studied the impact of the digital economy on CO₂ emissions. The results of this study indicated that at the beginning of digitalization, the development of the digital economy will increase CO₂ emissions and when the development of the digital economy reaches a certain level, CO₂ emissions can be effectively alleviated. Therefore, all countries should adhere to the development of the digital economy to shorten the pollution time caused by it in the early stage.

We draw on the literature review to conclude that digitalization plays a significant role in shaping the EU labor market, its economic development and sustainability and that further investigation of the digitalization outcomes is needed.

3. Methodology and data

For a more representative evaluation of the main types of states, a cluster analysis was performed for the 27 EU member countries based on criteria such as digitalization, economic level and contribution regarding improving sustainability. Following the methodological approach proposed by Stancu (2022), the next steps were checked to execute an accurate analysis:

Step 1. The preparation of a data collection according to the goal of the analysis

We selected the most suitable indicators for grouping the EU countries according to the level of digitalization, economic development and level of sustainability by considering the environmental impact. Regarding economic development, we gathered data on BERD, high-technology employment, labor cost, and net earnings, while for digitalization, the DESI was considered. Finally, in terms of sustainability and environmental impact we used indicators reflecting CO₂ emissions and renewable energy. The data was collected from official sources (i.e. Eurostat) for the context of the year 2022.

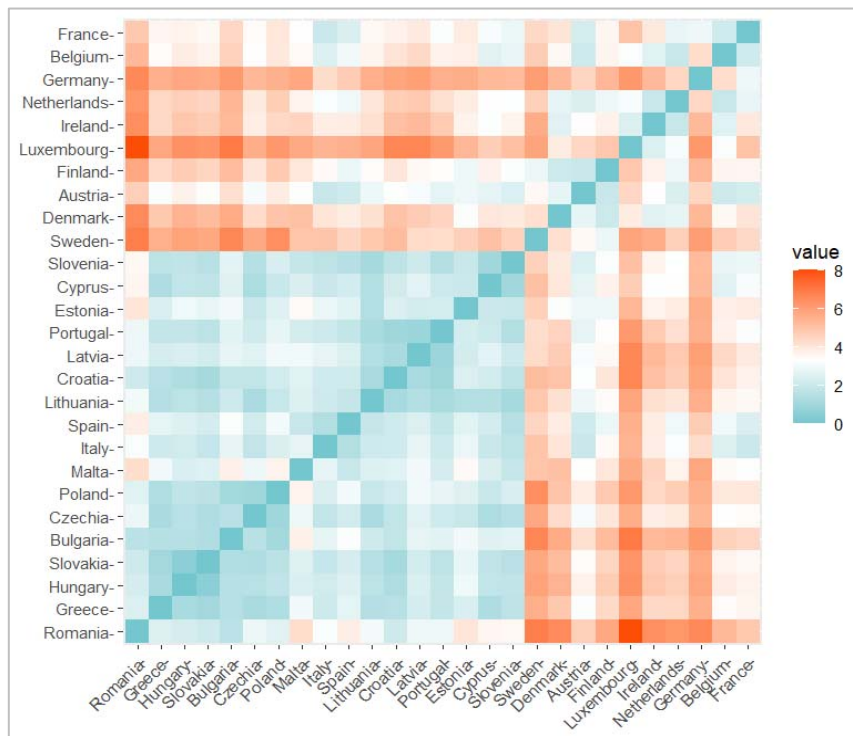
Step 2. Descriptive analysis and standardization of the data set

In this stage, the data set was analyzed through a descriptive analysis to observe trends in digitalization, economic development, and environmental impact. In addition, this stage of data preparation is typically used to identify missing values and potential outliers for each indicator. When outliers are detected, we need to decide whether or not to exclude the country with the outliers. In general, in order not to lose the overall picture of the EU, countries are not excluded from the analysis, even if some values may be outliers.

Data standardization is also necessary in order to ensure the comparability from one indicator to another. In this case, the standardization was achieved by applying the min-max method, being the most common used for clustering, and no missing values or outliers were identified. During the data preparation step, it is recommended as well to analyze the data's similarity by computing the distance between all of the assessed countries. Due to its

suitability for data sets without outliers and with equivalent attribute significance, the Euclidean distance was chosen in the present research. Figure depicts the similarity between each two countries as follows: the intense blue cells indicate a great similarity, while intense red cells show minimal similarities.

Figure 1. *The similarity matrix*

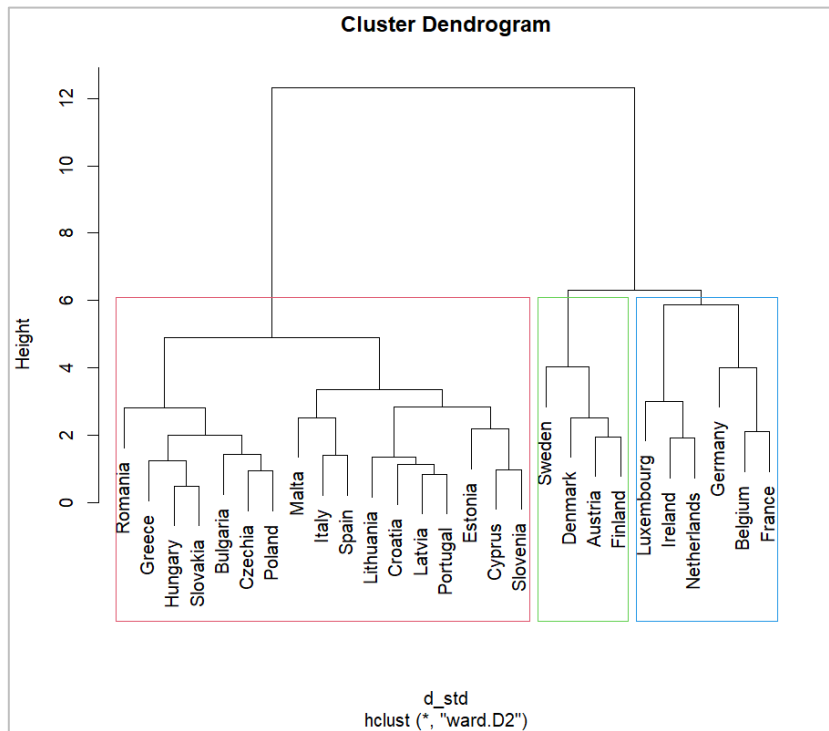


Source: authors' own calculations

This makes it possible to identify two possible groupings that the research may return: the larger blue square, which consists of several countries such as Romania, Hungary, and Poland, and the second, smaller blue square, which includes Luxembourg, Austria, and Finland.

Step 3. The cluster analysis

There are multiple approaches for determining the optimal number of clusters, however the 'NbClust' package and the NbClust() function in R were implemented in this research, with the most suitable result of 3 clusters. Another important detail that must be established at this stage tackles the grouping method. Out of the five most popular techniques, average, single, complete, and Ward, the one with the highest agglomeration coefficient is selected. In the current situation, the highest coefficient was calculated for the ward method, a method known for the fact that it also aims to minimize the loss of information when creating the clusters. Following application of the already stated, the outcome is visible as a dendrogram that shows each cluster's component (Figure 2).

Figure 2. *The dendrogram*

Source: authors' own calculations

4. Main findings

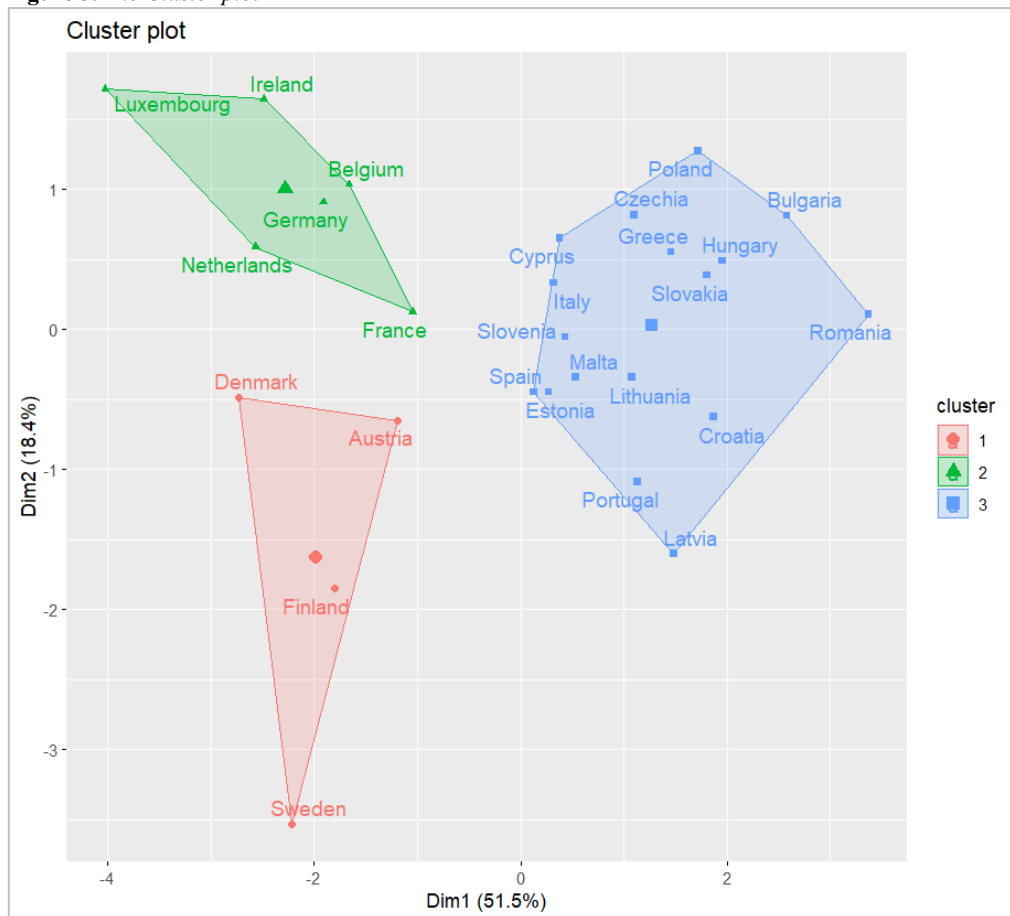
Following the implementation of the cluster analysis methodology, the results can be interpreted both by visual and numerical methods. Figure 3 illustrates through a Cluster Plot the main information related to the clusters, such as the clusters' composition, the separation between them, their sizes and densities. As can be observed, the cluster represented in blue considerably outnumbers the other two in terms of size and density, which suggests a stronger similarity between the member countries.

Using the concept of centroid, the three groupings can be described in this way by extending specific features across the component countries. As a result, the following groups are formed:

1. The digitalized and sustainable cluster: Sweden, Finland, Denmark and Austria
2. The digitalized but less sustainable cluster: Luxembourg, Ireland, Belgium, Germany, France and Netherlands
3. The sustainable but less digitalized cluster: Romania, Greece, Hungary, Slovakia, Bulgaria, Czechia, Poland, Malta, Italy, Spain, Lithuania, Croatia, Latvia, Portugal, Estonia, Cyprus and Slovenia.

As can be observed, the most prosperous countries in terms of digitization and the impact on the environment are also the least numerous. These 4 countries are characterized by the highest values of the DESI index at the EU level, a high labor cost (considering the payment of employees and taxes, but not subsidies) correlated with high net earnings. In terms of sustainability, these countries have the highest percentage of renewable energy consumption and the lowest GHG (greenhouse gas) emissions.

Figure 3. *The Cluster plot*



Source: authors' own calculations.

As for the next two clusters, there is no longer a matter of prosperity on both fields. The second cluster is prosperous in terms of digitalization but less in terms of sustainability, whereas the third is the opposite. The second one, marked in the Figure 3 with green, can be described by a high level of digitalization through the increased level of business enterprise expenditure on R&D (BERD) and the highest percentages at EU level of employment in knowledge-intensive activities. However, when it comes to environmental care, this cluster is at the opposite pole, since these countries have the greatest GHG emissions and the lowest level of renewable energy use.

The final cluster stands out as having low values compared to the rest of the countries in terms of labour costs, net earnings, and digitalization indicators (DESI and BERD). However, the CO₂ emissions from these countries are the lowest.

Table illustrates the interior of the first cluster by displaying the values of the component countries for each indicator.

Table 1. *The components of the first cluster*

Country	Energy - renewable sources	BERD	LaborCost	DESI	Net Earnings	Employment - knowledge-intensive	CO ₂ Emissions
Austria	33.758	9856.78	39	0.138	22249.29	37.8	7.68
Denmark	41.601	6766.76	46.8	0.173	21782.76	39.5	13.46
Finland	47.886	5396.90	35.9	0.175	20763.32	38.5	8.67
Sweden	66.002	14104.97	40.1	0.163	19108.53	50.7	4.72

Source: authors' own calculations.

Of the four countries that were considered prosperous from both the digital and sustainability perspectives, Sweden stands out with best performances. The most noticeable differences are registered in terms of energy - renewable sources, BERD, employment - knowledge-intensive and CO₂ emissions.

Table 2. *The components of the second cluster*

Country	Energy - renewable sources	BERD	LaborCost	DESI	Net Earnings	Employment - knowledge-intensive	CO ₂ Emissions
Belgium	13.759	13885.61	43.5	0.125	21937.91	45.6	9.02
France	20.259	37782.03	40.8	0.133	16433.56	40.3	6.45
Germany	20.796	81808.90	39.5	0.133	19635.94	38.6	9.41
Ireland	13.107	3887.15	37.9	0.158	23649.59	44.7	14.41
Luxembourg	14.356	384.72	50.7	0.148	29319.28	58.9	14.31
Netherlands	14.972	14970.85	40.5	0.170	25036.22	44.3	9.85

Source: authors' own calculations.

In cluster 2, Luxembourg is the country that stands out. Overall, an increased homogeneity can be observed among the values compared to the previous cluster (Table). Even if there are no major discrepancies, Luxembourg ranks first in terms of labor costs (50.7), net earnings (29319.28) and percentage of employment in knowledge-intensive activities (58.9 %).

As we proceed to the third group of countries, the disparities among its members become even more insignificant (see Table 3).

Table 3. *The components of the third cluster*

Country	Energy - renewable sources	BERD	LaborCost	DESI	Net Earnings	Employment - knowledge-intensive	CO ₂ Emissions
Bulgaria	19.095	438.87	8.2	0.095	4205.88	28.3	9.12
Croatia	29.354	520.60	12.1	0.118	6126.02	32.4	6.24
Cyprus	19.429	87.00	19.4	0.120	11160.87	41.5	9.62
Czechia	18.195	3484.37	16.4	0.120	8376.2	33.5	10.14
Estonia	38.472	360.73	16.4	0.140	9070.52	36.9	11.52
Greece	22.678	1514.36	14.5	0.098	8564.79	36.9	8.82
Hungary	15.19	1689.83	10.7	0.108	5377.33	35.7	6.82
Italy	19.006	15189.12	29.4	0.123	14544	33	7.28
Latvia	43.316	104.42	12.2	0.125	6863.82	34.5	6.16

Country	Energy - renewable sources	BERD	LaborCost	DESI	Net Earnings	Employment - knowledge-intensive	CO ₂ Emissions
Lithuania	29.599	334.85	13.1	0.130	7440.76	35.9	8.58
Malta	13.404	72.74	14	0.150	10547.63	43.1	4.38
Poland	16.873	6285.63	12.5	0.103	6395.75	31.2	11.02
Portugal	34.677	2572.40	16.1	0.125	8643.46	36.7	5.84
Romania	24.14	810.72	9.5	0.078	4524.48	23.9	5.86
Slovakia	17.501	615.05	15.6	0.108	6319.58	33.9	6.99
Slovenia	22.937	846.46	23.1	0.133	8814.35	39.7	7.9
Spain	22.116	10901.73	23.5	0.153	13205.59	34.6	6.37

Source: authors' own calculations.

The few countries that differ slightly from one another in terms of sustainability are Latvia, which has the largest share of energy derived from renewable sources (43.316%), and Malta, which has the lowest GHG emissions (4.38), although having relatively similar values. This last cluster, being the most numerous, records low values in terms of the level of technical and innovative development, having an average value of the DESI index of only 0.119 and an average of expenses in the R&D of 2695.82 million euros.

5. Conclusions

Digitalization is playing a major role in shaping labor markets and the sustainable development of our society, as technologies are worldwide integrated into everyday life and digitally skilled workers are required more and more on the labor market. Having this into consideration, our paper carried out a cluster analysis among the 27 EU member states to investigate how digitalization has influenced the EU labor market so far and to pinpoint the main similarities among the EU countries in terms of digitalization, economic development and sustainability.

Using a set of seven relevant indicators, we managed to group the countries into three clusters and to differentiate between digitalized and sustainable economies and the least digitalized or with less sustainable economic developments countries. Among the most digitalized and green economies, having high labor costs, high net earnings, as well as the highest percentage of renewable energy consumption and the lowest greenhouse gas emissions, Sweden stands out with best performances. From the cluster with digitalized but less sustainable and green economies, Luxembourg ranks first in terms of labor costs, net earnings and percentage of employment in knowledge-intensive activities. Finally, the third cluster was the most numerous, with low technical and innovative developed countries, where only a few countries differ slightly from one another in terms of sustainability (namely Latvia with the largest share of energy derived from renewable sources and Malta with the lowest GHG emissions).

The main limitations of our investigation are twofold. First, the cluster analysis can only reflect a static image of the current digital labor markets in the EU, limited to the last available year for the dataset. Second, a trade-off between total number of variables in the

dataset and the significance of the cluster analysis results was made. Even so, we believe that the limited number of variables considered in our analysis were relevant to illustrate how the EU economies are currently shaping in terms of digitalization, sustainability and economic and green development.

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References

- He, M. and Pérez Estébanez, R., 2023. Exploring the impact of R&D intensity, human capital, patents, and brand value on business performance in small and medium enterprises (SMEs), *Economic Research*, 36:1, 2181839, DOI: 10.1080/1331677X.2023.2181839, <<https://www.tandfonline.com/doi/full/10.1080/1331677X.2023.2181839>>
- Imran, M., Liu, X., Wang, R., Saud, S., Zhao, Y. and Khan, M.J., 2022. The Influence of Digital Economy and Society Index on Sustainable Development Indicators: The Case of European Union. *Sustainability*, 14, 11130. <<https://doi.org/10.3390/su141811130>>
- Khan, M.A., Bin, M., Wang, C., Bilal, H., Khan, A. A., Ullah, I., Iqbal, A. and Rahman, M.U., 2023. Impact of R&D on Firm Performance: Do Ownership Structure and Product Market Competition Matter? *Original Research*, SAGE Open, 1-17, DOI: 10.1177/21582440231199560. <<https://journals.sagepub.com/doi/full/10.1177/21582440231199560>>
- Kovács, T.Z., Bittner, B., Nagy, A.S. and Nábrádi, A., 2022. Digital transformation of human capital in the EU according to the DESI index, *Issues in Information Systems*, Volume 23, Issue 4, pp. 293-311, DOI: https://doi.org/10.48009/4_iis_2022_125
- Kuzior, A., Vyshnevskiy, O. and Trushkina, N., 2022. Assessment of the Impact of Digitalization on Greenhouse Gas Emissions on the Example of EU Member States, *Production Engineering Archives*, 28(4), pp. 407-419, ISSN 2353-7779 (online) <<https://sciendo.com/article/10.30657/pea.2022.28.50>>
- Laitsou, E. and Xenakis, A., 2023. The impact of digital development on human well-being and vice versa, *32nd European Conference of the International Telecommunications Society (ITS)*: "Realising the digital decade in the European Union – Easier said than done?", Madrid, Spain, 19th-20th June 2023, International Telecommunications Society (ITS), Calgary, <<https://www.econstor.eu/bitstream/10419/277995/1/Laitsou-Xenakis.pdf>>
- Li, X.; Liu, J. and Ni, P., 2021. The Impact of the Digital Economy on CO₂ Emissions: A Theoretical and Empirical Analysis. *Sustainability*, 13, 7267. <<https://doi.org/10.3390/su13137267>>
- Stancu, S., 2022. *Analiza datelor în mediul R. Teorie și aplicații*. Editura ASE.
- Sultanova, G., Djuraeva, R. and Turaeva, S., 2022. The impact of the digital economy on renewable energy consumption and generation: evidence from European Union Countries. In *The 6th International Conference on Future Networks & Distributed Systems (ICFNDS '22)*, December 15, 2022, Tashkent, TAS, Uzbekistan. ACM, New York, NY, USA, 11 pg. <<https://doi.org/10.1145/3584202.3584218>>