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ORIGINAL ARTICLE

Assessing the role of institutional reform in enhancing Balkan sustainable competitiveness: An Entropy-MARCOS perspective

Anđelka Štilić[1], Adis Puška[2], Darko Božanić[3,*], Duško Tešić[3]

[1] *Academy of Applied Studies Belgrade, The College of Tourism, 11070 Belgrade, Serbia*

[2] *Government of the Brčko District of Bosnia and Herzegovina, Department of Public Safety, 76100 Brčko, Bosnia and Herzegovina*

[3] *Military Academy, University of Defence in Belgrade, 11000 Belgrade, Serbia*

ABSTRACT

This research paper aims to assess the sustainable competitiveness of Balkan countries. Sustainable competitiveness was measured based on the indicators in The Sustainable Competitiveness Report from 2022, published by Solability. According to this report, sustainable competitiveness is evaluated using six grouped criteria. In this paper, the competitiveness of the Balkan countries was assessed through the application of the multicriteria analysis methods Entropy and MARCOS (Measurement Alternatives and Ranking according to the Compromise Solution). The weight of each criterion was determined using the Entropy method. The results highlighted that the most significant criteria were Natural Capital and Resource Efficiency & Intensity, which carried the highest weight, whereas the Social Cohesion criterion was of lesser importance, represented by the lowest weight. Using the MARCOS method, the Balkan countries were ranked, with Greece securing the top position, closely followed by Albania, while North Macedonia exhibited the weakest performance. Sensitivity analysis further substantiated these findings. The outcomes of this study significantly contribute to the academic understanding of sustainable competitiveness and provide valuable practical insights for policymakers and stakeholders interested in advancing sustainable development efforts in the Balkan region.

KEYWORDS

sustainable competitiveness; Balkan countries; methods of multicriteria analysis

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*CORRESPONDING AUTHOR
Darko Božanić, Military Academy, University of Defence in Belgrade, 11000 Belgrade, Serbia; darko.bozanic@va.mod.gov.rs

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1. Introduction

In recent years, the concept of sustainable development has gained significant attention worldwide as nations strive to achieve economic prosperity while ensuring the long-term

preservation of natural resources and social well-being (Adamowicz, 2022). The pursuit of sustainable competitiveness has emerged as a critical goal for countries seeking to balance economic growth with environmental and social considerations (Veličkovska et al., 2022). Ensuring sustainable competitiveness requires a comprehensive understanding of a country's strengths and weaknesses across multiple dimensions, going beyond traditional economic indicators.

Traditional country comparisons based solely on economic and financial indicators fail to capture the factors that contribute to long-term economic success. Such indicators, at best, reflect the current economic performance of a country, but they do not provide insights into what makes this success possible, nor do they consider current and future developments that shape a nation's competitiveness (Oliinyk et al., 2023). As a result, there is a need for a more comprehensive assessment framework that integrates economic, environmental, and social dimensions.

To address these limitations, the Global Sustainable Competitiveness Index (GSCI) has been developed. The GSCI provides a holistic assessment of a country's green growth by incorporating economic, environmental, and social factors. It goes beyond traditional economic measurements and accounts for the sustainability of a nation's development trajectory (Solability, 2022). By tracking green growth across all dimensions, the GSCI offers valuable insights into a country's performance and identifies areas for improvement and policy insufficiencies.

The Balkan region, known for its rich cultural heritage and diverse natural landscapes, has undergone significant transformations since the political and economic transitions of the 1990s. Despite progress in various areas, sustainable development remains a pressing challenge for many Balkan countries (Jakovljevic et al., 2021). Achieving sustainable competitiveness in this context requires a comprehensive understanding of the region's strengths and weaknesses across multiple dimensions.

This research paper aims to contribute to the academic understanding of sustainable competitiveness in the Balkans by employing the Entropy-MARCOS (Measurement Alternatives and Ranking according to the Compromise Solution) method. The Entropy-MARCOS method provides a robust approach to evaluating sustainable competitiveness by incorporating both quantitative and qualitative assessments (Solability, 2022). It considers criteria such as Natural Capital, Resource Intensity, Social Capital, Intellectual Capital, Economic Sustainability, and Governance. By employing this methodology, the research paper will provide insights into the relative performance of Balkan countries, identify areas for improvement, and offer recommendations for policymakers and stakeholders seeking to enhance sustainable development efforts.

The significance of ascertaining sustainable competitiveness lies in its potential to ameliorate the prevailing conditions within these nations while upholding sustainability objectives. The comparative analysis of sustainable competitiveness vis-à-vis neighboring countries assumes pivotal importance in the developmental trajectory of these nations. It is imperative to discern the relative positioning of individual countries in relation to their neighbors, identifying areas of strength and areas needing improvement. Armed with this information, targeted efforts can be directed towards enhancing favorable conditions and fostering growth and development within these countries.

It is noteworthy that the majority of these nations aspire to join the European Union (EU), with Greece being the sole EU member among them. To attain EU membership, bolstering specific

criteria, particularly sustainability criteria, becomes a requisite. Thus, it becomes imperative to identify inadequately developed factors and fortify them. Furthermore, it is crucial to identify areas where certain countries outperform their neighbors and harness these strengths to enhance sustainable competitiveness. Augmenting sustainable competitiveness reinforces a nation's commitment to preserving its available resources. This, in turn, enhances the capacity to create and sustain resources while ensuring their rational utilization.

In light of the aforementioned, the objectives of this paper are threefold. Firstly, employing a multi-criteria analysis, it endeavors to ascertain the current status of sustainable competitiveness within the Balkan countries. Secondly, building upon this assessment, it aims to delineate the requisite steps for these countries to attain enhanced sustainable competitiveness. Thirdly, by scrutinizing habitability, it seeks to identify the pivotal criteria influencing country rankings and the areas in which these nations should focus their efforts to bolster sustainable competitiveness relative to neighboring countries.

Additionally, the research paper will conduct a sensitivity analysis to pinpoint specific areas within the identified criteria that require attention and improvement. This analysis will identify the key drivers and bottlenecks of sustainable competitiveness in the Balkan region, enabling policymakers to prioritize their efforts and allocate resources more effectively (Puška, Štilić, and Stojanović, 2023).

The structure of this paper is as follows: Section 2 will provide a review of the relevant literature on sustainable competitiveness and institutional reform, offering insights into the current state of research in this field. Section 3 will outline the methodology employed, including data collection, criteria selection, and the application of the Entropy-MARCOS method. Section 4 will present the results of the analysis, highlighting the relative performance of Balkan countries in terms of sustainable competitiveness. Section 5 will conduct a sensitivity analysis to identify key areas for improvement. Finally, Section 6 will conclude the paper by summarizing the findings and discussing their implications for policymakers and stakeholders in the Balkan region.

2. Review of literature

The notion of development has been a primary concern for nations globally, aiming to attain economic growth and enhance living standards (Štilić et al., 2023). In the past, the focus predominantly relied on economic measures such as Gross Domestic Product (GDP) and income levels to assess a nation's progress (Coscieme et al., 2020). Nevertheless, this narrow emphasis on economic growth often neglects the adverse effects on the environment and social welfare (Du et al., 2021).

Over time, the limitations of this approach became evident, necessitating a more comprehensive framework that incorporates the long-term sustainability of development. The emergence of sustainable development denoted a paradigm shift towards balancing economic, environmental, and social factors (Durmić et al., 2020). Sustainable development aims to meet present needs without compromising the ability of future generations to meet their own needs, emphasizing the preservation of natural resources, social equity, and environmental protection (Komasi et al., 2023).

As nations pursued development, competitiveness assumed a pivotal role in economic growth

(Stojanović et al., 2022). Traditional country comparisons primarily focus on economic and financial indicators to gauge a country's competitiveness (Melnyk et al., 2020). Nevertheless, these metrics failed to encompass the broader elements that contribute to long-term economic success. They provided a snapshot of current economic performance but overlooked the underlying drivers and future developments that shape a nation's competitive position (Kolluru and Suresh, 2020).

In response to this issue, the concept of sustainable competitiveness emerged as a strategic approach that integrates economic growth with environmental and social considerations (Vasiljević et al., 2018). Sustainable competitiveness acknowledges that economic prosperity should not be achieved at the expense of the environment or societal well-being (Jakob et al., 2020). It emphasizes the significance of long-term economic viability while considering ecological and social sustainability.

To overcome the limitations of traditional economic indicators and assess a country's sustainable competitiveness, the Global Sustainable Competitiveness Index (GSCI) was formulated. The GSCI provides a comprehensive assessment framework that integrates economic, environmental, and social dimensions (Solability, 2022). By capturing the interplay between these dimensions, the GSCI offers a more accurate evaluation of a nation's green growth and sustainability trajectory (J. Wang and Feng, 2022). The GSCI surpasses conventional economic measurements and incorporates indicators related to resource efficiency, social capital, innovation, and governance (J. Wang and Feng, 2022). It enables policymakers and stakeholders to identify areas that require improvement and policy insufficiencies, thereby facilitating informed decision-making and the implementation of sustainable policies (Solability, 2022).

To evaluate sustainable competitiveness, several Multi-Criteria Decision-Making (MCDM) methods have been employed throughout the literature. MCDM techniques provide a structured and systematic approach to analyzing complex problems that involve multiple criteria and stakeholders (Tian et al., 2023). The application of different MCDM methods, allows researchers to assess the relative performance of countries, identify areas for improvement, and design effective policies and strategies to enhance sustainable development efforts (Lahane and Kant, 2022). In their paper, authors employed the PF-AHP (Pythagorean Fuzzy Analytic Hierarchy Process) and PF-CODAS (Pythagorean Fuzzy Combinative Distance-Based Assessment) methods. The PF-AHP was utilized to subjectively determine the criteria's weights through expert assessment, whereas the PF-CODAS method was employed to rank countries based on their sustainability. These methods facilitate decision-making by providing a structured framework for comparing and prioritizing alternatives based on multiple criteria.

Through the application of MCDM methods, scholars can conduct an analysis of countries' sustainable competitiveness without relying on subjective judgments (Lo, 2023). In their paper, authors used the CRITIC (Criteria Importance Through Intercriteria Correlation) method for objective weight determination and the CTOPSIS (Classifiable Technique for Order Preference by Similarity to Ideal Solution) method for ranking. This analytical process entails the assessment of each country's strengths and weaknesses across multiple dimensions, including economic sustainability, environmental preservation, social capital, and governance effectiveness (Escandon-Barbosa et al., 2019). By quantifying and comparing these dimensions, researchers can identify countries that excel in specific areas and those that require improvement.

Furthermore, MCDM methods, particularly sensitivity analysis, enable researchers to delve deeper into the identified criteria and evaluate their impact on sustainable competitiveness (Alimohammadlou and Khoshsepehr, 2021). Sensitivity analysis helps in identifying critical drivers and bottlenecks that significantly influence a country's performance (Qazi, 2022). In their paper, authors created a network model and examined the mutual relations of these countries through a sensitivity analysis. A comprehensive understanding of these key factors allows policymakers to prioritize their efforts, allocate resources effectively, and implement targeted interventions to address specific challenges (Badi and Abdulshahed, 2021; Bradley et al., 2021).

The literature on sustainable competitiveness and the application of MCDM methods in this domain is continuously expanding (Gautam et al., 2020; Verma et al., 2022). Numerous studies have centered on investigating the relationship between sustainable development, competitiveness, and the integration of environmental and social considerations into decision-making frameworks. These studies emphasize the significance of adopting a holistic approach that transcends traditional economic indicators and embraces multidimensional assessments for sustainable development.

Širá et al. (2020) investigated the relationship between competitiveness, knowledge economy, and sustainability, employing the TOPSIS method in European Union countries as an example. Hu et al. (2018) explored sustainable competitiveness by developing the Air Cargo Terminal Quality System using the ANP (Analytic Network Process) and DEMATEL (Decision-Making Trial and Evaluation Laboratory) methods to enhance Taiwan's competitiveness on the global market. Deng (2023) utilized CRITIC and TODIM (Portuguese acronym for Interactive Multi-Criteria Decision Making) methods, incorporating fuzzy number intuitionistic fuzzy sets, to rank financial centers in different countries.

These and similar studies have demonstrated the applicability of MCDM methods in ranking countries. To achieve this, it is essential to employ methods for the objective determination of weights. By doing so, only data regarding the sustainable competitiveness of countries is considered, rather than relying on subjective expert evaluations. Methods for subjectively determining criteria weights are best suited for localized studies where experts are well-acquainted with the specific conditions of a country. However, ranking countries is a more complex task, making it challenging to find suitable experts for weight determination. Therefore, it is logical to employ objective methods for determining criteria weights in such cases, while various MCDM methods can be utilized for ranking.

Moreover, the literature underscores the importance of institutional reforms in shaping sustainable competitiveness. Effective governance, policy coherence, and stakeholder engagement are crucial elements for establishing an enabling environment conducive to sustainable development. Institutions that promote transparency, accountability, and participatory decision-making processes contribute to the long-term success of sustainable competitiveness initiatives.

The literature on sustainable competitiveness has evolved from a narrow focus on economic growth to a broader perspective that encompasses environmental and social dimensions. Combination of the GSCI and MCDM methods has emerged as valuable tools for evaluating sustainable competitiveness. These approaches offer insights into the relative performance of countries, identify areas for improvement, and provide guidance to policymakers and stakeholders in formulating effective strategies for sustainable development. As the literature continues to

expand, current research is focused on enhancing comprehension of sustainable competitiveness and exploring innovative approaches and best practices for achieving a harmonious balance between economic growth, environmental stewardship, and social well-being in various regions and contexts.

3. Methodology

Different indicators are utilized to assess sustainable competitiveness. Since 2011, Solability has been publishing the Global Sustainable Competitiveness Index, which is a report produced by a sustainable research center. This report incorporates 188 indicators obtained from various data sources. The present study employs the 2022 report and its corresponding indicators as the most up-to-date reference for measuring sustainable competitiveness. Six specific indicators are examined in this report, namely: Natural Capital, Resource Efficiency & Intensity, Social Cohesion, Intellectual Capital, Economic Sustainability, and Governance Efficiency (**Table 1**). Each of these indicators is calculated based on multiple criteria. In the context of this research, these criteria will be applied to evaluate the sustainable competitiveness of Balkan countries. The inclusion criterion for Balkan countries is that at least 50% of their territory lies on the Balkan Peninsula. Consequently, eight countries meet this criterion; however, data and indicators are available for only seven of them: Albania, Bosnia and Herzegovina, Bulgaria, Greece, Montenegro, North Macedonia, and Serbia. These countries will be considered alternatives in this paper, and a comparative analysis of their sustainable competitiveness will be conducted.

Table 1. Indicators of the GSCI.

ID	Indicator	Description	References
C1	Natural Capital	This indicator encompasses the availability of natural resources and the extent of their depletion	Dabbous et al., 2023; Januškaitė and Užienė, 2018; Milić and Jovanović, 2019; Užienė, 2018
C2	Resource Efficiency & Intensity	It pertains to the level of efficiency in utilizing available resources	Dabbous et al., 2023; Milić and Jovanović, 2019
C3	Social Cohesion	This indicator encompasses various aspects of society, including health, safety, freedom, equality, and citizen satisfaction	Dabbous et al., 2023; Iqbal et al., 2023
C4	Intellectual Capital	It refers to the capacity to generate wealth and employment through innovation and value-added industries	Dabbous et al., 2023; Iqbal et al., 2023; Januškaitė and Užienė, 2018; Milić and Jovanović, 2019
C5	Economic Sustainability	It pertains to the capacity to generate wealth through the implementation of sustainable economic development	
C6	Governance Efficiency	It refers to the effectiveness of state institutions in creating conditions conducive to enhancing sustainability.	Dabbous et al., 2023; Januškaitė and Užienė, 2018

In assessing the sustainable competitiveness of the Balkan countries, a multi-criteria approach will be employed, specifically utilizing the Entropy and MARCOS methods. The Entropy method, as a technique for determining criterion weights, was chosen for its objectivity in weight assignment (Mukhametzyanov, 2021). It gauges these weights objectively by leveraging the values of the alternatives. In methods of objective weight determination, including the Entropy method, the weights hinge upon the dispersion exhibited by the alternatives across observed criteria. If a specific

criterion exhibits greater dispersion among alternative values, its relative importance escalates in comparison to criteria with less dispersion (Z. Wang et al., 2021). This stems from the rationale that less dispersion implies greater similarity among alternative values, rendering the criterion less influential in determining the overall ranking. The selection of the Entropy method is motivated by its extensive application in objective weight determination among all available methods. Its foundations were laid in 1948 by Shannon (1948), and it has been adapted for calculating criterion weights with the advancement of multi-criteria analysis methods. The cornerstone of this method's application is the determination of the Entropy value, simplifying the criterion weight calculation process. In contrast, other objective weight determination methods necessitate the calculation of multiple indicators. For instance, the CRITIC method mandates the computation of mutual correlations between criteria and standard deviation (Krishnan et al., 2021), while the MEREC (Method based on the Removal Effects of Criteria) method requires assessing criteria performance, performance without a specific criterion, and subsequent exclusion (Keshavarz-Ghorabaee et al., 2021; Narang et al., 2023). Comparatively, the standard deviation method stands out as more straightforward, relying solely on standard deviation calculation to determine criterion weights (Keshavarz-Ghorabaee et al., 2021). Research has shown that weights derived from the Entropy method align closely with those from other methods (Keleş, 2023; Puška, Stojanović, and Štilić, 2023), validating its selection for criterion weight calculation in this study.

Following the establishment of criterion weights as the basis for assessing sustainable competitiveness, the Balkan countries are ranked accordingly, employing the MARCOS method. Despite being relatively new among multi-criteria analysis techniques, this method ranks alternatives by measuring deviations from ideal and anti-ideal solutions. Notably, its widespread practical application is attributed to its congruence with results from other methods (Jokić et al., 2021; Narang et al., 2023). Moreover, this method consistently maintains ranking orders (Stević et al., 2020), enhancing decision-making confidence. Having elucidated the rationale for selecting these methods, the subsequent sections will expound on the research phases.

Based on the aforementioned information, this research will be conducted in four distinct phases:

Phase 1. Formation of the initial decision matrix.

During this phase, indicators will be selected for the seven Balkan countries based on the specified criteria (**Table 1**). Consequently, an initial decision matrix, representing the preliminary step for each MCDM method, will be created.

Phase 2. Determination of criteria weights.

The Entropy method, categorized as an objective weight determination technique, will be employed to ascertain the weights of the criteria. The following steps outline the procedure involved in this method:

Step 1. Formation of the initial decision matrix

Step 2. Normalization of the initial decision matrix

$$n_{ij} = \frac{x_{ij}}{x_{j\,max}} \text{ for benefit criteria} \quad (1)$$

$$n_{ij} = \frac{x_{j\,min}}{x_{ij}} \text{ for cost criteria} \quad (2)$$

Since maximizing the value of the observed criteria is essential, all criteria fall under the benefit category, and normalization for benefit criteria will be applied.

Step 3. Determining the Entropy value (E_i)

During this step, the natural logarithm value for the normalized elements of the decision matrix is first computed, followed by multiplying these values with the corresponding normalized values of the decision matrix. Subsequently, the sum of these products is calculated and divided by the natural logarithm value of the number of observed alternatives (n).

$$E_i = \frac{\sum_{j=1}^{n} p_{ij} \cdot \ln p_{ij}}{\ln n} \quad (3)$$

Step 4. Calculating the weight of criteria

In this step, the value of one (1) is subtracted from the Entropy value. Consequently, the resulting values are divided by the total sum of those values ($1 - E_i$).

$$w_i = \frac{1 - E_i}{\sum_{i=1}^{m}(1 - E_i)} \quad (4)$$

This process yields the weights of the criteria required to determine the ranking of the Balkan countries in terms of sustainable competitiveness.

Phase 3. Ranking of the Balkan countries in terms of sustainable competitiveness.

During this stage, the ranking of the observed countries will be determined utilizing the MARCOS method, an MCDM approach that ranks alternatives based on their proximity to ideal and anti-ideal solutions. The closer an alternative is to the ideal solution and the further it is from the anti-ideal solution, the better it is considered. The following steps outline the procedure employed by this method:

Step 1. Formation of the initial decision matrix

Step 2. Expansion of the initial decision matrix

This expansion involves introducing an ideal and an anti-ideal solution. The ideal solution represents the maximum values of the alternatives for specific criteria, while the anti-ideal solution represents the minimum values of the alternatives for the same criteria.

Step 3. Normalization of the initial decision matrix

The normalization process employs the same formulas as the Entropy method.

Step 4. Computation of the difficulty of the initial normalized decision matrix

In this step, the values of the normalized decision matrix are multiplied by their corresponding criteria weights:

$$v_{ij} = n_{ij} \cdot w_j \tag{5}$$

Step 5. Calculation of the degree of utility (K_i) relative to the ideal and anti-ideal solutions:

$$K_i^- = \frac{S_i}{S_{aai}} \tag{6}$$

$$K_i^+ = \frac{S_i}{S_{ai}} \tag{7}$$

where S_i, S_{aai}, and S_{ai} represent the sums of the values of the weighted normalized alternative.

Step 6. Calculation of the utility function.

The utility function is calculated using the following equations:

$$f(K_i) = \frac{K_i^+ + K_i^-}{1 + \frac{1 - f(K_i^+)}{f(K_i^+)} + \frac{1 - f(K_i^-)}{f(K_i^-)}} \tag{8}$$

where $f(K_i^-)$ represents the utility function based on the ideal solution, while $f(K_i^+)$ represents the utility function based on the anti-ideal solution. These functions are computed according to:

$$f(K_i^-) = \frac{K_i^+}{K_i^+ + K_i^-} \tag{9}$$

$$f(K_i^+) = \frac{K_i^-}{K_i^+ + K_i^-} \tag{10}$$

Based on the utility function, the value of the MARCOS method is determined. A higher value using the MARCOS method indicates a better ranking, and vice versa.

Phase 4. Sensitivity analysis.

This phase involves conducting a sensitivity analysis to assess the impact of changes in criteria weights on the ranking of the Balkan countries under observation. The weights assigned to individual criteria will be systematically reduced by 15%, 30%, 45%, 60%, 75%, and 90%. The resulting changes in the final ranking will be observed. A larger deviation in ranking resulting from the reduction in weight indicates a greater significance of these criteria in determining the overall ranking. This analysis aims to identify areas in which countries should focus on improvement in order to enhance their sustainable competitiveness.

4. Results

To ascertain the weight and ranking of Balkan countries in relation to competitive vitality, the establishment of an initial decision matrix is imperative. The formation of this decision matrix was predicated on the data sourced from the Global Sustainable Competitiveness Index report (**Table 2**). The decision matrix serves as the foundation for calculating the criteria weights through the employment of the Entropy method, as well as for determining the ranking order of countries utilizing the MARCOS method.

Table 2. Initial decision matrix.

Country	Natural Capital	Resource Intensity	Social Capital	Intellectual Capital	Economic Sustainability	Governance Efficiency
Albania	53.4022	47.5137	57.0699	37.0724	46.0223	45.0485
Bosnia and Herzegovina	47.6325	40.8597	53.5387	32.5989	44.0335	50.0623
Bulgaria	45.8954	41.5739	49.6902	40.8521	47.0748	57.8884
Greece	36.3415	49.7991	53.5233	43.4342	52.1162	58.9536
Montenegro	44.4182	41.0708	51.7144	36.6495	42.7537	53.1778
North Macedonia	37.6603	42.9805	56.4848	33.5828	40.1750	52.8799

Graphically represented, the results are depicted in **Figure 1**. Observing both **Table 2** and **Figure 1**, it becomes evident that no single country exhibits unequivocal supremacy over the others across all these criteria. Consequently, the determination of the top-ranked Balkan country necessitates a compromise approach. While none of these countries secures the highest standing in every aspect of sustainable competitiveness, a few among them excel in certain criteria, positioning them as the overall best performers.

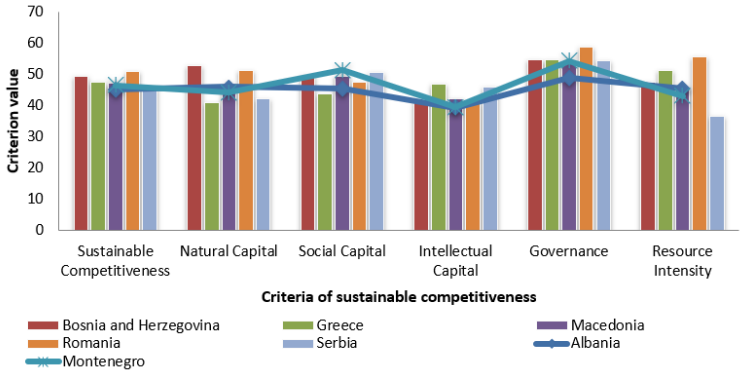

Figure 1. Graphic representation illustrating the outcomes of sustainable competitiveness criteria.

Once the initial decision-making matrix is established, the criteria weights are determined using the Entropy method. This step is crucial as it enables the subsequent ranking of alternatives based on their weighted criteria. Thus, the Entropy method is employed to calculate the weights of the criteria.

During the process of data normalization, an assessment is made to determine whether the criteria values should be higher or lower, indicating whether they are in the form of benefits or costs. In the context of these criteria, it is desirable for the values to be as high as possible; thus, all criteria are considered benefit criteria. Subsequently, the highest value among the countries is identified for each criterion, and the values of individual countries are divided by their respective maximum values. For example:

n_{11} = 53.4022/53.4022 = 1.0000; n_{22}= 40.8597/49.7991 = 0.8205

Using the same approach, normalized values are calculated, resulting in the formation of a normalized decision matrix (**Table 3**). Since both methods employ the same normalization technique, this matrix remains consistent for both methods. The purpose of normalization is to

uniformly rescale all values in the initial decision matrix. In this case, the alternative with the highest value for a specific criterion is assigned a value of one (1), while the other values are proportionately adjusted relative to the maximum value among the alternatives.

Table 3. Normalized initial decision matrix.

	C1	C2	C3	C4	C5	C6
Albania	1.0000	0.9541	1.0000	0.8535	0.8831	0.7641
Bosnia and Herzegovina	0.8920	0.8205	0.9381	0.7505	0.8449	0.8492
Bulgaria	0.8594	0.8348	0.8707	0.9406	0.9033	0.9819
Greece	0.6805	1.0000	0.9379	1.0000	1.0000	1.0000
Montenegro	0.8318	0.8247	0.9062	0.8438	0.8204	0.9020
North Macedonia	0.7052	0.8631	0.9897	0.7732	0.7709	0.8970
Serbia	0.8750	0.6370	0.9772	0.9533	0.9308	0.9240

The subsequent step in the Entropy method involves calculating the natural logarithm (ln) for the values within the normalized decision matrix. This calculation is performed as follows:

$\ln(n_{11}) = \ln(1.0000) = 0.0000$; $\ln(n_{22}) = \ln(0.8205) = -0.1979$

Similarly, the natural logarithm values are computed for all elements in the normalized decision matrix. These logarithmic values are then multiplied by the corresponding values from the normalized decision matrix. For example:

$n_{11} \cdot \ln(n_{11}) = 1.0000 \cdot 0.0000 = 0.0000$; $n_{22} \cdot \ln(n_{22}) = 0.8205\ (-0.1979) = -0.1623$

This process is repeated for all elements of the decision matrix. Subsequently, these new values for individual criteria are summed and divided by the value ln (n), where "n" represents the number of observed countries. In this case, the natural logarithm of 7 is required, with a value of 1.9459. This yields the formation of Entropy (E_i) values (**Table 4**). The Entropy values (E_i) are utilized in the calculation of the final criterion weights. This is achieved by subtracting the Entropy value from one (1) and dividing that result by the sum of all ($1 - E_i$) values for all criteria. Consequently, the final criterion weights are obtained (**Table 4**).

Table 4. Entropy method results.

	C1	C2	C3	C4	C5	C6
E_i	–0.5193	–0.4785	–0.1864	–0.4091	–0.3977	–0.3216
$1 - E_i$	1.5193	1.4785	1.1864	1.4091	1.3977	1.3216
w_i	0.1828	0.1779	0.1427	0.1695	0.1681	0.1590

The results obtained from the Entropy method indicate that criterion C1—Natural Capital receives the highest weight, while criterion C3—Social Cohesion receives the lowest weight. This discrepancy arises due to the largest dispersion in the values of the criteria among the observed countries being observed in criterion C1, whereas the smallest dispersion is observed in the values of criterion C3.

Once the criteria weights are determined, the Balkan countries are ranked according to their sustainable competitiveness using the MARCOS method. During the formation of the initial decision-making matrix, it is expanded to include ideal and anti-ideal solutions. The ideal solution represents the highest value for each criterion among the alternatives, while the anti-ideal solution represents the lowest value. Subsequently, the data is normalized (**Table 3**).

The next step in the MARCOS method involves the construction of an extended normalized decision matrix (**Table 5**). This matrix takes into account the weights assigned to the criteria. Following this, aggregate values are computed for all alternatives and extended elements. These aggregate values serve as the basis for calculating the degree of utility and utility functions.

Table 5. Weighted normalized decision matrix.

	C1	C2	C3	C4	C5	C6	
Ideal	0.1828	0.1779	0.1427	0.1695	0.1681	0.1590	1.0000
Albania	0.1828	0.1697	0.1427	0.1447	0.1485	0.1215	0.9098
Bosnia and Herzegovina	0.1630	0.1459	0.1339	0.1272	0.1421	0.1350	0.8472
Bulgaria	0.1571	0.1485	0.1243	0.1594	0.1519	0.1561	0.8973
Greece	0.1244	0.1779	0.1339	0.1695	0.1681	0.1590	0.9327
Montenegro	0.1520	0.1467	0.1293	0.1430	0.1379	0.1434	0.8524
North Macedonia	0.1289	0.1535	0.1413	0.1311	0.1296	0.1426	0.8270
Serbia	0.1599	0.1133	0.1395	0.1616	0.1565	0.1469	0.8777
Anti-ideal	0.1244	0.1133	0.1243	0.1272	0.1296	0.1215	0.7403

The degree of utility is calculated by dividing the sum of values in the extended decision matrix for each alternative by the values of the ideal and anti-ideal solutions. Taking the first country, Albania, as an example, the calculations are as follows:

$K_1^- = 0.9098/0.7403 = 1.2291;\ K_1^+ = 0.9098/1.0000 = 0.9098$

The degrees of utility for all countries are determined using the same approach. Subsequently, utility functions for the ideal and anti-ideal solutions are calculated. Using the same example, the calculations are as follows:

$f(K_1^-) = 0.9098/(0.9098 + 1.2291) = 0.4254;\ f(K_1^+) = 1.2291/(1.2291 + 0.9098) = 0.5746$

These functions are calculated in the same manner for all alternatives, and their solutions remain consistent. Once all the elements are derived, the value of the MARCOS method is computed using the respective expression 8. The results of the MARCOS method indicate that Greece exhibits the best performance in terms of sustainable competitiveness among the observed countries, followed by Albania, while North Macedonia demonstrates the weakest performance (**Table 6**).

Table 6. Results of the MARCOS method.

	K_i^-	K_i^+	$f(K_i^-)$	$f(K_i^+)$	$f(K_i)$	Rank
Albania	1.2291	0.9098	0.4254	0.5746	0.6920	2
Bosnia and Herzegovina	1.1444	0.8472	0.4254	0.5746	0.6443	6
Bulgaria	1.2121	0.8973	0.4254	0.5746	0.6824	3
Greece	1.2600	0.9327	0.4254	0.5746	0.7094	1
Montenegro	1.1515	0.8524	0.4254	0.5746	0.6483	5
North Macedonia	1.1171	0.8270	0.4254	0.5746	0.6289	7
Serbia	1.1856	0.8777	0.4254	0.5746	0.6675	4

To scrutinize these findings and thoroughly assess criterion weights, this paper conducted an additional analysis. Building upon the initial decision-making matrix, criterion weights were computed using alternative objective methods (**Table 7**). It is noteworthy that each of these methods yielded disparate weights. For instance, in the MEREC method, the highest weight was attributed to criterion C2, while in the standard deviation (SD) method, criterion C4 claimed the highest weight. In contrast, the CRITIC method assigned the highest weight to criterion C3. This analysis further underscored that the Entropy method resulted in the most consistent criterion weights when compared to other methodologies, wherein substantial variations between the best and worst weights were observed. This divergence was particularly pronounced with the MEREC method.

Table 7. Criterion weights derived through different objective methods.

	C1	C2	C3	C4	C5	C6
Entropy	0.1828	0.1779	0.1427	0.1695	0.1681	0.1590
MEREC	0.2238	0.3237	0.0667	0.1325	0.0930	0.1602
SD	0.1669	0.1539	0.1748	0.1822	0.1589	0.1633
CRITIC	0.2036	0.1576	0.2058	0.1422	0.1182	0.1726

Utilizing these assigned weights, the rankings of Balkan countries concerning sustainable competitiveness were computed (**Figure 2**). These results reveal that the ranking of countries differs only when employing the MEREC method. The first three countries maintain the same ranking order across all methodologies, while the ranking order diverges for Montenegro, which, according to the weights derived from this method, occupies the fourth position. Bosnia and Herzegovina secures the fifth spot, with Serbia trailing in sixth place. North Macedonia occupies the final position, mirroring the results obtained through other weight assignment methods.

The most significant factor contributing to the distinctiveness of the MEREC method's ranking list lies in its utilization of cost-type normalization, in contrast to the benefit-type normalization employed by all other methods. This normalization yields reverse-normalized values, meaning that the alternative with the most favorable indicators under this scheme receives the lowest value. In the context of sustainable competitiveness criteria, higher values across all criteria are desirable for a country to achieve a higher rank. The utilization of this reverse normalization is a key factor driving the divergence in results when employing these weights.

Based on these findings, it is reasonable to accept the ranking of countries obtained through

the Entropy method, as it aligns closely with the outcomes derived from other methods and corresponding weights.

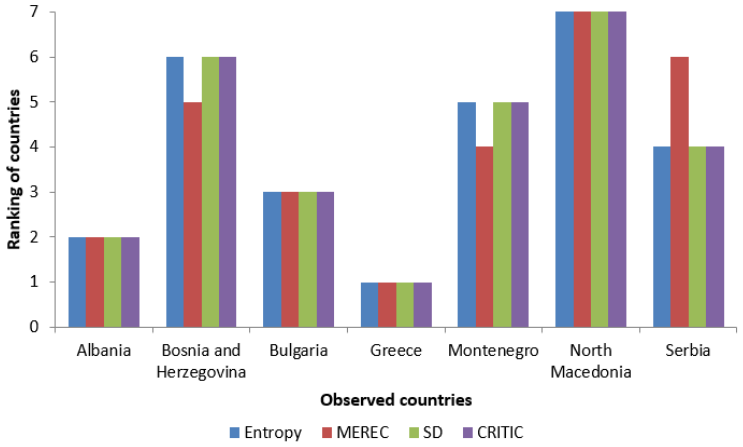

Figure 2. Rankings of Balkan countries.

To examine the influence of criteria on the ranking of Balkan countries, a sensitivity analysis will be conducted. This analysis involves adjusting the weights of individual criteria by 15% increments (Ali et al., 2023; Pamučar and Dimitrijecvić, 2021; Tešić et al., 2023). Specifically, the weight of each criterion will be reduced by 15%, 30%, 45%, 60%, 75%, and 90%. By doing so, the impact of each criterion on the final ranking will be diminished. As there are six criteria and six reductions, a total of 36 scenarios will be generated (**Figure 3**).

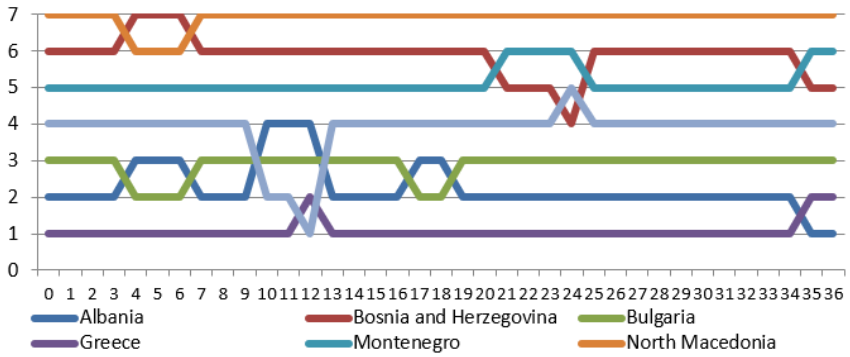

Figure 3. Results of the sensitivity analysis.

The results of these scenarios demonstrate that altering the weights of criteria leads to changes in the ranking of alternatives. This indicates that criteria do indeed play a significant role in determining the final ranking. Notably, when examining the top-ranked country, Greece, it is evident that it was placed second in three scenarios. These scenarios involved reducing the weights of criteria C2 and C6. The reason Greece initially secured the first rank is due to its superior performance in these criteria compared to other countries. Consequently, by reducing the weight of criterion C2 by 90%, Serbia, which was originally ranked fourth, emerged as the top-ranked country. This outcome stems from Serbia having the poorest Resource Efficiency & Intensity indicators among the observed countries. Therefore, for Serbia to enhance its sustainable competitiveness, it must focus on improving resource efficiency. By doing so, Serbia could surpass other Balkan countries in the ranking.

Additionally, when the weights of the Governance Efficiency criterion were reduced by 75% and 90%, there were changes in the ranking order, with Albania being ranked the highest in those scenarios. Analyzing the impact of these criteria on country rankings reveals that only the C5 Economic Sustainability criterion did not alter the ranking. This criterion aligns with the final ranking, indicating that it best represents the relative performance of the countries. Consequently, reducing the weight of this criterion did not impact the ranking order. Conversely, other criteria did affect the ranking when their weights were reduced.

For instance, North Macedonia exhibited inferior indicators compared to Bosnia and Herzegovina for criterion C1. Therefore, by reducing the weight of this criterion, Bosnia and Herzegovina became the lowest-ranked country. Similar situations occurred in Albania and Bulgaria. This analysis sheds light on the areas that countries need to improve to enhance their sustainable competitiveness. Each country can utilize this analysis to identify the specific criteria that require attention for better performance in sustainable competitiveness.

5. Discussion

Global market dynamics influence the management practices of each country. An increasing number of countries are adopting life preservation and sustainability principles. However, international policies lack a resource protection aspect to achieve sustainability goals (Litvinenko et al., 2022). Therefore, countries need to safeguard their resources and pursue sustainability goals while considering the sustainable utilization of these resources (Trofymenko et al., 2022). It is crucial for them to enhance their competitiveness in terms of sustainability. The annual Global Sustainable Competitiveness Index report published by Solability provides a foundation for observing countries using 188 indicators categorized into six main criteria. These criteria include Natural Capital, Resource Efficiency & Intensity, Social Cohesion, Intellectual Capital, Economic Sustainability, and Governance Efficiency. All of these criteria should be directed towards elevating the sustainability level of countries.

This research employed indicators from the Global Sustainable Competitiveness Index to evaluate the mutual competitiveness of the Balkan countries. The MCDM methods, specifically Entropy and MARCOS, were employed for the analysis. The Entropy method was adopted to objectively determine the criteria weights. This method determines weights based on the dispersion of alternative values within each criterion. Greater dispersion leads to a higher weight for the criterion, and vice versa. In this study, the Entropy method utilized linear normalization type 1 and some other normalization techniques (Mukhametzyanov, 2021). Linear normalization type 1 was selected as it provided the most significant difference in criteria weights compared to other normalization techniques. The results demonstrated that the Natural Capital criterion received the highest weight, while the Social Cohesion criterion received the lowest weight. This signifies a preference for the Natural Capital criterion over others, although the differences in weight values ranged from 0.1427 to 0.1828, indicating a relatively small advantage.

After determining the weights of the criteria essential for ranking the alternatives, the MARCOS method was employed to establish the ranking of Balkan countries in terms of sustainable competitiveness. This method utilizes the ranking of alternatives based on their proximity to the ideal solution and distance from the anti-ideal solution. The closer an alternative is to the ideal

solution and the further it is from the anti-ideal solution, the better its ranking (Mijajlović et al., 2020). By applying this method, Greece emerged as the country with the best indicators and highest ranking. It was followed by Albania and Bulgaria, while Western Macedonia ranked the lowest. Greece obtained the top ranking because it demonstrated the best indicators in four out of six criteria compared to the other observed countries, while Albania displayed the best indicators in the remaining two criteria. Consequently, these two countries secured the top positions in the ranking.

Unlike the present study, a prior investigation (Milić and Jovanović, 2019) initially categorized these criteria into two distinct groups before evaluating sustainable competitiveness. Their resultant ranking contrasts with that of the Global Sustainable Competitiveness Index report. However, the ranking of countries as established by our current research aligns concordantly with the ranking documented in said report. Additionally, other scholarly works that referenced this report employed these criteria to test hypotheses and examine their impact on other variables (Dabbous et al., 2023; Iqbal et al., 2023).

To assess the impact of criteria on the ranking of Balkan countries in terms of sustainable competitiveness, a sensitivity analysis was conducted. This analysis examined how altering a specific criterion by 15%, 30%, 45%, 60%, 75%, and 90% influenced the ranking of alternatives (Puška, Božani, et al., 2022). Through this analysis, a single scenario was obtained, even though Serbia did not possess a single best indicator that demonstrated superior results. This discrepancy arises because the MCDM method generates a ranking order that represents a compromise between the results obtained from various criteria. As a result, Serbia secured the top ranking due to its poorest performance in the C2 criterion. By modifying the weight of this criterion or disregarding it, Serbia obtained the highest rank in one scenario. Based on this finding, other observed countries can enhance their sustainable competitiveness by identifying the criteria in which they exhibit poor indicators and making concerted efforts to improve them. A sensitivity analysis can assist them in identifying the key criteria for enhancing sustainable competitiveness among the Balkan countries.

6. Conclusion

Dedication to the comprehensive evaluation of sustainable competitiveness among the Balkan countries has been the hallmark of this research, with data drawn from the 2022 Global Sustainable Competitiveness Index report by Solability. Serving as the foundation for our investigation, this report encompasses an extensive array of 188 diverse indicators meticulously categorized into six primary criteria. To navigate this intricate task, the MCDM methodology was strategically adopted, with a hybrid approach encompassing the Entropy and MARCOS methods being leveraged. The pivotal role played by the Entropy method in objectively assigning weights to the criteria, ultimately highlighting the paramount importance of the Natural Capital criterion, is noteworthy. Subsequently, the ranking of Balkan countries was facilitated by the MARCOS method, thereby revealing Greece's preeminence in terms of sustainable competitiveness within this cohort.

Substantial academic contributions have been made by this research:

- The adept utilization of multi-criteria analysis methods to rank countries based on sustainable competitiveness has been demonstrated, marking a pioneering endeavor within this research domain.

- Nuanced insights into the relative standings of Balkan countries concerning sustainable competitiveness have been presented, thus offering a scholarly foundation for future investigations.
- Valuable recommendations have been proffered, providing a roadmap for countries aspiring to strengthen their sustainable competitiveness, thereby fostering prospects for robust growth, development, and accelerated European Union membership.

Complementing these insights, a sensitivity analysis was thoughtfully conducted to identify and elucidate the salient criteria instrumental in enhancing sustainable competitiveness among the Balkan countries. These findings not only enrich our understanding but also offer actionable guidance to these nations as they endeavor to fortify their sustainable competitiveness, thereby charting a course toward heightened growth, development, and expeditious accession to the European Union.

However, alongside these contributions, it is imperative to acknowledge research limitations. Primarily, a focus exclusively on Balkan countries has characterized this research, with comparative analysis with nations exhibiting higher rankings being neglected. Future research mandates the inclusion of countries surpassing the Balkan nations' standings, affording the opportunity for comparative evaluation and illuminating avenues for elevating sustainable competitiveness. Additionally, a limitation arises from the choice of multi-criteria analysis methods, with discernible variations in criteria weights calculated through different methods necessitating supplementary analyses, such as sensitivity assessments or results validation, to substantiate the accuracy of these findings, as addressed within the scope of this research.

Author contributions

Conceptualization, AŠ and AP; methodology, DB; software, AP; validation, AŠ, DB and DT; formal analysis, DB; investigation, AP; resources, AŠ; data curation, DT; writing—original draft preparation, AŠ; writing—review and editing, AP; visualization, AŠ; supervision, DB; project administration, DT; funding acquisition, DB. All authors have read and agreed to the published version of the manuscript.

Conflict of interest

The authors declare no conflict of interest.

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