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Position of Southeast European Countries in the Digitalization of Manufacturing Processes Within SMEs: A Comparative Analysis Using EDAS and Entropy Weighting Methodology

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Abstract: The digitalization of manufacturing processes in Small and Medium-Sized Enterprises (SMEs) is increasingly recognized as a pivotal factor for business growth, market expansion, innovation, and improved investment efficiency. Despite the European Union's overarching goal of fostering digital transformation across all sectors by 2030, significant regional disparities persist, particularly within Southeast Europe (SEE). Although substantial research has been conducted on the digitalization of businesses within the EU, limited attention has been paid to the specific dynamics of Southeast European countries, especially those aspiring to join the Union. This study aims to fill this gap by analyzing the degree of digitalization and the adoption of Information and Communication Technologies (ICT) in SMEs across Southeast Europe. The Evaluation Based on Distance from the Average Solution (EDAS) method, enhanced by the Entropy weighting technique, was employed to assess the relative position of these countries in relation to the EU digitalization benchmark. Data obtained from the Eurostat database were utilized to evaluate ICT integration in SMEs with 10 to 249 employees. The results highlight a significant divide between EU member states and the candidate countries, with several SEE nations lagging behind the EU average in terms of digital maturity. Notably, discrepancies were identified not only between EU members and non-members but also within the SEE region itself, with clear divisions emerging between countries that have already joined the EU and those in the accession process. These findings underscore the urgent need for accelerated digital transformation and infrastructure development in countries where ICT adoption remains limited. The study emphasizes the importance of targeted policy interventions to foster digital integration and competitiveness among SMEs in Southeast Europe, thus contributing to the broader objectives of the EU's digital agenda.

Keywords: South-East Europe (SEE); Small and Medium-Sized Enterprises (SMEs); Manufacturing; Digitization; Evaluation Based on Distance from the Average Solution (EDAS); Information and Communication Technologies (ICT)

1. Introduction

Digital technologies are becoming vital and are the ground for communication, business, and innovation. The manufacturing technologies available nowadays offer great opportunities for digitization and process automation but require a certain level of readiness to be adopted and bring competitiveness. These technologies, categorized as Industry 4.0, support four core technologies: Internet of Things (IoT), cloud computing, big data and artificial intelligence (AI) and several front-end technologies, comprising product design systems, simulation, augmented reality (AR) and virtual reality (VR), additive manufacturing (AM) and progressive robotics (Meindl et al., 2021; Milošević et al., 2022; Stojanović, 2022). Industry 4.0 is considered the future of manufacturing (Doyle & Cosgrove, 2019) as manufacturers continuously seek ways to improve productivity, efficiency, quality, and sustainability. Consequently, they transition toward new technologies that provide these advantages (Hughes et al., 2022). The path to adopting and implementing Industry 4.0 technology in manufacturing industries is complex and versatile, and significant technical and organizational challenges may arise. However, in order not to be left behind by large companies and early adopters, SMEs must also evolve and integrate information and digital technologies into their production and operations (Ghobakhloo & Ching, 2019).

SMEs in Europe are considered essential contributors to economic growth, but they face several challenges, including administrative burdens, limitations in size and scale, and difficulty accessing funding. Despite these obstacles, the growing digitization of industries has uncovered further vulnerabilities and divisions among businesses. The European Commission's document, "2030 Digital Compass", emphasizes the gap between businesses that fully utilize the advantages of digitization and those that have yet to embrace it. By 2030, it is anticipated that key production processes will incorporate technologies from Industry 4.0, including the IoT, edge computing, AI, AR and robotics. The pace of change in businesses will largely depend on SMEs' ability to adopt these new technologies (European Commission, 2021). As a result, many scholars and policymakers are focused on assisting SMEs in their digital transformation efforts. The European Commission aims to empower SMEs to thrive in an economy that strives to be environmentally neutral, efficient in resource utilization, and digitally agile, ultimately enhancing their long-term competitiveness and resilience (European Council, 2024).

However, it was noticed that regions and economies across Europe are lagging in the digital transformation process (Brodny & Tutak, 2022a). Recent reports and studies show that SEE countries have made significant progress in their development across all spheres. Nevertheless, these reports indicate that compared to their peers in Northern and Western Europe, they still lag behind and are in a weaker position (Makó et al., 2022). Literature research indicated researchers' interest in the specifics of accepting digital transformation in manufacturing SMEs in SEE. However, a more detailed review of the literature revealed that research mainly deals with individual countries or the comparison of a small number of countries and that there is a lack of systematic comparison of all countries belonging to the SEE region (Marcysiak & Pleskacz, 2021; Milošević et al., 2024; Opoku et al., 2024; Saáry et al., 2022; Voza et al., 2022).

This paper examines the level of digitization and the implementation of ICT in manufacturing in SMEs across Southeast European countries. The method known as EDAS is improved by integrating the entropy weighting technique. This advanced approach has been specifically used to assess and rank the positions of SEE countries (Keshavarz Ghorabaee et al., 2015; Sahoo & Choudhury, 2022). In order to compare the levels of digitization of SMEs in individual SEE countries, it is necessary to analyze existing indicators that enable a unique methodology for monitoring in several countries. Therefore, the study employs datasheets in the Eurostat database on ICT usage in enterprises, within which the indicators in 6 groups cover digital intensity, connection to the internet, e-commerce, websites and social media, e-business, and ICT security.

2. Literature Review

Many literature sources analyze the digitization of production in SMEs and investigate methods to facilitate this process (Koumas et al., 2021; McFarlane et al., 2022; Opoku et al., 2024; Stich et al., 2020; Sutherland et al., 2023). Digitization of production in SMEs requires numerous changes related to reorganizing business and production operations and organizational structure while considering business results, competitiveness and sustainability (Saáry et al., 2022). Preparing for introducing and implementing digitized processes, production, and products in SMEs brings numerous challenges, the most common being digital solutions' high costs and complexity (Horváth & Szabó, 2019; Sevinç et al., 2018). In light of the findings of Opoku et al. (2024), their insights provide a clearer understanding of how digitization can drive innovative outcomes in SMEs. The integration of digital technologies into operations and supply chains, along with the use of big data and technology-based processes, has shown only modest results, according to the findings of Opoku et al. (2024). The outcomes depend significantly on the specific type of digitization and innovation implemented. Similarly, Radicic & Petković (2023) explored the influence of specific digital technologies on innovations in SMEs and concluded that the effects are moderate and depend on the type of digitalization. McFarlane et al. (2022) introduced the idea of using technologies and processes aimed at innovatively employing existing non-industrial digital devices. These devices are specifically adapted for the low-cost digitalization of SMEs to improve and enhance their digital transformation outcomes.

Assessment of SMEs' digital level and readiness represents a significant inception for implementing digitized solutions in manufacturing. Numerous studies use the self-assessment approach to determine the readiness and level of digitization. Brozzi et al. (2021) proposed Key Readiness Indicators (KRI) that are based on self-assessment and confirm variations in the distribution of KRIs in relation to size, turnover and awareness of the existence and development of Industry 4.0 technologies. Stich et al. (2020) worked on courses of action for effective digital transformation of SMEs by defining four structuring forces: resources, information systems, culture and organizational structure, and their specific measures that could be used to build an individual road map for digital transformation. Similarly, Chonsawat & Sopadang (2020) grouped measures of SMEs' digital level through Industry 4.0 into five dimensions: organizational resilience, infrastructure system, manufacturing system, data transformation, and digital technology. However, Brozzi et al. (2021) argued that the self-assessment approach does not adequately assess all elements of the digital level and the implementation of Industry 4.0 technologies.

While defining the determinants of digitization in SMEs, Marcysiak & Pleskacz (2021), as a base for creating a self-assessment questionnaire, used the Digital Economy and Society Index (DESI) measures and evaluated priority areas of the digital economy in Poland. Their results showed the need for accelerating the efforts of SMEs to acquire the benefits of digitalization. Similarly, Kádárová et al. (2023) used econometric analysis of data collected from the various available sources in 27 EU countries (Eurostat, European Commission and European Investment Bank) to make conclusions about the causality of the digitalization of manufacturing processes and performance of SMEs. The results showed that digitally mature SMEs tend to achieve better business performance, including growth and an increase in employees. Skare et al. (2023) found DESI very useful as a proxy for SME digitalization. The study examined the influence of digital technologies in SMEs on various issues in business, such as consumers, competition, availability of funding, skilled employees, regulatory issues, etc., and found positive relations. Castelo-Branco et al. (2019) examined the adoption of Industry 4.0 in the manufacturing sector and identified several challenges. Their study utilized Eurostat data and cluster analysis, revealing significant disparities in fulfilling conditions and readiness for Industry 4.0 across different EU countries.

Studies often point to the differences between economically developed and underdeveloped economies, where it is concluded that economies with greater economic strength create good preconditions for the digitization of production in SMEs (Castelo-Branco et al., 2019). In contrast, SMEs in weaker economies face various challenges, such as insufficient capital, management's and employees' resistance to digital transformation, and a lack of necessary skills, all of which significantly impede growth. Brodny & Tutak (2022b), in research on Central and Eastern Europe (CEE) countries, used multi-criteria decision analysis and Eurostat data to evaluate the levels of digitalization and concluded they were influenced by GDP per capita and the amount of R&D expenditure. This paper also provided insight into the variation of digitization levels in CEE countries (Brodny & Tutak, 2022b).

The standardized methodology of gathering information on the degree of digitization and implementation of ICT carried out by the European Commission enables the monitoring of progress in integrating digital technologies in business. The practicality of the Eurostat database in comparative research has already been proven in previous research (Brodny & Tutak, 2022b; Kádárová et al., 2023; Skare et al., 2023). Using the Eurostat database in this research enables an objective and comprehensive analysis of the state of digitization of manufacturing in SMEs in SEE countries. Also, in this way, it is possible to identify areas that are adequately developed as well as those in which it is necessary to make improvements.

3. Methodology

When considering the structure of the available data, the problem of ranking SEE countries is defined as complex, with a significant number of elements that should be considered. Multi-criteria methods significantly contribute to research on the comparative analysis of countries based on their levels of digitalization. The complexity of the methods used has evolved along with the metrics for monitoring the level of digitization. In recent research, Balkan & Akyüz (2023) developed a composite index and performed PROMETHEE based on OECD data. Chang et al. (2021) used the DEMATEL-based analytic network process (DANP) and VIKOR to analyze how to reduce gaps in implementing Industry 4.0 technology in SMEs. Brodny & Tutak (2022b) employed various hybrid MCDA methods such as TOPSIS, VIKOR, entropy and CRITIC to determine the weights of measures and assess the level of digitalization of companies in CEE countries.

This paper proposes the EDAS method, enhanced by the entropy weighting technique. The proposed methodology is based on several steps:

1. Establishing criteria for evaluating the application of ICT and the digitization of processes and production in SMEs.
2. Identification of alternatives whose level of digitization in manufacturing SMEs will be analyzed.
3. The calculation of weights for specific criteria using the entropy method.
4. Determining the ranking of alternatives using the EDAS method.

3.1 Development of the Model and Defining the Criteria

The European Commission employs various indicators to monitor and evaluate digital performance. These data enable the development of a composite index to assess the current state of digitization comprehensively. These indicators are designed to measure various aspects of digitalization, including internet connectivity, digital skills, e-commerce activity, and the overall integration of digital technologies in economic and social processes. For a more detailed analysis of specific aspects of digital technologies, data is collected on ICT experts, e-invoicing, ICT security, cloud computing, AI, data analysis and electronic exchange. In addition, special modules on new technologies, such as IoT, robotics, and 3D printing, allow for the assessment of the capability to follow the latest trends and innovations. All of these indicators are relevant to creating a comprehensive picture of the level of digital transformation. Additionally, consistent data collection and a unique database enable a precise assessment of the state and progress in the various segments of digitization.

Table 1 presents a set of indicators monitored by the European Commission that reflect the level of digitalization among companies. Those indicators are used as a criterion in the proposed model.

Table 1. Indicators of digitalization in SMEs

Indicator	Index	Information on Indicator	Source
Connection to the Internet			
	C1	Enterprises where persons employed have access to the internet	isoc_ci_in_es
E-commerce			
	C2	Enterprises with e-commerce sales	isoc_ec_esels
	C3	Enterprises with web sales via their own websites or apps	isoc_ec_esels
Websites and use of social media			
	C4	Enterprises with a website	isoc_ciweb
	C5	Enterprises having a mobile app for clients	isoc_ciweb
	C6	Use social networks	isoc_cismt
	C7	Use multimedia content sharing websites	isoc_cismt
E-business			
Cloud computing services	C8	Buy cloud computing services used over the internet	isoc_cicce
Artificial intelligence	C9	Enterprises use at least one of the AI technologies	isoc_eb_ai
	C10	Enterprises use AI technologies for at least one of the purposes	isoc_eb_ai
Big data analysis	C11	Analyze big data internally from any data source	isoc_eb_bd
Data analytics	C12	Enterprises where data analytics for the enterprise is performed by own employees	isoc_eb_das
	C13	Enterprises where data analytics for the enterprise is performed by external enterprise or organisation	isoc_eb_das
Integration with customers/suppliers, supply chain management	C14	Enterprises sending e-Invoices, suitable for automated processing	isoc_eb_ics
	C15	Enterprises sending e-Invoices, not suitable for automated processing	isoc_eb_ics
	C16	Enterprises whose business processes are automatically linked to those of their suppliers and/or customers	isoc_eb_ics
Integration of internal processes	C17	Enterprises who have ERP software package to share information between different functional areas	isoc_eb_iip
	C18	Enterprises using Business Intelligence (BI) software	isoc_eb_iip
Internet of Things	C19	Enterprises use IoT (interconnected devices or systems that can be monitored or remotely controlled via the internet)	isoc_eb_iot

3D printing and robotics	C20	Use 3D printing	isoc_eb_p3d
	C21	Use industrial robots	isoc_eb_p3d
	C22	Use service robots	isoc_eb_p3d
ICT security			
	C23	Enterprises have documents on measures, practices or procedures on ICT security	isoc_cisce_ra
ICT specialists			
	C24	Enterprise employed ICT/IT specialists	isoc_ske_itspe

Source: Eurostat (2024)

3.2 Selection of Alternatives and Data Collection

The Eurostat database provides a valuable and irreplaceable data source in comparative research. However, certain limitations of using predefined questionnaires and, specifically, this database are incomplete data for countries not members of the EU or the interruption of timelines due to periodic data collection. The limited diversification of the sector can also be considered a disadvantage. However, the advantages of the unique data collection methodology greatly outweigh its disadvantages. First, a wide sample and regular updating enable different geographical and cross-sectoral analyses as well as longitudinal analyses. Also, the comprehensiveness of the indicators allows the use of data in various analyses and the use of the most diverse methodologies to reach valid conclusions.

Data on ICT usage and e-commerce in enterprises has been collected for the needs of Eurostat by national statistical institutes (NSIs) based on uniformly created surveys. NACE Rev. 2 (Nomenclature of Economic Activities - Revision 2) is a standardized classification of economic activities aimed at providing a single and consistent methodology for collecting, analyzing and comparing statistical data on economic activities in different countries. NACE Rev. 2 categorizes enterprises and organizations according to their main economic activities. The category predefined in the Eurostat database: “All activities (except agriculture, forestry and fishing, and mining and quarrying), without the financial sector”, is chosen in this research paper. In that way, it represents a wide range of manufacturing activities. Based on the two offered breakdown categories, data that intersect the SMEs and manufacturing sectors were taken. The reliability and validity of the data are provided by Eurostat, and their collection is carried out following the European business statistics compilers’ manual for ICT usage and e-commerce in enterprises. By this, a strong methodological standard for collecting and checking the accuracy and reliability of the data had been applied.

Data were collected on 8 SEE countries defined by OECD and EU27 (Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Montenegro, North Macedonia, Romania and Serbia) in the period from 2020 to 2023. This time span was chosen because more complete sets of data on ICT usage in enterprises can be found within it, considering that for some indicators, data is collected every year and for others, only every two years.

After analyzing the initial table, it was noticed that some data were missing. Since more than half of Albania’s indicator values are missing, removal was performed from further analysis. Other missing data were supplemented using the Excel function that fills in missing data based on neighbors nearest data to the missing one. Therefore, the final set consisted of data for 7 SEE countries and the EU average in order to perform additional positioning with the EU.

3.3 Entropy Method

The entropy approach is often used to calculate criteria weights, which are then incorporated into other methods, creating hybrid approaches. The entropy method is important because it determines the importance of criteria for the decision-making process based on the existing information compiled in the created decision-making model. Therefore, this makes the entropy method insensitive to decision-makers subjectivity and is classified as one of the essential objective methods (Mukhametzyanov, 2021; Sahoo & Choudhury, 2022; Setiawansyah, 2024). The entropy method consists of the steps presented in Figure 1 (Ersoy, 2021; Sahoo & Choudhury, 2022).

3.4 EDAS Method

Keshavarz Ghorabaee et al. (2015) proposed the EDAS method to determine the order of alternatives based on their distance from the average solution (Ulutaş, 2019). The method enables working with complex and multidimensional problems and is often used in research (Brodny & Tutak, 2021; Ersoy, 2021; Setiawansyah, 2024). The EDAS method is presented in Figure 2 (Keshavarz Ghorabaee et al., 2015).

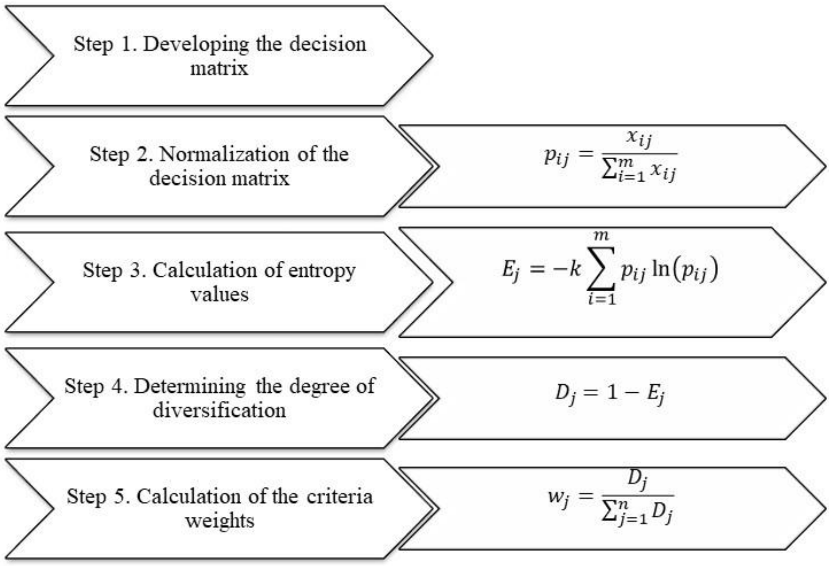

Figure 1. Entropy method
Note: This figure was prepared by the authors.

Step 1. Developing the decision matrix

Step 2. Determining the average solution for all criteria ⇨

$$AV = [AV_j]_{1\times m}$$

where $AV_j = \frac{\sum_{i=1}^{n} x_{ij}}{n}$

Step 3. Determination of the positive (PDA) and negative (NDA) distances of each alternative from the average solution for each criterion, distinguishing between beneficial and non-beneficial criteria. ⇨

$$PDA = [PDA_{ij}]_{n\times m}$$
$$NDA = [NDA_{ij}]_{n\times m}$$

if j[th] criterion is beneficial

$$PDA_{ij} = \frac{max\left(0, (x_{ij} - AV_j)\right)}{AV_j}$$
$$NDA_{ij} = \frac{max\left(0, (AV_j - x_{ij})\right)}{AV_j}$$

if j[th] criterion is non-beneficial

$$PDA_{ij} = \frac{max\left(0, (AV_j - x_{ij})\right)}{AV_j}$$
$$NDA_{ij} = \frac{max\left(0, (x_{ij} - AV_j)\right)}{AV_j}$$

Step 4: Determination of the weighted sum of PDA and NDA ⇨

$$SP_i = \sum_{j=1}^{m} w_j \, PDA_{ij}$$
$$SN_i = \sum_{j=1}^{m} w_j \, NDA_{ij}$$

where w_j is the weight of the j[th] criterion

Step 5: Normalization of the values of SP and SN ⇨

$$NSP_i = \frac{SP_i}{max_i(SP_i)}$$
$$NSN_i = \frac{SN_i}{max_i(SN_i)}$$

Step 6: Calculating the appraisal scores ⇨

$$AS_i = \frac{1}{2}(NSP_i + NSN_i)$$

where $0 \le AS_i \le 1$

Step 7: Ranking the alternatives according to AS

Figure 2. EDAS method
Note: This figure was prepared by the authors.

4. Results

The proposed procedure has been implemented to obtain the results of this study. Firstly, the initial decision matrix is created and presented in Table 2. The criteria are marked with C1-C24, and their meaning is previously defined in Table 1. All criteria in the research are stated to be beneficial. The alternatives include the countries of SEE and the EU average.

Table 2. Initial decision matrix

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24
European Union	98.9	22.2	16.3	77.3	7.8	55.3	26.8	40.1	7	4.3	12.2	27	10.1	31.6	62.2	23.5	42	13.9	28.1	4.9	4.3	2.1	36	19.3
Bulgaria	96	14.7	10.6	51	5.1	37.3	11.6	12	3	1.7	5.3	16.9	7.3	9.7	55.2	11.9	20.5	3.5	14.7	2.8	2.4	2	20.8	14.8
Croatia	96.6	29.2	20.9	66.9	5.4	49.5	21.6	38.2	8.3	4.2	12.3	46.5	7.4	42	72.6	13.2	23.7	10.8	22.6	5.4	2.2	2.9	47.4	15.1
Romania	98.9	10.9	8.2	50.3	6.5	35.1	10.3	13.5	1.2	0.9	4	18.2	6.1	16.5	43.8	8.8	21.4	6.6	10.1	1.5	1.9	1.4	43.9	10.2
Bosnia and Herzegovina	99.7	23.2	13.9	61.4	5.5	55	11.6	8.1	1.9	1.1	4.3	24.2	9.6	12.6	42	15.7	22.9	5	16.3	3.3	4.7	0.5	24.3	11.7
Montenegro	100	15.6	10.2	83.7	12.1	52.8	27.7	23.6	3.3	1.3	13.2	36.2	17.1	44.2	63.5	28.5	41.4	13.3	36	8.4	0.9	0.5	14.3	26.9
North Macedonia	96.2	8.1	6.6	47.7	9	48	10.7	12.9	2.05	1.5	11.8	29.1	12.1	7	40.3	29.5	42.4	14.3	16.6	5	1.9	6.4	4.9	10.8
Serbia	100	27.7	22.4	84	5.9	46	12.5	28	0.8	0.8	1.7	22	7.1	18.7	69.1	30.5	43.4	15.3	19	1.7	2.9	0.6	54	22.1

Source: Eurostat (2024)

The entropy method was used to determine the criteria weights. All obtained criteria weights are presented in Table 3. After performing the entropy method, it was determined that criteria C22 and C9 have the most significant weight, with over 10% influence. Criteria C1 and C6 have the weakest influence.

Table 3. Criteria weights obtained with the entropy method

C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24
5E-05	0.031	0.032	0.009	0.018	0.005	0.034	0.055	0.1	0.08	0.066	0.021	0.023	0.071	0.009	0.035	0.02	0.04	0.028	0.05	0.04	0.14	0.064	0.022

The order of alternatives was acquired using the EDAS method. The final ranking based on the obtained AS value is presented in Table 4 and Figure 3.

Table 4. The order of alternatives obtained with the EDAS method

Rank	Country	AS
1	Croatia	0.914
2	European Union - 27 countries	0.899
3	North Macedonia	0.540
4	Montenegro	0.495
5	Bulgaria	0.178
6	Serbia	0.145
7	Bosnia and Herzegovina	0.036
8	Romania	0.032

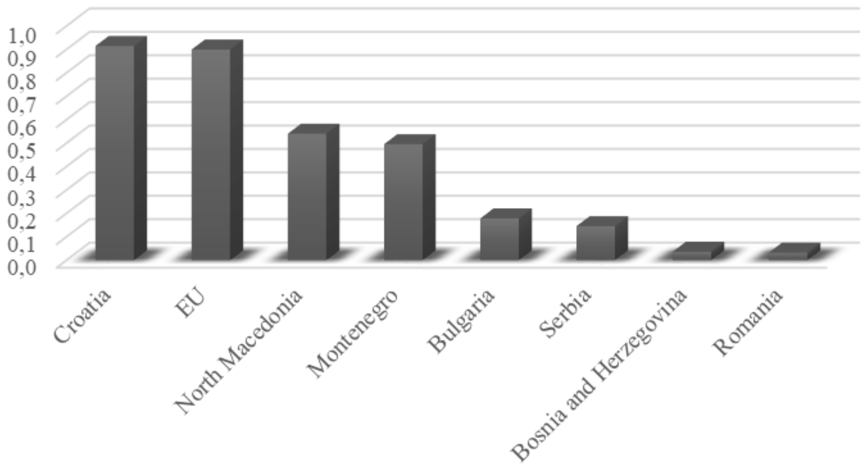

Figure 3. Ranking of alternatives

5. Discussion

The digitalization and implementation of ICT in manufacturing SMEs in SEE countries have been compared using hybrid entropy-EDAS methodology. The analysis comprised seven SEE countries and the EU average with available data on 27 indicators of digitalization. Data regarding the digitization of manufacturing SMEs, defined as having between 10 and 249 employees, were collected. The values of the obtained criteria weights indicate that the C22 - Use service robots and C9 - Enterprises use at least one of the AI technologies, which have the greatest differences in the values analyzed. That means the highest differences among countries in those segments of ICT implementation. By analyzing the data from the initial decision-making matrix, it can be concluded that although many SMEs have access to the Internet (over 95%), a very limited percentage of them sell their products via online sales (less than 30%). In using Industry 4.0 technologies, which are criteria C8-C22, it could be concluded that SMEs mostly use ICT for sharing information using the cloud, ERP software (the highest percentage is about 40%) and e-invoices (about 42-72%), while digitalization of production processes using, for example, 3D printing and robotics is quite low (only a few percent).

The results indicated strong differences in the levels of digitization of manufacturing SMEs in SEE countries. The findings suggest that Croatia is in the highest position, with a better result than the EU average. The rest of the countries are evidently quite below the EU average. In the research, three countries (Bulgaria, Croatia and Romania) are members of the EU, while four other countries (Bosnia and Herzegovina, Montenegro, North Macedonia and Serbia) are in the process of accession. By analyzing the EU membership, results do not indicate relations since the last positions belong to Bosnia and Herzegovina, which is not an EU member, and Romania, which is a member of the EU. Therefore, the results suggest that EU membership is not the only factor influencing the level of ICT development in a country, and it is possible that other factors play a significant role in shaping these positions. The outcomes can be influenced by various factors on a national level, such as economic development, infrastructure and political strategies. Based on the initial data, it can be determined that all countries in the research have reached a high level of digital infrastructure and coverage. However, when looking at the best- and worst-ranked countries, both EU members, a clear difference can be seen in the readiness of companies in Romania to use even basic ICT in their operations, while the involvement of advanced Industry 4.0 technologies is insignificant. This is due to Romania initially having insufficient institutional capacity to support rapid digital transformation, and despite the government's efforts, it is still lagging (World Bank, 2021). Croatia, on the other hand, has achieved stability in implementing digital policies, with significant support from public institutions and EU funds, enabling faster progress. The establishment of digital institutions significantly increased the aspiration of the economy to be highly efficient and digitized in performing business processes (World Bank, 2021).

The results emphasize that the entire region still faces numerous challenges, especially those countries that have not yet joined the EU and OECD (European Commission, 2021; OECD, 2024). Although they have the potential for progress in digital transformation, countries in the process of joining the EU, such as Bosnia and Herzegovina, Montenegro, North Macedonia and Serbia, face political and institutional challenges, such as lower efficiency in the use of EU funds due to administrative difficulties, the need for greater investments and education of entrepreneurs, and the differences in the implementation of e-government (Tiganasu & Lupu, 2023).

Several activities have already been undertaken to support the efforts of governments to continue on the path of socio-economic growth and improve the status of SMEs in a harsh competitive race. Brodny & Tutak (2021) emphasized the importance of the digitalization of SMEs since similar results had been obtained for CEE countries (Szabo et al., 2020). This is crucial for improving efficiency and productivity in manufacturing, as well as for promoting innovation and competitiveness of SMEs.

6. Conclusions

The paper aimed to explore the level of digitization in manufacturing in SMEs across SEE countries. Taking into account various indicators and using the entropy weighting method, the upgraded EDAS methodology provides a more nuanced assessment of the relative position of each country, allowing for a comprehensive analysis of their performance across multiple dimensions.

The results showed differences among SEE countries, which were all below the EU average in SME digitalization, except for Croatia, which exceeded the EU average. These findings can contribute to the body of literature while providing insight into the state of digitalization in SEE countries. Also, it points to those countries that need additional attention and efforts of governments and European support to face challenges and identify strategies to catch pace with highly digitally developed countries successfully.

Since digitizing production in SMEs requires coping with complex digital solutions, reorganizing business and production operations, changes in organizational structure and high costs (Saáry et al., 2022; Sevinç et al., 2018), improving the SEE countries should be based on specific and tailored strategies and initiatives. Firstly, many SEE countries have not fully utilized EU funds, so it is recommended that the education of entrepreneurs be improved and administrative barriers reduced for easier access to financial resources. Also, SMEs often do not know enough about all the benefits of digital technologies and their innovative potential (Opoku et al., 2024), so support is necessary while considering business results, competitiveness and sustainability based on digitalization. A significant push towards digitization was observed in states that digitized their government and administrative processes. Therefore, significant increases in the efficiency of SMEs can be encouraged by implementing simple solutions for electronic business and improving e-administration. Digital transformation of production processes in SMEs is still slow, and at the same time, the willingness and competence of employees to accept and implement such changes cannot be ignored (Hansen et al., 2024).

The limitation of the research is noted in the fact that the levels of digitalization of SMEs were considered without analyzing the level of readiness of management and employees in manufacturing SMEs to face the challenges of digitalization. Also, the lack of data for individual countries led to their exclusion from further analysis, and the results of a comprehensive analysis could contribute to drawing some more conclusions.

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Data Availability

The data used to support the research findings are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflict of interest.

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