**PROBLEMY EKOROZWOJU – PROBLEMS OF SUSTAINABLE DEVELOPMENT**

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# Clustering of European Countries by Strategies of Digitalization of their Business Environment

## Klastrowanie krajów europejskich według strategii cyfryzacji ich środowiska biznesowego

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## Abstract

This study examines the relationship between the digitalization of the business environment and the external institutional environment in the countries of the European Region, focusing on the hypothesis that countries with more favorable institutional conditions, as measured by the Legatum Prosperity Index, exhibit higher levels of business digitalization. Extending the analysis beyond traditional economic indicators such as GDP, the study examines how governance systems, public welfare and technological innovation together influence digital transformation in a variety of business environment. The results reveal different digitalization strategies in clusters of countries, each shaped by their unique macroeconomic and institutional contexts. Countries with developed digital environment are leading the way in integrating digital technologies into various sectors, while others focus on modernizing traditional industries and improving infrastructure. An important link between digitalization and economic security of business was identified, emphasizing that reliable digital infrastructures contribute to increased economic sustainability and competitiveness. Future research should examine longitudinal studies, sectorial analysis, and the impact of policy frameworks to better understand how digitalization strategies evolve and affect economic security. In addition, bridging the digital divide within and between countries remains important to promote equitable access to technology and maximize business opportunities. Special attention is paid to the connection between digital transformation and the UN Sustainable Development Goals, as business environment digitalization directly contributes to achieving SDG 8 (Decent Work and Economic Growth), SDG 9 (Industry, Innovation, and Infrastructure), SDG 10 (Reduced Inequalities), and SDG 17 (Partnerships for the Goals). Cluster analysis helps identify regional disparities and determine directions for balanced digital development in accordance with sustainable development principles Ultimately, this research aims to inform policymakers and business leaders about creating an enabling environment that uses digital technologies to promote economic growth, sustainability and competitive advantage.

**Key words:** digital transformation, European countries, digital economy, business economic security, business environment, digital strategy

## Streszczenie

W niniejszym badaniu analizuje się związek między digitalizacją środowiska biznesowego a zewnętrznym otoczeniem instytucjonalnym w krajach europy, skupiając się na hipotezie, że kraje o korzystniejszych warunkach instytucjonalnych, mierzonych indeksem dobrobytu Legatum, wykazują wyższy poziom digitalizacji biznesu. Rozszerzając analizę poza tradycyjne wskaźniki ekonomiczne, takie jak PKB, badanie bada, w jaki sposób systemy zarządzania, dobrobyt publiczny i innowacje technologiczne łącznie wpływają na transformację cyfrową w różnych środowiskach biznesowych. Wyniki ujawniają różne strategie digitalizacji w klastrach krajów, z których każdy jest kształtowany przez swój unikalny kontekst makroekonomiczny i instytucjonalny. Kraje z rozwiniętym środowiskiem cyfrowym są liderami w integrowaniu technologii cyfrowych z różnymi sektorami, podczas gdy inne koncentrują się na modernizacji tradycyjnych gałęzi przemysłu i ulepszaniu infrastruktury. Zidentyfikowano ważne powiązanie między digitalizacją a bezpieczeństwem ekonomicznym biznesu, podkreślając, że niezawodna infrastruktura cyfrowa przyczynia się do zwiększonej zrównoważoności gospodarczej i konkurencyjności. Przyszłe badania powinny zbadać badania longitudinalne, analizę sektorową i wpływ ram politycznych, aby lepiej zrozumieć, w jaki sposób strategie digitalizacji ewoluują i wpływają na bezpieczeństwo ekonomiczne. Ponadto, likwidacja przepaści cyfrowej wewnątrz i między krajami pozostaje ważna dla promowania równego dostępu do technologii i maksymalizacji możliwości biznesowych. Szczególną uwagę zwraca się na związek między transformacją cyfrową a Celami Zrównoważonego Rozwoju ONZ, ponieważ cyfryzacja środowiska biznesowego bezpośrednio przyczynia się do osiągnięcia SDG 8 (Godna praca i wzrost gospodarczy), SDG 9 (Przemysł, innowacje i infrastruktura), SDG 10 (Zmniejszenie nierówności) i SDG 17 (Partnerstwa na rzecz celów). Analiza klastrów pomaga zidentyfikować dysproporcje regionalne i określić kierunki zrównoważonego rozwoju cyfrowego zgodnie z zasadami zrównoważonego rozwoju. Ostatecznie, badania te mają na celu poinformowanie decydentów i liderów biznesowych o tworzeniu sprzyjającego środowiska, które wykorzystuje technologie cyfrowe w celu promowania wzrostu gospodarczego, zrównoważonego rozwoju i przewagi konkurencyjnej.

**Słowa kluczowe:** transformacja cyfrowa, kraje europejskie, gospodarka cyfrowa, bezpieczeństwo ekonomiczne przedsiębiorstw, środowisko biznesowe, strategia cyfrowa

## 1. Introduction

In recent years, the rapid advancement of digital technologies has transformed business landscapes across the globe, particularly within the European region. As economies increasingly pivot towards digitalization, understanding the multifaceted nature of this transformation has become critical. This research focuses on the hypothesis that European countries demonstrating more favorable external institutional environments – measured by the Legatum Prosperity Index – exhibit higher levels of business digitalization. By expanding the analytical lens beyond traditional economic indicators like GDP, this study aims to uncover the interplay between societal well-being, governance frameworks, and digital transformation efforts within various business environments across Europe (The Legatum Prosperity Index, 2023).

The Legatum Prosperity Index serves as a valuable tool in this exploration, capturing a range of multidimensional factors, including governance, education, innovation, and economic stability, that contribute to an enabling environment for digital business growth (Nogueira & Munita, 2019). The analysis of digitalization strategies across diverse clusters of countries reveals varying approaches to integrating technology into business ecosystems, reflecting distinct national priorities and challenges. As digitalization becomes integral to enhancing economic security, it is essential to understand how these strategies influence the resilience, competitiveness, and long-term sustainability of businesses (Voroniuk & Otenko, 2021).

Digital transformation of business environment has become a key factor in achieving the UN Sustainable Development Goals by 2030. According to the World Economic Forum, digitalization can accelerate the achievement of up to 70% of SDG targets, particularly in the areas of economic growth, innovation, and social equality.

This study is structured to provide insights into the specific digitalization models employed by different European countries and how these models are influenced by their unique macroeconomic and institutional contexts. By examining the strategies that countries adopt to foster digitalization, this research will offer a nuanced understanding of the role digital transformation plays in shaping the economic security of businesses within the European region. Ultimately, this work seeks to inform policymakers and business leaders on how to create supportive environments that leverage digital technologies for enhanced economic resilience and competitive advantage.

## 2. Literature Review

Business environment digitalization at both global and regional levels is increasingly acknowledged as a critical driver in enhancing economic competitiveness and societal well-being. The research methodology included a comprehensive review of academic literature, government reports, and industry publications, which help to understand

the diversity of strategic approaches to digitalizing the business environment being implemented by various European countries.

Digitalization is a defining characteristic of the modern world, raising important questions about its potential to drive economic development. Digital transformation serves as a catalyst for economic development evolution has long been acknowledged, resulting in significant shifts in economies over the years (Georgescu et al., 2023). Within the context of digitalization research, it is noteworthy that both digitalization and good governance are key drivers of economic growth in developing countries. However, their interaction may have a negative impact, indicating possible challenges when governance structures fail to keep pace with digital transformation. Additionally, openness to international trade plays a positive role in economic development by providing countries with access to new markets and technologies. Thus, to maximize economic growth, it is essential to balance digitalization, governance practices, and trade strategies, which will require well-grounded policy decisions and institutional reforms (Van Bon, 2021).

The Eurostat database on the *Digital Economy and Society* offers a comprehensive foundation for assessing digitalization in Europe. It highlights key indicators such as internet usage, digital skills, artificial intelligence adoption, and e-commerce participation, allowing for comparative analysis of the digital landscapes across different European countries (Eurostat, 2023). These statistics are invaluable for policymakers and researchers, as examining them over time can reveal the strengths and weaknesses of national digitalization strategies for the business environment.

As the basis of this research, the Legatum Prosperity Index was selected, which assesses overall well-being. Higher index rankings correlate with effective digital technology integration, demonstrating a strong correlation between digital development and economic growth (Legatum Institute, 2023). The presence of this connection emphasizes the importance of defining and implementing robust digital strategies to promote not only economic development but also social cohesion.

European countries demonstrate diverse sectorial priorities in their digitalization approaches. For example, in the healthcare sector, Belgium's National Convergence Plan outlines ambitious goals for integrating artificial intelligence to improve patient care, reflecting a broader trend in which digital technologies are seen as key factors for enhancing service quality (Belgium's National AI Plan, 2022). This example demonstrates that, while the primary focus is on improving healthcare services, the accompanying changes have also affected the business environment operating within this sector – so called indirect digitalization of business environment. In other words, business environment digitalization occurs through incremental technical and technological advances across different economic sectors.

Another example of mediated digitalization of the business environment is Spain's focus on digitizing its agricultural sector, which demonstrates how targeted strategies can address specific industry challenges while fostering innovation (Sadjadi & Fernández, 2023).

On the other hand, there are countries in the European region that have chosen other sectors as a priority for digitization, in particular, such as education and workforce development. Digital education is a critical area identified as a priority for investment by countries such as Finland and Denmark. These countries' experiences provide valuable insights for the entire European region, as evidenced by the fact that the United Nations has recognized these countries for their exemplary e-government services, which often include educational technology initiatives aimed at improving the digital skills of the workforce (UN, 2022 ). It can be said that these countries are creating strategic conditions for the next generation to be more ready for the digital economy, which only deepens with the passage of time.

Countries such as Ireland and Malta are positioning themselves as centers of innovation, attracting fintech companies and digital startups. Ireland's digital exports have now become a significant part of its economy, one of the largest in the world (Whelan, 2024). Malta's emphasis on being a leading fintech jurisdiction demonstrates how a focused regulatory framework can support the growth of the sector (Times & Woffenden, 2024).

However, European countries face common challenges despite their progress on the way to digitalization. Significant challenges persist, including cybersecurity threats, data privacy concerns, and digital accessibility gaps (Hungary - National Digital Decade Strategic Roadmap 2024).

The assessment of European digitalization strategies unveils a multifaceted landscape. While some countries lead in certain sectors, such as healthcare and fintech, others excel in education and public administration. Continued research and adaptive policies will be necessary to navigate the ongoing digital transformation, ensuring that digitalization serves as a foundation for sustainable growth and societal development in Europe.

The literature review informed the primary research objective and a hypothesis was put forward.

This research aims to assess the effectiveness of business digitalization strategies across European countries by examining the interrelation between digital transformation implementation and institutional environment factors, with particular focus on their impact on business development and economic security.

Hypothesis: Countries with more favorable institutional environments, as measured by the Legatum Prosperity Index rather than GDP, demonstrate higher levels of business digitalization success, suggesting that

comprehensive public welfare and governance systems are critical determinants of effective digital transformation in business environments.
This hypothesis proposes that an integrated assessment of external and internal factors, going beyond purely economic indicators such as GDP, provides a more nuanced understanding of how digitalization is progressing in different European region countries. The Legatum Prosperity Index takes into account multidimensional factors (such as governance, education and innovation) that are critical to fostering an enabling environment for digital business growth.

## 3. Methodology

The indicators chosen to achieve the goal of the study are aimed at obtaining a comprehensive understanding of what conditions are most favorable for the digital development of the business core and what can restrain this process in various countries of the European region. The indicator selection framework is based on two institutional environments, external and internal.
The external environment framework encompasses conditions that shape business operations. These conditions can both contribute to its development and digitization and hinder them. The practice of researching the effectiveness of GDP-based assessment of national economic measures is common, but In this research, it is proposed to use the data of the Prosperity Index instead of GDP, as an exclusively economic indicator, which more fully and multifaceted reflect the conditions of doing business. Within the framework of the internal environment, it was investigated the implementation of digitization that measures directly at the enterprise.
As a result were obtained data that allowed the clustering of the countries of the European region in accordance with their digitization results (Table 1).

Table 1. Indicators for Clustering European Countries by Digitalization Level Indicator System and Justification for Cluster Analysis of Digital Transformation across European Countries, (prepared by authors according to: (Eurostat – Database, 2023; The Legatum Prosperity Index, 2023)

| | Indicator | Justification of the choice |
|---|---|---|
| INDICATORS OF THE INTERNAL ENVIRONMENT | Enterprises use at least one of the AI technologies | The main indicator of digital transformation of business. The use of artificial intelligence allows you to increase business efficiency, reduce costs and open new opportunities for optimizing business processes. |
| | Enterprises using Customer Relationship Management (CRM) software | CRM systems allow companies to more effectively manage relationships with customers, improve service and increase loyalty. This is critical for business and helps improve sales management and marketing. |
| | Enterprises using Business Intelligence (BI) software | BI helps businesses make more informed decisions. The use of BI-analytics methods helps to more fully investigate business processes, which is especially important in the conditions of a complex competitive environment. This indicator provides information on the business's use of digital analytics tools to improve its strategy. |
| | Enterprises with e-commerce sales | E-commerce technologies are the main component of the digital economy. The presence of online sales demonstrates the degree of business integration into the digital economy and its ability to adapt to modern business conditions. |
| INDICATORS OF THE EXTERNAL ENVIRONMENT | Investment Environment | The investment climate is a reflection of favorable business conditions in the country. A good investment climate promotes the development of new enterprises and the introduction of innovations, which directly affects digitalization. |
| | Enterprise Conditions | Demonstrates the general conditions of doing business, including taxes, regulatory barriers and the level of corruption. Its importance is due to the fact that unfavorable business conditions can restrain the development and implementation of new digital technologies |
| | Infrastructure and Market Access | Developed infrastructure and access to markets support digitalization, as access to high-speed Internet, logistics centers, international markets encourages the implementation of digital technologies, in particular, electronic sales, the use of AI and AI tools |
| | Economic Quality | This indicator includes an assessment of various aspects of the economy, such as stability, diversification, poverty and inequality. Companies operating in a high-quality economy have more opportunities for growth and innovation. |

Table 1 presents the extensive information about every indicator including an justification. Indicators are divided into two pools: internal and external, each pool consists of four indicators. Sources of information about selected indicators and information about their calculation is presented in Table 2.

Table 2. Sources and Calculation Methods of European Countries' Digitalization Indicator, prepared by authors from: (Eurostat – Database, 2023; The Legatum Prosperity Index, 2023)

| Indicator | Data Collection Methods | Calculation |
|---|---|---|
| Source: Eurostat | | |
| Enterprises using at least one of the AI technologies | Data is collected through surveys by national statistical offices | The percentage is calculated by dividing the number of enterprises that reported using at least one AI technology by the total number of enterprises surveyed. |
| Enterprises using Customer Relationship Management (CRM) software | Surveys are conducted to gather information on the use of CRM systems | The percentage of enterprises using CRM software is obtained by dividing the number of enterprises that reported using CRM by the total number of respondents. |
| Enterprises using Business Intelligence (BI) software | Collected through industry surveys or digital economy reports | This is determined by the percentage of enterprises that report the use of BI software |
| Enterprises with e-commerce sales | Measured by asking enterprises if they conduct sales through digital platforms or websites | The percentage of enterprises engaged in e-commerce is calculated by dividing the number of businesses that have made e-commerce sales by the total number of enterprises surveyed |
| Source: Legatum Prosperity Index | | |
| Investment Environment (pillar) | Data is collected from international organizations such as the World Bank, IMF, OECD, UNCTAD and private data providers. Additionally, national statistics offices and central banks may provide specific investment-related | Data is normalized to ensure comparability between countries. The normalized scores for each indicator are aggregated using a weighted system to reflect the relative importance of each aspect of the investment environment. The overall pillar score is then calculated by summing up the weighted indicators |
| Enterprise Conditions (pillar) | Data comes from institutions like the World Bank's reports, the Heritage Foundation's Index of Economic Freedom, and the Global Entrepreneurship Monitor (GEM). National statistics are also utilized to assess the conditions for entrepreneurship. | Individual indicators are scored on a standard scale (typically 0 to 100), where higher scores represent a more conducive business environment. These scores are then weighted based on their importance to overall business conditions and aggregated to give an overall score for enterprise conditions. |
| Infrastructure and Market Access (pillar) | This data is typically drawn from global infrastructure reports. National transport, energy, and digital infrastructure statistics are also considered | Scores for individual infrastructure indicators are calculated by comparing a country's performance against the best and worst-performing countries. Weighted averages of these scores are then used to calculate the overall pillar score. More critical infrastructure factors (e.g., access to markets, digital infrastructure) may receive higher weights in the final calculation. |
| Economic Quality (pillar) | Data is sourced from international databases like the World Bank, International Monetary Fund (IMF), OECD, and national statistical agencies. Economic quality is evaluated through macroeconomic indicators and qualitative assessments of the economy. | Macroeconomic indicators are collected and normalized to ensure comparability across countries. Scores are then weighted based on the relative importance of each indicator to the quality of the economy (e.g., GDP growth and employment may have higher weights). The normalized and weighted scores are aggregated to create an overall score for the Economic Quality pillar. |

Table 2 presents basic information about data sources for each selected indicator and methods of their calculation. All information is collected from official sources and is publicly available.

During the process of collecting the necessary information, it was found that, according to Eurostat, not all indicators are presented for all countries of the European Union for the year 2023. Therefore, for the study were selected those countries for which calculations were presented for each of the indicators. Countries selected for research: Belgium, Bulgaria, Czech Republic, Denmark, Germany, Estonia, Ireland, Greece, Spain, France, Croatia, Italy, Cyprus, Latvia, Lithuania, Hungary, Malta, Netherlands, Austria, Poland, Portugal, Slovenia, Slovakia, Finland, Sweden. After the dataset was formed it became possible to identify the countries that received the highest and lowest values for each indicator:

Among the Enterprises using at least one of the AI technologies (%), Denmark leads with the highest percentage (15.2%), followed closely by Finland (15.1%). On the lower end, Bulgaria (3.6%), Hungary (3.7%), and Poland (3.7%) have the lowest values.

For Enterprises using Customer Relationship Management (CRM) software (%), Sweden (49.4%) and Austria (48.4%) rank at the top among all studied countries. Conversely, Slovenia (10.1%) and the Czech Republic (10.5%) are at the bottom of the list.

Regarding Enterprises using Business Intelligence (BI) software (%), Denmark (40.3%) and Finland (38.9%) stand out with the highest percentages. In contrast, Bulgaria (4.2%) and Greece (8.7%) demonstrated the weakest performance in 2023.

The results for Enterprises with e-commerce sales (%) reveal interesting insights. Lithuania leads this category with a share of 38.9%, followed by Sweden in second place (38.1%). Meanwhile, France (16.8%) and Bulgaria (15.1%) are at the lower end of the spectrum.

In the Investment Environment (overall pillar score), Finland ranks first (2), and the Netherlands second (3). The worst conditions for investment in 2023 were observed in Greece (69) and Croatia (51).

For Enterprise Conditions (overall pillar score), Germany (6) and the Netherlands (9) achieved the highest scores, while Hungary (96) and Slovakia (59) had the lowest scores.

The Infrastructure and Market Access (overall pillar score) shows the best conditions in the Netherlands (3) and Germany (5), whereas Bulgaria (52) and Hungary (44) scored the lowest.

Finally, regarding Economic Quality (overall pillar score), Ireland ranks first among the studied countries, followed by Denmark in second place (7). The lowest quality economies were observed in Greece (86) and Bulgaria (43).

For further calculations, each selected indicator was given an abbreviated name (Table 3).

Table 3. Initial Digitalization Indicators of European Countries for Clustering, own elaboration

| | |
|---|---|
| Enterprises use at least one of the AI technologies | X1 |
| Enterprises using Customer Relationship Management (CRM) software | X2 |
| Enterprises using Business Intelligence (BI) software | X3 |
| Enterprises with e-commerce sales | X4 |
| Investment Environment | X5 |
| Enterprise Conditions | X6 |
| Infrastructure and Market Access | X7 |
| Economic Quality | X8 |

The first step was to detect outliers in the finished dataset using Kolmogorov-Smirnov Goodness-of-Fit Test. The results demonstrated the low standard deviation, which indicates data stability, which is a positive sign of data reliability.

Next step to undertaking a cluster analysis, it is widely advised to standardize the data, because the indicators selected for analysis are presented in different units of measurement. This is a vital step, as clustering algorithms of hierarchical clustering, frequently rely on distance measures like Euclidean distance. Presented in Table 4 dataset includes variables that have been measured on disparate scales, those with larger ranges may exert a disproportionate influence on the results. Standardization ensures that each variable contributes equally to the clustering process, (Nogueira, A., Munita, C. S., 2019). The procedure of standardization of variables takes into account the current conditions for the selection of observations and the weights of observations. In standardization, all values of the selected variables are replaced by standard values, which are calculated as:

$$\text{Standard value} = (\text{original value} - \text{mean})/\text{standard deviation}$$

Table 4. Statistical Characteristics of Digital Transformation Indicators across European Countries, own elaboration

| European Countries | Indicators coded names of indicators | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 |
| Belgium | 1,432 | 0,01 | 1,487 | 0,817 | -1,05 | -0,38 | -0,67 | -0,15 |
| Bulgaria | -1,195 | 1,218 | -1,411 | -1,495 | 1,45 | 0,82 | 1,72 | 0,74 |
| Czech Republic | -0,603 | -1,488 | -0,692 | -0,166 | -0,16 | 0,37 | 0,90 | -0,70 |
| Denmark | 1,792 | -0,617 | 2,463 | 1,496 | -1,23 | -1,14 | -1,22 | -1,26 |
| Germany | 0,865 | 1,49 | -0,338 | -0,512 | -0,45 | -1,23 | -1,49 | -1,04 |
| Estonia | -0,783 | 0,104 | -0,155 | -0,498 | -0,04 | -0,47 | 0,36 | -0,87 |
| Ireland | -0,062 | -0,654 | 0,424 | 1,274 | -0,87 | -0,78 | -0,19 | -1,43 |
| Greece | -1,092 | 0,104 | -0,928 | -0,816 | 2,40 | 0,68 | -0,05 | 3,13 |
| Spain | 0,247 | -1,048 | 0,07 | 1,066 | -0,28 | -0,30 | -0,94 | 1,24 |
| France | -0,603 | 0,198 | -0,714 | -1,259 | -0,63 | -0,70 | -0,74 | 0,02 |
| Croatia | -0,088 | -0,177 | -0,574 | 0,596 | 1,33 | 2,42 | 0,22 | 0,97 |
| Italy | -0,834 | -0,654 | 0,027 | -0,941 | 0,62 | 0,10 | 0,97 | 0,19 |
| Cyprus | -0,912 | -0,673 | 0,371 | -0,332 | 0,50 | -0,07 | 0,56 | 0,69 |
| Latvia | -0,963 | 0,291 | -0,853 | -0,858 | 0,62 | 0,10 | 0,97 | 0,19 |
| Lithuania | -0,86 | -0,926 | -0,617 | 1,8 | 0,26 | 0,02 | 1,04 | 0,08 |
| Hungary | -1,169 | 0,376 | -1,014 | -0,387 | 0,97 | 2,77 | 1,18 | -0,04 |
| Malta | 1,277 | -0,551 | 0,499 | 0,9 | 0,56 | -0,16 | 0,77 | -0,65 |
| Netherlands | 1,329 | 1,2 | 1,326 | 0,471 | -1,53 | -1,10 | -1,63 | -1,09 |
| Austria | 0,659 | 2,061 | 0,049 | 0,014 | -0,75 | -0,65 | -0,87 | -0,26 |
| Poland | -1,169 | 0,31 | -0,735 | -1,093 | 0,79 | 0,51 | 0,83 | 0,35 |
| Portugal | -0,088 | 0,198 | -0,595 | -1,093 | 0,02 | -0,12 | -0,60 | 0,91 |
| Slovenia | 0,814 | -1,525 | -0,456 | -0,276 | 0,08 | -0,03 | 0,15 | 0,30 |
| Slovakia | -0,319 | -0,561 | -0,467 | -1,038 | 0,32 | 1,13 | 1,24 | 0,41 |
| Finland | 1,766 | -0,842 | 2,313 | 0,637 | -1,58 | -0,96 | -1,15 | -0,54 |
| Sweden | 0,556 | 2,155 | 0,521 | 1,689 | -1,35 | -0,83 | -1,35 | -1,20 |

After the dataset was normalized next step is correlation analysis, which is a useful tool for assessing relationships between variables and detecting multicollinearity, which can distort clustering results. In the event of a high degree of correlation between specific variables, these may exert a dominant influence on the clustering algorithm, resulting in the formation of groupings that are skewed in their composition. By conducting a correlation analysis initially, it is possible to identify variables that are redundant and either remove or combine them. This ensures that the clustering process reflects the true structure of the data, rather than being influenced by a few dominating variables. This step facilitates the enhancement of the precision and intelligibility of cluster analysis outcomes (Qian et al., 2022).

Table 5. Correlation Matrix of Digitalization Indicators for European Countries, own elaboration

| | X1 | X2 | X3 | X4 | X5 | X6 | X7 | X8 |
|---|---|---|---|---|---|---|---|---|
| X1 | 1 | | | | | | | |
| X2 | ***0,03651*** | 1 | | | | | | |
| X3 | **0,818088** | ***-0,09684*** | 1 | | | | | |
| X4 | 0,567238 | -0,13608 | 0,6109 | 1 | | | | |
| X5 | **-0,72175** | -0,12192 | **-0,73723** | -0,51244 | 1 | | | |
| X6 | -0,56836 | -0,14047 | -0,58962 | -0,31133 | **0,742794** | 1 | | |
| X7 | **-0,72088** | -0,33007 | -0,61668 | -0,41078 | **0,725802** | **0,677557** | 1 | |
| X8 | -0,48763 | -0,15647 | -0,50348 | -0,42969 | **0,752997** | 0,505617 | 0,311371 | 1 |

*Note: Strongest positive and negative correlation* – **Bold style**
*Weakest positive and negative correlation* – ***Cyrillic bold style***

## 4. Results & Discussion

### *4.1. Retrospective review of countries development according to the chosen indicators*

The indicators selected for clustering shown in Table 1 were calculated for the selected countries at different times. In our opinion, for retrospective review it is optimal to compare the values of these indicators in 2023 compared to 2020 as a year, based on available information. Exceptions are such indicators as *Enterprises using Customer Relationship Management (CRM) software (as of 2023)* and *Enterprises using Business Intelligence (BI) software, which were calculated exclusively for 2023*.

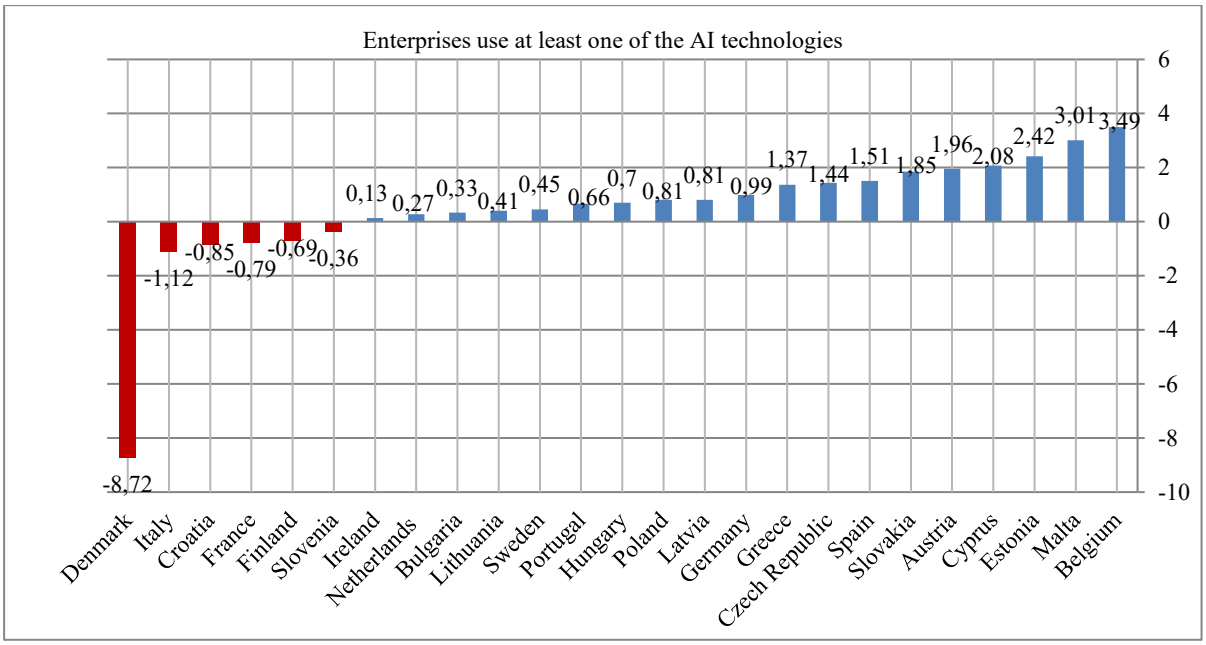


Figure 1. Visualization of the comparison of countries by *Enterprises use at least one of the AI technologies* indicator, 2023 vs. 2020 (for Belgium and Greece starting from 2021), prepared by authors from: (Eurostat – Database, 2023)

As can be seen from the visualization presented in Fig. 2, the main positive results are observed in such countries as Belgium (+3.49), Malta (+3.01), Estonia (+2.42), Cyprus (+2.08). In these countries, the percentage of businesses using AI is increasing. Denmark (-8.72) shows a serious decrease in the number of enterprises that implement AI, with negative dynamics also visible in France, Slovenia, Italy. Fig. 2 shows the results of comparing the achievements of countries according to the indicator *Enterprises with e-commerce sales (All activities (except agriculture, forestry and fishing, and mining and quarrying), without financial sector*).

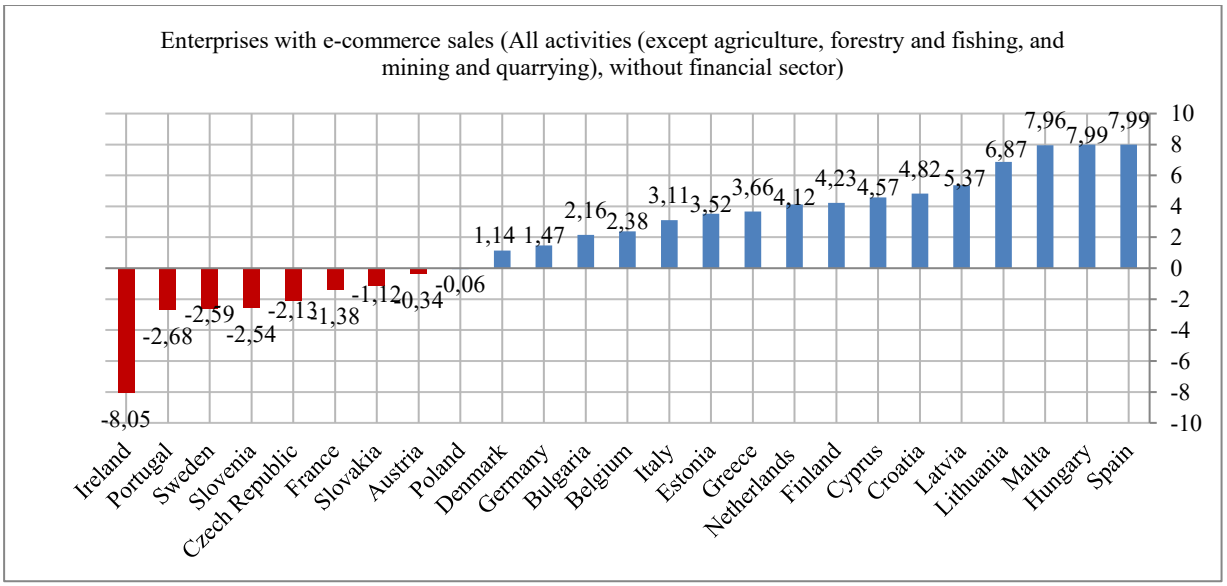


Figure 2. Visualization of the comparison of countries by *Enterprises with e-commerce sales (All activities (except agriculture, forestry and fishing, and mining and quarrying), without financial sector)* indicator, 2023 vs. 2020 (for Belgium and Greece starting from 2021), prepared by authors from: (Eurostat – Database, 2023).

E-commerce, as shown in Figure 2, also demonstrates both positive and negative trends. Thus, positive trends are demonstrated by countries in which the percentage of companies that implement e-commerce is increasing, the leaders are: Spain (+7.99), Hungary (+7.99), Malta (+7.96), Lithuania (+6.87). On the other hand, the countries where business is decreasing its participation in e-commerce: Ireland (-8.05), Portugal (-2.68), Sweden (-2.59) and others.

A comparative analysis of the developmental trajectories of chosen countries has been conducted using the pillars of the Legatum Prosperity Index. The following pillars were examined: 2023 vs. 2020: Investment Environment,

Enterprise Conditions, Infrastructure and Market Access, Economic Quality, and are presented in Figures 3 through 6, respectively. It is imperative to note that, in accordance with the methodology employed to calculate the Legatum Prosperity Index, the interpretation of the results presented in Figs. 3-6 should be conducted in accordance with the following principle: *negative values indicate positive results, and vice versa, high positive values indicate negative results*.

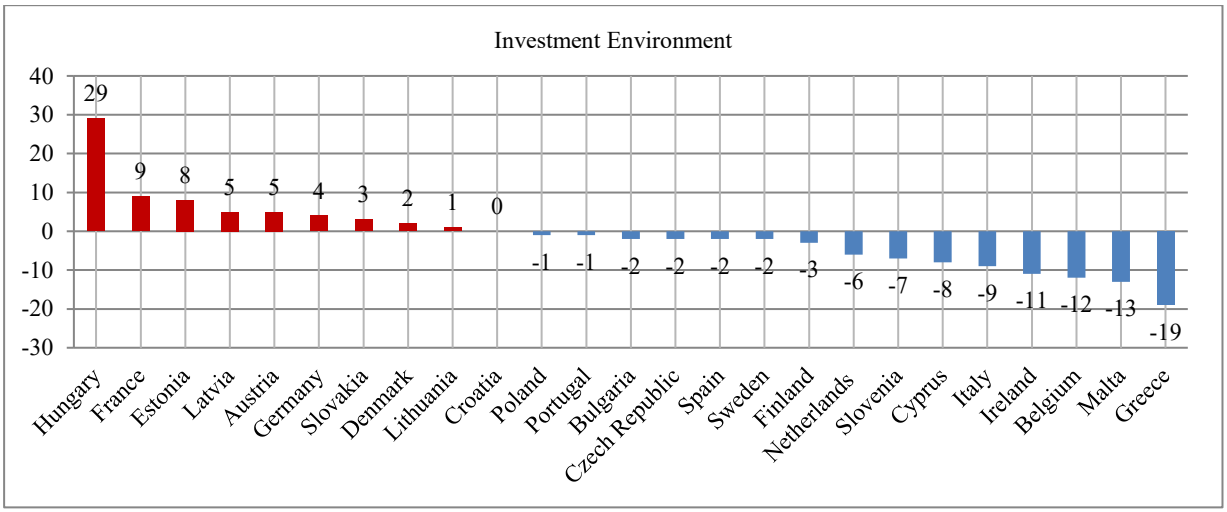


Figure 3. Visualization of the comparison countries by *Investment Environment* pillar of The Legatum Prosperity Index, 2023 vs. 2020, prepared by authors from: (The Legatum Prosperity Index, 2023; The Legatum Prosperity Index, 2020)

According to the data presented in Fig. 3, Greece (-19), Malta (-13), Belgium (-12), Ireland (-11) have significantly improved their investment environment. At the same time, over the 4 years studied, deterioration was observed in Hungary (+29), France (+9), and Estonia (+8). Fig. 4 shows the results of the comparison of countries by Enterprise Conditions, also comparing 2023 with 2020.

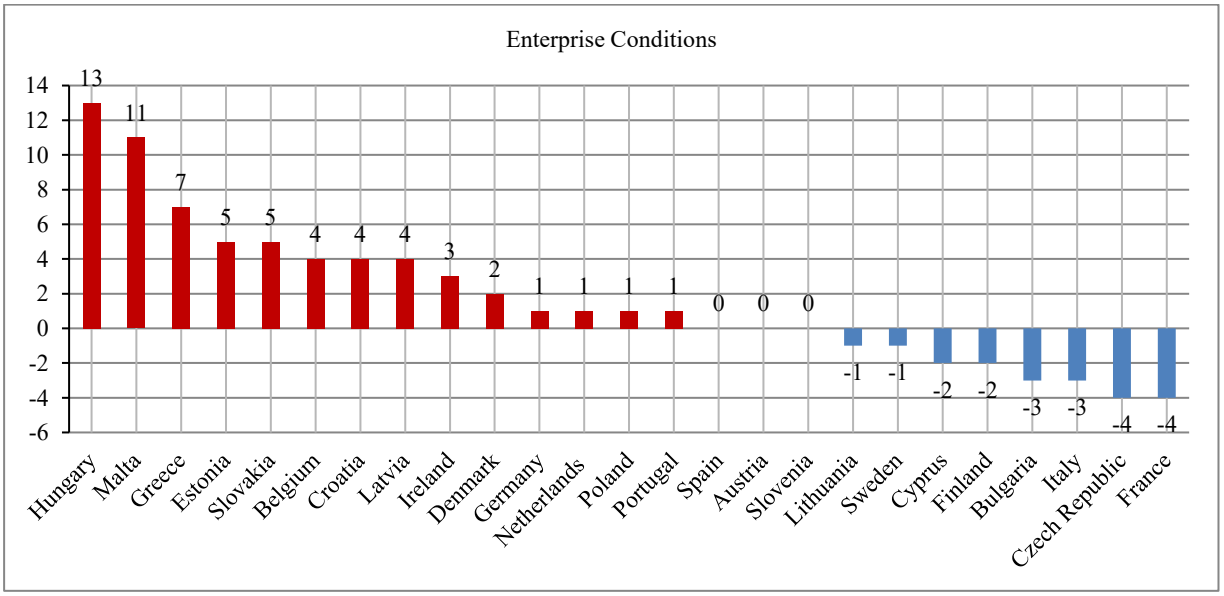


Figure 4. Visualization of the comparison of countries by *Enterprise Conditions* pillar of The Legatum Prosperity Index, 2023 vs. 2020, prepared by authors from: (The Legatum Prosperity Index, 2023; The Legatum Prosperity Index, 2020)

The results of the calculations presented in Figure 4 also demonstrate a deterioration of conditions for enterprises in Hungary (+13). Negative trends are also observed in Malta (+11) and Greece (+7). Conversely, positive developments are evident in France (-4), the Czech Republic (-4), Italy (-3), and Bulgaria (-3).

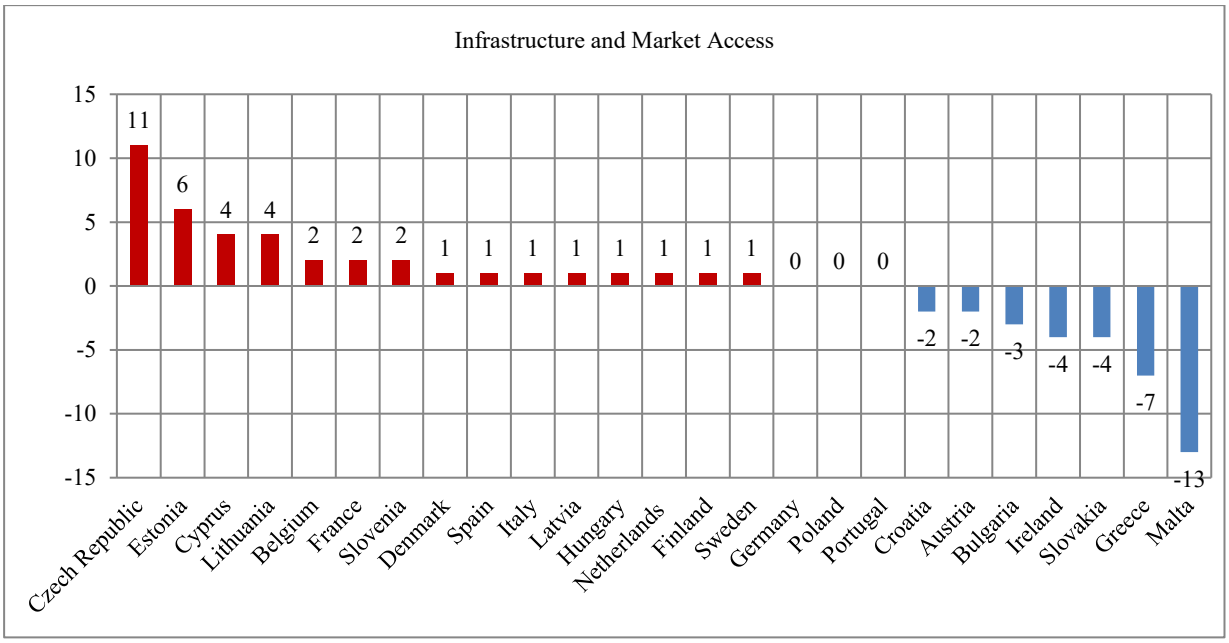


Figure 5. Visualization of the comparison of countries by *Infrastructure and Market Access* pillar of The Legatum Prosperity Index, 2023 vs. 2020, prepared by authors from:(The Legatum Prosperity Index, 2023; The Legatum Prosperity Index, 2020)

As illustrated in Figure 5, the Czech Republic (+11) exhibits the most unfavorable values, followed by Estonia (+6), Cyprus (+4), and Lithuania (+4), which also demonstrate this trend. Conversely, Malta (-13) exhibits a notable positive shift in Infrastructure and Market Access, a trend also observed in Greece (-7).

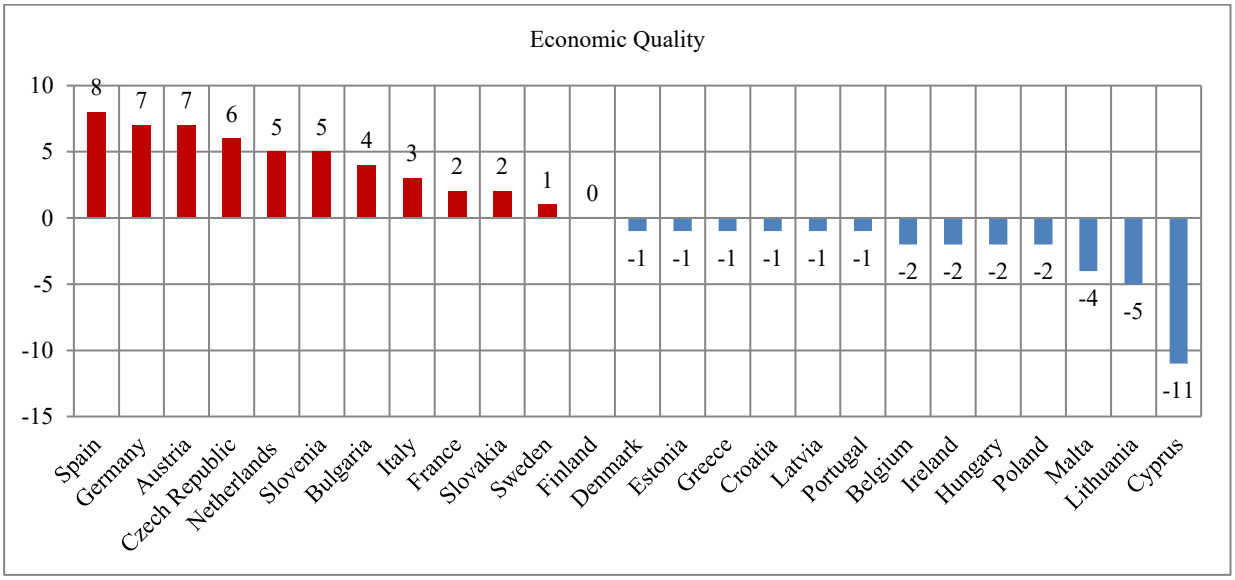


Figure 6. Visualization of the comparison of countries by *Economic Quality* pillar of The Legatum Prosperity Index, 2023 vs. 2020, prepared by authors from:(The Legatum Prosperity Index, 2023; The Legatum Prosperity Index, 2020)

As illustrated in Figure 6, the Quality of Economy in 2023 compared to 2020 has experienced the most significant decline in Spain (+8), Germany (+7), and Austria (+7). Cyprus (-11) has demonstrated the most positive value of this indicator, while Lithuania (-5) and Malta (-4) have shown a similar trend.

*4.2. The results of correlation analyses*

The results of correlation analyses (Table 5) presented negative and positive correlations between some indicators. For better understanding was prepared a dataset (Table 6).

Table 6. Strongest and Weakest Correlations Between Digital Transformation Indicators in European Countries

| Strongest Positive Correlation Results Variable Pairs | Indicator Decoding - Correlation Strength | Strongest Negative Correlation Results Variable Pairs | Indicator Decoding - Correlation Strength |
|---|---|---|---|
| X1 – X3<br>0,818088 | Enterprises use at least one of the AI technologies and Enterprises using Business Intelligence (BI) software | X3 – X5<br>-0,73723 | Enterprises using Business Intelligence (BI) software and Economic Quality |
| X5 – X8<br>0,752997 | Investment Environment and Economic Quality | X1 – X5<br>-0,72175 | Enterprises use at least one of the AI technologies and Economic Quality |
| X5 – X6<br>0,742794 | Investment Environment and Enterprise Conditions | X1 – X7<br>-0,72088 | Enterprises use at least one of the AI technologies and Infrastructure and Market Access |
| X5 – X7<br>0,725802 | Investment Environment and Infrastructure and Market Access | - | - |
| X5 – X8<br>0,752997 | Investment Environment and Economic Quality | - | - |
| X6 – X7<br>0,677557 | Enterprise Conditions Infrastructure and Market Access | - | - |
| Weakest Positive Correlation Results - Variable Pairs | Indicator Decoding - Correlation Strength | Weakest Negative Correlation Results - Variable Pairs | Indicator Decoding - Correlation Strength |
| X1 – X2<br>0,03651 | Enterprises use at least one of the AI technologies and Enterprises using Customer Relationship Management (CRM) software | X2 – X3<br>-0,09684 | Enterprises using Customer Relationship Management (CRM) software and Enterprises using Business Intelligence (BI) software |

As it described in the Table 6, there is a strong connection, both positive and negative, between indicators selected for the research.

Next step for achieving the aim of the study is clustering, which was made using STATISTA program (fig.7). For calculation the distances and merge clusters were used:

1. Distance Metric – Euclidean distance:

$$d(p,q) = \sqrt{\sum_{i=1}^{n}(p_i - q_i)^2}$$

Where,

d(p,q) - represents the Euclidean distance between two points $p$ and $q$

$p$ and $q$ - are the two points in n-dimensional space. Each point can be represented as a vector:

$p$=($p1$, $p2$,…., $p$n)

$q$=($q1$, $q2$,….. $q$n)

n - the number of dimensions

2. Ward's Method as a Linkage Criteria -i t aims to minimize the total within-cluster variance. When merging two clusters and $B$, the increase in total within-cluster variance is given by

$$\Delta = \frac{n_A n_B}{n_A + n_B} * d^2(A,B)$$

Where, $nA$ and $nB$ - are the number of observations in clusters $A$ and $B$, respectively, and d(A,B) is the distance between the centroids of the clusters.

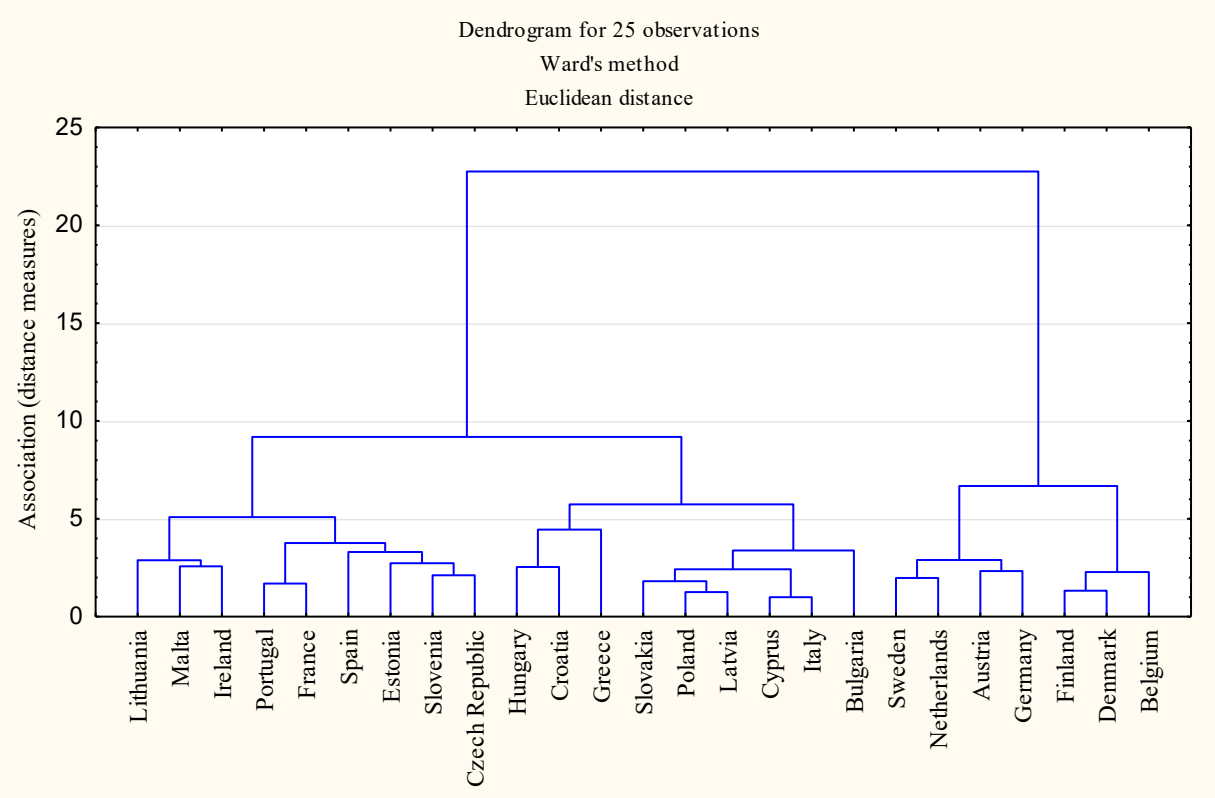


Figure 7. Visualization of the results of clustering countries by their results in digitalization

After obtaining the dendrogram, to verify the accuracy of the visual interpretation of the division into three clusters, an analysis was conducted using the K-means method:
Number of variables: 8
Number of observations: 25
Clustering method: K-means
Number of clusters: 3
The solution was obtained after 2 iterations, and the corresponding graph is presented in fig. 8.

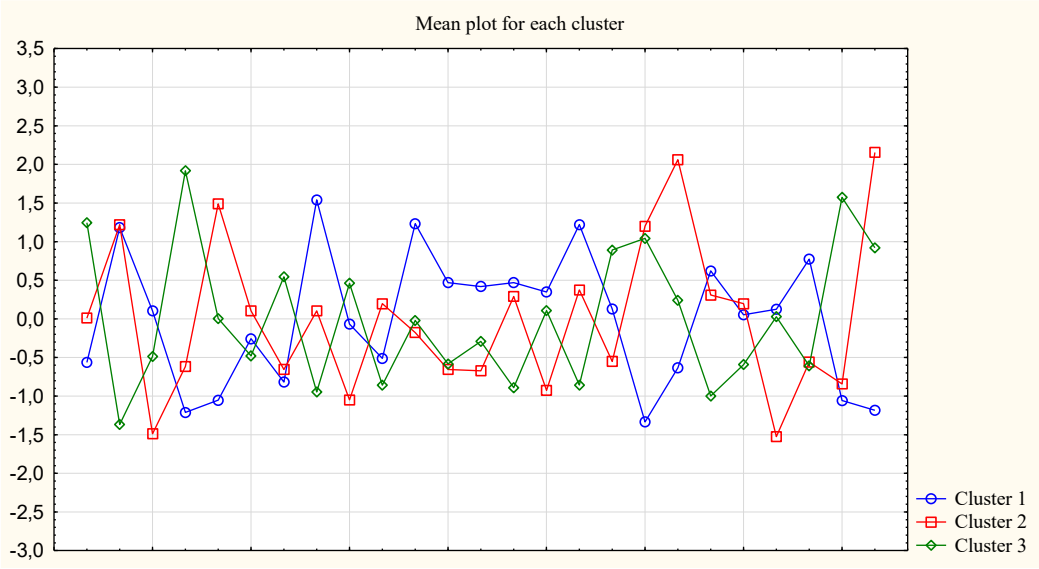


Figure 8. Visualization of the results of k-means clustering analysis of countries by their results in digitalization

According to the Fig. 7 clustering analyses divided selected 25 countries into several clusters. Based on the fact that cluster analysis involves calculating the closeness of connection (distance) between objects in space, quantity of clusters can be interpreted in different ways. To achieve the goals of the research, based on the results of the

analysis, were identified lower-level clusters that demonstrate the smallest distance between objects - countries, that is, the greatest similarity (Fig. 9).

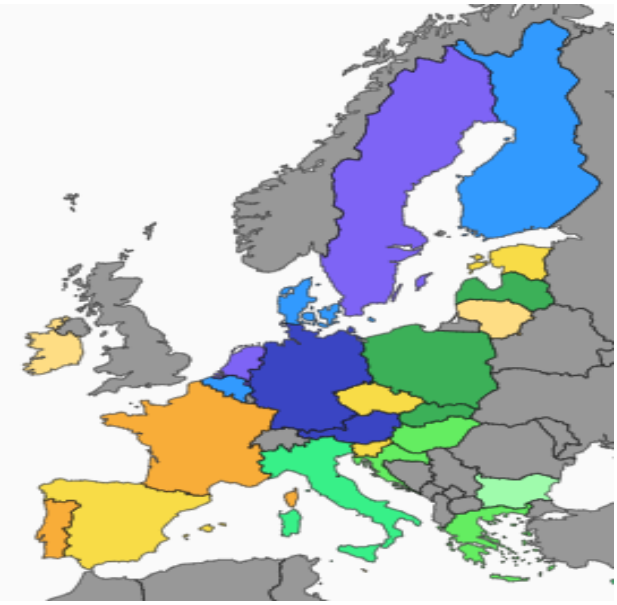

Figure 9. Visualization of Clustering of European Countries by Digital Transformation Level, prepared by authors according to Fig. no.7, using RegToolMap
*Note: shades of yellow – first cluster*
*shades of green – second cluster*
*shades of blue – third cluster*

According to the Fig. 9 the results of clustering of selected countries based on the digitalization of their business environment demonstrated three main clusters, which can be divided in some sub-clusters. The decision to highlight the sub-clusters is conditioned by necessity to demonstrate the highest similarity of digitalization of business environment in the countries.
First cluster include such countries as Lithuania, Malta, Ireland, Portugal, France, Spain, Estonia, Slovenia, Czech Republic, which are divided into three sub-clusters. In this cluster digitalization of business environment has more similarity between Lithuania, Malta, Ireland (first sub-cluster); Portugal and France (second sub-cluster); Spain, Estonia, Slovenia, Czech Republic (third sublucter).
Second cluster is formed from such countries as: Hungary, Croatia, Greece, Slovakia, Poland, Latvia, Cyprus, Italy, Bulgaria. It is the biggest cluster which has four sub-clusters: Hungary, Croatia, Greece (first sub-cluster); Slovakia, Poland, Latvia (second sub-cluster); Slovakia, Poland, Latvia (third cluster); and Bulgaria which was classified as a separate cluster (fourth sub-cluster).
Third cluster represented by such countries as: Sweden, Netherlands, Austria, Germany, Finland, Denmark. Belgium. They are also divided: Sweden, Netherlands (first sub-cluster); Austria, Germany (second sub-cluster); Finland, Denmark. Belgium (third sub-cluster).

*4.3. Clusters explanation according to geographical approach*
Based on the results of clustering, became clear that geographical boundaries and even the belonging of countries to one geographical sub regions are not a criterion for forming a cluster:
1. First Cluster
1.1. First Sub-cluster: Lithuania, Malta, Ireland - Lithuania is located in Northern Europe (Baltics), Ireland in Western Europe, and Malta in the Mediterranean region (Southern Europe). Despite their geographical separation, these countries share similar sub-cluster of business environment digitalization. Ireland and Malta are small but economically strong nations with a focus on digital services and modern technologies. Lithuania, too, has been developing its IT infrastructure, which explains their digital commonalities.
1.2. Second Sub-cluster: Portugal and France - both countries are situated in Western Europe, which lends some geographical logic to this sub-cluster. Portugal and France share historical and cultural ties, but they also exhibit comparable achievements in business digitalization.
1.3. Third Sub-cluster: Spain, Estonia, Slovenia, Czech Republic - in this sub-cluster, countries are distributed across different regions: Spain in Southern Europe, Estonia in Northern Europe (Baltics), and Slovenia and Czech

Republic in Central Europe. Nevertheless, these countries are grouped based on similar economic characteristics and digitalization levels, where technology plays a key role in their business development.
2. Second Cluster
2.1. First Sub-cluster: Hungary, Croatia, Greece - here, geography is somewhat more cohesive: Hungary and Croatia are situated in Central and Southeastern Europe, while Greece is in Southern Europe. These countries historically share strong economic ties within the region and exhibit similar levels of digitalization.
2.2. Second Sub-cluster: Slovakia, Poland, Latvia - this sub-cluster consists of countries from Central and Eastern Europe (Slovakia and Poland) and a Baltic country (Latvia). Although geographically closer, they also demonstrate similar trends in digital transformation.
2.3. Third Sub-cluster: Slovakia, Poland, Latvia - this sub-cluster repeats the previous one.
2.4. Fourth Sub-cluster: Bulgaria - Bulgaria is classified as a separate sub-cluster, indicating its unique position in business digitalization compared to other countries in the region. This could be explained by specific economic factors or levels of digital development.
3. Third Cluster
3.1. First Sub-cluster: Sweden, Netherlands - these countries are in different parts of Europe: Sweden in Northern Europe and the Netherlands in Western Europe. However, both nations demonstrate high levels of innovation and leadership in digitalization, which naturally groups them together.
3.2. Second Sub-cluster: Austria, Germany - these are geographically close countries in Central Europe. Austria and Germany share similar economic structures and levels of digitalization, justifying their clustering.
3.3. Third Sub-cluster: Finland, Denmark, Belgium - Finland and Denmark are Northern European countries, while Belgium is in Western Europe. Despite geographical differences, these nations share similar levels of digital technology development, explaining their clustering.
The clusters of countries based on the digitalization of business environment demonstrate that geographical proximity is not the main criterion for forming sub-clusters. Instead, economic characteristics, the level of technological development, and innovation are the key factors.

*4.4. Clusters explanation according to approach of digital transformation strategies*
An analysis of the digitalization models of countries in each cluster and sub-cluster helps highlight the specific features and trends that set these nations apart despite their geographic differences.
1. First Cluster. This cluster includes countries that are actively implementing digital technologies in their business environment, albeit with different strategies and speeds.
1.1. First Sub-cluster: Lithuania, Malta, Ireland:
Ireland - a leader in digital technologies, particularly due to significant foreign investment and the presence of major tech companies like Google, Facebook, and Microsoft. Ireland actively develops advanced technologies such as artificial intelligence, big data, and cloud computing. Ireland's export of digitally delivered services demonstrates systematically growth (Whelan, 2024).
Malta - strongly focused on fintech and blockchain technologies. Malta positions itself as a hub for cryptocurrencies and decentralized technologies, Times and Woffenden (2024).
Lithuania - a leader in the development of digital public services, such as e-government. Lithuania also plays a significant role in the fintech sector and actively implements solutions based on big data and AI (Peter, 2024).
Countries in this sub-cluster are key players in fintech and cloud technology, with digitalization strategies aimed at attracting tech companies and innovative solutions for public administration.
1.2. Second Sub-cluster: Portugal and France
France - focuses on supporting startups, developing artificial intelligence (Efretier, 2024), and digitalizing public services. France is also investing heavily in developing its digital infrastructure (French Tech Mission, 2024).
Portugal - focuses on digitalizing small and medium-sized enterprises (SMEs) (European Investment Bank, 2023), promoting digital services, and encouraging innovation through various government programs. IT and telecommunications are also actively developed (International Trade Administration, 2023)
Both countries focus on digital infrastructure and startup support but with different emphases: France on national platforms and high-tech solutions, Portugal on supporting SMEs and IT development.
1.3Third Sub-cluster: Spain, Estonia, Slovenia, Czech Republic.
Spain - recently focuses on digitalizing tourism and agriculture. Additionally, Spain promotes green digital technologies, Sadjadi and Fernández (2023).
Estonia - a leader in digital government and e-democracy, widely known for solutions like e-identification, online voting, and digital public services (Nõmmik, 2024).
Slovenia - primarily focuses on digitalizing its industrial sector and fostering innovation in startups (Government of Slovenia, 2022). It also pursues AI and blockchain integration (Slovenia AI Strategy Report, 2021).
Czech Republic - prioritizes the automation and digitization of industries and public administration while fostering IT education and the startup environment (Czech Industry Analysis, 2022).

Countries in this sub-cluster emphasize digitalizing public services and supporting startups, with each focusing on a unique aspect: Estonia on e-government; Slovenia and Czech Republic on industrial digitalization and automation; Spain on service sector digitalization.
2. Second Cluster. This cluster is characterized by moderate levels of digitalization, with a focus on improving infrastructure and modernizing traditional industries.
2.1. First Sub-cluster: Hungary, Croatia, Greece.
Hungary - focuses on integrating digital technologies in education and industry, including robotics and automation (Hungary - National Digital Decade strategic roadmap, 2024;. Hungary - Digital economy 2023).
Croatia - emphasizes digitalizing tourism (Simmonds, 2023) and public services, with programs aimed at improving IT infrastructure (Croatia - Digital Economy, 2024).
Greece - aims to modernize public administration and improve digital skills through education (Greece - Information and Communications Technology, 2023; Digital transformation in Greece, 2023).
These countries are on a path toward modernizing traditional industries and improving public digital services, with tourism, education, and administration as key areas of focus.
2.2. Second Sub-cluster: Slovakia, Poland, Latvia.
Slovakia - focuses on industrial digitalization (Slovakia - Digital Economy, 2024) and developing digital competencies through education (Slovakia - 2030 Digital Transformation Strategy, 2022).
Poland - prioritizes IT sector development and public sector digitalization (Government of Poland, 2023), actively supporting startups and AI technologies (Stefson, 2024).
Latvia - a leader in e-government in the Baltics (Latvia (2023 eInvoicing Country Sheet), 2023), actively adopting IoT and blockchain technologies (Gustavs Lapiņš, 2023).
This sub-cluster focuses on public sector digitalization and supporting startups. E-commerce platforms and digital services also play a significant role.
2.3. Third Sub-cluster: Bulgaria
Bulgaria - actively develops its IT sector, with a focus on software exports and public sector digitalization. Bulgaria is also a key player in IT outsourcing (Bulgaria - Digital Economy, 2024). Additionally, Bulgaria is noted for its competitive corporate tax rates and a strong emphasis on cloud services and digital mobility, making it an attractive destination for tech companies (The Tech Sector in 2024: Separating Facts From Fiction, 2024).
Country stands out for its digitalization model focused on the IT sector and outsourcing, which explains its classification as a separate sub-cluster.
3. Third Cluster. This cluster includes countries with highly developed digital environment and leading digitalization levels.
3.1. First Sub-cluster: Sweden, Netherlands.
Sweden -a leader in innovation and technology, focusing on sustainable and green technologies, digital health, and education (Si, 2024; The Digital Transformation of Healthcare - Health by Sweden, 2023).
Netherlands - boasts one of the most advanced digital service markets in Europe, actively developing AI and big data solutions (Netherlands - Digital economy, 2024; Netherlands Digital Transformation market Trends, 2024).
Sweden and the Netherlands stand out for their high degree of technology integration across sectors, with a focus on sustainable and green solutions.
3.2. Second Sub-cluster: Austria, Germany.
Germany -a leader in industrial automation (Industry 4.0), actively developing AI, big data, and digitizing manufacturing processes (Germany AI in Manufacturing, 2024).
Austria - focuses on developing digital infrastructure and supporting innovation, particularly in sectors like healthcare and industry (Digitalization report, 2023).
These countries focus on industrial digitalization and innovation, with a priority on automation and IT integration in manufacturing.
3.3. Third Sub-cluster: Finland, Denmark, Belgium.
Finland and Denmark - leaders in digital education, e-services, and sustainable technologies, emphasizing smart cities and IoT development (United Nations, 2022; Fagan, 2019).
Belgium - actively develops digital services in healthcare and education, with a focus on AI (Belgium's National Convergence Plan for the Development of Artificial Intelligence, 2022; Nick Amies, 2023).
This sub-cluster stands out for its high degree of digitalization in healthcare, education, and sustainable development, with a focus on smart cities and AI.
Summarizing the above, it can be said that digitalization models in each cluster vary depending on countries' economic priorities and strategies. Countries in the first cluster focus on supporting innovative solutions and startups, the second on modernizing traditional industries, and the third on implementing cutting-edge digital technologies across all sectors.
5.3. The influence of digitalization strategies of European region on business economic security
Digitalization has emerged as a pivotal factor influencing the economic security of businesses across Europe. As countries adopt various digitalization strategies, their ability to enhance resilience, efficiency, and competitiveness

becomes increasingly crucial. This analysis explores how these strategies impact business economic security, drawing from recent studies and reports.

Business economic security encompasses a firm's ability to maintain profitability, manage risks, and ensure long-term sustainability in a rapidly changing environment. The development of entrepreneurial activity is impossible without an effective system of ensuring economic security. (Voroniuk Ye. V. & Satusheva K. V., 2024) Especially in conditions of digitalization, when risks and threats to economic security of business activities are complicated by the transition to new levels of IT technologies.

Table 7. Key risk factors from the implementation of digitalization strategies that affect the economic security of business in the European region, own elaboration

| Risk/Factor | Description | References |
|---|---|---|
| Cybersecurity Threats | Increasing incidents of cyberattacks pose significant risks to business operations and data integrity. | Eurostat (2023), Voroniuk & Otenko (2021) |
| Regulatory Compliance | Changes in laws and regulations regarding digitalization and data protection can impact operational strategies. | International Trade Administration (2023), Digitalization report (2023) |
| Market Volatility | Economic fluctuations and uncertainties may affect investment in digital technologies. | Legatum Prosperity Index (2023), Sadjadi & Fernández (2023) |
| Technological Advancements | Rapid changes in technology can lead to obsolescence of existing business models and practices. | Nogueira & Munita (2019), Digital transformation in Greece (2023) |
| Investment in Digital Infrastructure | A lack of investment in necessary technologies can hinder the effectiveness of digital strategies. | Government of Slovenia (2022), Digital economy (2023) |
| Talent Shortages | Difficulty in finding skilled workers to implement and maintain digital solutions poses a risk to business growth. | Hungary - National Digital Decade strategic roadmap (2024), Stefson (2024) |
| Data Privacy Issues | Concerns about data collection and usage can impact customer trust and brand reputation. | e-Estonia (2024), Latvia eInvoicing Country Sheet (2023) |
| Global Competition | Increased competition from international players in the digital market can threaten local businesses. | Times & Woffenden (2024), Fagan (2019) |
| Digital Divide | Disparities in access to technology can result in unequal business opportunities within the European region. | European Investment Bank (2023), Whelan (2024) |

The integration of digital technologies is not merely a trend but a necessity for businesses to thrive and adapt. Research indicates that countries investing in robust digital infrastructure are better positioned to enhance their economic security (Eurostat, 2023). For instance, countries like Sweden and Denmark have adopted innovative digital solutions, fostering a resilient economy that can withstand external shocks (UN, 2022).

The varying digitalization strategies across Europe highlight the different approaches to enhancing business economic security. In Ireland, significant investments in digital exports have positioned the nation as a leader in the digital economy, contributing substantially to its economic security (Whelan, 2024). Similarly, Malta has emerged as a fintech hub, implementing strategic frameworks that not only boost its economy but also fortify the financial security of businesses operating within its borders (Times & Woffenden, 2024).

Conversely, countries like Greece are focusing on modernizing public administration and improving digital skills to enhance overall economic resilience. The adoption of digital technologies in public services can create a more favorable business environment by streamlining processes and reducing bureaucratic hurdles (Greek News Agenda, 2023). This indicates a trend where public sector digitalization directly influences the economic security of private enterprises by providing a more stable operational landscape.

Sector-specific innovations, particularly in healthcare and agriculture, further illustrate the positive impact of digitalization on economic security. For instance, Belgium's integration of AI in healthcare has improved patient care and operational efficiencies, enhancing the overall stability of the healthcare sector and its associated businesses (Nick Amies, 2023). Similarly, Spain's focus on digitizing its agricultural sector demonstrates how tailored digital strategies can address unique industry challenges, promoting resilience and sustainability (Sadjadi & Fernández, 2023).

While digitalization presents numerous opportunities for enhancing economic security, challenges such as cybersecurity threats and data privacy concerns remain prominent. Countries must navigate these risks carefully to ensure that their digital strategies do not compromise the security of businesses (Hungary - National Digital Decade strategic roadmap, 2024).

The economic security of businesses in the European region is increasingly influenced by a variety of risks and factors associated with digitalization. Cybersecurity threats, regulatory compliance issues, and technological

advancements are among the foremost concerns for organizations. Moreover, market volatility and investment in digital infrastructure are critical for sustaining competitive advantages. As digital transformation continues to reshape the business landscape, understanding these factors is essential for safeguarding economic security.
Therefore, the analysis of digitalization strategies across the European region underscores their significant influence on business economic security. By adopting targeted digital initiatives, countries can enhance the resilience and competitiveness of their economies, ultimately fostering a more secure business environment. Continued investment in digital technologies and infrastructure will be essential for navigating the complexities of the modern economic landscape.

*4.3. Sustainable Development Goals in the context of Clustering results*

The digitalization of the business environment in European countries is developing in accordance with their economic priorities and strategies.The results of the cluster analysis allowed for the highlighting of the following characteristics of the countries of each cluster within the framework of the Sustainable Development Goals (UN Statistical Division, 2023).
SDG 8 - the first cluster focuses on innovation and support for startups; the second cluster modernizes traditional industries and improves infrastructure; the third cluster integrates advanced technologies into all sectors, ensuring sustainable development and global leadership.
It is evident that all countries are engaged in attaining SDG 9 through the modernization of industry, the development of innovative technologies, and the establishment of advanced digital infrastructure.
Additionally, countries within each cluster prioritize the realization of SDG 10 through digitalization, albeit with distinct emphases. The first cluster places significant emphasis on innovation and global integration, while the second prioritizes the accessibility of digital services and the promotion of regional development. The third cluster, meanwhile, places a strong focus on inclusivity and sustainable development, aiming to create conditions that foster equal opportunities across all sectors.
The achievement of SDG 17 is being implemented by the countries of the first cluster through active participation in global technology partnerships; the second cluster through deepening regional cooperation for economic modernization; and the third cluster through leadership in international initiatives for the implementation of innovations and sustainable development.In general, it should be noted that the research countries together form a network of partnerships that ensures the exchange of technologies, knowledge, and resources necessary for sustainable development.

## 5. Conclusions

The findings of this research provide compelling evidence to support the hypothesis that countries in the European Union with more favorable external institutional environments, as measured by the Legatum Prosperity Index, exhibit higher levels of business digitalization. This conclusion underscores the importance of a multifaceted approach to understanding digital transformation in business contexts, moving beyond traditional economic metrics like GDP. The analysis highlights that broader societal well-being and governance frameworks significantly influence digitalization strategies, enabling nations to foster an environment conducive to technological innovation and growth.
Clusters of countries exhibiting varied digitalization strategies were identified, illustrating the impact of unique national contexts on the digital transformation process. The research revealed that countries in the first cluster, characterized by advanced digital environment and innovative approaches, are leading the charge in integrating digital technologies across sectors. In contrast, countries in the second cluster, while making strides in digitalization, focus primarily on modernizing traditional industries and improving infrastructure. Finally, the third cluster includes countries with emerging digital ecosystems, highlighting the diversity of digital transformation trajectories across the EU.
The findings of the study indicate a close correlation between the extent of digital transformation and the progress in accomplishing the Sustainable Development Goals. The identified clusters underscore the necessity to formulate diversified digital development strategies, taking into account the particularities inherent to each cluster. This necessitates the reinforcement of international cooperation to bridge the digital divide between nations. Furthermore, there is a pressing need to integrate the Sustainable Development Goals into national digital transformation strategies. Additionally, the establishment of mechanisms to monitor the impact of digitalization on the achievement of the Sustainable Development Goals is imperative.
The cluster analysis conducted demonstrates the unevenness of the digital transformation of European countries, which has a direct impact on the achievement of the SDGs:
Goal 8 - countries with a higher level of digitalization demonstrate better labor productivity indicators and the creation of new jobs in the digital sector.
Goal 9 - the identified clusters reflect the different level of development of digital infrastructure and the introduction of innovations, which affects the overall competitiveness of economies.

Goal 10 - the digital divide between clusters indicates the need for additional measures to ensure equal access to digital opportunities.
Goal 17 - inter-cluster differences emphasize the importance of international cooperation for harmonizing digital development.
Moreover, the analysis demonstrates the critical link between digitalization and business economic security. As digital technologies become integral to business operations, countries that invest in robust digital infrastructure and innovative solutions are better equipped to enhance economic resilience and competitiveness. Conversely, countries facing challenges such as cybersecurity threats and data privacy concerns must navigate these risks to protect their businesses and foster a secure digital environment.
Future research should aim to explore the following areas to deepen the understanding of digitalization strategies and their impacts on business economic security:
Longitudinal Studies - conduct longitudinal analyses to examine how digital transformation strategies evolve over time within specific countries and their correlation with economic security indicators. This approach can help identify trends and long-term effects of digitalization initiatives.
Sector-Specific Analyses - investigate the impact of digitalization strategies on specific sectors, such as healthcare, agriculture, and manufacturing, to understand how tailored approaches can address unique industry challenges and enhance economic resilience.
Comparative Studies - explore comparative studies between EU countries and other regions to identify best practices in digital transformation and governance frameworks. This research could provide insights into how different institutional environments shape digitalization efforts.
Impact of Policy Frameworks - analyze the role of national and EU-level policies in facilitating or hindering digital transformation initiatives. Understanding how regulatory environments affect business digitalization can inform policymakers in designing supportive frameworks.
Focus on Digital Divide - investigate the implications of the digital divide within and between countries in the EU. Understanding how disparities in access to technology affect business opportunities and economic security will be crucial in addressing inequalities.
By addressing these areas in future studies, it is possible to contribute to a more comprehensive understanding of digitalization in the European business landscape and its implications for economic security. This, in turn, will aid policymakers and business leaders in formulating strategies that harness the potential of digital transformation while mitigating associated risks.

## 6. References


1. AI-WATCH, 2021, *Slovenia AI Strategy Report, https://ai-watch.ec.europa.eu/countries/slovenia/slovenia-ai-strategy-report_en* (10.10.2024).
2. ALTIOS, 2024, *IT sector in Poland 2023: opportunities for international companies. https://altios.com/publication/it-sector-in-poland-2023/*(13.10.2024).
3. BRUSSELS TIMES, 2023, *Belgian hospitals harness AI capabilities to improve patient care, https://www.brusselstimes.com/645427/belgian-hospitals-harness-ai-capabilities-to-improve-patient-care* (12.10.2024).
4. BUSINESS FRANCE NORDIC, 2024, *AI Race: How France is positioning itself as a leader, https://world.businessfrance.fr/nordic/ai-race-how-france-is-positioning-itself-as-a-leader/* (12.10.2024).
5. CZECH TECHNICAL UNIVERSITY IN PRAGUE, 2022, *Czech Industry Analysis 2022: Smart Industry 4.0 technologies help in the crisis, https://aktualne.cvut.cz/en/reports/20220606-czech-industry-analysis-2022-smart-industry-40-technologies-help-in-the-crisis* (13.10.2024).
6. DIGITAL AUSTRIA, 2023, *Mission Posible: AI as an enabler for Austria's regions, https://www.digitalaustria.gv.at/eng/insights/digitalization-report.html* (28.10.2024).
7. DIGITAL SKILLS & JOBS PLATFORM, 2022, *Slovakia - 2030 Digital Transformation Strategy, https://digital-skills-jobs.europa.eu/en/actions/national-initiatives/national-strategies/slovakia-2030-digital-transformation-strategy* (03.11.2024).
8. DIGITAL SKILLS & JOBS PLATFORM, 2024, *Hungary - National Digital Decade strategic roadmap, https://digital-skills-jobs.europa.eu/en/actions/national-initiatives/national-strategies/hungary-national-digital-decade-strategic-roadmap* (05.11.2024).
9. DIGITAL WATCH OBSERVATORY, 2022, *Belgium's national convergence plan for the development of Artificial Intelligence, https://dig.watch/resource/belgiums-national-convergence-plan-for-the-development-of-artificial-intelligence* (23.10.2024).
10. E-ESTONIA, 2024, *E-Democracy & Open Data, https://e-estonia.com/solutions/e-governance/e-democracy/* (07.11.2024).
11. EUROPEAN COMMISSION, *Latvia 2023: eInvoicing Country Sheet, https://ec.europa.eu/digital-building-blocks/sites/pages/viewpage.action?pageId=658735768* (17.10.2024).
12. EUROPEAN INVESTMENT BANK, 2023, *Digitalization of SMEs in Portugal: Summary, https://www.eib.org/attachments/thematic/digitalization_of_smes_in_portugal_summary_en.pdf* (17.10.2024).
13. EUROSTAT – DATABASE, 2023, *Digital economy and society, https://ec.europa.eu/eurostat/web/digital-economy-and-society/database* (16.10.2024).

14. FRENCH TECH MISSION, 2024, *Presentation of the French Tech Mission - French Tech Mission, https://lafrenchtech.gouv.fr/en/about-us/presentation-of-the-french-tech-mission/* (09.11.2024).
15. GEORGESCU M. R. ., LUNGU A. E., BOGOSLOV I. A., STOICA E. A., 2023, European Efficiency or Inefficiency in Economic Growth Through Digital Transformation, *Scientific Annals of Economics and Business* 70(SI): 19–31, https://doi.org/10.47743/saeb-2023-0010 (03.11.2024).
16. GOVERNMENT OF POLAND, 2023, *Artificial Intelligence Strategy for Poland 2022-2027, https://www.gov.pl/attachment/928200fa-b1a6-4c0c-b3a8-d1fbf1e1175a* (05.11.2024).
17. GOVERNMENT OF SLOVENIA, 2022, *Digitalization in business, https://www.gov.si/en/topics/digitalization-in-business/* (11.11.2024).
18. GREEK NEWS AGENDA, 2023, Digital transformation in Greece 2021-2022, *Foundation report, https://www.greeknewsagenda.gr/digital-transformation-in-greece-2021-2022-found-ation-report/* (11.11.2024).
19. HEALTH BY SWEDEN, 2023, *The Digital Transformation of Healthcare, https://www.swecare.se/healthbysweden/the-digital-transformation-of-healthcare/* (30.10.2024).
20. INTERNATIONAL TRADE ADMINISTRATION, U.S. DEPARTMENT OF COMMERCE, 2023, *Portugal - Digital economy, https://www.trade.gov/country-commercial-guides/portugal-digital-economy* (02.11.2024).
21. INTERNATIONAL TRADE ADMINISTRATION. U.S. DEPARTMENT OF COMMERCE, 2024, *Bulgaria - Digital economy, https://www.trade.gov/country-commercial-guides/bulgaria-digital-economy* (15.11.2024).
22. INTERNATIONAL TRADE ADMINISTRATION. U.S. DEPARTMENT OF COMMERCE, 2023, *Hungary - Digital economy, https://www.trade.gov/country-commercial-guides/hungary-digital-economy* (06.11.2024).
23. INTERNATIONAL TRADE ADMINISTRATION. U.S. DEPARTMENT OF COMMERCE, *Croatia - Digital economy, https://www.trade.gov/country-commercial-guides/croatia-digital-economy* (24.10.2024).
24. INTERNATIONAL TRADE ADMINISTRATION. U.S. DEPARTMENT OF COMMERCE, 2023, *Greece - Information and Communications Technology, https://www.trade.gov/country-commercial-guides/greece-information-and-communications-technology* (21.10.2024).
25. INTERNATIONAL TRADE ADMINISTRATION. U.S. DEPARTMENT OF COMMERCE, 2024, *Slovakia - Digital economy, https://www.trade.gov/country-commercial-guides/slovakia-digital-economy* (23.10.2024).
26. INTERNATIONAL TRADE ADMINISTRATION. U.S. DEPARTMENT OF COMMERCE, 2024, *Netherlands - Digital economy, https://www.trade.gov/country-commercial-guides/netherlands-digital-economy* (29.10.2024).
27. INTERNATIONAL TRADE ADMINISTRATION. U.S. DEPARTMENT OF COMMERCE, 2024, *Germany AI in manufacturing, https://www.trade.gov/market-intelligence/germany-ai-manufacturing* (02.11.2024).
28. KARČIAUSKAS J., 2024, Lithuania political briefing: Lithuania's Fintech Story, *China-CEE Institute,* https://china-cee.eu/2024/04/12/lithuania-political-briefing-lithuanias-fintech-story/ (18.11.2024).
29. LAPIŅŠ G., 2023, *Invest in Latvia. ICT and smart city sectors, https://investinlatvia.org/en/key-sectors/sectors/ict-smart-city* (23.10.2024).
30. MORDOR INTELLIGENCE, 2024, *Netherlands Digital Transformation market Trends, https://www.mordorintelligence.com/industry-reports/netherlands-digital-transformation-market/market-trends* (04.11.2024)
31. NOGUEIRA A., MUNITA, C. S., 2019, The effect of data standardization in cluster analysis, *INAC 2019*, https://pdfs.semanticscholar.org/dc48/4119443486b15dff9098efac5e01bda7532d.pdf (14.10.2024).
32. QIAN J., LIU W., SHI Y., ZHANG M., WU Q., CHEN K., CHEN W., 2022,. C-CORA: a Cluster-Based method for correlation analysis of RNA-SEQ data, *Horticulturae*, 8(2), 124, https://doi.org/10.3390/horticulturae8020124 (12.10.2024).
33. REGTOOLMAP, *Map creator tool, https://regtool.net/ru/maps* (24.11.2024).
34. SADJADI E. N., FERNÁNDEZ R., 2023, Challenges and opportunities of agriculture digitalization in Spain, *Agronomy*, 13(1), 259. https://doi.org/10.3390/agronomy13010259 (21.10.2024).
35. SIMMONDS L., 2023, *E-Tourism: New set of digital public services for Croatian tourism launched, https://total-croatia-news.com/news/e-tourism/* (22.10.2024).
36. SUSTAINABILITY TIMES, 2019, *A small smart city in Finland shows the way on sustainability, https://www.sustainability-times.com/clean-cities/a-small-smart-city-in-finland-shows-the-way-on-sustainability/* (13.11.2024).
37. SWEDISH INSTITUTE, 2024, *Sweden and sustainability, https://sweden.se/climate/sustainability/sweden-and-sustainability* (17.11.2024).
38. TELERIK ACADEMY, 2024, *The Tech Sector in 2024: Separating Facts from Fiction, https://www.telerikacademy.com/blog/the-tech-sector-in-2024-separating-facts-from-fiction* (26.10.2024).
39. THE LEGATUM INSTITUTE, 2023*, Legatum Prosperity Index 2023, https://www.prosperity.com/* (07.10.2024).
40. THE LEGATUM INSTITUTE, 2020*, Legatum Prosperity Index 2020, https://docs.prosperity.com/3916/0568/0669/The_Legatum_Prosperity_Index_2020_Overview.pdf* (06.04.2025).
41. TIMES F., WOFFENDEN C., 2024, *Malta: a leading European fintech jurisdiction, https://thefintechtimes.com/malta-a-leading-european-fintech-jurisdiction/* (07.11.2024).
42. UNITED NATIONS, 2022, *Denmark, Finland and South Korea top the 2022 UN e-government ranking, https://unric.org/en/denmark-finland-and-south-korea-top-the-2022-un-e-government-ranking/* (03.11.2024).
43. UNITED NATIONS STATISTICS DIVISION, 2023, *The Sustainable Development Goals Report Special edition https://unstats.un.org/sdgs/report/2023/The-Sustainable-Development-Goals-Report-2023.pdf* (12.11.2024).
44. VAN BON, 2021, The Digitalization – Economic Growth Relationship in Developing Countries and the Role of Governance, *Scientific Annals of Economics and Business* 68(4): 481–493, https://doi.org/10.47743/saeb-2021-0028 (23.10.2024).
45. VORONIUK YE. V., SATUSHEVA K. V., 2024, Global experience of implementation of ethical principles in the organization of economic security of business. *Collection of Scientific Papers 'Scientific Notes', 34* (1), 6-15. http://doi.org/10.33111/vz_kneu.34.24.01.01.005.011 [Ukrainian] (08.04.2025)

46. VORONIUK YE. V., SATUSHEVA K. V., 2024, Synergy of risk management and organizational behavior in the context of ensuring economic security of enterprises. *Collection of Scientific Papers 'Scientific Notes', 37* (4), 31-43. http://doi.org/10.33111/vz_kneu.37.24.04.03.019.025 [Ukrainian] (08.04.2025)
47. WHELAN J., 2024, Ireland's digital exports now third largest internationally, *Irish Examiner*, *https://www.irishexaminer.com* (08.11.2024).