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Digital Readiness Assessment of Western Balkan Countries: A MCDM Framework for WB DESI Evaluation

Aleksandra Radić[1,*], Sanela Arsić[1]

[1] Engineering Management Department, Technical Faculty in Bor, University of Belgrade, Serbia

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ABSTRACT

Digitalisation has become a major driver of economic growth, competitiveness, and societal development, making the assessment of countries' digital readiness an increasingly important research area. The Digital Economy and Society Index (DESI) is widely recognised as a comprehensive framework for monitoring and comparing digital development. This study evaluates the digital readiness of the Western Balkan countries using the Western Balkans Digital Economy and Society Index (WB DESI). An entropy-weighted TOPSIS model serves as the primary evaluation method, while several established multi-criteria decision-making (MCDM) techniques are employed to examine the robustness, reliability, and stability of the results. The analysis identifies Serbia as the highest-ranked country in terms of digital readiness, followed by Montenegro, Albania, Bosnia and Herzegovina, and North Macedonia. Robustness analysis demonstrates a high degree of consistency across the applied MCDM methods, indicating that the obtained rankings are stable and largely independent of the selected evaluation technique. By addressing both geographical and methodological gaps in the existing literature, this study provides a comprehensive decision-support framework that can assist policymakers in monitoring digital convergence and designing more effective digital transformation strategies across the Western Balkans.

1. Introduction

The digital age and its ongoing transformation have profoundly reshaped everyday life, changed business operations, and affected the economic growth, competitiveness, and development of countries worldwide [1]. Advances in technology have altered how people communicate, access information, shop, and work [2], while businesses now rely on digital tools [3]. Consequently, digital transformation has become a driving force for innovation, efficiency, and competitiveness across nearly every context. At the national level, the increasing adoption of digital technologies has affected how government, business, and society operate. As a result, a country's digital readiness has become a dominant topic and a focus of many studies [4].

* *Corresponding author.*
E-mail address: aradic@tfbor.bg.ac.rs

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In this context, many international organisations have developed indicators and composite indices to monitor and compare the level of digital development across countries. A prominent composite index that quantifies a country's level of digitalisation is the Digital Economy and Society Index (DESI). The DESI serves as a comprehensive international benchmarking instrument, enabling the examination and comparison of the digital landscape of various economies and societies [5].

Digitalisation is often considered a process that should be unaffected by geographical factors. However, regional and territorial factors are crucial to the use of digital technologies and data, and digital advancement is not evenly distributed across regions and countries [6]. The Western Balkans, as part of Europe, has not yet completed a full digital transition and is therefore lagging behind its neighbours. In addition to support from the European Union through numerous projects promoting regional digitalisation, Western Balkan countries have recently initiated collaborations, such as the Digital Summits, to advance digitalisation [7].

In this region, the Regional Cooperation Council (RCC) was established to promote regional cooperation and Euro-Atlantic integration of South East Europe to foster development for the benefit of its people. The RCC currently contributes to Roaming Free WB, participates in regional dialogue, develops a sustainable regional framework to support digital upskilling, and plays a crucial role in developing digital strategies [8].

One of the main roles of the RCC is to monitor and report on the digital development of the Western Balkan countries. For this purpose, the Western Balkans DESI index (WB DESI) has been developed as a framework based on the DESI. It applies the DESI methodology to Western Balkan countries, enabling comparison within the region and monitoring digital convergence with the European Union. WB DESI is not a new index but rather the application and adaptation of the DESI framework to the Western Balkan countries. It enables the assessment of digital readiness in the region and provides a basis for benchmarking with European Union member states.

Despite the growing body of literature on digital development assessment using Multi-Criteria Decision Making (MCDM) methods [9-10], two important research gaps remain. First, existing studies have predominantly focused on developed economies [11-14], while Western Balkan countries have received considerably less attention [15] despite undergoing intensive digital transformation and facing challenges related to digital infrastructure, human capital development, technology adoption, and digital public services. Second, although the developed Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method has been most frequently used for evaluating the DESI index [16-17] especially in combination with an entropy-based approach for determining t-he weights of criteria [18], previous studies indicate that rankings may vary depending on the selected MCDM method [19-21].

For that purpose, the evaluation was conducted using the entropy-weighted TOPSIS method, complemented by established MCDM techniques to validate the robustness, stability, and reliability of the results. The originality of this study lies in integrating MCDM methods into a comprehensive decision-support framework for assessing digital readiness in the Western Balkans. Unlike previous studies that predominantly focus on EU member states or rely on a single evaluation method, this research combines an entropy-weighted TOPSIS model with six additional MCDM techniques to provide a robust validation framework. It also offers one of the first comprehensive WB DESI-based assessments of digital readiness across Western Balkan economies using the latest available dataset, thereby contributing, both geographically and methodologically, to the literature on digital transformation.

This paper is organised as follows. The Literature Review section outlines previous research that has used MCDM methods to analyse the DESI index. The Methods section provides a detailed step-by-step explanation of the MCDM approach used. The Results and Discussion section highlights the main findings and results of the study. The Conclusion section summarises the implications, study limitations, and future research agenda.

2. Literature Review

Multi-Criteria Decision Making (MCDM) is a powerful and essential analytical framework for addressing complex decision problems in which multiple, often competing, criteria are used to evaluate the issue [22]. As digital technologies transform how organisations and individuals gather and process information, MCDM methods offer valuable tools for navigating complex decisions involving multiple, often conflicting, criteria. The integration of digital tools such as big data analytics, artificial intelligence, and decision support systems has significantly enhanced the effectiveness of MCDM by enabling faster, more data-driven, and transparent evaluations [23].

Digitalisation streamlines the systematic assessment of alternatives and supports real-time analysis, making MCDM essential for strategic, operational, and tactical decision-making in today's rapidly evolving digital landscape. Consequently, the composite DESI index has attracted scholarly attention, frequently serving as the focal point of numerous studies employing MCDM for its analysis. The study by Małkowska *et al.,* [16] analysed the impact of digital transformation across 28 EU member countries through a comparative analysis in three dimensions: Society 4.0, Economy 4.0, and Companies 4.0. For this purpose, Hierarchical and K-Means cluster analysis were applied along with the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method. The study findings demonstrate considerable variation in the level of digitalisation across EU countries across the three explored dimensions. The study highlighted that the differences are primarily due to low levels of digital skills and ineffective use of modern technologies in some EU countries.

The study by Zerhouni and Özarı [18] analysed the DESI index for 45 European countries from 2015 to 2018 using the Entropy, TOPSIS, and Entropy-based TOPSIS methods. The results of the entropy-based weighting method showed that the weight for "Integration of Digital Technology and Business" was 28%, and for "Connectivity" was 27%. Integration of Digital Technology by Businesses was weighted at 24%. Furthermore, the entropy method assigns approximately twice the weight to the "Use of Internet Services by Citizens" dimension (20%) compared to "Digital Public Services" (9%). In comparison, the DESI scoring model assigns equal priority to "Connectivity" (25%) and "Human Capital" (25%). Integration of Digital Technology by Businesses is assessed as moderate (20%), while "Use of Internet Services by Citizens" and "Digital Public Services" are both weighted equally at 15%. The results show a very strong positive relationship between the DESI ranking model and the three study-proposed MCDM models.

The study by Radulescu *et al.,* [24] employed a hybrid approach consisting of the Borda Method and the Group Best-Worst Method (GBWM) to determine the weights of composite Digital Development Indicators for a group of countries. Among the indicators were the DESI, the ICT Development Index, the E-Government Development Index, and the Network Readiness Index. The Borda method is applied by a group of experts to select the best and weakest criteria. These criteria are used by every expert in the group to calculate the individual criterion weights in GBWM. The results of the applied hybrid approach indicate that the DESI has the highest weight ($w_j = 0.589$) compared with the weights of the other indexes considered. The weights obtained with the hybrid approach can be used to rank countries using other MCDM methods.

The study by Zhao *et al.,* [20] also used a hybrid MCDM approach to evaluate the level of the digital economy in China from 2015 to 2020. Firstly, the authors set the evaluation indicator system, including digital infrastructure, integrated development, social benefits, innovation ability, and electronic commerce dimensions and a total of 17 sub-indicators. Secondly, the authors applied objective weight-calculation approaches, such as the anti-entropy (AEW) method, and a subjective weight-calculation approach via the Best-Worst Method (BWM). Furthermore, the MARCOS model is applied to evaluate the digital development of various regions in China. The robustness of the proposed approach has been validated by selecting four comparison models and utilising three ranking similarity coefficients. The ranking comparison discussion indicated that changing the weighting method does not affect the ranking results for overall performance and sub-performance.

The study by Marti and Puertas [17] applied TOPSIS to rank 27 European Union countries using a synthetic indicator that combines factors related to innovation, measured by the Global Innovation Index, and digitalisation, based on DESI. The TOPSIS method is applied to rank EU members by their levels of digitalisation and innovation. The ranking results indicate that the countries occupy similar positions over the five years analysed in the study, demonstrating the robustness of the proposed approach.

The research by Bánhidi *et al.,* [21] employed Data Envelopment Analysis (DEA) and TOPSIS to rank the digital readiness of Visegrad Group Countries (Czechia, Hungary, Poland and Slovakia). The ranking is performed using the Data Envelopment Analysis/Common Weights Analysis (DEA-CWA) and the TOPSIS method. Results indicated that the weight vectors differ significantly from the arbitrary weights set by the European Commission, the country rankings remain similar, displaying relatively little sensitivity to the weighting method chosen.

The review of previous studies indicates increasing scholarly interest in assessing digital development using MCDM methods. Existing research has mainly focused on European Union member states and has employed various MCDM approaches. Despite the contributions of earlier studies, two significant research gaps remain. First, most existing studies focus on EU member states, while the Western Balkans are largely underrepresented. This is important because the Western Balkan countries are currently undergoing intensive digital transformation and facing challenges in digital infrastructure, human capital development, technology adoption, and digital public services. Further investigation of digital development in this region is therefore justified. Previous studies have shown that different MCDM methods may produce variations in the country rankings. Although several authors report a high degree of consistency among alternative approaches, they also emphasise the importance of robustness checks and methodological validation. Building on these observations, this study focuses on the Western Balkan countries and adopts a multi-MCDM framework to assess digital development using DESI indicators. By combining complementary methods, the study aims to provide a more robust and comprehensive evaluation of digital readiness while contributing to the limited body of knowledge on digital transformation in the Western Balkan region.

3. Methods

This section provides an overview of the MCDM approach used in the study. It describes the data, the entropy method employed to compute the criteria weights, and the TOPSIS approach used to rank Western Balkan countries.

3.1 Data

The data employed in this study were obtained from the Western Balkans Digital Economy and Society Index (WB DESI) 2025 Report published by the Regional Cooperation Council [8]. This report provides a comprehensive and accessible overview of digital transformation across the Western Balkan economies during 2023-2024. By comparing their progress with EU standards using the EU DESI methodology, the report highlights achievements and identifies ongoing challenges and opportunities for future growth in the region. As noted in the report, data sources include Eurostat, national statistical offices, electronic communications regulators, broadband competence offices, and relevant ministries, supplemented where necessary by targeted market and desk research.

The WB DESI 2025 results are presented across four core dimensions: Digital Skills (5 sub-indicators), Digital Infrastructure (10 sub-indicators), Digital Transformation of Businesses (9 sub-indicators), and Digitalisation of Public Services (8 sub-indicators). Figure 1 presents the WB DESI dimensions, corresponding indicators, and their sub-ndicators.

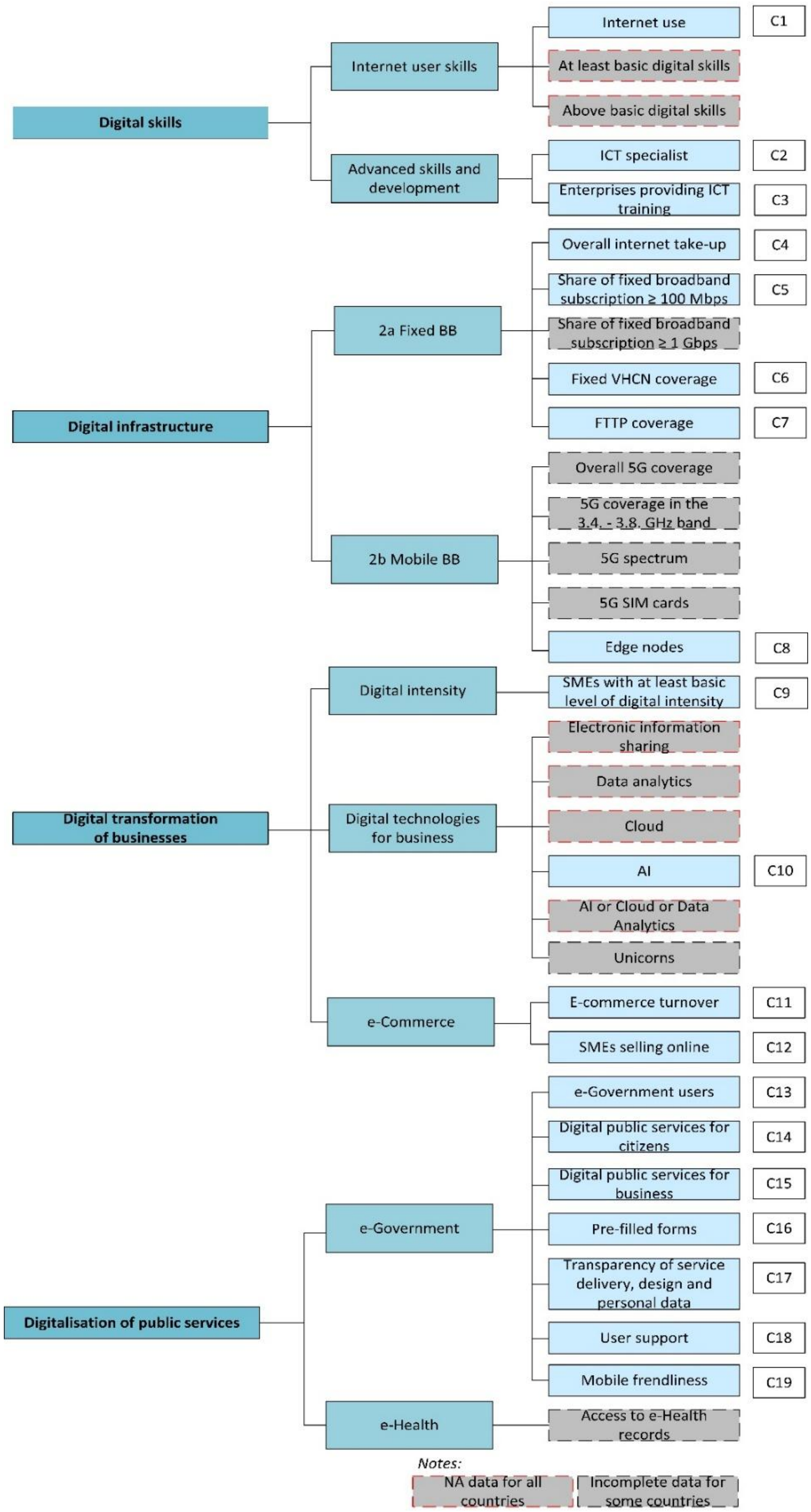

Fig. 1. WB DESI 2025 dimensions, indicators and sub-indicators

However, because the decision matrix required for applying MCDM methods must not contain missing values, some sub-indicators are excluded from the analysis due to missing data in the initial database. Therefore, the decision matrix consists of five alternatives representing Western Balkan countries (Albania, Bosnia and Herzegovina, Montenegro, North Macedonia, and Serbia) and nineteen criteria representing Western Balkan DESI sub-indicators. As a higher criterion value indicates better performance, all criteria are labelled as beneficial.

3.2 Entropy Method

This subsection outlines the step-by-step calculation of entropy-based weights for all established criteria in the MCDM model. The entropy-based method was selected because it eliminates subjectivity in the calculated criteria weights [25]. The DESI sub-indicators described are used as key criteria in the entropy-based TOPSIS approach within the MCDM model.

First step: Data normalization by using Eq. (1).

$$p_{ij} = \frac{x_{ij}}{\sum_{i=}^{m} x_{ij}} \tag{1}$$

Second step: Computation of entropy index by using Eq. (2).

$$H_j = -\frac{1}{\ln(m)} \cdot \sum_{i=1}^{m} p_{ij} * \ln(p_{ij}) \tag{2}$$

where *m* presents number of alternatives.

Third step: Entropy-based weight computation using Eq. (3).

$$w_j = \frac{1-H_j}{\sum_{j=1}^{n} Hj};\ \sum_{j=1}^{n} w_j = 1,\ (j = 1, \dots, n) \tag{3}$$

3.3 TOPSIS method

Hwang and Yoon developed the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) as an MCDM method in 1981 for the selection of the best alternative that is closest to the positive ideal solution (PIS) and the furthest from the negative ideal solution (NIS) [26]. This section offers a step-by-step breakdown of the used method, ensuring a clear understanding of its processes and applications.

TOPSIS was selected because it is widely recognised as a moderately complex, highly accurate, and computationally efficient MCDM method that is easy to implement and suitable for ranking alternatives in medium-sized datasets [27]. The method enables the simultaneous consideration of multiple dimensions of digital development by evaluating countries according to their relative distances from the ideal and anti-ideal solutions. In contrast to composite indices that rely on predefined or subjective weighting schemes, TOPSIS can be combined with objective weighting techniques, such as entropy weighting, thereby enhancing the transparency and credibility of the evaluation process. Moreover, its straightforward interpretation and ability to handle numerous indicators make it particularly suitable for comparative analyses of national digital performance. Previous studies have successfully employed TOPSIS to assess the digital development of EU countries and have demonstrated its effectiveness in producing meaningful rankings based on DESI dimensions [21]. Furthermore, the integration of entropy and TOPSIS has proven to be a valuable approach for evaluating DESI-based digital development, as it combines objective weight determination with a robust ranking mechanism, providing deeper insights into countries' digital performance and transformation readiness [1,18]. Therefore, TOPSIS represents an appropriate methodological framework for assessing and ranking the digital readiness of countries using DESI indicators.

First step: Construct the initial decision matrix $X = \left[x_{ij}\right]_{m \times n}$. For a decision-making problem involving n criteria (n = 1, 2,…, j) and m alternatives (m = 1, 2, …, i), the initial decision matrix can be expressed as it follows (Eq. (4)):

$$\begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & \vdots \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \tag{4}$$

Second step: Normalize decision matrix X by converting into structured matrix R = [ri,j]m x n (Eq. (5)):

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}{}^2}} \tag{5}$$

Third step: Compute the weighted nomalized decision matrix Vij = [vij]m×n by using Eq. (6):

Fourth step: Resolve the Positive ideal solution (PIS) and Negative ideal solution (NIS) using Eq. (7):

$$PIS = max_{\ i}\ V_{ij} \tag{7}$$

$$NIS = \min_{\ i}\ V_{ij} \tag{8}$$

Fifth step: Calculate the distance of the alternative from ideal solution (Eq. (9) and Eq. (10)):

$$S_i{}^{+} = \sqrt{\sum_{j=1}^{n}\left(V_{ij-}V_j{}^{+}\right)^2} \tag{9}$$

$$S_i{}^{-} = \sqrt{\sum_{j=1}^{n}\left(V_{ij-}V_j{}^{-}\right)^2} \tag{10}$$

Sixth step: Compute the TOPSIS score $C_i{}^{*}$following the Eq. (11):

$$C_i{}^{*} = \frac{S_i{}^{-}}{S_i{}^{+} + S_i{}^{-}} \tag{11}$$

where $0 \leq C_i{}^{*} \leq 1$.

3. Results and Discussion

To analyse the digital readiness of Western Balkan countries, this study employs an entropy-based TOPSIS approach. In this model, Western Balkan countries are treated as alternatives, and WB DESI index sub-indicators serve as criteria.

The entropy-based calculation indicates that C5, „Share of fixed broadband subscription ≥ 100 Mbps“, is the most important criterion (w_j = 0.2141), while C1, „E-Government“ (w_j = 0.0004), is the least important. According to the entropy weighting principle, criteria that exhibit greater variability among alternatives receive higher weights because they provide more discriminative information for the decision-making process. Conversely, criteria with similar values across countries receive lower weights because they contribute less to differentiating the alternatives. Therefore, the high weight assigned to C5 indicates substantial variation among Western Balkan countries, whereas the extremely low weight of C1 suggests that the observed values are relatively homogeneous across the countries analysed and consequently have limited influence on the final ranking [25]. More specifically, values for criterion C1 span only 4.9 points according to the WB-DESI 2025 report, and such low variability indicates that this criterion has limited discriminative power and provides relatively little information for distinguishing among the countries. By contrast, criterion C5 exhibits substantially greater variation, with values ranging from 14.5 to 70.0, and this pronounced dispersion enables C5 to differentiate the alternatives more effectively. Consequently, C5 receives a considerably higher entropy weight and exerts a stronger influence on the final ranking.

The weighting coefficients for the criteria considered are presented in Figure 2.

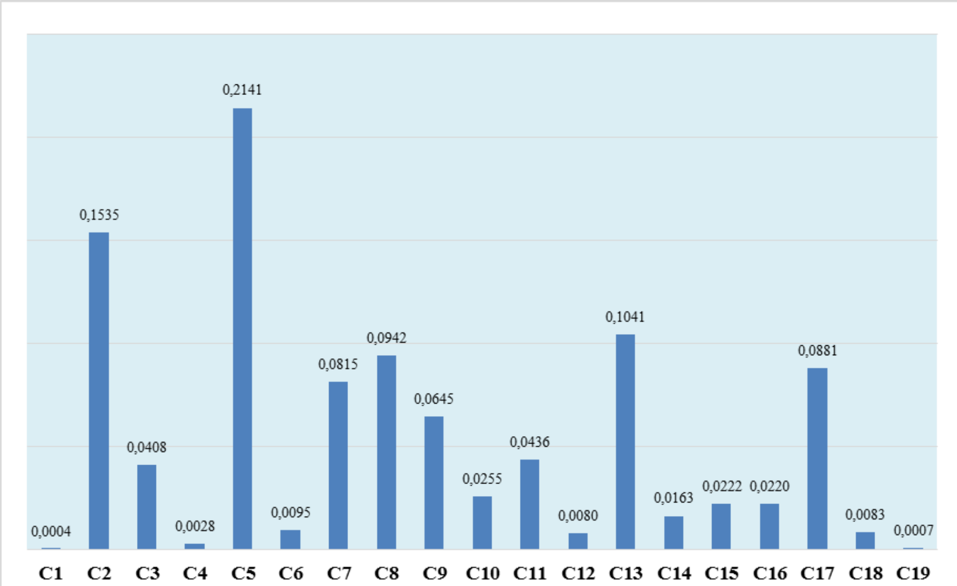

Fig. 2. Weight coefficients of considered criteria

The results show considerable variability in the importance of individual criteria. The distribution indicates that the decision-making process is mainly driven by a few highly influential criteria, such as C5 „Share of fixed broadband subscription ≥ 100 Mbps", C2 „ICT specialists", C13 „e-Government users", C8 „Edge nodes", and C17 „Transparency of service delivery, design and personal data", while the remaining criteria play a supporting role. Some criteria, such as C4 „Overall internet take-up" and C19 „Mobile friendliness", have little influence on the ranking results. This distinction highlights the need to prioritise key dimensions when interpreting the results and making recommendations.

Furthermore, to rank Western Balkan countries, the TOPSIS approach has been applied. The findings from applying the TOPSIS methodology are presented in Table 1. The results show the distance of each alternative from the ideal anti-ideal solution (Si^+ and Si^-), the TOPSIS scores (C_i^*), and insights into the ranks of the analysed countries.

Table 1
TOPSIS method ranking results

Western Balkan country	Si^+	Si^-	C_i^*	Rank
Albania	0.105	0.078	0.427	3
Bosnia and Herzegovina	0.120	0.050	0.293	4
Montenegro	0.066	0.128	0.660	2
North Macedonia	0.139	0.055	0.283	5
Serbia	0.043	0.131	0.753	1

According to the results (Table 1), the countries are ranked as follows: Serbia (0.753), Montenegro (0.660), Albania (0.427), Bosnia and Herzegovina (0.293), and North Macedonia (0.283). This indicates that Serbia has the best overall WB DESI performance, while North Macedonia has the lowest digitalisation performance among Western Balkan countries.

Additionally, this paper aims to provide a more robust and comprehensive evaluation of the results. To achieve this, additional MCDM methods were tested on the same dataset. To validate the results, the Preference Ranking Organization METHod for Enrichment Evaluations (PROMETHEE II) method [28], the Weighting Sum Approach (WSA), the Additive Ratio ASsessment (ARAS) method [29], the COmbinative Distance-based ASsessment (CODAS) method [30], the Evaluation based on Distance from Average Solution (EDAS) method [31], and the Multi-Attributive Border Approximation Area Comparison (MABAC) method [32] were applied. The results of the MCDM methods are presented in Table 2.

Table 2
Western Balkan country rankings obtained by various MCDM methods

MCDM method →	PROMETHEE II		WSA		ARAS		CODAS		EDAS		MABAC	
Western Balkan country ↓	Φ	rank	u	Rank	K	Rank	H_i	rank	S_i	rank	Q	rank
Albania	-0.092	3	0.451	3	0.643	3	-0.182	3	0.431	3	0.040	3
Bosnia and Herzegovina	-0.214	4	0.283	4	0.554	4	-0.873	4	0.218	4	-0.128	4
Montenegro	0.303	2	0.592	2	0.764	2	0.872	2	0.717	2	0.181	2
North Macedonia	-0.616	5	0.170	5	0.487	5	-1.052	5	0.053	5	-0.241	5
Serbia	0.618	1	0.786	1	0.875	1	1.234	1	0.969	1	0.375	1

The robustness results (Table 2) demonstrate high consistency across all MCDM methods applied, confirming the stability of the rankings obtained. The ranking of Western Balkan countries remains identical across all methods, indicating that the ranking outcomes are not sensitive to the choice of methodological approach. Such methodological stability is particularly important in multi-criteria evaluations of digital development, as previous studies emphasise that MCDM results can be affected by weighting schemes and normalisation procedures if robustness checks are not applied [21]. The observed strong agreement across methods therefore reinforces the reliability of the entropy-weighted TOPSIS framework and supports its suitability for digital readiness assessments based on composite indicators such as DESI.

Serbia emerged as the leading performer in the region, demonstrating relatively strong results across connectivity, digital public services, and digital skills dimensions. In contrast, North Macedonia exhibited the weakest overall performance, while Montenegro, Albania, and Bosnia and Herzegovina showed intermediate but heterogeneous levels of digital development. These findings confirm the existence of a persistent digital gap within the Western Balkans, consistent with broader evidence of structural digital inequality across Europe [8,33].

Serbia consistently ranks as the highest-performing country in the Western Balkans. This finding is aligned with the Regional Cooperation Council (RCC) reports, which consistently identify Serbia as the regional leader in digital connectivity, e-government adoption, and digital skills development [8]. Serbia's dominance across multiple DESI dimensions can be explained by relatively stronger broadband infrastructure, higher levels of digital public service usage, and more advanced integration of digital technologies in both the public and private sectors. This pattern is consistent with broader DESI-based studies of EU and non-EU countries, which highlight that digital frontrunners tend to exhibit balanced development across connectivity, human capital, and digital public services dimensions [33].

In contrast, North Macedonia exhibits the weakest overall performance across WB DESI indicators, particularly in connectivity and digital public services. This result is consistent with findings in the digital development literature indicating that lower-income and transition economies often face structural constraints, including limited broadband penetration, insufficient digital skills, and slower institutional digital transformation [33]. Similar constraints are also observed in Bosnia and Herzegovina, where digital infrastructure development and human capital formation remain key bottlenecks. The European Commission DESI methodological reports emphasize that insufficient digital skills and low SME digital intensity significantly hinder overall digital competitiveness, particularly in catching-up economies [33].

Albania shows moderate but uneven progress, with notable improvements in connectivity-related indicators such as overall internet take-up, fixed Very High Capacity Network (VHCN) coverage, Fibre to the Premises (FTTP) coverage, and increasing uptake of e-government services. However, as highlighted in DESI-based empirical studies, infrastructure improvements alone are insufficient to ensure sustainable digital transformation unless accompanied by parallel improvements in digital skills and business digitalization [34]. Montenegro demonstrates a relatively balanced performance but still exhibits weaknesses in digital public service utilisation and advanced e-government functionalities, which is consistent with evidence suggesting that service-layer digitalisation often lags behind infrastructure development in developing digital economies [35].

The comparative analysis confirms a persistent digital divide within the Western Balkan region, which mirrors broader European patterns of digital inequality between core and peripheral economies. Prior DESI-based studies on European digital convergence suggest that narrowing this gap requires coordinated policy interventions focused on digital skills development, SME digital transformation, and expansion of high-capacity network infrastructure [21, 33]. Therefore, policy efforts in the Western Balkans should prioritize integrated digital strategies that simultaneously address infrastructure, human capital, and digital public service delivery in order to accelerate convergence with EU digital performance standards.

To further validate the robustness of the obtained rankings, Spearman's rank correlation coefficient [20, 21] and Kendall's tau [36] coefficient were calculated between the TOPSIS results and the rankings generated by the alternative MCDM methods. All coefficients were equal to 1.000, indicating perfect agreement among the methods and providing additional quantitative evidence of the stability and reliability of the proposed evaluation framework.

Additionaly, this study performed sensitivity analysis to see how changes in the criteria weights affect the final TOPSIS ranking of the alternatives [19, 37]. Following common practices in MCDM sensitivity analysis, the weight of the most influential criterion was increased and decreased by 10% and 20%, while the remaining criteria weights were proportionally adjusted to preserve normalization. This approach is frequently used to assess the robustness and stability of ranking results under different weighting scenarios [21]. The results of sensitivity analysis based on TOPSIS calculation are presented in Table 3.

Table 3
Sensitivity analysis results for the TOPSIS method under alternative weighting scenarios

WB country→	Albania		Bosnia and Herzegovina		Montenegro		North Macedonia		Serbia	
Scenario↓	C_i^*	Rank	C_i^*	Rank	C_i^*	Rank	C_i^*	Rank	C_i^*	Rank
C5 -20%	0.427	3	0.293	4	0.660	2	0.282	5	0.753	1
C5 -10%	0.419	3	0.304	4	0.636	2	0.299	5	0.756	1
C5 +10%	0.435	3	0.282	4	0.683	2	0.264	5	0.749	1
C5 +20%	0.442	3	0.273	4	0.704	2	0.248	5	0.746	1

The results in Table 3 indicate that variations in the weight of the most influential criterion (C5) do not affect the ranking order of the Western Balkan countries. The obtained rankings remain identical across all tested scenarios, confirming the robustness and stability of the proposed entropy-weighted TOPSIS framework.

5. Conclusions

This study evaluated the digital readiness of Western Balkan countries using a multi-method MCDM framework based on WB DESI indicators. An entropy-based TOPSIS approach was used as the primary evaluation method, while PROMETHEE II, WSA, ARAS, CODAS, EDAS, and MABAC were applied to validate the robustness of the results. Sensitivity analysis was conducted by varying the weight of the most influential criterion by ±10% and ±20% and proportionally adjusting the remaining criteria weights. The results showed that neither changes in the evaluation method nor variations in criteria weights affected the final country ranking. This high level of consistency confirms the robustness, reliability, and stability of the proposed evaluation framework. The findings show that Serbia has the highest level of digital readiness, followed by Montenegro, Albania, Bosnia and Herzegovina, and North Macedonia.

This study addresses two important research gaps identified in the literature. First, it helps reduce the geographical research gap by expanding knowledge on digital development in the Western Balkans, a region that has received considerably less scholarly attention than European Union member states despite undergoing intensive digital transformation. Second, it addresses the methodological research gap by demonstrating the value of applying multiple complementary MCDM methods instead of relying on a single approach. Accordingly, the study contributes by offering one of the first comprehensive assessments of the digital readiness of Western Balkan countries and by demonstrating the applicability and robustness of an integrated MCDM-based framework for DESI-driven evaluations.

Several theoretical and practical implications arise from this research. Theoretically, the study extends the existing body of knowledge by integrating WB DESI indicators with a multi-method MCDM framework, providing a comprehensive and replicable approach for assessing digital readiness. Practically, the findings may support policymakers, governments, and regional organisations in identifying strengths and weaknesses in digital development and prioritising investments in areas such as digital infrastructure, digital skills, technology adoption, and digital public services. In particular, the results may serve as a decision-support tool for monitoring digital convergence towards European Union standards.

Despite these contributions, the study has several limitations. First, the analysis is based on a single year of WB DESI data, which restricts the ability to capture dynamic changes and long-term convergence trends in digital development. Also, changes in the DESI composite index indicators and sub-indicators over time prevent longitudinal studies. Second, the study relies exclusively on DESI sub-indicators, which, while comprehensive, may not fully capture informal digital practices or emerging patterns of technology adoption in the region. Additionally, several sub-indicators were excluded due to missing data, which may have affected the comprehensiveness of the evaluation. Finally, methodological choices such as normalization techniques and MCDM model selection, although tested through robustness analysis, may still influence subtle variations in ranking outcomes.

Future research could extend this study in several directions. First, panel-based analyses covering multiple years of WB DESI data would enable the examination of convergence dynamics and digital transformation trajectories over time. Second, future studies could incorporate additional dimensions of digital development, such as artificial intelligence adoption and digital entrepreneurship indicators, to provide a more comprehensive assessment framework. Furthermore, methodological extensions using advanced MCDM and machine learning approaches could further improve ranking stability and predictive capabilities. Finally, comparative studies between Western Balkan countries and EU member states would provide deeper insights into structural digital gaps and convergence pathways toward the European digital single market.

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Conflicts of Interest
The authors declare no conflicts of interest.

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