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HYBRID MCDM SOLUTIONS FOR EVALUATION OF THE LOGISTICS PERFORMANCE INDEX OF THE WESTERN BALKAN COUNTRIES

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Original Article

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ABSTRACT

The Logistics Performance Index (LPI) performed by the World Bank is an indicator of the logistics environment quality of a country in which logistics operators act. The LPI is an interactive tool designed to help countries identify challenges, innovative solutions, and opportunities they face in their work in the field of trade and logistics. The aim of this paper is to conduct a comparative analysis and ranking of the LPI of the countries in the Western Balkans (Bosnia and Herzegovina, North Macedonia, Albania, Serbia and Montenegro), calculated by the World Bank for 2018, using an integrated Criteria Importance Through Intercriteria Correlation (CRITIC)-Measurement Alternatives and Ranking according to Compromise Solution (MARCOS) model and thus show the real picture of the logistics environment. In order to determine the performance of countries and show the overall logistics performance, six key dimensions are used: customs, infrastructure, international transport, logistics capability, tracking and tracing of goods and shipment delivery within scheduled or expected times. Using the CRITIC method, the weight values of the previously mentioned six criteria were calculated, whereby the criterion related to shipment delivery within scheduled times was singled out as the most significant criterion. Then, by applying the MARCOS method, the countries of the Western Balkans were ranked on the basis of the six defined criteria. Based on the results obtained, the best-ranked country is Serbia. The analysis of the sensitivity of the results to changes in the significance of the criteria does not show significant changes in the ranking.

Keywords: *Logistics Performance Index (LPI), MCDM model, CRITIC, MARCOS.*

1. INTRODUCTION

The Global Logistics Performance Index or Logistics Performance Index (LPI) was developed by the World Bank to regulate logistics performance in 160 countries. More precisely, the LPI represents the ranking of countries by the quality of logistics. The LPI is an interactive tool designed to help countries identify the challenges and opportunities they face in their work in trade and logistics, as well as make recommendations on what countries can do to improve their performance. The Logistics Index is based on a global survey of stakeholders - operators, in the field (global freight forwarders and carriers) providing feedback on the "friendship in logistics" of the countries in which they do business and those with whom they do business. Operator feedback is complemented by quantitative data on the performance of key components of the logistics chain in the country of work. That is why the LPI consists of qualitative and quantitative measures and helps to create a logistics profile for these countries. Additionally, the LPI measures supply chain performance within a country and offers two different perspectives – international and domestic

(World Bank, 2022).
The World Bank uses six key dimensions to determine countries' performance and demonstrate overall logistics performance.

1. Customs
2. Infrastructure
3. Ease of arranging shipments
4. Quality of logistics services
5. Tracking and tracing
6. Delivery of shipments within scheduled or expected times (timeliness).

The first results of the survey were published by the World Bank in 2007, and since then the results of new surveys have been published every two years. The table of results allows comparison with the rest of the world, insights into the best performance in the world and comparison with the region. Not surprisingly, an efficient logistics sector is now recognized almost everywhere as one of key development drivers. It has been proven that there are numerous direct and indirect links between the sectors of logistics, economic growth and development (Shepherd, 2013).
The increase in global trade has led to logistics activities becoming an important tool in providing a strategic competitive advantage globally. The logistics industry, which helps to facilitate activities related to the movement of goods in the supply chain, is one of the fastest growing sectors and has important effects on the economic performance of countries. Measuring and evaluating countries' logistics performance can enable them to achieve their goals of reaching a sustainable competitive advantage by identifying the strengths and weaknesses of logistics services throughout the supply chain. In this regard, the purpose of this study is to analyze and rank the logistics performance of five Western Balkan countries (Bosnia and Herzegovina, North Macedonia, Albania, Serbia and Montenegro).
The paper provides an insight into the logistical performance of the Western Balkan countries and conducts a comparative analysis of these countries based on the value of LPI, which is the main contribution of this paper. Unlike the World Bank, which observes all parameters with the same significance, this research calculates the significance, ie. weight values of each parameter and later uses these values during the ranking process. Therefore, based on the obtained results, it is possible to determine the level of success of a certain country in relation to other countries in the region in the field of logistics. In addition, the research results can be used when creating guidelines and business strategies to further improve logistics performance.
Therefore, the aim of this paper is to conduct a comparative analysis and ranking of the LPI of the countries in the Western Balkans, calculated by the World Bank, using an integrated Criteria Importance Through Intercriteria Correlation (CRITIC) - Measurement Alternatives and Ranking according to the Compromise Solution (MARCOS) model and thus show the real picture of the logistics environment. Using the CRITIC method, the weight values of six previously defined criteria were calculated, and using the MARCOS method, the countries of the Western Balkans were ranked based on the criteria defined. At the very end, it was performed an analysis of the sensitivity of the results to changes in the significance of the criteria.

2. LITERATURE REVIEW

2.1. IMPORTANCE OF MONITORING AND MEASURING THE LOGISTICS PERFORMANCE INDEX

Since logistics has many factors, activities and functions, it is a challenge to be competitive in the market and have a level of efficiency that satisfies the user. In order for a company to remain competitive in the market and satisfy users with its performance, it is necessary to measure factors, activities and functions. In order to measure logistics factors, activities and functions, it is necessary to consider the time and costs associated with logistics processes (port processes, customs clearance, transport, etc.). Due to different organizations of countries, there are differences in the supply chain and due to these differences it is not possible to collect information related to logistics processes into one consistent database. The Logistics Performance Index (LPI) is calculated by the World Bank. It is an indicator of the quality of the logistics environment of the country in which logistics operators act. The Logistics Performance Index analyzes differences between countries in terms of customs procedures, logistics costs and the quality of land and maritime transport infrastructure. Improvements in any of the components of the LPI can lead to a significant increase in a country's trade flows. In particular, LPI components are becoming increasingly important for international trade in many countries in Africa, South America and Eastern Europe. Daniel and Shepherd, (2014) find that logistics performance is particularly important for trade among developing countries in the Asia-Pacific region, which is where the emergence of production networks has been most pronounced. Networked trade in parts and components is more sensitive to the importer's logistics performance than is final goods trade. A complex network of business relationships has assigned logistics a key role in determining international competitiveness between countries (Martí, Puertas and García, 2014). A clear and comprehensive set of performance indicators at a national level is crucial for the effectiveness of policies, preparation and implementation. The LPI provides the most comprehensive international tool for comparison, for measuring trade and facilitating transport cooperation between countries. Understanding and dissecting the components of trade and logistics performance can help countries improve the efficiency and identification of freight transport where international cooperation could help overcome barriers. The use of LPI has significantly enhanced the dialogue between policy makers and the private sector as they set priorities in trade and transport. However, making trade logistics work on competitiveness at a national or regional level requires more than just raising awareness. An in-depth multidimensional assessment of trade and transport performance in relation to action plans and policies such as changes in national regulations and taxes or infrastructure investments in specific links, nodes and corridors requires a variety of different analytical approaches (Ojala and Celebi, 2015). The studies (Sénquiz-Díaz, 2021b) and (Sénquiz-Díaz, 2021c) concludes that logistics performance is a strong contributor-directly and indirectly-in the development of countries where transportation alone may not be enough. Hence, countries should prioritize logistics development strategies to harness global production networks, improve policies and practices, and enhance their standards of living. Governments should prioritize the integration of logistics stakeholders in the public sector to optimize the benefits of global networks. Inefficient logistics services impede trade by imposing an extra cost in terms of time as well as money. As developed nations shift from traditional manufacturing and agriculture and are increasingly engaging in international vertical specialization, the need for efficient logistics services becomes ever more important (Korinek and Sourdin, 2011). The LPI, which is used in conjunction with other internal resources, can encourage discussion of the elements that drive logistics performance and those areas where barriers to performance exist. Understanding trends in logistics performance requires considering LPI results and rankings to see the interactions between logistics performance and policy activities, competitive strength, economic and political environment (Arvis et al, 2016). The findings of research conducted by D'Aleo and

Sergi, (2017), show a positive influence of global competitiveness index on gross domestic product (GDP) and this effect is by far more evident when other variables (e.g. the logistics performance index) interact simultaneously. Arvis et al. (2010) conclude that the countries that have the most efficient logistics, i.e. the countries that best manage transport routes and trade processes, are the ones that will be able to make the most of technological advantages, economic liberalization and access to international markets. In order to achieve sustainable business system performance, it is crucial that processes are managed, and process management requires continuous measurement of their performance. Performance measurement models help in the process of building performance measurement systems, clarifying performance measurement boundaries, specifying dimensions or aspects of performance measurement, and they can also provide insight into the relationships between performance dimensions (Rouse and Putterill, 2003). Generally, countries with high logistics costs do not have much international competitiveness (Devlin and Yee, 2005). In order to develop a logistics competitive advantage, governments need to assess the current logistics system at a national level and identify which subsystems need to be optimized, developed, created or completely eliminated through policies and initiatives (Jhawar, Garg, & Khera, 2017). Efficient logistics is vital for economic growth, diversification and poverty reduction. For this reason, logistics has become of public interest, for governments, regional and international organizations, although it is still mostly run by private operators. Finally, it can be clearly seen that the development of logistics is largely correlated with the overall level of development of a country (Popescu and Sipos, 2014).

2.2. APPLICATION OF MCDM MODEL FOR EVALUATION OF LOGISTICS PERFORMANCE INDEX

In logistics, performance measurement is considered a key competency to achieve world-class performance. Accordingly, Çakır (2017) presents a new methodology that integrates CRITIC, Simple Additive Weighting (SAW) and Peters' fuzzy regression method with the aim of measuring the logistics performance of the Organization for Economic Co-operation and Development (OECD) countries. The applied methodology, which is suitable for modeling imprecise relationships between system parameters, has proven to be a very practical alternative approach for estimating logistics performance. Logistics and transport are increasingly playing a key role in international trade relations. The Logistics Performance Index measures the effectiveness of supply chains or logistics performance in the field. The paper (Martí, L., Martín, J. C., & Puertas, 2017) proposed an approach that includes the Data Envelopment Analysis (DEA) model for calculating the synthetic total logistics performance index (DEA-LPI). Observing the six dimensions of LPI, the proposed approach uses the DEA as a multi-criteria decision-making tool (MCDM). The authors have concluded that the logistics impact largely depends on revenue and geographical area. Ozmen (2019) believes that assessing the logistics competitiveness of countries is a technical issue of decision-making that includes a number of criteria, and that the criteria conflict with each other and often act and react to each other, i.e. they are interdependent. Taking these situations into account, in order to address the interactions of these criteria, Ozmen (2019) develops the TODIM (an acronym in Portuguese for Interactive and Multicriteria Decision Making) method based on Mahalanobis distance (MD) used to assess the logistics competitiveness of OECD countries. Bottani, Montanari, Rinaldi and Vignali (2015) apply MCDM methods to analyze cost and strategic indicators of logistics performance with the aim of optimizing a closed supply chain. Logistic performance is an important factor that affects the competitiveness of the nation, but also companies. Poor performance is an obstacle to trade and foreign direct investment, and thus to economic growth. Patricia and Tuljak-Suban (2020) use the the Analytic Network Process (ANP), the Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE) and the Analytical Hierarchy Process (AHP) method to analyze logistics performance to select the best logistics

provider. Measuring supply chain performance is normally a function of various parameters. Such a problem often involves the problem of multi-criteria decision-making where different criteria need to be defined and calculated, correctly. Najmi and Makui (2010) apply the AHP and Decision making trial and evaluation laboratory (DEMATEL) method with the aim of measuring the supply chain performance index. The study (Yu and Hsiao, 2016) presents an alternative the meta-frontier data envelopment analysis with assurance regions (Meta-DEA-AR) approach for assessing the efficiency of the logistics performance index of individual countries, taking into account differences in income of different countries. The results show that the LPI ranking obtained by the proposed model is very comparable to the World Bank LPI ranking. Özceylan, Çetinkaya, Erbaş and Kabak (2016) assess the logistics performance of provinces in Turkey using the AHP- Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) and ANP-TOPSIS model observing 16 geographical and economic indicators. It was concluded that the proposed methodology provides an opportunity to analyze the impact of indicators on logistics performance and create a map of countries' logistics performance. In today's organizations, performance measurement is increasingly coming to the fore with advances in high technology. The paper (Aydogan, 2011) presents a conceptual framework for measuring performance that takes into account both quantitative and qualitative factors and the interrelationships between them. Thus, an integrated Rough-AHP-fuzzy TOPSIS approach has been proposed to measure the performance of an air transport company. Countries can check the performance of their logistics activities in order to determine their competitiveness in trade logistics. One way to check this performance is to analyze the LPI values published by the World Bank. The World Bank takes into account the weights of indicators equally when calculating LPI values. To overcome this problem, the study (Ulutaş and Karaköy, 2019) integrates both a subjective (Stepwise Weight Assessment Ratio Analysis- SWARA) and objective (CRITIC) method in determining the weights of criteria to balance all the advantages and disadvantages of these two weighting methods. Isik, Aydin and Kosaroglu (2020) analyze and rank the logistics performance of 11 selected Central and Eastern European countries using the Statistical Variance (SV) and Multi-Attributive Border Approximation area Comparison (MABAC) method. The fact that the ranking of the proposed hybrid model is the same as the original logistics performance index (LPI) ranking of the selected countries suggests that the proposed model is consistent. Yildirim and Adiguzel Mercangoz, (2020) use the gray additive ratio assessment (ARAS-G) method to assess the logistics performance of OECD countries in the period from 2010 to 2018, and compare the results with existing LPI rankings. Different from the World Bank survey, the fuzzy analytical hierarchy method is used to determine the weighting scores of defined six indicators. The paper (Oğuz, Alkan and Yılmaz, 2019) analyzes the logistical performance of selected Asian countries using the TOPSIS method. Kisa and Ayçin (2019) assess the logistics performance of countries using the hybrid SWARA- the Evaluation Based on Distance from Average Solution (EDAS) model. According to the results of the implementation, the most important criteria are the quality of logistics services, infrastructure and international shipping.

3. METHODOLOGY

The paper evaluates the logistics performance index of five Balkan countries using the integrated CRITIC-MARCOS model. The methodology of the paper includes the following five steps, ie. phases:

1. Data preparation,
2. Analysis of the LPI values of the Western Balkan countries,
3. Calculation of weight values of criteria using CRITIC,

4. Ranking the countries of the Western Balkans using MARCOS,
5. Sensitivity analysis.

The first phase refers to the preparation and extraction of the necessary data for the analysis and evaluation of the LPI of the Western Balkan countries, based on all available data published by the World Bank. In the second phase, the results of the Logistics Performance Index of the Western Balkans from 2007 to 2018 were compared for each dimension, i.e. criterion individually. The criteria on the basis of which the comparison of the previously mentioned five countries was made are the following: customs, infrastructure, ease of arranging shipments, quality of logistics services, tracking and tracing and timeliness. The third phase includes the calculation of weight values of defined criteria using the CRITIC method, where all criteria are of benefit type and should be maximized. The CRITIC method is conducted through the following four steps: formation of an initial matrix, normalization of the initial matrix depending on the type of criteria, determination of the symmetric matrix of linear correlation, and calculation of the objective weights of the criteria. The fourth phase refers to the ranking of the Western Balkan countries, based on data for 2018, using the MARCOS method. The MARCOS method is conducted through the following steps: formation of an initial decision matrix, formation of an extended decision matrix, normalization of the extended initial matrix, determination of a weighted matrix, calculation of the utility degree of alternatives, determination of the utility function of alternatives. In the final phase, an analysis of the sensitivity of the obtained results to changes in the significance of the criteria was conducted. The steps for applying the methods used are explained in more detail below.

3.1. CRITIC METHOD

The steps of this method are presented as follows (Diakoulaki, Mavrotas and Papayannakis, 1995).

Step 1: Forming the decision matrix (X)

$$x_{ij} = \begin{bmatrix} x_{11} & x_{12} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix} i = 1,2,\dots,m;\ j = 1,2,\dots,n \tag{1}$$

Step 2: Normalization of initial decision matrix depending on a criterion type.

$$r_{ij} = \frac{x_{ij} - \min\limits_i x_{ij}}{\max\limits_i x_{ij} - \min\limits_i x_{ij}} \quad if\ j \in B \rightarrow \max \tag{2}$$

$$r_{ij} = \frac{x_{ij} - \max\limits_i x_{ij}}{\min\limits_i x_{ij} - \max\limits_i x_{ij}} \quad if\ j \in C \rightarrow \min \tag{3}$$

Step 3. Calculation of symmetric linear correlation matrix $r_{ij.}$

$$r_{ij} = \frac{n\sum x_i y_i - \sum x_i \sum y_i}{\sqrt{n\sum x_i^2 - \left(\sum x_i\right)^2} \cdot \sqrt{n\sum y_i^2 - \left(\sum y_i\right)^2}} \tag{4}$$

Step 4. Determination of objective weights

$$W_j = \frac{C_j}{\sum_{j=1}^{n} C_j}, \quad C_j = \sigma \sum_{j'=1}^{n} 1 - r_{ij}, \quad \sigma = \sqrt{\frac{1}{n-1} \sum_{i=1}^{n} \left(x_i - \bar{x}\right)^2} \tag{5}$$

3.2 MARCOS METHOD

The MARCOS method developed by Stević, Pamučar, Puška and Chatterjee (2020) consists of the following steps (Stević and Brković, 2020):

Step 1: Formation of an initial decision matrix.

Step 2: Formation of an *extended* initial matrix. In this step, the extension of the initial matrix is performed by defining the ideal (*AI*) and anti-ideal (*AAI*) solution.

$$X = \begin{array}{c} \\ AAI \\ A_1 \\ A_2 \\ \cdots \\ A_m \\ AI \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \ldots & C_n \end{array} \\ \begin{bmatrix} x_{aa1} & x_{aa2} & \ldots & x_{aan} \\ x_{11} & x_{12} & \ldots & x_{1n} \\ x_{21} & x_{22} & \ldots & x_{2n} \\ \ldots & \ldots & \ldots & \ldots \\ x_{m1} & x_{22} & \ldots & x_{mn} \\ x_{ai1} & x_{ai2} & \ldots & x_{ain} \end{bmatrix} \end{array} \tag{6}$$

The anti-ideal solution (*AAI*) is the worst alternative, while the ideal solution (*AI*) is an alternative with the best characteristic defined by applying Equations (7) and (8):

$$AAI = \min_i x_{ij} \quad if \ j \in B \quad and \quad \max_i x_{ij} \quad if \ j \in C \tag{7}$$

$$AI = \max_i x_{ij} \quad if \ j \in B \quad and \quad \min_i x_{ij} \quad if \ j \in C \tag{8}$$

where *B* represents a benefit group of criteria, while *C* represents a group of cost criteria.

Step 3: Normalization of the extended initial matrix (*X*). The elements of the normalized matrix $N=[n_{ij}]mxn$ are obtained by applying Equations (9) and (10):

$$n_{ij} = \frac{x_{ai}}{x_{ij}} \quad if \ j \in C \tag{9}$$

$$n_{ij} = \frac{x_{ij}}{x_{ai}} \quad if \ j \in B \tag{10}$$

where elements x_{ij} and x_{ai} represent the elements of the matrix *X*.

Step 4: Determination of the weighted matrix $V= [v_{ij}]mxn$, Equation (11).

$$v_{ij} = n_{ij} \times w_j \tag{11}$$

Step 5: Calculation of the utility degree of alternatives K_i applying Equations (12) and (13).

$$K_i^- = \frac{S_i}{S_{aai}} \tag{12}$$

$$K_i^+ = \frac{S_i}{S_{ai}} \tag{13}$$

where S_i (i=1,2,..,m) represents the sum of the elements of the weighted matrix V, Equation (14).

$$S_i = \sum_{i=1}^{n} v_{ij} \tag{14}$$

Step 6: Determination of the utility function of alternatives $f(K_i)$ defined by Equation (15).

$$f(K_i) = \frac{K_i^+ + K_i^-}{1 + \frac{1 - f(K_i^+)}{f(K_i^+)} + \frac{1 - f(K_i^-)}{f(K_i^-)}}; \tag{15}$$

Where $f(\boldsymbol{K_i^-})$ represents the utility function in relation to the anti-ideal solution, while $f(\boldsymbol{K_i^+})$ represents the utility function in relation to the ideal solution.
Utility functions in relation to the ideal and anti-ideal solution are determined by applying Equations (16) and (17).

$$f(K_i^-) = \frac{K_i^+}{K_i^+ + K_i^-} \tag{16}$$

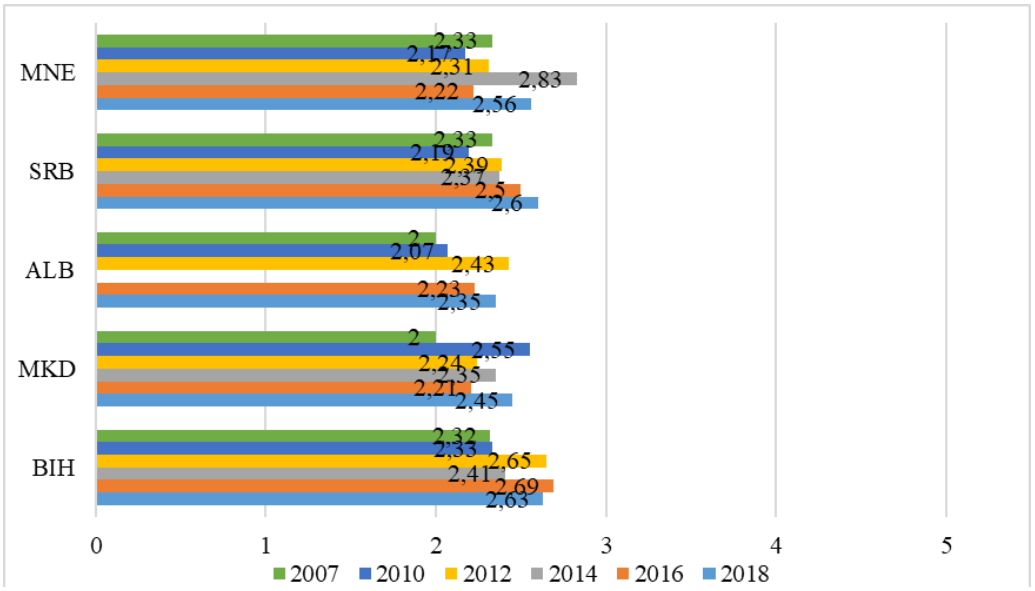
$$f(K_i^+) = \frac{K_i^-}{K_i^+ + K_i^-} \tag{17}$$

Step 7: Ranking the alternatives. Ranking of the alternatives is premised on the final values of utility functions. It is desirable that an alternative has the highest possible value of the utility function.

4. ANALYSIS OF THE INTERNATIONAL LOGISTICS PERFORMANCE INDEX OF THE WESTERN BALKAN COUNTRIES

The analysis of the LPI of the Western Balkan countries is performed according to all six dimensions considered within the LPI. Data for LPI dimensions calculated by the World Bank were used in the analysis. The countries of the Western Balkans are: Bosnia and Herzegovina (BiH), North Macedonia (MKD), Albania (ALB), Serbia (SRB) and Montenegro (MNE).
The first core element of the LPI indicator is the efficiency of customs and border control. The indicator ranges from "very low" (1) to "very high" (5). The customs clearance process measures the efficiency and effectiveness of the customs clearance procedure (speed, simplicity and predictability of customs authorities). All this is configured through a series of administrative tasks that enable the implementation of existing legislation on international trade and the collection of taxes on imports/exports of goods and services. The results of the Western Balkan countries are shown in Figure 1.

Figure 1. Diagram of customs efficiency and border control results.

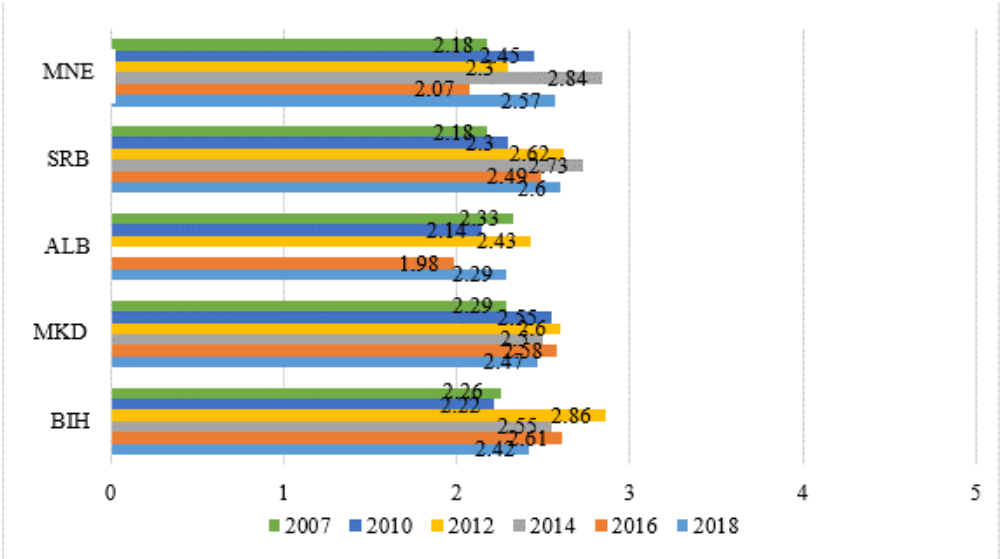


Source: Author's creation.

According to the results presented, it can be seen the trend of customs efficiency and border control in the group of selected countries from 2007 to 2018. The leaders in efficiency in 2018 are Bosnia and Herzegovina and Serbia with an indicator of 2.63 and 2.60, respectively, although this is still considered low efficiency, which means that the procedure of processing the customs declaration and other activities is slow. A higher indicator represents less time for processing the customs declaration (shorter procedures), which leads to less congestion at borders, airports, and river and sea ports. From 2007 to 2018, all Western Balkan countries made some progress in this category: North Macedonia by 22.5%, Albania by 17.5%, Bosnia and Herzegovina by 13.36%, Serbia by 11.59% and Montenegro by 9.87%. It can be seen that the efficiency indicator of customs is growing in all countries, but it is still far from ideal.

The second core element for the LPI assessment is transport quality and transport infrastructure (Sénquiz-Díaz, 2021a). Indicators range from "very low" (1) to "very high" (5). The results are shown in Figure 2.

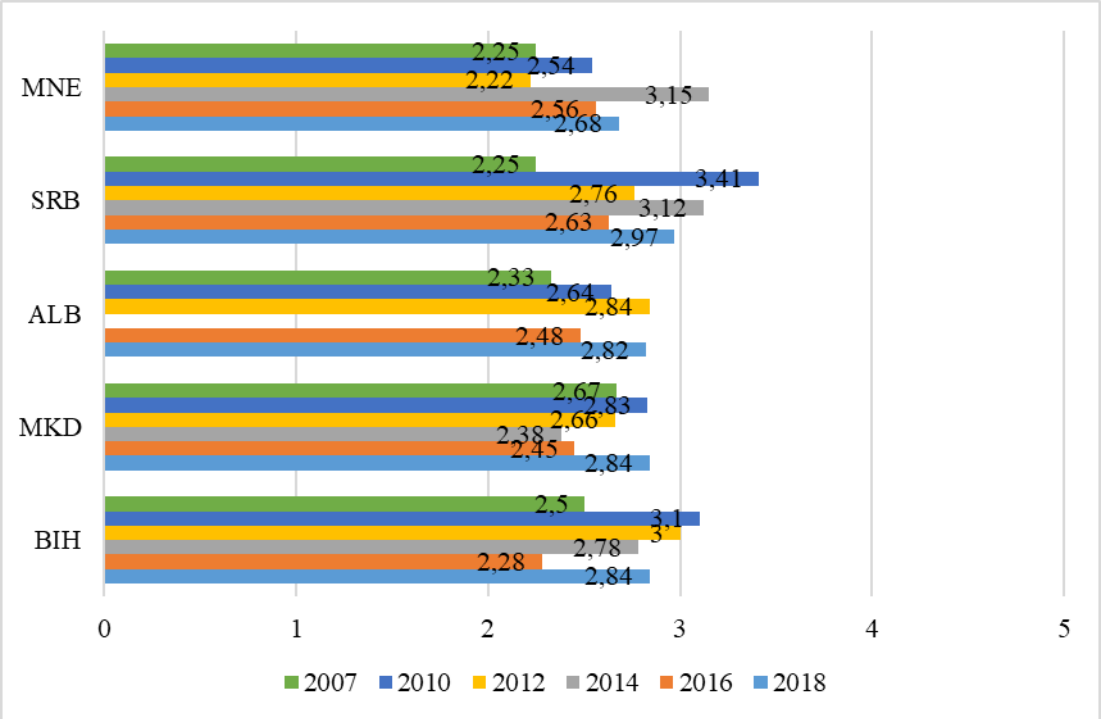
Figure 2. Diagram of transport quality and transport infrastructure results.



Source: Author's creation.

According to the results presented, it can be seen the trend of the quality of trade and transport infrastructure in the selected countries. This element shows the state of transport infrastructure and transport safety through each country. When considering observing e.g. the quality of road infrastructure, it is observed road connectivity (motorways, main roads, tunnels, etc.) and traffic regulation. Also in the case of railway infrastructure, it is observed the connection between the railway and the condition of the railway (at which average speed one vehicle runs without compromising safety). The country with the highest quality is Serbia with an indicator of 2.6 and leads this category, although it is still low transport quality. All countries have advanced since the first performance index in 2007 except Albania, which performed worse in 2018 than in 2007.
The third core element for the LPI is the indicator of ease of negotiating the price of transport. Indicators range from ''very difficult" (1) to ''very easy" (5). The results are shown in Figure 3.

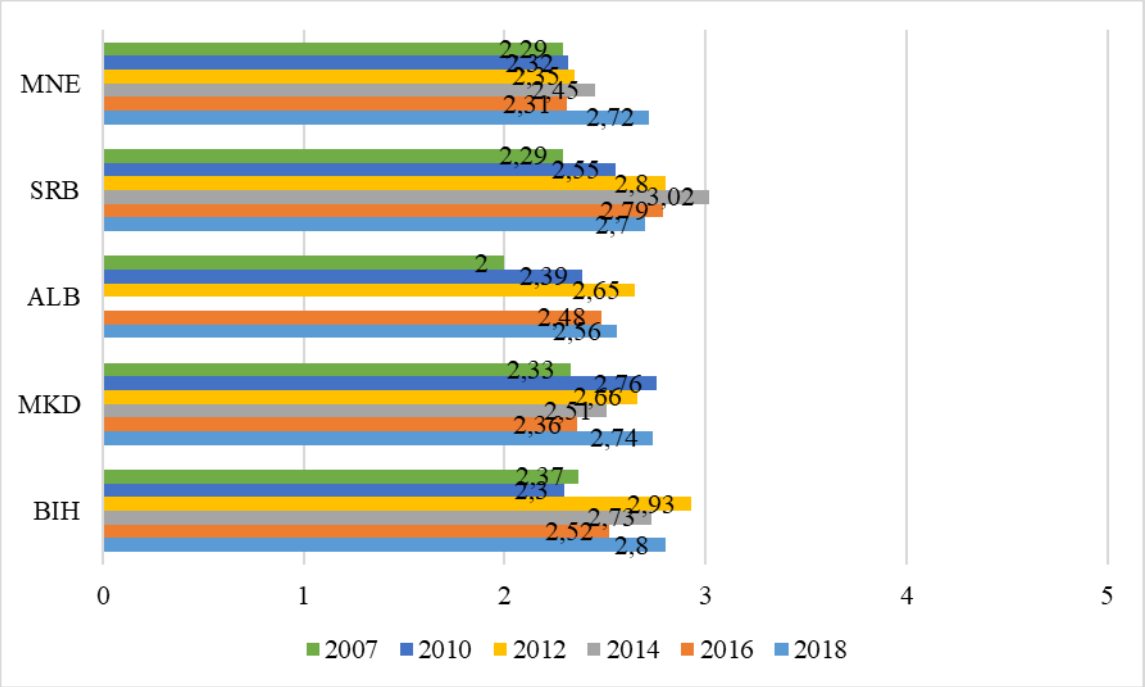
Figure 3. Diagram of the results of ease of negotiating transport prices.



Source: Author's creation.

According to the results presented, it can be seen the ease of negotiating transport prices in the selected countries. In terms of ease of negotiating transport prices, Serbia (2.97), North Macedonia (2.84) and Bosnia and Herzegovina (2.84) have the highest index in 2018, and according to the data, it is easier for them to negotiate transport prices, although we can see that the value still does not exceed 3 and that these countries achieved better results in previous years. This applies to Serbia and Bosnia and Herzegovina, with an exception of North Macedonia.
The fourth core element for the LPI is the logistics service quality indicator. Indicators range from "very low" (1) to "very high" (5). The results are shown in Figure 4.

Figure 4. Diagram of the results of the logistics service quality indicator.

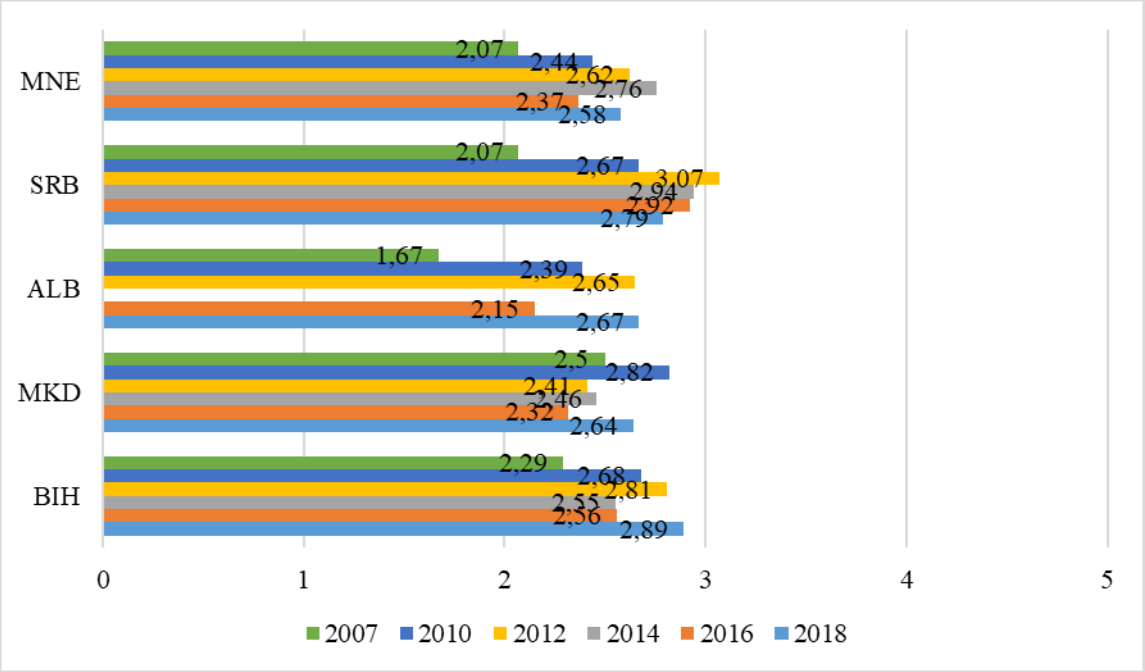


Source: Author's creation.

Quality and competence of logistics measures the competence and quality of logistics services. It shows how certain parties behave within the organizational structure, presenting the quality of service to the client and optimizing the relationship between organizations and customers. According to the results presented, it can be seen the quality of logistics services in the markets of selected countries. This indicator identifies how well organizations meet customer requirements (shows their flexibility), apply high-tech vehicles, apply transport process management systems using modern information technologies (Intelligent Transport Systems), and meet environmental requirements. This indicator shows the value of the logistics service. The countries with the highest quality of logistics services are Bosnia and Herzegovina (2.8), North Macedonia (2.74) and Montenegro (2.72), but other countries have also achieved approximate results. As with the previous indicators, the value does not exceed 3, which represents a good quality of logistics services, so that the countries of the Western Balkans achieved better results in previous indices, with an exception of Montenegro.

The fifth core element for the LPI is an indicator of the ability and quality of shipment tracking and tracing. Indicators range from "very low" (1) to "very high" (5). The results are shown in Figure 5. According to the results presented, it can be seen the level of ability and quality of shipment tracking and tracing. The shipment tracking and tracing is a value-added service. This category shows reliability when tracking and tracing a shipment in transport. Out of the selected group of countries, Bosnia and Herzegovina (2.89) and Serbia (2.79) lead in terms of ability and quality of shipment tracking and tracing. As with the previous indicators, the value does not exceed 3, which represents an insufficient level of traceability of shipments. It can be seen that all countries achieved better results compared to 2016, except Serbia.

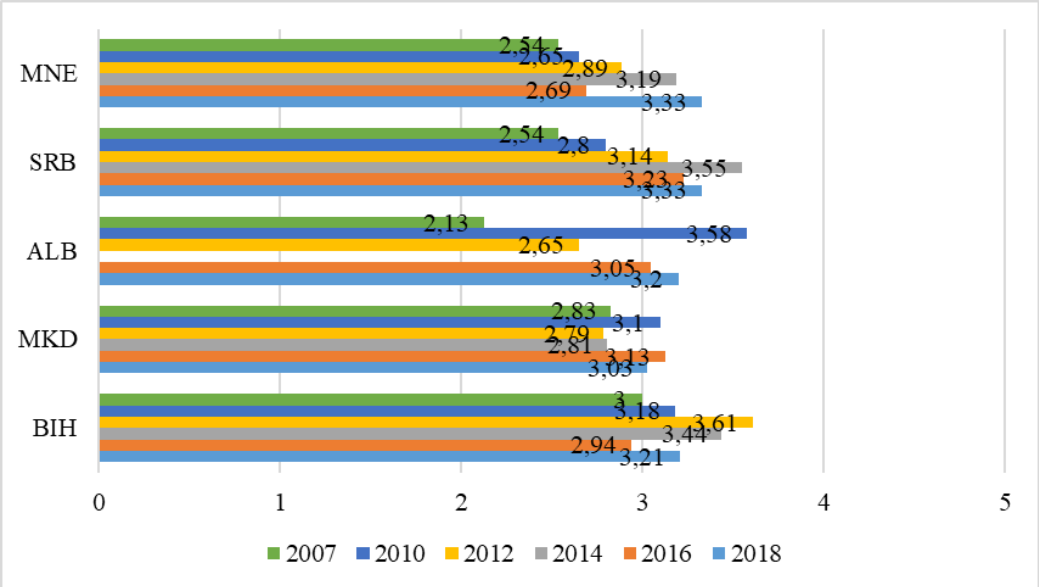
Figure 5. Diagram of the results of the ability and quality of shipment tracking and tracing.



Source: Author's creation.

The sixth core element for the LPI and also the last one is an indicator of shipment delivery frequency compliance with scheduled or expected delivery times. This is an important factor to consider since, with the existing high level of competition, non-compliance with delivery times is unacceptable. Indicators range from "almost never" (1) to "almost always" (5). The results are shown in Figure 6. Based on the indicators, it can be seen that all the Western Balkan countries have crossed the limit of 3 and have a solid level in meeting expected delivery times. All countries achieved better results compared to 2016 except Serbia. In this segment, all Balkan countries performed better in comparison to other indicators.

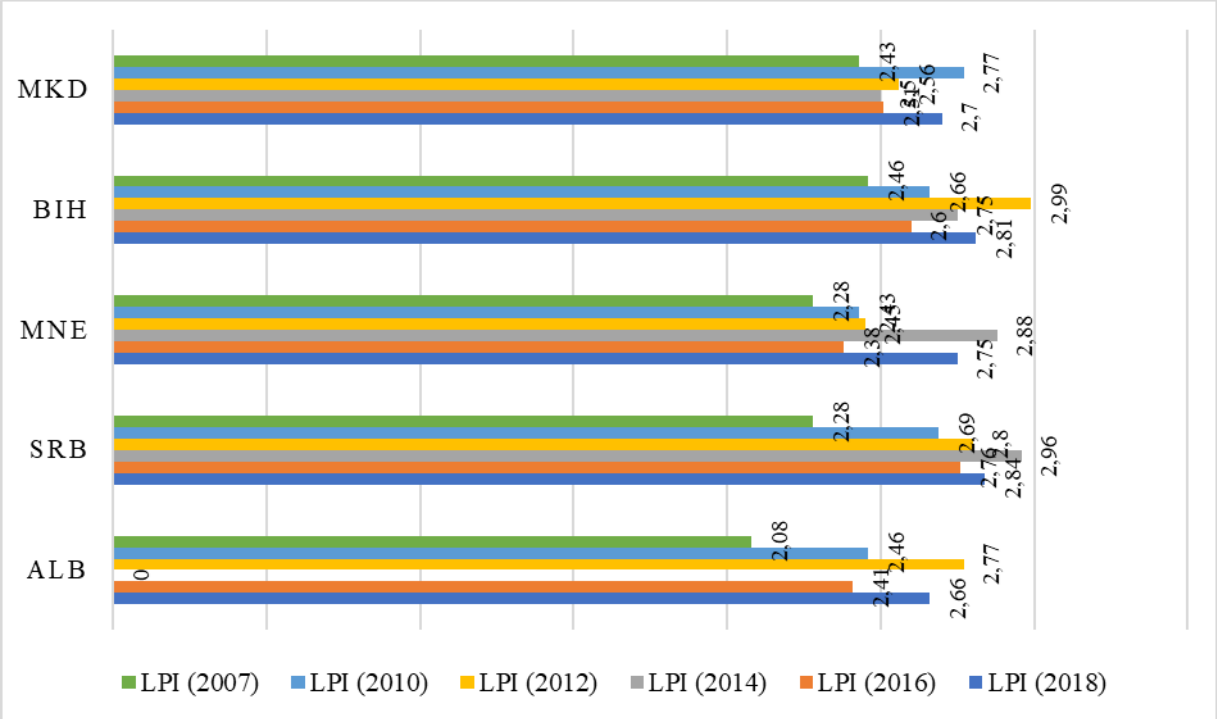
Figure 6. Diagram of indicators of shipment delivery frequency compliance with the scheduled or expected delivery time of the Western Balkan countries.



Source: Author's creation.

LPI values considering all six previously mentioned dimensions are shown in the Figure 7.

Figure 7. Diagram of international LPI results for the Western Balkans countries.



Source: Author's creation.

5. RESULTS OF THE APPLICATION OF THE INTEGRATED CRITIC-MARCOS MODEL

5.1. RESULTS OF CRITIC METHOD APPLICATION

We use six criteria: Customs (C1), infrastructure (C2), ease of arranging shipments (C3), quality of logistics services (C4), tracking and tracing of goods (C5) and shipment delivery within scheduled or expected times (timeliness) (C6) on the basis of which the LPI is defined. All criteria are of benefit type and should be maximized. The alternatives in this model are the Western Balkan countries. Accordingly, Table 1 shows the initial matrix of the CRITIC method.

Table 1. Initial matrix of the CRITIC method.

	C1	C2	C3	C4	C5	C6
Albania	2.350	2.290	2.820	2.560	2.670	3.200
Serbia	2.600	2.600	2.970	2.700	2.790	3.330
Montenegro	2.560	2.570	2.680	2.720	2.580	3.330
BIH	2.630	2.420	2.840	2.800	2.890	3.210
North Macedonia	2.450	2.470	2.840	2.740	2.640	3.030
MAX/MIN	MAX	MAX	MAX	MAX	MAX	MAX

Source: Author's calculation.

The second step is to normalize the initial matrix. Matrix normalization is performed according to Equation (2):

$$X_{11} = \frac{2.35-2.35}{2.63-2.35} = 0; \quad X_{12} = \frac{2.29-2.29}{2.60-2.29} = 0; \quad X_{13} = \frac{2.82-2,68}{2.97-2.68} = 0{,}483 \text{ ; etc.}$$

The minimum values of the criteria for normalization: C1=2.35; C2=2.29; C3=2.68; C4=2.56; C5=2.58; C6=3.03. The maximum values of the criteria for normalization: C1=2.63; C2=2.60; C3=2.97; C4=2.80; C5=2.89; C6=3.33.
This is followed by the calculation of the standard deviation for each criterion individually. The obtained values of the normalized initial matrix and standard deviations are shown in Table 2.

Table 2. Normalized initial matrix and standard deviation.

	C1	C2	C3	C4	C5	C6
Albania	0.000	0.000	0.483	0.000	0.290	0.567
Serbia	0.893	1.000	1.000	0.583	0.677	1.000
Montenegro	0.750	0.903	0.000	0.667	0.000	1.000
BIH	1.000	0.419	0.552	1.000	1.000	0.600
North Macedonia	0.357	0.581	0.552	0.750	0.194	0.000
STDEV	0.415	0.401	0.355	0.370	0.402	0.411

Source: Author's calculation.

After that, it is necessary to determine the correlation between the criteria. An example of the calculation is as follows:

$$r_{12} = r_{21} \frac{5 \cdot 2.196 - 3.000 \cdot 2.903}{\sqrt{5 \cdot 2.487 - (3.000)^2} \cdot \sqrt{5 \cdot 2.49 - (2.903)^2}} = 0.685$$

Table 3 shows the obtained values of linear correlation coefficients.

Table 3. Matrix of linear correlation coefficients.

	C1	C2	C3	C4	C5	C6
C1	1.000	0.685	0.153	0.797	0.566	0.503
C2	0.685	1.000	0.088	0.503	0.071	0.480
C3	0.153	0.088	1.000	-0.005	0.627	-0.057
C4	0.797	0.503	-0.005	1.000	0.409	-0.082
C5	0.566	-0.071	0.627	0.409	1.000	0.111
C6	0.503	0.480	-0.057	-0.082	0.111	1.000

Source: Author's calculation.

The formation of the matrix is completed by subtracting the correlation matrix from one (1-all values in the previous matrix). After subtraction, the values are summed in columns for all criteria. Then it is necessary to multiply the values of standard deviation with previously obtained individual values of sums per columns. C1 = 0.415 * 2.297 = 0.953; C2 = 0.401 * 3.316 = 1.330; C3 = 0.355 * 4.195 = 1.489; C4 = 0.370 * 3.378 = 1.249; C5 = 0.402 * 3.358 = 1.350 C6 = 0.411 * 4.046 = 1.663. Their sum is 8.034. The values of weight coefficients are obtained when an individual value of C_j is divided by the previous sum, e.g.: W1 = 0.953/8.034 = 0.119. Other values are obtained in the same way: W2 = 0.166; W3 = 0.185; W4 = 0.156; W5 = 0.168; W6 = 0.207. The weight coefficients

obtained in this way are used for further calculations when applying the MARCOS method. Based on the obtained weight values of the criteria, it can be concluded that the most significant is the sixth criterion related to timeliness, followed by the criteria for ease of arranging shipments, tracking and tracing of goods and infrastructure. In the fifth place in significance is the criterion related to quality of logistics services and in the last place in significance is the criterion that takes into account customs.

5.2. RESULTS OF THE MARCOS METHOD APPLICATION

At the very beginning, it is necessary to form an extended initial decision matrix. Thus, in this step, the matrix is expanded by defining an ideal (AI) and anti-ideal (AAI) solution. The anti-ideal solution (AAI) is the worst alternative while the ideal solution (AI) is the best-performing alternative. The extended initial matrix of the MARCOS method is shown in Table 4.

Table 4. Extended initial matrix for the MARCOS method.

	C1	C2	C3	C4	C5	C6
AAI	2.350	2.290	2.680	2.560	2.580	3.030
Albania	2.350	2.290	2.820	2.560	2.670	3.200
Serbia	2.600	2.600	2.970	2.700	2.790	3.330
Montenegro	2.560	2.570	2.680	2.720	2.580	3.330
BIH	2.630	2.420	2.840	2.800	2.890	3.210
North Macedonia	2.450	2.470	2.840	2.740	2.640	3.030
AI	2.630	2.600	2.970	2.800	2.890	3.330
MAX/MIN	MAX	MAX	MAX	MAX	MAX	MAX

Source: Author's calculation.

The next step is the normalization of the extended initial matrix, which is performed by Equation (10). An example of calculation is as follows:

$$X_{11} = \frac{2.35}{2.63} = 0.894\ ;\ X_{21} = \frac{2.60}{2.63} = 0.989\ ;\ X_{31} = \frac{2.56}{2.63} = 0.973\ ;$$

The values of the normalized matrix obtained in this way are shown in the table 5.

Table 5. Normalized extended initial matrix.

	C1	C2	C3	C4	C5	C6
AAI	0.894	0.881	0.902	0.914	0.893	0.910
Albania	0.894	0.881	0.949	0.914	0.924	0.961
Serbia	0.989	1.000	1.000	0.964	0.965	1.000
Montenegro	0.973	0.988	0.902	0.971	0.893	1.000
BIH	1.000	0.931	0.956	1.000	1.000	0.964
North Macedonia	0.932	0.950	0.956	0.979	0.913	0.910
AI	1.000	1.000	1.000	1.000	1.000	1.000
Wj	0.119	0.166	0.185	0.156	0.168	0.207

Source: Author's calculation.

The fourth step is to determine a weighted matrix. Multiplication of the normalized matrix with weighting coefficients is performed by Equation (11). An example of calculation is as follows:
$V_{11} = 0.894 * 0.119 = 0.106$; $V_{21} = 0.989 * 0.119 = 0{,}117$; $V_{31} = 0.973 * 0{,}119 = 0{,}115$;
The values of the weighted matrix are shown in the table 6.

Table 6. Weighted matrix of the MARCOS method.

	C1	C2	C3	C4	C5	C6	Σ
AAI	0.106	0.146	0.167	0.142	0.150	0.188	0.900
Albania	0.106	0.146	0.176	0.142	0.155	0.199	0.924
Serbia	0.117	0.166	0.185	0.150	0.162	0.207	0.987
Montenegro	0.115	0.164	0.167	0.151	0.150	0.207	0.954
BIH	0.119	0.154	0.177	0.156	0.168	0.200	0.973
North Macedonia	0.110	0.157	0.177	0.152	0.153	0.188	0.939
AI	0.119	0.166	0.185	0.156	0.168	0.207	1.000

Source: Author's calculation.

The fifth step involves the calculation of the utility degree of alternatives K_i, and is performed by Equation (12) and (13): An example of calculation is as follows:

$$K_1^- = \frac{0.924}{0.900} = 1.027; \quad K_1^+ = \frac{0.924}{1.000} = 0.924;$$

The next step is to determine the utility function of the alternative and it is calculated by Equation (15). The utility function represents a compromise of the observed alternative in relation to the ideal and anti-ideal solution.

$$f(K_1) = \frac{K_i^+ + K_i^-}{1 + \frac{1 - f(K_i^+)}{f(K_i^+)} + \frac{1 - f(K_i^-)}{f(K_i^-)}};$$

The utility function according to the anti-ideal solution is obtained applying Equation (16), as follows:

$$f(K_1^-) = \frac{0.924}{0.924+1.027} = 0.474;$$

While the utility function according to the ideal solution is obtained by applying Equation (17), as follows:

$$f(K_1^+) = \frac{1.027}{0.924+1.027} = 0.526$$

Finally, the utility function of alternative A1 is obtained by applying Equation (15), as follows:

$$f(K_i) = \frac{1.027 + 0.924}{1 + \frac{1 - 0.526}{0.526} + \frac{1 - 0.474}{0.474}} = 0.648;$$

Table 7 shows the results obtained using the MARCOS method.

Table 7. Results of applying the MARCOS method.

	Ki -	Ki +	$f(K_1^-)$	$f(K_1^+)$	$f(K_i)$	Rank
Albania	1.027	0.924	0.474	0.526	0.648	**5**
Serbia	1.098	0.987	0.474	0.526	0.692	**1**
Montenegro	1.061	0.954	0.474	0.526	0.669	**3**
BIH	1.082	0.973	0.474	0.526	0.682	**2**
North Macedonia	1.044	0.939	0.474	0.526	0.658	**4**

Source: Author's calculation.

According to the results obtained, the best-ranked country in the Western Balkans is Serbia, while Bosnia and Herzegovina is in second place. The third place in the ranking is occupied by Montenegro, and the fourth by North Macedonia. The worst-ranked country in the Western Balkans is Albania.

5.3. Analysis of the sensitivity of the results to changes in the significance of the criteria

It is known that there are different MCDM methods, and the results change depending on changes in the significance of criteria as well as the selection of a MCDM method. For that reason, it is necessary to perform a sensitivity analysis, i.e. to compare the results when the weights of criteria changes. Sensitivity analysis is conducted for greater security during implementation in the real sector. In this part of the sensitivity analysis, it is analyzed the impact of changes in all criteria. The weights of the criteria in the range of 15-90% were changed, starting with the most significant criterion. The most significant criterion is C6, followed by C3, C5, C2, C4 and C1 criteria. By applying Equation (18), a total of 36 scenarios were formed.

$$W_{n\beta} = \left(1 - W_{n\alpha}\right)\frac{W_\beta}{\left(1 - W_n\right)} \tag{18}$$

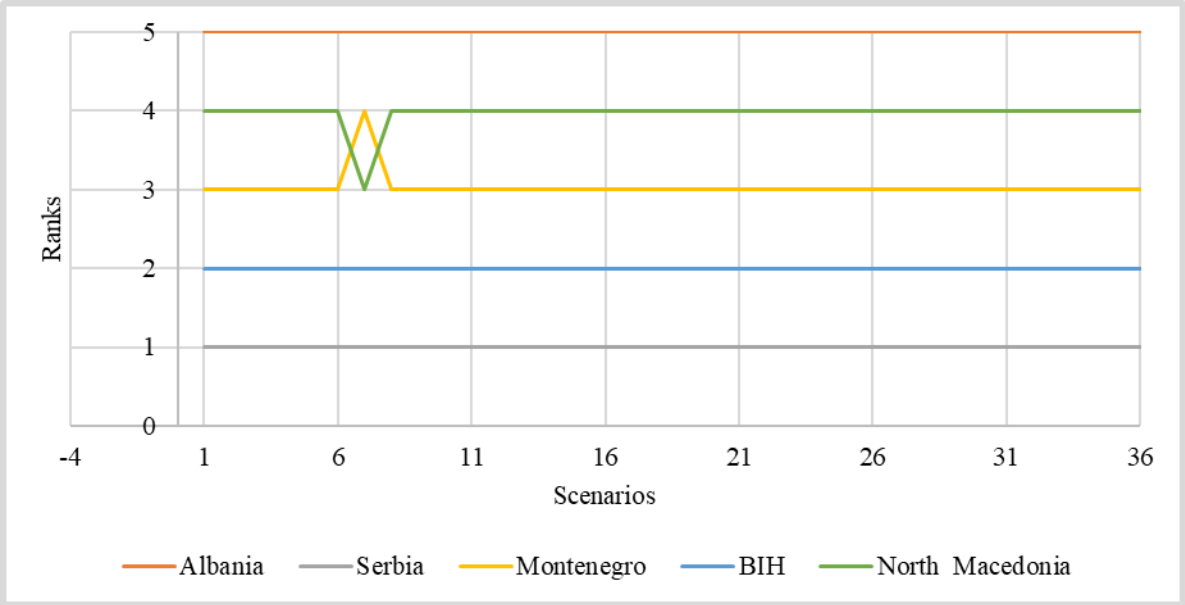
In scenarios S1-S6, it has been changed the most significant criterion C6, criterion C3 in scenarios S7-S12, criterion C5 in scenarios S13-S18, criterion C2 in scenarios S19-S24, criterion C4 in scenarios S25-S30 and criterion C1 in scenarios S31-S36. Wnβ represents a new value of the criteria Ci, Ci, Ci, Ci, Ci, Ci. Wna represents the reduced value of the criterion Ci, Wp is the original value of the observed criterion and Wn represents the original value of the criterion with a reduced value - Ci (for the first group of scenarios, S1 -S6). All simulated criteria values through the newly formed 36 scenarios are presented in Table 8, as well as in Figure 8.

Table 8. Simulated values of the criteria through newly formed 36 scenarios.

	W1	W2	W3	W4	W5	W6		W1	W2	W3	W4	W5	W6
S1	0.123	0.172	0.193	0.162	0.175	0.176	S19	0.122	0.141	0.191	0.160	0.173	0.213
S2	0.128	0.178	0.200	0.168	0.181	0.145	S20	0.126	0.116	0.196	0.165	0.178	0.219
S3	0.132	0.185	0.207	0.174	0.188	0.114	S21	0.129	0.091	0.202	0.169	0.183	0.225
S4	0.137	0.191	0.214	0.180	0.194	0.083	S22	0.133	0.066	0.207	0.174	0.188	0.232
S5	0.142	0.198	0.222	0.186	0.201	0.052	S23	0.136	0.041	0.213	0.179	0.193	0.238
S6	0.146	0.204	0.229	0.192	0.208	0.021	S24	0.140	0.017	0.218	0.183	0.198	0.244
S7	0.123	0.171	0.158	0.161	0.174	0.214	S25	0.122	0.170	0.191	0.132	0.173	0.213
S8	0.127	0.177	0.130	0.166	0.180	0.221	S26	0.125	0.175	0.196	0.109	0.177	0.218
S9	0.131	0.182	0.102	0.171	0.185	0.228	S27	0.128	0.179	0.201	0.086	0.182	0.224
S10	0.135	0.188	0.074	0.177	0.191	0.235	S28	0.132	0.184	0.206	0.062	0.187	0.230
S11	0.139	0.194	0.046	0.182	0.197	0.242	S29	0.135	0.188	0.211	0.039	0.191	0.236
S12	0.143	0.199	0.019	0.187	0.202	0.249	S30	0.138	0.193	0.216	0.016	0.196	0.241
S13	0.122	0.171	0.191	0.160	0.143	0.213	S31	0.101	0.169	0.189	0.159	0.171	0.211
S14	0.126	0.176	0.197	0.165	0.118	0.220	S32	0.083	0.172	0.193	0.162	0.175	0.215
S15	0.129	0.181	0.202	0.170	0.092	0.226	S33	0.065	0.176	0.197	0.165	0.178	0.220
S16	0.133	0.186	0.208	0.174	0.067	0.232	S34	0.047	0.179	0.200	0.168	0.182	0.224
S17	0.136	0.191	0.213	0.179	0.042	0.238	S35	0.030	0.182	0.204	0.171	0.185	0.228
S18	0.140	0.196	0.219	0.184	0.017	0.245	S36	0.012	0.186	0.208	0.174	0.188	0.232

Source: Author's calculation.

Figure 8. Results of sensitivity analysis with new criterion values.



Source: Author's creation.

Based on the 36 sets that represent the new criteria, it can be seen that there have been no significant changes. Although the criteria have been changed, we come to the conclusion that the fifth alternative is the worst solution, while the first alternative is the best solution. The only change that occurred was when the third alternative (Montenegro) and the fourth alternative (North Macedonia) swapped rankings in the sixth scenario. The change of ranks in the sixth scenario is influenced by the reduction of the weight value of the most important criterion (C6) by 90%. In general, it can be concluded that there are no significant changes in the ranking.

6. CONCLUSION

One of the most important factors that enable countries to compete in national or international trade is the efficiency and productivity of their logistics performance. Logistics is one of the fastest growing sectors in the world, which has significant positive effects on the economic and social policy of countries' development. It is very important to create regulations in the logistics sector in order to improve the trade capacity of countries and increase international competitiveness. The Logistics Performance Index (LPI), calculated by the World Bank, is an indicator of the logistics environment quality of a country in which logistics operators act. The World Bank collects data on logistics environment quality through a survey of logistics operators. In this way, logistics operators provide feedback on logistics in the countries with which they do business and trade. The LPI is an indicator that shows the performance of the logistics sector by combining main data from the six logistics performance components into one indicator.

The 2018 LPI data published by the World Bank were used to compare the performance of the international logistics of the Western Balkans countries using the CRITIC and MARCOS method. First, the weight values of the defined criteria were obtained by applying the CRITIC method. Thus, it has been analyzed the following six criteria: Customs (C1), infrastructure (C2), ease of arranging shipments (C3), quality of logistics services (C4), tracking and tracing of goods (C5) and timeliness (C6) based on which the LPI is defined. All criteria are of benefit type and should be maximized. The initial matrix was formed with LPI data for 2018. The most significant criteria for the countries of the Western Balkans were C6 > C3 > C5 > C2 > C4 > C1. The summed weighting coefficients were used for further calculation in the MARCOS method. As for the Western Balkan countries, according to the results of MARCOS, the best-ranked country is Serbia, followed by Bosnia and Herzegovina. It is followed by Montenegro and North Macedonia, while Albania is the worst-ranked country in the Western Balkans. In the section of the analysis of the sensitivity of the results to changes in the significance of the criteria, it was noticed that there are no significant changes.

Therefore, it can be concluded that nowadays measuring and analyzing the logistics performance index is increasingly coming to the fore since the efficiency or inefficiency of the logistics sector directly and indirectly affects all other economic sectors, and contributes to the overall development of a country. Hence, it is necessary to perform various processes of measuring, analyzing and evaluating the LPI, and the mentioned processes can greatly improve and simplify the application of MCDM models.

One of the limitations of this research is the period observed as well as the number of countries analyzed. These limitations can be compensated through future research that will include data on the value of LPI for several years, and analyze and compare the values of LPI in the Western Balkans compared to other countries and regions. Some directions of future studies can be manifested by determining the level of impact of individual indicators on the value of LPI using different subjective and objective methods, or methods that include fuzzy or gray numbers and comparing the results of these approaches.

REFERENCES

Arvis, J. F., Alina Mustra, M., Ojala, L., Shepherd, B., & Saslavsky, D. (2010). Connecting to Compete 2010: Trade Logistics in the Global Economy-The Logistics Performance Index and Its Indicators. World Bank.
https://doi.org/10.1596/24599

Arvis, J. F., Saslavsky, D., Ojala, L., Shepherd, B., Busch, C., & Raj, A. (2016). Trade logistics in the global economy: the logistics performance index and its indicators. The report was designed, edited, and typeset by Communications Development Incorporated, Washington, DC.

Aydogan, E. K. (2011). Performance measurement model for Turkish aviation firms using the rough-AHP and TOPSIS methods under fuzzy environment. *Expert Systems with Applications*, 38(4), 3992-3998.
https://doi.org/10.1016/j.eswa.2010.09.060

Bottani, E., Montanari, R., Rinaldi, M., & Vignali, G. (2015). Modeling and multi-objective optimization of closed loop supply chains: A case study. *Computers & Industrial Engineering*, 87, 328-342.
https://doi.org/10.1016/j.cie.2015.05.009

Çakır, S. (2017). Measuring logistics performance of OECD countries via fuzzy linear regression. *Journal of Multi- Criteria Decision Analysis*, 24(3-4), 177-186.
https://doi.org/10.1002/mcda.1601

Daniel Saslavsky & Ben Shepherd (2014). Facilitating international production networks: The role of trade logistics, The Journal of International Trade & Economic Development, 23(7), 979-999.
https://doi.org/10.1080/09638199.2013.811534

D'Aleo, V. and Sergi, B.S. (2017), "Does logistics influence economic growth? The European experience", *Management Decision*, 55 (8), 1613-1628.
https://doi.org/10.1108/MD-10-2016-0670

Devlin, J., & Yee, P. (2005). Trade logistics in developing countries: The case of the Middle East and North Africa. *World Economy*, 28(3), 435-456.
https://doi.org/10.1111/j.1467-9701.2005.00620.x

Diakoulaki, D., Mavrotas, G., & Papayannakis, L. (1995). Determining objective weights in multiple criteria problems: The critic method. *Computers & Operations Research,* 22(7), 763-770.
https://doi.org/10.1016/0305-0548(94)00059-H

Isik, O., Aydin, Y., & Kosaroglu, S. M. (2020). The assessment of the logistics Performance Index of CEE Countries with the New Combination of SV and MABAC Methods. LogForum, 16(4).
https://doi.org/10.17270/J.LOG.2020.504

Jhawar, A., Garg, S. K., & Khera, S. N. (2017). Improving logistics performance through investments and policy intervention: a causal loop model. *International Journal of Productivity and Quality Management*, 20(3), 363-391.
http://dx.doi.org/10.1504/IJPQM.2017.10003289

Kisa, A. C. G., & Ayçin, E. (2019). OECD ülkelerinin lojistik performanslarının SWARA tabanlı EDAS yöntemi ile değerlendirilmesi. *Çankırı Karatekin Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi*, 9(1), 301-325.
https://doi.org/10.18074/ckuiibfd.500320

Korinek, J. and P. Sourdin (2011), "To What Extent Are High-Quality Logistics Services Trade Facilitating?", OECD Trade Policy Papers, No. 108, OECD Publishing, Paris
https://doi.org/10.1787/18166873

Martí, L., Puertas, R., & García, L. (2014). The importance of the Logistics Performance Index in international trade. *Applied economics*, 46(24), 2982-2992. https://doi.org/10.1080/00036846.2014.916394

Martí, L., Martín, J. C., & Puertas, R. (2017). A DEA-logistics performance index. *Journal of applied economics*, 20(1), 169-192. https://doi.org/10.1016/S1514-0326(17)30008-9

Najmi, A., & Makui, A. (2010). Providing hierarchical approach for measuring supply chain performance using AHP and DEMATEL methodologies. *International Journal of Industrial Engineering Computations,* 1(2), 199-212. https://doi.org/10.5267/j.ijiec.2010.02.008

Oğuz, S., Alkan, G., & Yılmaz, B. (2019). Seçilmiş Asya ülkelerinin lojistik performanslarının TOPSİS yöntemi ile değerlendirilmesi. *IBAD Sosyal Bilimler Dergisi*,(Özel Sayı), 497, 507. https://doi.org/10.21733/ibad.613421

Ojala, L., & Celebi, D. (2015). The World Bank's Logistics Performance Index (LPI) and drivers of logistics performance. Proceeding of MAC-EMM, OECD.

Ozmen, M. (2019). Logistics competitiveness of OECD countries using an improved TODIM method. *Sādhanā*, 44(5), 1-11. https://doi.org/10.1007/s12046-019-1088-y

Özceylan, E., Çetinkaya, C., Erbaş, M., & Kabak, M. (2016). Logistic performance evaluation of provinces in Turkey: A GIS-based multi-criteria decision analysis. *Transportation Research Part A: Policy and Practice*, 94, 323-337. https://doi.org/10.1016/j.tra.2016.09.020

Patricija, B., & Tuljak-Suban, D. (2020). Most Frequently used Multi-Criteria Decision Making Models in Logistic Service Provider selection: *A Comparative Performance Analysis of a Real Case Study*. International Scientific Conference THE SCIENCE AND DEVELOPMENT OF TRANSPORT TRANSFORMATION OF TRANSPORTATION 29 th – 30 th September, ON-LINE CONFERENCE

Popescu, A., & Sipos, C. (2014). Logistics Performance and Economic Development-A Comparison within the European Union. Proceedings of "MAC-EMM".-Prague, Czech Republic, 1-9.

Rouse, P., & Putterill, M. (2003). An integral framework for performance measurement. *Management Decision*, 41(8), 791–805. https://doi.org/10.1108/00251740310496305

Sénquiz-Díaz, C. (2021a). Transport infrastructure quality and logistics performance in exports. Economics-Innovative and *Economic Research*, 9(1), 107-124. https://doi.org/10.2478/eoik-2021-0008

Sénquiz-Díaz,C.(2021b). Effect Size of Logistics: Evidence from Selected Countries. *LOGI – Scientific Journal on Transport and Logistics*,12(1) 123-134. https://doi.org/10.2478/logi-2021-0012

Sénquiz-Díaz,C.(2021c). The Effect of Transport and Logistics on Trade Facilitation and Trade: A PLS-SEM Approach. *ECONOMICS*,9(2) 11-24. https://doi.org/10.2478/eoik-2021-0021

Shepherd, B. (2013). Aid for Trade and value Chains in Transport and Logistics. WTO/OECD.

Stević, Ž., & Brković, N. (2020). A novel integrated FUCOM-MARCOS model for evaluation of human resources in a transport company. *Logistics,* 4(1), 4. https://doi.org/10.3390/logistics4010004

Stević Ž., Pamučar. D., Puška, A., & Chatterjee, P. (2020). Sustainable supplier selection in healthcare industries using a new MCDM method: Measurement of alternatives and ranking according to Compromise solution (MARCOS). *Computers & Industrial Engineering*, 140, 106231. https://doi.org/10.1016/j.cie.2019.106231

Ulutaş, A., & Karaköy, Ç. (2019). An analysis of the logistics performance index of EU countries with an integrated MCDM model 1. *Economics and Business Review*, 5(4), 49-69. https://doi.org/10.18559/ebr.2019.4.3

Yu, M. M., & Hsiao, B. (2016). Measuring the technology gap and logistics performance of individual countries by using a meta-DEA–AR model. *Maritime Policy & Management*, 43(1), 98-120. https://doi.org/10.1080/03088839.2015.1037372

Yildirim, B. F., & Adiguzel Mercangoz, B. (2020). Evaluating the logistics performance of OECD countries by using fuzzy AHP and ARAS-G. *Eurasian Economic Review*, 10(1), 27-45. https://doi.org/10.1007/s40822-019-00131-3

https://lpi.worldbank.org/sites/default/files/International_LPI_from_2007_to_2018.xlsx Accesed 25.02.2022.

https://lpi.worldbank.org/ Accesed 20.02.2022.