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Analysis of Sustainable Development Goals Within the Framework of Industry, Innovation, and Infrastructure in Serbia Based on the PIPRECIA-S and MARCOS Methods

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Summary: *Applying the concept of sustainable development goals (economic, social, and environmental dimensions) has a positive effect, in principle, on the overall performance of all entities. This study analyzes the dynamics of implementing sustainable development goals (SDGs) in the framework of industry, innovation, and infrastructure (Goal 9) in Serbia based on the PIPRECIA-S and MARCOS methods. The results of this study show the growing trend of applying the concept of sustainable development goals within the framework of industry, innovation, and infrastructure in Serbia. The effect of this is an improvement in overall performance.*

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INTRODUCTION

Recently, due to its exceptional importance, more and more attention has been paid to the concept of sustainable development goals. It consists of three dimensions: economic, social, and environmental (Alkan, 2024, Brodny & Magdalena Tutak, 2023; Burhan, 2024; Estrada et al., 2024; Osmani et al., 2020; Ricciolini et al., 2024; Raman et al., 2024; Stoenoiu, 2022). It is applied to all entities (national economy, region, sector, company, institution). The concept of sustainable development goals is also connected with the concept of circular economy (Lukić, 2024a, b, c). Applying this concept improves the overall performance of all entities (Šeremešić et al., 2024). In this study, starting from the overall importance of the application of the concept of sustainable development goals, the dynamics of the realization of sustainable development goals in the framework of industry, innovation, and infrastructure in Serbia are analyzed using the PIPRECIA-S and MARCOS methods. The aim of this is to, by using several relevant indicators - criteria whose significance is determined mathematically, realistically assess the trend of sustainable development goals within the framework of industry, innovation, and infrastructure in Serbia. This is the main research hypothesis in this study. There is a very rich literature devoted to the goals of sustainable development (Fernández-Portillo et al., 2024). This study serves as the basis for a more complete understanding of the complexity and significance of the issue of sustainable development goals and the direction of its further theoretical, methodological, and empirical research. Relevant empirical data for the research of the treated problem in this study were collected from Eurostat statistics. They are also available in the statistics of the World Bank. Many countries, which is also the case with Serbia, have their statistics of indicators of sustainable development goals. In our opinion, it should be harmonized with the statistics of indicators of sustainable development goals of Eurostat and the World Bank to improve the quality of international comparison, which unfortunately is not always the case.

METHODOLOGY

The research into the dynamics of the achievement of sustainable development goals in the framework of industry, innovation, and infrastructure in Serbia in this study was carried out using the PIPRECIA-S and MARCOS methods, the characteristics of which are shown below.

PIPRECIA-S Method

This method originates from the PIPRECIA (PIvot Pairwise RElative Criteria Importance Assessment) method (Stanujkić et al., 2017), which improves the computational aspects. Contrary to the PIPRECIA method, the comparison with the simple PIPRECIA-S method is made only about the first criterion, thereby facilitating the decision-making process.

Like the PIPRECIA method, the simple PIPRECIA-S method does not require prior sorting of criteria according to expected significance, which makes it suitable for application in the case of group decision-making. The Simple PIPRECIA-S method is used to define the weight of criteria and solve decision-making problems in different areas of business (Aytekin, 2022; Sulistiani et al., 2023; Mladenović et al., 2023; Setiawansyah et al., 2024). The calculation procedure of the PIPRECIA-S method takes place through the following steps (Stanujkić et al., 2021; Mirčetić et al., 2024):

Step 1: Defining a set of evaluation criteria.

Step 2: Calculation of the relative importance s_j of each criterion, except the first one, as follows:

$$s_j = \begin{cases} 1\ if\ c_j > c_1 \\ 1\ if\ c_j = 1 \\ 1\ if\ c_j < 1 \end{cases} \tag{1}$$

Where $j \neq 1$. Similar to the PIPRECIA method, the value s_j is equal to 1, while the values c_j belong to the interval (1, 1.9] when $c_1 > c_j$, and to the interval [0.1, 1) when $c_1 < c_j$.

Step 3: Determining the value of the coefficient k_j as follows:

$$k_j = \begin{cases} 1 & if\ j = 1 \\ 2 - s_j & if\ j > 1 \end{cases} \tag{2}$$

Step 4: Calculating the weight of the coefficient q_i again as follows:

$$q_j = \begin{cases} 1\ if\ j = 1 \\ \dfrac{1}{k_j}\ if\ j > 1 \end{cases} \tag{3}$$

Step 5: Defining the relative weight of the criteria as follows:

$$q_j = \frac{q_j}{\sum_{k=1}^{n} q_k} \tag{4}$$

Step 6: In the case of group decision-making, the total weight coefficient of each criterion is determined using the following equation:

$$GM_j = \left(\prod_{k=1}^{K} w_j^k\right)^{1/k} \tag{5}$$

$$w_j = GM_j \Big/ \sum_{l=1}^{n} GM_l \tag{6}$$

Where GM_j is the geometric mean of the weighting coefficients obtained by the decision-makers included in the evaluation of criterion j, w_j denotes the weighting coefficient of criterion j, and K is the number of decision-makers.

MARCOS Method

The MARCOS method is based on defining the relationship between alternatives and reference values (ideal and anti-ideal alternatives) (Đalić, 2020; Kovač, 2021; Miškić, 2021; Nedeljković, 2021; Puška, 2021; Stević, 2020a, b; Stanković, 2020; Trung, 2021). Based on the defined relationships, the utility functions of alternatives are determined and a compromise ranking is made about ideal and anti-ideal solutions. Decision preferences are then defined based on the utility function. Utility functions represent the position of the alternative about ideal and anti-ideal solutions. The best alternative is the one closest to the ideal and at the same time furthest from the anti-deal reference point. The MARCOS method proceeds through the following steps (Stević, 2020a, b; Lukić, 2022a, b, c, 2023a, b, c):

Step 1: Formation of the initial decision-making matrix. A multi-criteria model involves defining a set of *n* criteria and *m* alternatives. In the case of group decision-making, a group of *r experts* is formed who evaluate the alternatives concerning the criteria. In this case, the matrices of expert evaluation are aggregated into the initial matrices of group decision-making.

Step 2: Forming the expanded initial matrix. In this step, the expansion initial matrix is defined with ideal (AI) and anti-ideal (AAI) solutions.

$$X = \begin{array}{c} \\ AAI \\ A_1 \\ A_2 \\ \cdots \\ A_m \\ AI \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \cdots & C_n \end{array} \\ \begin{bmatrix} x_{aa1} & x_{aa2} & \cdots & x_{aan} \\ x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \\ x_{ai1} & x_{ai2} & \cdots & x_{ain} \end{bmatrix} \end{array} \tag{7}$$

The anti-ideal solution (AAI) is the worst alternative. The ideal solution (AI) is, on the contrary, the alternative with the best characteristics. Depending on the nature of the criteria, AAI and AI are defined using the following equations:

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

$$AI = \max_i x_{ij}\ if\ j \in B\ and\ \min_i x_{ij}\ if\ j \in C \tag{9}$$

Where B represents the benefit and C the cost group of criteria.

Step 3: Normalization of the expanded initial matrix (X). The elements of the normalized matrix $N = [n_{ij}]_{\mathrm{mxn}}$ were obtained by applying the following equations:

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

$$n_{ij} = \frac{x_{ij}}{x_{ai}}\ if\ j \in B \tag{11}$$

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

Step 4: Defining the weighting matrix $V = [v_{ij}]_{mxn}$. The weighting matrix V is obtained by multiplying the normalized matrix N with the weighting coefficients of the criteria w_j using the following equation:

$$v_{ij} = n_{ij} x v_j \tag{12}$$

Step 5: Determining the level of usefulness of alternatives K_i. The degree of usefulness of alternatives to anti-ideal and ideal solutions is determined using the following equations:

$$K_i^- = \frac{S_i}{S_{aai}} \tag{13}$$

$$K_i^+ = \frac{S_i}{S_{ai}} \tag{14}$$

Where S_i ($i = 1, 2, \dots, m$) represents the sum of the elements of the weight matrix V, shown in the following equation:

$$S_i = \sum_{i=1}^{n} v_{ij} \tag{15}$$

Step 6: Determining the utility function of alternatives $f(K_i)$. The utility function is the compromise of the observed alternative about ideal and anti-ideal solutions. The utility function of alternatives is defined with the following equation:

$$f(K_i) = \frac{K_i^+ + K_i^-}{1 + \frac{1 - f(K_i^+)}{f(K_i^+)} + \frac{1 - f(K_i^-)}{f(K_i^-)}} \tag{16}$$

Where $f(K_i^-)$ represents the utility function of the anti-ideal solution and $f(K_i^+)$ represents the utility function of the ideal solution.

Utility functions for ideal and anti-ideal solutions are determined using the following equations:

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

$$(K_i^+) = \frac{K_i^-}{K_i^+ + K_i^-} \tag{18}$$

Step 7: Ranking of alternatives. The ranking of alternatives is based on the final value of the utility function. The alternative that has the highest possible value of the utility function is preferred.

RESULTS AND DISCUSSION

Due to their importance, several indicators measure sustainable development goals. These are detailed in Eurostat and World Bank statistics. Eurostat identifies 17 sustainable development goals, including:

Goal 1 – No poverty
Goal 2 – Zero hunger
Goal 3 – Good health and well-being
Goal 4 – Quality education
Goal 5 – Gender equality
Goal 6 – Clean water and sanitation
Goal 7 – Affordable and clean energy
Goal 8 – Decent work and economic growth
Goal 9 – Industry, innovation and infrastructure
Goal 10 – Reduced inequalities
Goal 11 – Sustainable cities and communities
Goal 12 – Responsible consumption and production
Goal 13 – Climate action
Goal 14 – Life below water
Goal 15 – Life on land
Goal 16 – Peace, justice, and strong institutions
Goal 17 – Partnerships for the goals

So, for example, to analyze the goals of sustainable development in the framework of industry, innovation, and infrastructure (Goal 9- Industry, innovation, and infrastructure), the following indicators are presented in Eurostat statistics:

1. Gross domestic expenditure for research and development by sector.
2. Research and development personnel by sector.
3. Patent applications to the European Patent Office by applicants/inventors with residence.
4. Participation in buses and trains in internal passenger traffic.
5. Participation in railways and inland waterways in inland freight traffic.
6. Intensity of emissions into the air from industry.
7. Higher education by gender.
8. Gross added value in the sector of ecological goods and services.
9. High-speed Internet coverage, according to the type of area.

Each country has its indicators of sustainable development goals, adapted to the specifics.

These indicators in the case of applying multi-criteria decision-making methods are nothing but criteria. At the same time, they are performance factors (i.e. achievement of goals) of sustainable development. Effective control of them can influence the trend of sustainable development goals. The essence of Goal 9 - Industry, innovation, and infrastructure is reflected in the following: build resilient infrastructure, promote inclusive and sustainable industrialization, and encourage innovation. Statistics Eurostat has data for Serbia only for 7 out of 9 indicators. For some indicators within Goal 9 – Industry, innovation, and infrastructure, empirical data are not available for all years. Table 1 shows the goals of sustainable development in the framework of industry, innovation, and infrastructure (Goal 9) in the European Union (EU).

Table 1. Sustainable Development Goal (SDG) indicators.
Goal 9 – Industry, innovation and infrastructure, EU

Indicator	Period	Annual growth rate	Assessment
R&D and innovation			
Gross domestic expenditure on R&D	2007–2022	Observed: 1.5 % Required: 2.2 %	↗
	2017–2022	Observed: 0.8 % Required: 2.6 %	↘
Patent applications to the European Patent Office	2008–2023	0.9 %	↗
	2018–2023	0.7 %	↗
R&D personnel	2007–2022	2.9 %	↑
	2017–2022	3.3 %	↑
Tertiary educational attainment (*)	2008–2023	Observed: 2.5 % Required: 1.9 %	↑
	2018–2023	Observed: 2.2 % Required: 1.3 %	↑
Sustainable industry			
Air emissions intensity of industry	2008–2021	– 4.6 %	↑
	2016–2021	– 3.0 %	↑
Gross value added in environmental goods and services sector (*)	2006–2021	3.4 %	↑
	2016–2021	3.8 %	↑
Sustainable infrastructure			
Share of buses and trains in inland passenger transport	2006–2021	– 1.4 %	↓
	2016–2021	– 4.8 %	↓
Share of rail and inland waterways in inland freight transport	2007–2022	– 1.0 %	↘
	2017–2022	– 2.0 %	↓
Share of households with high-speed internet connection (*)	Time series too short for long-term assessment		:
	2017–2022	Observed: 20.2 % Required: 9.9 %	↑

Note: See Annex II for a description of the methodology used for the compound annual growth rate calculation and the trend assessment. For indicators without a target, the growth rates observed over the specified periods are given. For indicators with a quantified EU target (marked with a target sign), both the observed growth rates and the growth rates that would have been required in the specified periods for meeting the target are given. See Table A.1 in Annex I for the full list of EU policy targets considered for monitoring in this report.
(*) Multi-purpose indicator.

Symbol	With quantitative target	Without quantitative target
◎	Trends for indicators marked with this 'target' symbol are calculated against an official and quantified EU policy target. In this case the arrow symbols should be interpreted according to the left-hand column below. Trends for all other indicators should be interpreted according to the right-hand column below.	
↑	Significant progress towards the EU target	Significant progress towards SD objectives
↗	Moderate progress towards the EU target	Moderate progress towards SD objectives
→	[Category not applicable]	No progress towards nor movement away from SD objectives
↘	Insufficient progress towards the EU target	Moderate movement away from SD objectives
↓	Movement away from the EU target	Significant movement away from SD objectives
:	Calculation of trend not possible (for example, time series too short)	

Source: Eurostat

Table 2 shows the indicators of the goals of sustainable development, Goal 9 - industry, innovation, and infrastructure, in Serbia for the period 2016 - 2022. In this study, due to the nature of multi-criteria decision-making methods, they are marked as relevant criteria (C1, C2,. .., C7) for the analysis of the treated problem using PIPRECIA-S and MARCOS methods. The alternatives are the observed years: A1 - 2016, A2 - 2017, A3 - 2018, A4 - 2019, A5 - 2020, A6 - 2021 and A7 - 2022 (Table 2).

Table 2. Sustainable Development Goal indicators, Goal 9- Industry, innovation and infrastructure, Serbia, 2016 – 2022.

		A1	A2	A3	A4	A5	A6	A7
		2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
C1	Gross domestic expenditure on R & D by sector (Percentage of gross domestic product)	0.84	0.87	0.92	0.89	0.91	0.99	0.97
C2	R & D personnel by sector (Percentage of population in the labor force)	0.72	0.69	0.69	0.68	0.71	0.70	0.73
C3	Patent applications that the European Patent Office by applicants `/ inventors ` of residence (Number)	1	10	9	9	8	20	13
C4	Share of buses and trains in inland passenger transport (Percentage) (% of passenger-km)	13.8	13.4	14.9	13.6	10.5	11.2	13.5
C5	Air emission intensity from industry (Grams per euro, chain-linked volumes)	0.73	0.75	0.81	0.80	0.79	0.71	0.00
C6	Tertiary educational attainment by sex (Percentage)	0.00	32.3	32.8	33.4	32.6	33.9	33.4
C7	Gross value added in the environmental goods and services sector (Percentage of gross domestic product (GDP)	0.00	0.00	0.72	0.76	0.82	0.79	0.0

Source: Eurostat

The significance of the criteria was determined using the PIPRECIA-S method (Table 3). (All calculations and results in this study are the author's.)

Table 3. Weighting coefficients of criteria - PIPRECIA-S method

	sj	kj	what	wj
C1		1	1.00	0.12
C2	0.7	1.3	0.769231	0.09
C3	1.4	0.6	1.67	0.20
C4	1.2	0.8	1.25	0.15
C5	1.3	0.7	1.43	0.17
C6	1.3	0.7	1.43	0.17
C7	0.9	1.1	0.91	0.11
			8.45	1.00

The most important criterion in this particular case is C3 - Patent applications to the European Patent Office by applicants/inventors with residence. The goals of sustainable development in Serbia can therefore be achieved with an increase in the number of patents. In this direction, the other criteria should be treated appropriately.

In Table 4. the process steps and results of the MARCOS method are presented.

Table 4. Steps and results of the MARCOS method

Initial Matrix							
Weights of criteria	0.12	0.09	0.2	0.15	0.17	0.17	0.11
Kind of criteria	1	1	1	1	1	1	1
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**
A1	0.84	0.72	1	13.8	0.73	0	0
A2	0.87	0.69	10	13.4	0.75	32.3	0
A3	0.92	0.69	9	14.9	0.81	32.8	0.72
A4	0.89	0.68	9	13.6	0.8	33.4	0.76
A5	0.91	0.71	8	10.5	0.79	32.6	0.82
A6	0.99	0.7	20	11.2	0.71	33.9	0.79
A7	0.97	0.73	13	13.5	0	33.4	0
MAX	0.99	0.73	20	14.9	0.81	33.9	0.82
MIN	0.84	0.68	1	10.5	0	0	0
Extended Initial Matrix							
Weights of criteria	0.12	0.09	0.2	0.15	0.17	0.17	0.11
Kind of criteria	1	1	1	1	1	1	1
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**
AAA	0.84	0.68	1	10.5	0	0	0
A1	0.84	0.72	1	13.8	0.73	0	0
A2	0.87	0.69	10	13.4	0.75	32.3	0
A3	0.92	0.69	9	14.9	0.81	32.8	0.72
A4	0.89	0.68	9	13.6	0.8	33.4	0.76
A5	0.91	0.71	8	10.5	0.79	32.6	0.82
A6	0.99	0.7	20	11.2	0.71	33.9	0.79
A7	0.97	0.73	13	13.5	0	33.4	0
AI	0.99	0.73	20	14.9	0.81	33.9	0.82

Normalized Matrix							
Weights of criteria	0.12	0.09	0.2	0.15	0.17	0.17	0.11
Kind of criteria	1	1	1	1	1	1	1
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**
AAA	0.848485	0.931507	0.05	0.704698	0	0	0
A1	0.8485	0.9863	0.0500	0.9262	0.9012	0.0000	0.0000
A2	0.8788	0.9452	0.5000	0.8993	0.9259	0.9528	0.0000
A3	0.9293	0.9452	0.4500	1.0000	1.0000	0.9676	0.8780
A4	0.8990	0.9315	0.4500	0.9128	0.9877	0.9853	0.9268
A5	0.9192	0.9726	0.4000	0.7047	0.9753	0.9617	1.0000
A6	1.0000	0.9589	1.0000	0.7517	0.8765	1.0000	0.9634
A7	0.9798	1.0000	0.6500	0.9060	0.0000	0.9853	0.0000
AI	1	1	1	1	1	1	1

Weighted Normalized Matrix							
	C1	**C2**	**C3**	**C4**	**C5**	**C6**	**C7**
AAA	0.101818	0.083836	0.01	0.105705	0	0	0
A1	0.1018	0.0888	0.0100	0.1389	0.1532	0.0000	0.0000
A2	0.1055	0.0851	0.1000	0.1349	0.1574	0.1620	0.0000
A3	0.1115	0.0851	0.0900	0.1500	0.1700	0.1645	0.0966
A4	0.1079	0.0838	0.0900	0.1369	0.1679	0.1675	0.1020
A5	0.1103	0.0875	0.0800	0.1057	0.1658	0.1635	0.1100
A6	0.1200	0.0863	0.2000	0.1128	0.1490	0.1700	0.1060
A7	0.1176	0.0900	0.1300	0.1359	0.0000	0.1675	0.0000
AI	0.12	0.09	0.2	0.15	0.17	0.17	0.11

Results of the MARCOS Method								
	Si	**Ki-**	**Ki+**	**f(K-)**	**f(K+)**	**f(K)**		**Ranking**
AAA	0.3014							
A1	0.4927	1.6350	0.4878	0.2298	0.7702	0.4565	0.4565	**7**
A2	0.7448	2.4715	0.7374	0.2298	0.7702	0.6901	0.6901	**5**
A3	0.8677	2.8791	0.8591	0.2298	0.7702	0.8039	0.8039	**2**
A4	0.8560	2.8404	0.8475	0.2298	0.7702	0.7931	0.7931	**3**
A5	0.8228	2.7304	0.8147	0.2298	0.7702	0.7624	0.7624	**4**
A6	0.9440	3.1326	0.9347	0.2298	0.7702	0.8747	0.8747	**1**
A7	0.6410	2.1269	0.6346	0.2298	0.7702	0.5939	0.5939	**6**
AI	1.0100							

In Serbia, the most significant positive trend of sustainable development goals within industry, innovation, and infrastructure was recorded in 2021. Recently, a positive trend in sustainable development goals for industry, innovation, and infrastructure has generally been observed in Serbia. This trend is supported by several factors: employment in the processing industry is growing, the share of small industrial enterprises in the total added value of the processing industry is also growing, and CO2 emissions are decreasing according to various indicators. Total investments in research and development are increasing. The number of researchers per million inhabitants is also increasing. The share of the population covered by the mobile network is growing. The unsatisfactory trend of sustainable development goals in the framework of industry, innovation, and infrastructure in Serbia in 2022 is the result of not having all relevant empirical data available for all indicators. In the context of international comparison, this partially reflects the limitations of the results of this study. It is therefore necessary in Serbia, based on Eurostat and World Bank statistics, to improve the system of creating relevant empirical data for all indicators of sustainable development goals within the framework of industry, innovation, and infrastructure. The effects of this are the improvement of the quality of the international comparison of sustainable development goals, in the specific case of Goal 9 - Industry, innovation, and infrastructure, with other comparable countries. Taken as a whole, Serbia is still far from achieving the defined goals of sustainable development (Goal 9 – Industry, innovation, and infrastructure) in the European Union. In the future, we should strive for that.

Applying multi-criteria decision-making methods to analyze sustainable development goals provides realistic insights. The results of this study confirm their effectiveness, and thus these methods are recommended for the analysis of sustainable development goals.

CONCLUSION

The pursuit of sustainable development goals is highly challenging. The concept of sustainable development goals is applied at all organizational levels. The application of the concept of sustainable development goals has a positive impact on the development of the circular economy and the overall performance of all entities. Multi-criteria decision-making methods offer realistic answers to questions such as: What is the situation regarding the goals of sustainable development, specifically Goal 9 - Industry, innovation, and infrastructure? This is also indicated by the results of this study. Therefore, they are recommended in the analysis of sustainable development goals.

In recent years in Serbia, a positive trend in sustainable development goals within industry, innovation, and infrastructure has been observed, though this progress is still far from the achievements in the European Union. We need to work intensively to optimally achieve the goals of sustainable development in Serbia within the framework of industry, innovation, and infrastructure. The effects of this are the improvement of the overall performance of the Serbian economy.

References

1) Alkan, N. (2024). Evaluation of sustainable development and utilization-oriented renewable energy systems based on the CRITIC-SWARA-CODAS method using interval-valued picture fuzzy sets. *Sustainable Energy, Grids and Networks*, *38,* 101263. https://doi.org/10.1016/j.segan.2023.101263.
2) Aytekin, A. (2022). Determining criteria weights for vehicle tracking system selection using PIPRECIA-S. *Journal of process management and new technologies*, *10*(1-2), 115-124. https://doi.org/10.5937/jpmnt10-38145
3) Brodny, J., & Tutak, M.(2023). Assessing regional implementation of Sustainable Development Goal 9 "Build resilient infrastructure, promote sustainable industrialization and foster innovation" in Poland. Technological Forecasting and Social Change, 195, https://doi.org/10.1016/j.techfore.2023.122773.
4) Burhan, H. A. (2024). Sustainability in Industry, Innovation, and Infrastructure: A MCDM Based Performance Evaluation of European Union and Türkiye for Sustainable Development Goal 9 (SDG 9). *Verimlilik Dergisi,* 21-38. https://doi.org/10.51551/verimlilik.1333767
5) Đalić, I., Stević, Ž., Erceg, Ž., Macura, P., & Terzić, S. (2020). Selection of a distribution channel using the integrated FUCOM-MARCOS model. *International Review*, 3-4, 80-96. https://doi.org/10.5937/intrev2003080Q
6) Estrada, L.M., Haase, M., Baumann, M., & Müller, T. (2024). Multicriteria Decision Analysis for Sustainability Assessment for Emerging Batteries. In: Passerini, S., Barelli, L., Baumann, M., Peters, J., Weil, M. (eds) Emerging Battery Technologies to Boost the Clean Energy Transition. The Materials Research Society Series. Springer, Cham. https://doi.org/10.1007/978-3-031-48359-2_18
7) Fernández-Portillo, L.A., Demir, G., Sianes, A. et al. (2024). Setting a shared development agenda: prioritizing the sustainable development goals in the Dominican Republic with fuzzy-LMAW. *Sci Rep, 14,* 12146. https://doi.org/10.1038/s41598-024-62790-w
8) Kovač, M., Tadić, S., Krstić, M., and Bouarima, M.B. (2021). Novel Spherical Fuzzy MARCOS Method for Assessment of Drone-Based City Logistics Concepts. WILEY Hindawi Complexity Volume 2021, Article ID 2374955, 17 pages. https://doi.org/10.1155/2021/2374955
9) Lukic, R. (2022b). Application of the MARCOS Method in Analysis of the Positioning of Electronic Trade of the European Union and Serbia. *Informatica Economică*, 26(3), 50-63. DOI: 10.24818/issn14531305/26.3.2022.05
10) Lukic, R. (2023c). Merenje i analiza dinamike profitabilnosti bankarskog sektora u Srbiji na bazi FLMAW-MARCOS metoda. Measurement and Analysis of Profitability Dynamics of the Banking Sector in Serbia Based on the FLMAW-MARCOS Method. *Banking – Bankarstvo*, *4*, 8-47. DOI: 10.5937/bankarstvo2301028L
11) Lukic, R.(2022a). Application of MARCOS method in the evaluation of efficiency of trade companies in Serbia. *Ekonomski pogledi – Economic Outlook*, *24*(1). 1-14. DOI: 10.5937/ep24-38921
12) Lukić, R. (2022c). Analysis of financial performance and efficiency of banks in Serbia using fuzzy LMAW and MARCOS methods. *Bankarstvo – Banking*, *4*, 130-169. DOI: 10.5937/bankarstvo2204130L
13) Lukić, R. (2023a). Measurement and Analysis of The Information Performance of Companies in The European Union and Serbia Based on The Fuzzy LMAW and MARCOS Methods. *Informatica Economică, 27*(1), 17 – 31. DOI: 10.24818/issn14531305/27.1.2023.02
14) Lukić, R. (2023b). Comparative analysis of transport and storage information systems of the European Union and Serbia using fuzzy LMAW and MARCOS methods. *Economy, Business & Development, 4*(1). 1-17. DOI: 10.47063/ebd.00011
15) Lukić, R. (2024a). Analysis of the circular economy of Serbia based on the COBRA method. *Journal of Economics, 9*(1),10-20. DOI: https://doi.org/10.46763/JOE2491010l

16) Lukić, R. (2024b Analysis of emission of greenhouse gases by economic activities and by pollutants of the European Union based on the RAM method. XIV International Symposium Engineering Management and Competitiveness 2024 (EMC 2024) 21-22nd June, Zrenjanin, Serbia, 208-213.

17) Lukić, R. (2024c). Analysis of the Circular Economy Performance of the European Union and Serbia. *Review of International Comparative Management*, *25*(3),525-540. DOI: 10.24818/RMCI.2024.3.525

18) Mirčetić, V., Popović, G., and Vukotić, S. (2024). Unveiling the characteristics of the EU charismatic leaders using the PIPRECIA-S method. *Journal of process management and new technologies*, *12*(1-2), 99-109. doi: 10.5937/jpmnt12-51159

19) Miškić S, Stević, Ž, and Tanackov, I. (2021). A novel integrated SWARA-MARCOS model for inventory classification. *IJIEPR*., *32* (4), 1-17. URL: http://ijiepr.iust.ac.ir/article-1-1243-en.html

20) Mladenović, M., Đukić, T., & Popović, G. (2023). Analysis of financial reporting platforms based on the PIPRECIA-S Method. *Journal of process management and new technologies*, *11*(3- 4), 95-104. https://doi.org/10.5937/jpmnt11-48186

21) Nedeljković, M, Puška, A, Doljanica, S, Virijević Jovanović, S, Brzaković, P, Stević, Ž, et al. (2021). Evaluation of rapeseed varieties using novel integrated fuzzy PIPRECIA – Fuzzy MABAC model. *PLoS ONE*, *16*(2): e0246857. https://doi.org/10.1371/journal.pone.0246857

22) Osmani, F., Kochov, A., Shabani, B., and Ilazi, M. (2020). The Importance of SD Goals Indicators 7, 8, 9, and 12 in the Industry Development by Using Multi Criteria and Decision Making Method. *Tehnički glasnik, 14* (4), 524-530. https://doi.org/10.31803/tg-20200917084550

23) Puška, A., Stević, Ž., and Stojanović, I (2021). Selection of Sustainable Suppliers Using the Fuzzy MARCOS Method. *Current Chinese Science*, *1*(2), 218-229. https://dx.doi.org/10.2174/2210298101999201109214028

24) Raman, R., Lathabai, H. & Nedungadi, P. (2024). Sustainable Development Goal 12 and its synergies with other SDGs: identification of key research contributions and policy insights. *Discov Sustain, 5,* 150. https://doi.org/10.1007/s43621-024-00289-0

25) Ricciolini, E., Tiralti, A., Paolotti, L., Rocchi, L., & Boggia, A. (2024). Sustainable development according to 2030 agenda in European Union countries: Evidence of the enlargement policy. *Sustainable Development, 32*(3), 1894–1912. https://doi.org/10.1002/sd.2758

26) Setiawansyah, S., Sintaro, S., Saputra, V. H., & Aldino, A. A. (2024). Combination of Grey Relational Analysis (GRA) and Simplified Pivot Pairwise Relative Criteria Importance Assessment (PIPRECIA-S) in Determining the Best Staff. *Bulletin of Informatics and Data Science*, *2*(2), 57-66.

27) Stanković,M., Stević,Ž., Das, D.K., Subotić, M., and Pamučar, D. (2020). New Fazzy MARCOS Method for Road Traffic Risk Analysis. *Mathematics*, MDPI,8, 457, 181-198.

28) Stanujkić, D., Karabašević, D., Popović, G., & Sava, C. (2021). Simplified pivot pairwise relative criteria importance assessment (PIPRECIA-S) method. *Romanian Journal of Economic Forecasting*, *24*(4), 141.

29) Stanujkić, D., Zavadskas, E. K., Karabašević, D., Smarandache, F., & Turskis, Z. (2017). The use of the pivot pairwise relative criteria importance assessment method for determining the weights of criteria. *Romanian Journal of Economic Forecasting*, *20*(4), 116-133.

30) Stević, Ž., Pamučar, D., Puška, A., and Chatterjee, P. (2020a). 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.

31) Stević, Ž., and Brković, N. A. (2020). Novel Integrated FUCOM-MARCOS Model for Evaluation of Human Resources in a Transport Company. *Logistics*, *4,* 4. https://doi.org/10.3390/logistics4010004

32) Stoenoiu, C.E. (2022). Sustainable Development—A Path to a Better Future. *Sustainability, 14, 9192. https://doi.org/10.3390/su14159192*

33) Sulistiani, H., Palupiningsih, P., Hamidy, F., Sari, P. L., & Khairunnisa, Y. (2023, November). Employee Performance Evaluation Using Multi-Attribute Utility Theory (MAUT) with PIPRECIA-S Weighting: A Case Study in Education Institution. In 2023 International Conference on Informatics, Multimedia, Cyber and Informations System (ICIMCIS) (pp. 369-373). IEEE. https://doi.org/10.1109/ICIMCIS60089.2023.10349017

34) Šeremešić, S., Dolijanović, Ž., Tomaš Simin, M., Milašinović Šeremešić, M., Vojnov, B., Brankov, T., & Rajković, M. (2024). Articulating Organic Agriculture and Sustainable Development Goals: Serbia Case Study. *Sustainability*, *16*(5),1842. https://doi.org/10.3390/su16051842

35) Trung, Do Duc. (2021). Application of EDAS, MARCOS, TOPSIS, MOORA, and PIV Methods for Multi-Criteria Decision Making in Milling Process. *Strojnícky časopis - Journal of Mechanical Engineering*, 71(2), 69-84. https://doi.org/10.2478/scjme-2021-0019

Analiza ciljeva održivog razvoja u okviru industrije, inovacija i infrastrukture u Srbiji na bazi PIPRECIA-S i MARCOS metoda

Rezime: Primena koncepta ciljeva održivog razvoja (ekonomska, socijalna i okruženska dimenzija) pozitivno se u načelu odražava na ukupne performanse svih entiteta. U ovoj studiji analizira se dinamika primene koncepta ciljeva održivog razvoja (SDGs) u okviru industrije, inovacija i infrastrukture (Cilj 9) u Srbiji na bazi PIPRECIA-S i MARCOS metoda. Rezultati ove studije pokazuju rastući trend primene koncepta ciljeva održivog razvoja u okviru industrije, inovacija i infrastrukture u Srbiji. Efekat toga je poboljšanje ukupnih performansi.

Ključne reči: Sustainable Development Goals (SDG 9), Srbija, PIPRECIA-S, MARCOS