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EVALUATION OF THE PERFORMANCE OF EUROPEAN HEALTHCARE SYSTEMS THROUGH CRITERIA OPTIMISATION

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Abstract:
This study highlights the importance of using multi-criteria optimisation methods in the performance analysis of European health systems. The complementary use of SAW, TOPSIS, VIKOR and PROMETHEE II methods has enabled an assessment of the European healthcare system based on health indicators (life expectancy at birth, public expenditure on health (% of GDP), number of doctors per 1,000 inhabitants, preventable and treatable mortality rate, Euro Health Consumer Index (EHCI), number of beds per 1,000 inhabitants and infant mortality rate (per 1,000 births). The results of the study show that while Western European countries perform exceptionally well, Eastern European and Balkan countries perform less well, reflecting the need for public policies aimed at reducing inequalities and improving access to healthcare. According to the study, multi-criteria approaches are optimisation tools for the comprehensive assessment of health system performance. The combination of the methods analysed reinforces the conclusions and provides an understanding of the current state of public health in Europe.

Keywords: Multi-criteria optimisation methods, SAW, TOPSIS, VIKOR, PROMETHEE II

JEL classification: C61, I18

1. INTRODUCTION

In the current context, health systems are an essential pillar of sustainable development and social cohesion within the European Union. Public health policies are under constant pressure, generated by demographic developments as well as economic and epidemiological challenges. However, the performance of health systems varies considerably between EU Member States, which calls for rigorous comparative analysis based on an objective and balanced framework. Due to budgetary constraints, demographic pressures and increasingly complex health needs, decision-making in the health sector requires analytical tools capable of integrating multiple criteria simultaneously – economic, social and clinical.

The evaluation of health systems is a constant concern in the field of public policy, being closely linked to the objectives of efficiency, equity and sustainability. Various international bodies, such as the World Health Organisation (WHO), the European Commission and the OECD, have proposed analytical frameworks for measuring health performance, but convergence on a single evaluation model remains difficult due to the multiple dimensions involved: clinical outcomes, accessibility, quality, costs and patient satisfaction. Therefore, we believe that multi-criteria optimisation provides an appropriate methodological framework for evaluating and selecting decision options and allows alternatives to be compared based on several indicators defined by decision-makers. The use of optimisation techniques, SAW, TOPSIS, VIKOR and PROMETHEE II, makes the decision-making process more transparent, reproducible and scientifically sound, contributing to the identification of optimal solutions and the improvement of health policies.

2. LITERATURE REVIEW

Decision-making in this area is complex, and using a single indicator, such as life expectancy at birth, cannot provide a complete picture of the quality and efficiency of healthcare services. As mentioned above, healthcare systems are influenced by a variety of factors: public investment,

accessibility of services, available human resources, treatment efficiency, and concrete results in terms of population health. To overcome the limitations of a one-dimensional assessment, the literature frequently resorts to multi-criteria analysis methods, MCDA – Multi-Criteria Decision Analysis) (Chakraborty et al., 2023; Pereira et al., 2020). These allow alternatives to be compared according to a set of heterogeneous criteria and provide a formal framework for aggregating decision-makers' preferences (Belton & Stewart, 2012). In the field of health, MCDA has been applied to resource allocation, medical technology prioritisation, and the evaluation of the performance of hospitals or national health systems (Baltussen et al., 2019; Thokala et al., 2016; Sevim & Aldogan, 2024).

Multi-criteria methods enable transparent, robust and replicable decisions to be made, supporting decision-makers in identifying the best possible alternatives. In this context, multi-criteria optimisation becomes a valuable tool for classifying decision alternatives and supporting evidence-based public policies.

Among the most widely used methods are SAW - Simple Additive Weighting (Taherdoost, 2023; Ibrahim & Surya, 2019; Ichsan & Prasetya, 2021), TOPSIS - Technique for Order Preference by Similarity to Ideal Solution (Hwang & Yoon, 1981), VIKOR - Technique for Order Preference by Similarity to Ideal Solution (Opricovic & Tzeng, 2004) and PROMETHEE - Preference Ranking Organisation Method for Enrichment Evaluationb (Brans, & Vincke, 1985), each having advantages and limitations depending on the nature of the problem analysed. For example, TOPSIS evaluates alternatives in relation to an ideal and an anti-ideal solution, while PROMETHEE uses preference functions to estimate net dominance flows.

The objective of this study is to apply and compare several multi-criteria optimisation methods, such as SAW, TOPSIS, VIKOR and PROMETHEE II, listed above, to evaluate the performance of health systems in European Union member states, as well as in other important European countries. The analysis is based on a set of seven relevant macroeconomic indicators, selected according to data accessibility and comparability. The study aims to highlight not only the rankings obtained, but also the methodological differences between the techniques used, thus providing insight into the usefulness of multi-criteria optimisation in complex decision-making.

3. METHODS

The study aims to compare the performance of health systems in European Union member states by applying several multi-criteria decision analysis (MCDA) methods. The goal is to identify differences in country rankings based on the method used and to highlight the robustness of the results.

Seven relevant indicators were selected for performance evaluation, based on data availability and relevance in the literature. These are:

1. Life expectancy at birth
2. Public expenditure on health (% of GDP)
3. Number of doctors per 1,000 inhabitants
4. Preventable and treatable mortality rate
5. Euro Health Consumer Index (EHCI)
6. Number of beds per 1,000 inhabitants
7. Infant mortality rate (per 1,000 births)

The indicators *Preventable and treatable mortality* and *Infant mortality rate* are considered minimisation criteria, as lower values signify better performance, while the rest are maximisation criteria.

The data were collected from official and comparable European sources, such as Eurostat, OECD Health Statistics, the World Bank and the EHCI report.

The methodological steps common to the optimisation methods used included:

- Building the decision matrix, in which the rows correspond to countries and the columns to indicators.
- Normalising the data to bring the indicators to a comparable scale. Data normalization was performed according to the requirements of each multicriteria decision-making method. For SAW and PROMETHEE II, a linear min–max normalization was applied, distinguishing between benefit and cost criteria. For TOPSIS, vector normalization was employed, while for the VIKOR method, normalization was based on the distance from the ideal and anti-ideal values for each criterion.
- Applying weights according to the perceived relevance of each indicator. Weights can be equal or set by experts.

3.1.SAW – SIMPLE ADDITIVE WEIGHTING

SAW is one of the most intuitive methods. All values are normalised (to make them comparable), weights are applied, and the weighted sum of each criterion for each alternative is calculated using the equation (Aryafar & Roshanravan, 2021):

$$S_i = \sum_{j=1}^{n} w_j * r_{ij} \quad (1)$$

where:

- S_i is the score of the alternatives/ratings (countries),
- w_j is the weight of the criterion,
- r_{ij} is the normalised value of the alternative.

Authors Mardani, Jusoh, Nor, Khalifah, Zakwan and Valipour (Mardani et al, 2015) present applications of multi-criteria methods in health and education. The SAW method is used in health systems to evaluate and select optimal treatments, medical technologies and intervention strategies. Several criteria are considered simultaneously (effectiveness, patient safety, operational/care costs and patient satisfaction). The method is used in other areas of decision-making by comparing different complex options.

3.2. TOPSIS – TECHNIQUE FOR ORDER PREFERENCE BY SIMILARITY TO IDEAL SOLUTION

The TOPSIS method is a better alternative the closer it is to the ideal solution (the best on all criteria) and the further away from the anti-ideal solution (the worst on all criteria). The steps to be followed in this technique are (Madanchian & Taherdoost, 2023):

- normalisation of the decision matrix;
- applying weights;
- calculation of distances from the ideal vector D^+ and the anti-ideal vector D^- ;
- calculation of the proximity score:

$$C_i^* = \frac{D_i^-}{D_i^+ + D_i^-} \quad (2)$$

The paper (Behzadian et al., 2012) presents the use of the TOPSIS method in healthcare systems. This method supports complex decision-making based on multiple criteria, treatment effectiveness, costs, healthcare safety and patient quality of life. Therefore, we can conclude that the method identifies options for an optimal balance between performance and resources by comparing

ideal and anti-ideal solutions. Thus, the method contributes to greater transparency and efficiency in the healthcare decision-making process.

3.3.VIKOR – VLSEKRITERIJUMSKA OPTIMIZACIJA I KOMPROMISNO RESENJE

VIKOR seeks a compromise between overall satisfaction and individual regret for the weakest criterion. It is appropriate when the decision-maker wants a compromise solution between the performances of different criteria. The steps involved in this method are briefly as follows (Taherdoost & Madanchian, 2023):

- The ideal and anti-ideal values for each criterion are determined;
- Calculate:
  - S_i : the aggregate distance from the ideal,
  - R_i : the weakest criterion (maximum regret).
- Calculate the VIKOR index:

$$Q_i = v * \frac{S_i - S^*}{S^- - S^*} + (1 - v) * \frac{R_i - R^*}{R^- - R^*} \quad (3)$$

where: v is a balance coefficient (usually 0.5).

Like other methods, the VIKOR method is used for decision-making in the healthcare system, but by identifying compromise solutions. This allows decision-makers to select the option that offers the optimal balance between clinical performance. The method is used to evaluate medical technologies, select equipment, set priorities for interventions, and optimise resource allocation. We believe that the method contributes to establishing the basis for evidence-based decision-making and improving the efficiency of healthcare systems.

3.4.PROMETHEE II – PREFERENCE RANKING ORGANISATION METHOD FOR ENRICHMENT EVALUATIONS

The PROMETHEE II method compares all alternatives in pairs, using preference functions for each criterion. It determines "net preference flows" between alternatives. The steps of this method are (Brans & Mareschal, 2005):

- Preference functions (linear, stepwise, etc.) are defined for each criterion;
- The preference of alternatives A over B is calculated for each pair;
- Aggregate all preferences to obtain:
  - the output flow (how much an alternative dominates);
  - the input flow (how much it is dominated);
  - the net flow: $\phi = \phi^+ - \phi^-$

This technique allows for a complete hierarchical classification of options, treatments, medical devices, health institutions, and intervention strategies, based on the priorities of decision-makers and preference functions for each criterion. By analysing both negative and positive flows, this method promotes a balanced understanding of the performance of each option ( ) (Soldati et al., 2022), allowing the selection of options that represent an optimal compromise between clinical effectiveness, costs and quality of health services.

4. RESULTS

Based on the four multi-criteria methods (SAW, TOPSIS, VIKOR and PROMETHEE II), we obtained rankings for 39 European countries (the vast majority from the EU), using the seven health indicators (life expectancy at birth, public health expenditure (% of GDP), number of doctors per

1,000 inhabitants, preventable and treatable mortality rate, Euro Health Consumer Index (EHCI), number of beds per 1,000 inhabitants and infant mortality rate (per 1,000 births) and healthcare system performance. Each method generates an individual ranking, and by calculating the average positions, a final aggregate ranking was obtained that balances the methodological differences.

Table No. 1. Ranking obtained using the four optimisation methods

	Country	SAW	TOPSIS	VIKOR	PROMETHEE II	AVG	RANK
1	**Albania**	37	38	38	38	37.75	38
2	**Austria**	1	1	1	1	1	1
3	**Belgium**	8	7	6	8	7.25	8
4	**Bulgaria**	30	26	27	23	26.5	28
5	**Croatia**	26	24	22	26	24.5	24
6	**Cyprus**	21	23	28	21	23.25	23
7	**Czech Republic**	12	3	4	7	6.5	6
8	**Denmark**	13	16	21	15	16.25	17
9	**Estonia**	22	21	16	24	20.75	20
10	**Finland**	10	12	19	12	13.25	12
11	**France**	5	4	5	3	4.25	3
12	**Germany**	3	2	2	2	2.25	2
13	**Greece**	15	6	13	10	11	9
14	**Hungary**	31	28	32	31	30.5	31
15	**Iceland**	9	10	17	11	11.75	10
16	**Ireland**	20	22	24	22	22	22
17	**Italy**	11	11	14	13	12.25	11
18	**Latvia**	32	31	31	33	31.75	32
19	**Lithuania**	23	18	25	20	21.5	21
20	**Luxembourg**	17	17	12	18	16	16
21	**Malta**	19	20	10	19	17	19
22	**Moldova**	39	39	39	39	39	39
23	**Montenegro**	25	29	30	30	28.5	30
24	**Netherlands**	16	19	15	17	16.75	18
25	**North Macedonia**	33	34	33	35	33.75	34
26	**Norway**	4	9	7	5	6.25	5
27	**Poland**	29	25	29	28	27.75	29
28	**Portugal**	7	5	8	6	6.5	6
29	**Romania**	35	35	34	34	34.5	35
30	**Russia**	34	33	35	32	33.5	33
31	**Serbia**	28	30	18	27	25.75	27
32	**Slovakia**	27	32	11	29	24.75	25
33	**Slovenia**	18	13	9	16	14	14
34	**Spain**	14	14	20	14	15.5	15
35	**Sweden**	6	15	23	9	13.25	12
36	**Switzerland**	2	8	3	4	4.25	3
37	**Turkey**	38	37	37	37	37.25	37
38	**Ukraine**	36	36	36	36	36	36
39	**United Kingdom**	24	27	26	25	25.5	26

Source: Authors Computation with Excel based on data from Eurostat, OECD Health Statistics, World Bank and EHCI report

The top positions are dominated by countries such as Austria, Germany, France and Switzerland, which rank highly in all methods and have remarkable health indicators (high life expectancy, low mortality, efficient spending). Lower positions are occupied by countries such as Albania, Moldova and Turkey, reflecting the significant challenges in their health systems.

In general, the methods show a strong consensus on the extreme positions (first and last places), while for countries in the middle range there are greater variations between methods.

All methods tend to produce similar rankings, with Spearman correlations between 0.865 and 0.98 (Table 2), indicating a high degree of consistency. Some differences are observed in certain methods, which may highlight subtleties in performance on specific criteria. For example, the Czech Republic ranks much higher in TOPSIS and VIKOR (3, 4) than in SAW (12), suggesting that methods that take into account distances from the ideal solution recognise its more balanced performance. Romania ranks similarly in all methods (between 34-35), indicating a stable situation but with limited potential compared to other countries.

Tabel No 2. Correlations

			SAW	TOPSIS	VIKOR	PROMETHEE II
Spearman's rho	SAW	Correlation Coefficient	1.000	.950**	.865**	.980**
		Sig. (2-tailed)	.	.000	.000	.000
		N	39	39	39	39
	TOPSIS	Correlation Coefficient	.950**	1.000	.877**	.980**
		Sig. (2-tailed)	.000	.	.000	.000
		N	39	39	39	39
	VIKOR	Correlation Coefficient	.865**	.877**	1.000	.883**
		Sig. (2-tailed)	.000	.000	.	.000
		N	39	39	39	39
	PROMETHEE II	Correlation Coefficient	.980**	.980**	.883**	1.000
		Sig. (2-tailed)	.000	.000	.000	.
		N	39	39	39	39

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Authors Computation with the aid of IBM SPSS Statistics, version 26

Looking closely at the results, we see a clear difference between regions. Western European countries like Austria, Germany, and France are consistently at the top, showing off their big investments in healthcare infrastructure, well-trained medical staff, and better health indicators. On the other hand, countries in Eastern Europe and the Balkan region, such as Albania, Moldova and Bulgaria, are at the bottom of the ranking, indicating persistent challenges related to access to quality healthcare services and more difficult socio-economic conditions.

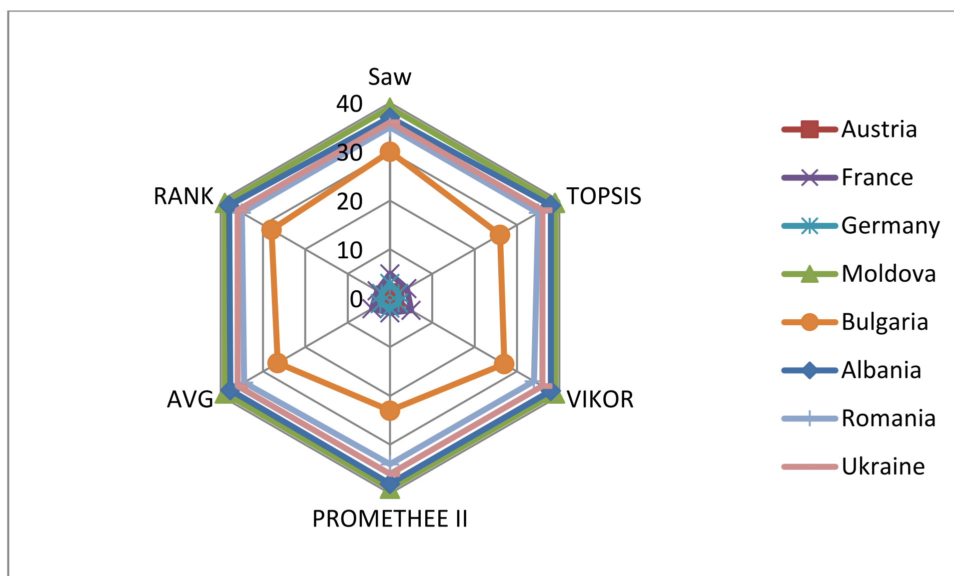

Figure No 1. Comparison between top and Romania (+neighbours)

As illustrated in Figure 1, Romania occupies a consistently low position across all multicriteria methods, with close rankings obtained through SAW, TOPSIS, VIKOR and PROMETHEE II. The limited surface of Romania's radar profile reflects relatively weak performance on several key healthcare indicators, particularly preventable and treatable mortality, infant mortality rate, and healthcare resource availability. These results indicate structural deficiencies in the healthcare system, including limited access to medical services and lower efficiency compared to Western European countries. However, the relative stability of Romania's position across all methods suggests a robust classification rather than a method-dependent outcome.

These differences are supported by the selected indicators, in particular infant mortality and preventable mortality, which have a significant impact on the final ranking. Also, the low number of doctors and hospital beds relative to the population in these countries contributes to a lower performance of the health system. In this context, the aggregate ranking obtained by averaging the positions in the applied methods provides a balanced and comprehensive picture, avoiding the assessment being distorted by the limitations or particularities of a single method.

The results obtained have important practical value, as they can serve as a tool for policy makers and European institutions interested in improving health systems. The multi-criteria ranking highlights areas of strong performance and, at the same time, weaknesses that require additional interventions and resources. This allows for the efficient prioritisation of fund allocation and the implementation of policies tailored to the specificities of each country.

However, it is essential to recognise some limitations of the analysis. The quality and timeliness of the data used directly influence the results, and some criteria may have a subjective weighting depending on the decision-making context. Furthermore, methodological diversity can lead to slight variations in rankings, which highlights the importance of combining several methods to obtain a robust and balanced assessment. Despite these issues, the use of multi-criteria methods remains the most appropriate approach for the complex assessment of health system performance, providing an integrated and transparent perspective that goes beyond single-indicator analysis.

5. CONCLUSIONS

This study has demonstrated the importance of applying multi-criteria methods in the evaluation and selection of health systems in Europe, given the complexity and diversity of indicators relevant to their performance. The simultaneous use of the SAW, TOPSIS, VIKOR and PROMETHEE II methodologies allowed for a comprehensive, balanced and transparent analysis, which highlighted both the convergences and differences in the ranking of countries.

The results indicate superior performance by Western European countries, reflecting consistent investment and developed infrastructure in the health sector, while Eastern European and Balkan countries were ranked lower, highlighting the need for public policies aimed at reducing disparities and improving access to quality healthcare services.

The multi-criteria approach proved essential for a more nuanced and objective understanding of performance, avoiding the limitations of assessment using a single indicator, such as life expectancy. At the same time, combining several methods ensured the robustness of the conclusions, providing a holistic picture of the situation.

The limitations of the study mainly relate to the quality and timeliness of the available data, as well as the possible subjectivity in defining and weighting the criteria. These issues can be addressed in future research by expanding the database and refining multi-criteria models.

In conclusion, multi-criteria optimisation is a valuable and practical tool for supporting complex decisions in the field of public health, contributing to the development of balanced and effective policies at national and European level.

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