SECURITY POLICY IN DIGITAL TRANSFORMATION AND DYNAMICS OF ECONOMIC DIGITALIZATION IN EU COUNTRIES

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Abstract: This paper examines the digital transformation of Southeast European (SEE) European Union (EU) member states by analysing their performance in the Global Digitalization Index (GDI) 2024, the Global Innovation Index (GII) 2024, and firm-level digital adoption data. The study evaluates key trends in digitalization, economic development, and innovation across Bulgaria, Croatia, Greece, Romania, and Slovenia. Using bibliometric analysis, the research also maps the academic discourse on digitalization and its impact on economic growth. The findings reveal that while SEE EU countries demonstrate progress in digital adoption, disparities remain in innovation capacity, business digitalization, and climate risk management. The study also highlights that security policy plays a key role in supporting successful digital transformation efforts across the region. The paper also presents a country classification based on digital and climate indicators to support cross-country comparisons. The findings may support future policy efforts aimed at fostering digital development and addressing national and institutional challenges in the region.

Key words: digitalization, economic growth, Southeast European EU Members, bibliometric analysis, competitive analysis, security policy.

1. INTRODUCTION

The accelerating pace of digitalization is reshaping economies, transforming the way businesses operate and government's function. Digitalization plays a crucial role in fostering economic growth and development, and integrating digital technologies into various sectors leads to significant economic benefits.

Digitization involves converting information into a digital format, whereas digitalization encompasses the broader transformation of business processes and activities to leverage digital technologies and data. According to [1], digitalization in business refers to the integration of digital tools and technologies into physical spaces, as well as the conversion of information into digital formats, to enhance efficiency and boost profitability within an organization. Digitalization can be considered as a technological disruption that influences key economic outcomes -including competition, productivity, and employment - while also interacting with institutional frameworks and governance structures [2]. Digital transformation emerges from shifts in the political, economic, cultural, or other fundamental processes that underpin digitization. It refers to the process of transitioning an organization from traditional methods to new ways of operating and thinking by leveraging digital, social, mobile, and emerging technologies [3]. According to [4], digital transformation requires the incorporation of new technologies to improve performance. Digitalization is a key driver of economic development, influencing productivity, competitiveness, and innovation. In Southeast Europe, digital transformation is accelerating, yet countries in the region face structural and policy-related challenges in fully leveraging digital technologies. At the same time, the role of security policy has become increasingly significant. As digital technologies become more integrated in economic activity and public systems, cybersecurity measures and well-defined security strategies are essential for protecting data, minimizing cyber risks, and maintaining trust in digital platforms and services.

This paper offers a regional comparison of digital transformation processes in SEE EU countries by combining different types of data - bibliometric analysis, international digitalization indices, and firm-level indicators. By linking academic research trends with practical performance measures, the study provides a more complete picture of how digitalization is progressing in the region. Special attention is also given to the role of security policy as an essential factor for achieving long-term and reliable digital development. This study aims to analyse the current state of digitalization in SEE EU member states by analysing their positions in global digitalization and innovation rankings, investigating digital adoption trends at the firm level, identifying barriers to further digital development, and classifying countries based on digital and climate indicators. Additionally, this research addresses key topics in digital transformation, e-governance, and knowledge-based technologies, offering valuable insights into digitalization trends and their impact on economic growth.

2. LITERATURE REVIEW

The progress of the global financial innovations focuses on the digitalization of payments and the role of money [5]. The study [6] examines the countries of the European Union and demonstrates that digital readiness, especially through human capital and technology integration, plays a key role in driving Gross domestic product (GDP) growth. The authors in [7] examine the effects of internationalization and digitalization on eco-innovation by analysing panel data from 27 EU Member States between 2013 and 2022. Their findings indicate that digitalization has a positive impact on eco-innovation, which in turn promotes sustainability and economic growth in the EU. The study [8] highlights that the digitization of Bulgarian Small and medium-sized enterprises (SMEs) encounters various challenges, primarily including financial issues, a shortage of skilled personnel, and the overall adverse effects of the operating environment. The study [9] examines the challenges of Bulgaria's adaptation to the EU's Single Digital Market in the post-pandemic era. The study shows that Bulgaria's digital transition has contributed to GDP growth and improvements in the human development index (2010-2020). However, institutional weaknesses in regulation and the business environment may deepen technological divergence from EU standards, hindering faster integration into the EU's Digital Market.

The research [10] offers policy recommendations to speed up Slovenia's digital transformation, focusing on closing the urban-rural broadband divide. Slovenia's digitalization efforts aim to boost productivity, counteract a shrinking workforce, and enhance business competitiveness. Key priorities include reducing broadband disparities, promoting innovation, and upgrading Information and communications technology (ICT) skills, all of which support sustainable economic growth and development. Slovenia's digital economy is defined by extensive internet and broadband access, robust ICT investments, and a growing ICT sector. Key components include e-business, e-commerce, social media, cloud computing, and the Internet of Things, supported by a workforce with diverse e-skills. In the 2022 Digital Economy and Society Index (DESI), Slovenia ranked 11th among EU countries, reflecting its strategic commitment to digitalization through improvements in digital skills, infrastructure, and public sector digitalization [11].

The study [12] argues that digital transformation in Croatia can drive economic growth by utilizing the ICT sector's potential, enhancing business models, and tackling institutional challenges. This transformation could revitalize the country's low-tech, service-based economy and create a more dynamic economic landscape. The research [13] emphasizes that, while digitalization through ICT sectors supports economic growth and sustainable development, its effects in Croatia remain underexplored. Their study measures ICT's contribution to national gross value added and employment, uncovering notable differences between sectors. ICT manufacturing lags behind service industries, and integration levels vary across individual ICT sectors.

Digitalization in Greece promotes economic growth by enabling households to generate income through online accommodation platforms, thereby increasing disposable income and aggregate demand. Supported by EU funding, this shift is crucial for addressing high public debt and economic recovery challenges. Advancing digitalization could help Greece achieve its macroeconomic policy objectives and strengthen its economy [14]. The study [15] investigates corporate sustainability within Romania's technology sector, analysing data from 4,825 companies collected between 2019 and 2023. Their study reveals that improved social performance has a positive impact on return on equity (ROE), and across all models, larger company size is consistently linked to higher ROE. The research [16] investigates the effects of digitalization on Romanian public institutions, highlighting challenges such as inadequate infrastructure, limited digital literacy, and concerns over data security. Despite Romania's high internet speeds, its public sector has fallen behind in digital transformation. However, embracing digitalization could pave the way for a more efficient government. Exploring digitalization challenges and opportunities in European economies contributes to broader discussions on technological advancements, digital policies, and cybersecurity within digital transformation processes.

3. METHODOLOGY AND DATA

This study employs a quantitative and bibliometric approach to analyse digitalization trends in SEE EU member states. The use of quantitative and bibliometric methods reinforces the study's data-driven approach, supporting advancements in knowledge-based technologies and information management systems. The methodology consists of four key components: data collection, competitive analysis, bibliometric analysis, and a simple country classification based on threshold indicators. The study utilizes secondary data from three main sources [17, 18, 19].

A competitive analysis is conducted to compare the digitalization and innovation performance of Bulgaria, Croatia, Greece, Romania, and Slovenia. This approach examines GDI and GII rankings over multiple years to identify trends in digital competitiveness and Firm-level digital adoption across SEE EU countries, highlighting strengths and weaknesses in digital transformation. Although the study uses open-access data from well-known sources such as GDI, GII, and EIB, all tables and figures are developed by the author. The numerical information was extracted, compared, and interpreted independently to identify key differences, patterns, and implications related to digital policy and security across the countries examined, including a classification analysis linking institutional indicators to firm-level behaviour.

4. RESULTS AND DISCUSSION

4.1. Bibliometric analysis

This study employs bibliometric analysis to identify dominant research trends and highlight potential directions for future analysis. Bibliometric analysis facilitates the systematic mapping of scientific literature across various disciplines. The study applies a bibliometric approach structured in three phases: keyword selection and database choice, extraction of bibliographic records, and analysis aimed at identifying major research trends [20]. Data was obtained from Scopus, a leading database of peer-reviewed literature. The search focused on publications featuring the terms "digitalization" and "economic development" in their titles, abstracts, or keywords. The scope was narrowed to specific disciplines such as Social Sciences, Economics, and Business. Only journal articles, books, book chapters, and conference proceedings published between 2005 and 2025 were considered. The final sample included 617 documents, retrieved in February 2025.

To analyse the dataset, VOSviewer software was used to explore the relationship between digitalization and economic development within the academic literature. VOSviewer is a specialized tool designed for constructing and visualizing bibliometric networks [21]. The study employs co-occurrence analysis to examine keyword relationships. Keyword co-occurrence analysis identifies key research themes by constructing networks based on the frequency and relationships between terms used in scholarly publications. This method involves detecting recurring keywords, measuring their co-occurrence patterns, and mapping their connections to uncover central concepts and thematic clusters. In this study, the analysis was conducted on 2,648 keywords. To be included in the visualization, a keyword had to appear at least five times in the dataset.

A total of 139 keywords met this criterion, forming a structured network of research topics.

Table 1 presents the top 20 most frequently occurring keywords, along with their corresponding number of occurrences and total link strength. The most prevalent keyword is "digitalization," which appears 187 times and has a total link strength of 561, indicating its central role in the field of research. Other highly frequent keywords include "economic development" (140 occurrences, 699 link strength), "digital economy" (89 occurrences, 300 link strength), "China" (67 occurrences, 404 link strength), and "digital transformation" (64 occurrences, 208 link strength). These results highlight the primary areas of interest within literature, emphasizing the strong link between digitalization and economic progress.

Table 1. Keywords co-occurrence – top 20

Keywords	***Occurrences***	***Total link strength***
digitalization	*187*	*561*
economic development	*140*	*699*
digital economy	*89*	*300*
China	*67*	*404*
digital transformation	*64*	*208*
digitization	*61*	*383*
sustainable development	*59*	*334*
economic and social effects	*49*	*332*
economic growth	*44*	*263*
innovation	*42*	*230*
sustainability	*35*	*219*
economics	*30*	*177*
digital technologies	*30*	*139*
digitalisation	*27*	*66*
panel data	*23*	*158*
Industry 4.0	*23*	*80*
technological development	*21*	*162*
artificial intelligence	*21*	*77*
Covid-19	*17*	*54*
socio-economic development	*15*	*73*

Source: Author's systematization based on bibliographic data retrieved from Scopus and visualized with VOSviewer.

Figure 1 illustrates a co-occurrence network map generated using VOSviewer, which displays how frequently keywords appear together across the dataset. The terms "digitalization" and "economic development" show a strong interrelation, with a co-occurrence link strength of 41. A total of 139 keywords were grouped into seven distinct thematic clusters, each represented by a different colour:

- Red cluster: The red cluster contains 38 items including keywords such as: "digitalization", "digital society", "digital transformation", "economic and social effects", "digital transformation", "Industry 4.0", "regional economy", etc. These keywords are closely related and often co-occur together. This cluster highlights how digitalization impacts social structures, technological progress, and economic frameworks.

- Green cluster: The green cluster features keywords such as “China”, “carbon emissions”, “economic growth”, and “environmental protection”. These keywords are grouped together, suggesting a thematic connection between them, with a strong emphasis on China’s pivotal role in global digitalization efforts and its impact on carbon reduction and green technology initiatives.
- Blue cluster: The blue cluster includes keywords like: “economic growth”, “Accounting profession”, “developing world”, and “method of moments”. This grouping reflects research themes that centre on the interplay between economic development in emerging markets and the methodologies used to analyse growth and financial systems. The focus on the developing world indicates an interest in addressing global disparities in digitalization and economic integration.
- Yellow cluster: The yellow cluster consists of the following keywords: “innovation”, “sustainability”, and “entrepreneurship”. This cluster represents themes associated with the role of innovation and sustainable practices in fostering entrepreneurial activities.
- Purple cluster: The purple cluster includes terms like “developing countries”, “industrial development”, and “panel data”. This grouping focuses on industrialization in developing nations, emphasizing empirical methods, such as panel data analysis, to study the economic progress and industrial strategies of these countries in the digital era.
- Turquoise cluster: The turquoise cluster combines keywords such as “digital economy”, “economic development”, and “artificial intelligence”. The focus here lies in the transformative potential of AI to revolutionize traditional economic models.
- Orange cluster: The orange cluster features keywords like “digitalization”, “technological development”, “information and communication technology” and “financial system”. This cluster reflects themes related to the technological advancements that underpin digital transformation, particularly in ICT and its role in reshaping financial systems.

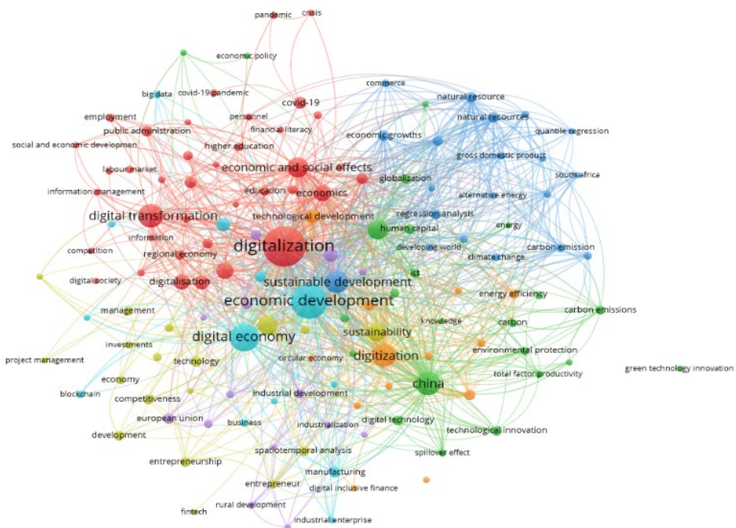

Figure 1. Network visualization map of keyword co-occurrence, created by the author using VOSviewer software based on bibliographic data retrieved from Scopus.

4.2. Analysis of Global Digitalization Index (GDI) for 2024 for Southeast European EU Members

GDI assesses a country's ICT development by evaluating infrastructure components such as computing power, storage, cloud systems, and green energy integration. It supports strategic decisions by quantifying ICT capacity and its economic impact. All five Southeast European EU countries are categorized as "Adopters," characterized by expanding basic connectivity and efforts to strengthen digital foundations. Most nations in this group are middle-income economies aiming to improve access and foster efficient digital services through targeted policy support. By investing in digital infrastructure, these countries seek to accelerate growth and digital transformation across key sectors [17].

Table 2 shows that GDI 2024 scores for the selected countries range from 46.5 to 49.9. Greece leads with 49.9, followed by Romania (49.0) and Slovenia (48.1). Croatia (46.7) and Bulgaria (46.5) have slightly lower scores, potentially reflecting weaker digital policies or investment levels. The narrow range suggests similar stages of digital maturity, though small differences may arise from varying infrastructure quality and national strategies.

Table 2. Global Digitalization Index (GDI) 2024 Scores for Southeast European EU Members

Country	***GDI 2024***
Bulgaria	*46.5*
Croatia	*46.7*
Greece	*49.9*
Romania	*49.0*
Slovenia	*48.1*

Source: Global Digitalization Index (GDI) 2024. (2025). Retrieved from Huawei website: https://www.huawei.com/en/gdi (Visited on 03.02.2025).

Figure 2 illustrates the GDI 2024 for the examined countries, representing consistent but moderate variation in digitalization levels across the region.

Figure 2. Global Digitalization Index (GDI) 2024 for Southeast European EU countries. Visualization prepared by the author based on source data from Huawei website: https://www.huawei.com/en/gdi (Visited on 03.02.2025).

4.3. Analysis of firms' adoption of advanced digital technologies and climate actions in 2022 in Southeast European EU Member States

Table 3 presents the percentage of firms in SEE EU Member States that have adopted advanced digital technologies and taken measures to address physical climate risks as of 2022. Slovenia leads with 83% of firms using advanced digital technology, showcasing its strong integration of digital solutions in business operations. Romania follows closely with 73%, while Bulgaria and Croatia show moderate adoption levels at 65% and 66%. Greece trails at 60%, indicating potential for greater digital integration among its businesses. In terms of climate-related actions, Romanian firms are the most proactive, with 60% having implemented measures to protect against physical climate risks. Croatia (43%) and Greece (42%) exhibit moderate levels of engagement, whereas Bulgaria (34%) and Slovenia (31%) demonstrate relatively lower involvement in climate risk management strategies.

Table 3. Firms' Adoption of Digital Technologies and Climate Actions (2022)

Country	***Share of firms using advanced digital technology (in %)***	***Share of firms taking actions to protect against physical climate risk (in %)***
Bulgaria	*65%*	*34%*
Croatia	*66%*	*43%*
Greece	*60%*	*42%*
Romania	*73%*	*60%*
Slovenia	*83%*	*31%*

Source: European Investment Bank. Digitalisation in Europe 2022-2023: Evidence from the EIB investment survey. LU: Publications Office, 2023. Retrieved from https://data.europa.eu/doi/10.2867/745542 (Visited on 03.02.2025).

Figure 3 illustrates the percentage of firms in Bulgaria, Croatia, Greece, Romania, and Slovenia that have adopted advanced digital technologies and taken actions to mitigate physical climate risks in 2022.

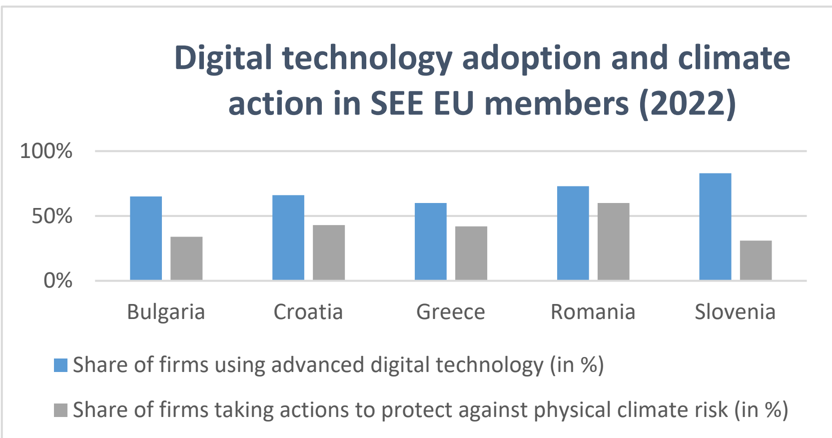

Figure 3. Firm-level adoption of digital technologies and climate actions (2022). The author's visualization based on data from the European Investment Bank survey (https://data.europa.eu/doi/10.2867/745542 (Visited on 03.02.2025)).

4.4. Analysis of Global Innovation Index 2024 for Southeast European EU Members

The GII 2024 reflects current innovation dynamics in the context of sluggish global economic growth, declining funding opportunities, and limited productivity gains. It ranks the innovation performance of approximately 130 economies, identifying both their strengths and areas for improvement [18]. Table 4 shows the GII positions of Bulgaria, Croatia, Greece, Romania, and Slovenia from 2020 to 2024, showcasing each country's relative performance in global innovation rankings. Slovenia consistently outperformed the others, maintaining the best position throughout the five years, although it dropped slightly from 32nd in 2020–2021 to 34th in 2024. This indicates that while Slovenia remains a leader in innovation within this group, there has been a slight decline in its global standing. Bulgaria showed some fluctuation, improving its position from 37th in 2020 to 35th in 2021–2022, but dropping back to 38th in 2023–2024. This suggests that while Bulgaria made progress initially, it struggled to maintain its gains over time. Croatia maintained a relatively stable position in the rankings, moving slightly between 41st and 44th place. Its consistent mid-range performance shows steady, albeit moderate, progress in fostering innovation. Greece's performance has been more dynamic. After initially dropping from 43rd in 2020 to 47th in 2021, it climbed back up to 42nd in 2023 before slipping slightly to 45th in 2024. This volatility suggests ongoing efforts to strengthen innovation, though challenges remain.

Table 4. GII Rankings of Southeast European EU Members, 2020–2024

Year	*Bulgaria GII Position*	*Croatia GII Position*	*Greece GII Position*	*Romania GII Position*	*Slovenia GII Position*
2020	*37th*	*41th*	*43th*	*46th*	*32nd*
2021	*35th*	*42nd*	*47th*	*48th*	*32nd*
2022	*35th*	*42nd*	*44th*	*49th*	*33rd*
2023	*38th*	*44th*	*42nd*	*47th*	*33rd*
2024	*38th*	*43rd*	*45th*	*48th*	*34th*

Source: World Intellectual Property Organization. Global Innovation Index. (2025). Retrieved from https://www.wipo.int/en/web/global-innovation-index (Visited on 05.02.2025).

4.5. Country Classification Based on Digitalization and Climate Indicators

To complement the descriptive analysis, a simple classification was applied to evaluate five Southeast European EU countries across four dimensions: national digital capacity (Global Digitalization Index – GDI), innovation performance (Global Innovation Index – GII), firm-level use of advanced digital technologies, and engagement in climate-related actions. Thresholds were set using benchmark values: GDI ≥ 48.0, GII ranking within the top 40, firm-level digitalization ≥ 70%, and climate actions ≥ 50%. Table 5 summarizes the results. Slovenia demonstrates strong institutional and technological performance but limited engagement in climate-related initiatives. Romania shows robust firm-level digitalization and climate actions, despite lower innovation and GDI scores. Greece has high digital infrastructure readiness but underperforms in business-level adoption. Bulgaria and Croatia lag across most indicators, suggesting a need for more comprehensive digital and environmental policy efforts. This profiling highlights the gap between institutional capacity and firm-level implementation. It provides useful insights for tailoring national strategies based on each country's specific strengths and weaknesses.

Table 5. Country Profiles Based on Digital and Climate Indicators

Country	*High GDI (≥48.0)*	*High GII (Top 40)*	*High Firm Digitalization (≥70%)*	*High Climate Action (≥50%)*	*Profile Summary*
Bulgaria	✗ *(46.5)*	✗ *(38th)*	✗ *(65%)*	✗ *(34%)*	*Overall weak performance*
Croatia	✗ *(46.7)*	✗ *(43rd)*	✗ *(66%)*	✗ *(43%)*	*Passive middle performer*
Greece	✓ *(49.9)*	✗ *(45th)*	✗ *(60%)*	✗ *(42%)*	*Strong institutional framework, weak firm-level engagement*
Romania	✓ *(49.0)*	✗ *(48th)*	✓ *(73%)*	✓ *(60%)*	*Strong firm-level initiative, low institutional positioning*
Slovenia	✓ *(48.1)*	✓ *(34th)*	✓ *(83%)*	✗ *(31%)*	*Digitally advanced, climate-inactive*

Source: Author's classification based on data from the GDI (2024), GII (2024), and EIB Investment Survey (2023).

5. CONCLUSION

The European Union and its member states increasingly recognize the importance of digitalization and digital transformation, striving to create supportive frameworks that can enhance competitiveness and economic resilience. This study examined digitalization trends in Southeast European EU member states, assessing their performance in GDI 2024, GII 2024, and firm-level digital adoption. The findings indicate that while all five countries have made progress in digital transformation, disparities persist in innovation capacity, digital business integration, and climate risk adaptation. Slovenia consistently outperforms the other SEE EU nations in digital adoption and innovation rankings, while Romania faces the most significant challenges. Despite moderate adoption of advanced technologies, firms in SEE countries still struggle with digital skills shortages, financial barriers, and policy implementation gaps. The bibliometric analysis supports these findings, highlighting growing academic interest in digitalization, particularly in areas such as Industry 4.0, competitiveness, and governance. In addition, the country classification analysis provides a structured comparison of institutional and firm-level indicators, helping to identify specific strengths and policy gaps across the five SEE EU countries.

As digital technologies continue to be adopted rapidly across various sectors, it is essential to recognize security policy as a fundamental component of successful digital transformation. Future research will focus on examining how digitalization strategies align with national and regional cybersecurity frameworks, emphasizing institutional readiness, effective risk mitigation, and cooperation on regulatory matters across EU borders. Understanding these connections is crucial for building secure digital infrastructures that support long-term economic development and technological innovation. As recent studies have highlighted, the success of digital security frameworks also depends on user awareness and digital literacy, particularly when handling personal data in virtual environments [22]. Therefore, improving public awareness and strengthening user competencies in this area should be seen as a strategic priority for both policymakers and future academic research.

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