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An Analysis of the Health Performance of G7 Countries: An Application Using the LPI-HI-Based DNMA Method

G7 Ülkelerinin Sağlık Performanslarının Analizi: LPI-HI Tabanlı DNMA Yöntemi ile Bir Uygulama

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Abstract

Aim: The purpose of this study is to analyze the health performance of G7 countries. **Materials and Methods:** In the study, the health performances of G7 countries were measured using the most recent and up-to-date 2023 Legatum Prosperity Index-Health Indicator (LPI-HI) data and the LPI-HI-based DNMA multi-criteria decision-making method (MCDM). **Results:** The health performance rankings of the countries, based on the LPI-HI-based DNMA method, have been identified as France, UK, Canada, Italy, USA, Germany, and Japan. It was also observed that only France and the UK have health performances exceeding the average performance value. Additionally, according to the sensitivity analysis of the LPI-HI-based DNMA MCDM method, it was found to be sensitive; according to the comparative analysis, it was credible and reliable; and according to the simulation analysis, it was robust and stable. **Conclusion:** It is believed that Canada, Italy, the USA, Germany, and Japan, which have health performances below the average value, need to improve their health performance to contribute more significantly to the global economy. Methodologically, the sensitivity, comparative, and simulation analysis results indicate that the health performances of G7 countries can be measured using the 2023 LPI-HI criteria with the LPI-HI-based DNMA method.

Öz

Amaç: Bu çalışmanın amacı, G7 ülkelerinin sağlık performansını analiz etmektir. **Gereç ve Yöntem:** Bu çalışmada, G7 ülkelerinin sağlık performansları, söz konusu ülkelerin en güncel 2023 Legatum Refah Endeksi-Sağlık Göstergesi (LPI-HI) verileri ile LPI-HI tabanlı DNMA çok kriterli karar verme (ÇKKV) yöntemi kullanılarak ölçülmüştür. **Bulgular:** LPI-HI tabanlı DNMA yöntemine göre belirlenen ülkelerin sağlık performansı sıralamaları Fransa, Birleşik Krallık, Kanada, İtalya, ABD, Almanya ve Japonya olarak tespit edilmiştir. Ayrıca, yalnızca Fransa ve Birleşik Krallık'ın ortalama performans değerini aşan sağlık performanslarına sahip olduğu gözlemlenmiştir. LPI-HI tabanlı DNMA MCDM yönteminin duyarlılık analizine göre duyarlı olduğu, karşılaştırmalı analizine göre güvenilir olduğu, simülasyon analizine göre ise sağlam ve istikrarlı olduğu tespit edilmiştir. **Sonuç:** Kanada, İtalya, ABD, Almanya ve Japonya'nın ortalama değerin altında kalan sağlık performanslarına sahip oldukları ve bu ülkelerin sağlık performanslarını iyileştirerek küresel ekonomiye daha önemli katkılarda bulunmaları gerektiği düşünülmektedir. Metodolojik olarak, duyarlılık, karşılaştırmalı ve simülasyon analizi sonuçları, G7 ülkelerinin sağlık performanslarının 2023 LPI-HI kriterleri kullanılarak LPI-HI tabanlı DNMA yöntemi ile ölçülebileceğini göstermektedir.

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INTRODUCTION

Health performance is an indicator that measures a country's overall health status and the effectiveness of its healthcare system (1). Having a healthy population contributes to national productivity, economic growth, and social stability (2). Therefore, countries aim to achieve a healthier and more prosperous society by implementing various policies and programs to improve their health performance (3). It is crucial for countries to strive to measure and enhance the performance of their healthcare systems (4). This is because measuring health performance determines the awareness of health issues within countries, identifies areas of progress, and highlights areas that need improvement (5). Consequently, measuring health performance helps countries allocate resources appropriately and improve the quality of healthcare services (6).

The efforts of G7 countries, which have the world's largest economies, to improve health performance are significant not only for themselves but also for other countries. This is because the health performance activities and strategies of G7 countries can influence the health policies of other nations and consequently the development of global health (7,8). Furthermore, considering the positive impact of health performance on economic growth, the health performances of G7 countries can also affect the global economy. Therefore, the measurement of health performance in G7 countries can be considered crucial (9). The health performance of developed countries not only influences their internal dynamics but also has a direct impact on global health and the economy. In this context, identifying which health criteria should be prioritized and determining which countries need to improve their health performance are of paramount importance, particularly for developed nations. This study aims to serve as a crucial guide in shaping health policies and strategies, contributing to the enhancement of health systems, making them more efficient and effective. By addressing these factors, this research seeks to provide valuable insights that can drive positive change, ensuring that the health systems of these nations are better aligned with global health objectives and the economic well-being of societies. In this context, the study measures the health performances of G7 countries using the most recent and up-to-date 2023 Legatum Prosperity Index-Health Indicator (LPI-HI) data, employing the LPI-HI-based DNMA Multi-Criteria Decision Making (MCDM) method. Accordingly, the first motivation of the research is to identify which G7 countries need to enhance their health performance to contribute more significantly to global health and the global

economy. The second motivation of the research is to evaluate, from a methodological perspective, whether the LPI-HI-based DNMA MCDM method can be used to measure health performance within the LPI-HI framework. Thus, the study first explains the importance of measuring the health performance of countries and the G7 group in the theoretical background section. The second part details the data set and analysis of the study. Finally, in the results section, the findings of the research are presented, and in the discussion section, interpretations of the identified quantitative values are provided based on these findings.

THEORETICAL BACKGROUND

Performance is fundamentally defined as the level at which a goal has been achieved (10,11). In other words, performance reflects the extent to which expectations are met under given conditions (12-14). Health performance, in a macro sense, is a metric that assesses a country's capacity to deliver healthcare services and improve health outcomes (15,16).

The primary purpose of measuring a country's health performance is to objectively determine how effectively it provides healthcare services to its citizens, assesses the quality of these services, and evaluates the level of access to healthcare (17,18). Given the importance of health performance, countries continuously monitor their own health outcomes. This enables them to gain awareness of their deficiencies, competencies, and strengths in healthcare. As a result, countries can develop strategies, methods, management practices, and activities to address deficiencies, enhance competencies, and ensure the sustainability of their strengths in healthcare (19,20). Additionally, countries monitor each other's health performance, as addressing gaps, improving competencies, and sustaining strengths in health security often involves collaboration and partnerships with countries that excel in health performance. Thus, the measurement of health performance becomes critically important, and countries increasingly rely on indices that assess their health outcomes (21). A review of the literature reveals numerous indicators that determine a country's health performance. These indicators are detailed in Table 1.

A review of the literature reveals that countries' health performance has generally been examined in two dimensions. The first dimension involves the interactional models of health performance with other factors, and the second concerns the measurement

and comparison of health performance across countries. In the context of the first interactional model, it has been found that a country's innovation activities in healthcare positively and significantly impact its health performance, highlighting the role of innovation in health (27-30). The second interactional model suggests that a country's health performance contributes meaningfully to economic growth and improvement (31-35). The third interactional model indicates that higher health performance levels are associated with an increase in a country's well-being (36,37). Lastly, the fourth interactional model shows that high health performance enhances a country's potential for sustainable development (38,39).

Table 1. Health Performance Indicators

Reference	Indicators
(22)	Health determinants and risks, health status, health system response
(23)	Per capita gross domestic product, educational level of women and differentiated by age, neonatal mortality rate, total fertility rate and prevalence of HIV/AIDS
(21)	Global Health Security Index (GHSI): Prevention, detection and reporting, rapid response, health system, compliance with international norms, risk environment.
(24)	Health status, risk factors for health, affordability, availability and use of services, quality and outcomes of care, health expenditure, health workforce, pharmaceutical sector, ageing and long-term care
(25)	Health Performance Index (HPI): Recognized occupational diseases, medical emergency preparedness, first aid, preventive medicine, health promotion
(26)	Legatum Prosperity Index-Health: Behavioral Risk Factors, Preventative Interventions, Care Systems, Mental Health, Physical Health, Longevity

In the second dimension, Yiğit (40) identified the health performance of 35 OECD countries for the year 2019 using six health performance criteria and the TOPSIS MCDM method. According to the findings, the health performance rankings of G7 countries were Italy, Japan, the UK, France, Germany, Canada, and the USA. Additionally, the study found that the countries with health performances above the average were Italy, Japan, the UK, France, and Germany. Sarıyıldız (41) measured the health performance of 12 regions in Türkiye using data from the Ministry of Health Statistics Yearbook 2019 and the ENTROPY-based TOPSIS method. The study first identified the maternal mortality rate as the most important health performance criterion within the ENTROPY method. It then observed that the regions with the highest

health performance were Western Anatolia, Western Black Sea, Eastern Black Sea, Eastern Marmara, and the Aegean. Sielska (42) calculated the health performance of 32 countries using 17 selected health performance indicators, based on input and output criteria provided by EUROSTAT for the period 2014-2016, through the CCSD-based TOPSIS method. Among G7 countries, the health performance rankings for input variables were Germany, Italy, and France, while for output variables, the rankings were Italy, Germany, and France. For other countries, Belgium, Luxembourg, and Switzerland had the highest input health performance values, whereas Cyprus, Italy, and Belgium had the highest output health performance values. Bordbar et al. (43) measured the health performance of 21 selected countries in the Middle East, Africa, and Asia using WHO health performance indicators from 2016-2019 through the CRITIC-based VIKOR method. The study found that Bahrain had the highest health performance in 2016, 2018, 2019, and 2020, while Qatar had the highest in 2017. Torkayesh et al. (44) evaluated the health performance of seven Eastern European countries using 2021 OECD health indicator data and the COCOSO method based on BWM and LBWA. The study determined that the health performances of Lithuania and Slovakia were better than those of Poland and Estonia. Legatum Institute (26) assessed the health performance of 167 countries using the components of the Legatum Prosperity Index-Health Indicator (LPI-HI). Among the G7 countries, the health performance rankings were Japan, Germany, Italy, France, Canada, the UK, and the USA. The study also measured the average health performance and found that Japan, Germany, Italy, and France exceeded this average. Sevim and Uğurluoğlu Aldoğan (45) analyzed the health performance of 36 OECD countries using health data from 2000-2017 through the MOORA method. The results showed that Switzerland, Germany, and Sweden had the highest health performance, while Mexico and Colombia had the lowest. Durur and Turgut (46) measured the health performance of G7 countries using selected World Bank health indicators through the PROMETHEE MCDM method. The health performance rankings were Japan, Italy, Canada, Germany, the UK, France, and the USA. The study also identified that Japan, Italy, Germany, and the UK had health performances above the average according to the PROMETHEE MCDM method.

According to data from the Legatum Institute (26), the average health performance score of 165

countries is 45.2, while the average for G7 countries is observed to be 74.9. This indicates that the G7 countries have an average health performance that is 66% higher than the global average. Given that the G7 countries are the world's largest economies, their strategies and actions in health performance have the potential to positively influence global health outcomes, other countries' health policies, the global economy, and various aspects related to the economy, such as innovation, well-being, and sustainable development. Therefore, the analysis of health performance in G7 countries is of significant importance (21,47). With this awareness, G7 countries frequently convene summits focused on global health performance (47). Notably, at the 2023 G7 Hiroshima Summit, the G7 countries set three primary goals concerning global health: enhancing the global health architecture, achieving more equitable and sustainable universal health coverage, and promoting health innovations (48). Consequently, it is crucial for the G7 countries to develop policies aimed at increasing domestic production capacity of health supplies, strengthening global health security, and providing more accessible healthcare services, not only to improve their own health performance but also to contribute to the health performance of other nations (9).

MATERIALS AND METHODS

Data Set and Analysis of the Research

The study utilized the most recent and up-to-date LPI-HI (criteria) values and weights of criteria for G7

countries available in 2023. These values, constituting the decision matrix for the analysis, are presented in Table 2.

Upon reviewing the health performance literature, LPI-HI (26) is more recent than WHO (22), PAHO and WHO (23), and Jessica et al. (21). Moreover, the LPI-HI is more comprehensive than the BASF (25) health performance indicators. Additionally, according to OECD (24), some G7 countries lack certain health indicator metrics. Therefore, LPI-HI was considered in the study to measure the health performance of the G7 countries. In scope of methodology, the DNMA method offers several distinct advantages within the MCDM literature. One of its key strengths is its ability to adapt to different decision-making scenarios. This flexibility allows researchers to adjust the weights assigned to various clustering models, decision-maker risk tolerance, and overall goals.

The DNMA method incorporates two normalization techniques, effectively mitigating the limitations of each individual method and minimizing information loss during the normalization process. This feature significantly enhances the overall reliability of the results compared to other MCDM methods, ensuring a more robust and credible decision-making framework. By utilizing three types of utility functions, the DNMA method strikes a balance between considering both overall performance and worst-case scenarios.

Table 2. Decision Matrix (Data Set)

LPI-HI (Criteria)	BRF	PI	CS	MH	PH	LO
Weights	0,1	0,15	0,15	0,1	0,2	0,3
Canada	40,2	88,4	69,5	67,7	78,7	95,5
France	41,4	91,4	78,4	63,8	79,2	95,5
Germany	49,6	92,2	79,6	71,3	75,5	94,8
Italy	55,1	87,1	70,3	69,1	79	96,8
Japan	78,2	84,5	83,4	74,6	82,9	98,2
UK	33,8	89,9	74,5	65,8	77,1	94,2
USA	21,2	88,4	71,9	52,7	73,9	90,2

Behavioral Risk Faktors (BRF)-(Weights: 0,10): Behavioral risk factors encompass a constellation of lifestyle patterns shaped by a complex interplay of influences that elevate the probability of contracting diseases, sustaining injuries or illnesses, or experiencing premature mortality.

Preventative Interventions (PI)-(Weights: 0,15): Preventative interventions encompass a comprehensive approach to healthcare that aims to proactively avert the onset of diseases, illnesses, and other medical complications. This proactive strategy plays a pivotal role in safeguarding individuals, particularly children and adults, from premature mortality.

Care Systems (CS)-(Weights:0,15): Care systems encompass the multifaceted capacity of a healthcare system to provide effective treatment and curative interventions for diseases and illnesses that have already manifested within the population.

Mental Health (MH)-(Weights:0,10): The Mental Health indicator assesses the prevalence and burden of mental disorders among the living population. Mental health plays a critical role in an individual's overall well-being and their ability to fully engage in the labor market.

The Physical Health (PH)-(Weights:0,20): The Physical Health indicator gauges the prevalence and impact of physical ailments within the living population. Physical health significantly influences an individual's overall well-being and their capacity to actively engage in the labor market.

Longevity (LO)-(Weights:0,30): The Longevity indicator assesses the mortality patterns of a nation's population across various life stages.

Reference: 26

This capability facilitates the effective ranking of decision alternatives. The integration approach employed in the DNMA method contributes to its overall simplicity. This allows researchers to derive a clear set of alternatives directly from the analysis (49,50). Therefore, due to the advantages of the DNMA method, the health performances of the G7 countries were measured using the DNMA method in this study. Lastly, the findings obtained during the implementation phases of the DNMA method were calculated using the Microsoft Excel 2010 software package, and the calculations were verified manually to ensure accuracy.

DNMA Method

The DNMA (Double Normalization-Based Multiple Aggregation) method is underpinned by the integration of linear and vector normalization techniques. This unique approach enables the identification of the ideal decision alternative. In this context, the ideal solution is defined as the alternative that exhibits the closest proximity to the expected solution. The expected solution, in turn, comprises the expected values of each criterion or component, representing the desired outcomes for each assessment factor (49,50). A comprehensive review of the literature on MCDM reveals that the DNMA method has gained widespread recognition and adoption among researchers. This method is frequently employed to evaluate the performance of various alternatives and address complex selection problems. Table 3 provides a comprehensive overview of studies that have utilized the DNMA method effectively.

Table 3. DNMA Literature

Author(s)	Method(s)	Theme
(51)	HFL-DNMA	Selection of shopping mall location
(52)	DNMA	Evaluation of economic freedom of OPEC countries
(53)	LMAW-DNMA	Determining of regional development agencies
(54)	LMAW-DNMA	Assessment of R&D EU and Serbia
(55)	Extended DNMA	Evaluation of sustainable location for a lithium-ion batteries' manufacturing plant
(56)	Interval-valued Pythagorean Fuzzy DNMA	Analysis of sustainable financial service systems
(57)	DNMA	Analysis of sustainable denim fabric

The following outlines the application steps of the DNMA method (49-50).

Step 1: Acquiring the Decision Matrix

$i: 1, 2, 3 \dots n, n$: Number of decision alternative

$j: 1, 2, 3, \dots m, m$: Number of criteria

D : Decision matrix

d_{ij} : The decision matrix is constructed using the Equality 1 for the i 'th decision alternative on the j 'th criterion.

$$D = [d_{ij}]_{n \times m} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1m} \\ x_{21} & x_{22} & \cdots & x_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ x_{n1} & x_{n2} & \cdots & x_{nm} \end{bmatrix} \quad (1)$$

Step 2: Calculation of Linear ($\tilde{x}_{ij}^{1N}$) and Vector ($\tilde{x}_{ij}^{2N}$) Normalization Values: ($\tilde{x}_{ij}^{1N}$)

Linear Normalization:

For benefit-oriented criteria:

$$(\tilde{x}_{ij}^{1N} = 1 - \frac{|x_{ij} - maks(x_{ij})|}{maks(x_{ij}) - min(x_{ij})} \quad (2)$$

For cost-oriented criteria:

$$(\tilde{x}_{ij}^{1N}) = 1 - \frac{|x_{ij} - min(x_{ij})|}{\sqrt{\sum_{i=1}^m (x_{ij})^2 + min(x_{ij})^2}} \quad (3)$$

Step 3: Adjustment of Criterion Weights

To achieve a balance between conflicting components, criterion weights are corrected. This step is executed through three operations.

1st Operation: Calculation of the standard deviation (σ_j) of criterion j .

$$\sigma_j = \sqrt{\frac{\sum_{i=1}^m (\frac{x_{ij}}{mak x_{ij}} - \frac{1}{m} \sum_{i=1}^m (\frac{x_{ij}}{mak x_{ij}}))^2}{m}} \quad (4)$$

2nd Operation: Calculation of normalized values for the standard deviations found in (i) concerning the criteria (ω_j^σ):

$$\omega_j^\sigma = \frac{\sigma_j}{\sum_{j=1}^n \sigma_j} \quad (5)$$

3rd Operation: Correction of weights ($\tilde{\omega}_j$):

$$\tilde{\omega}_j = \frac{\sqrt{\omega_j^\sigma \cdot \omega_j}}{\sum_{j=1}^n \sqrt{\omega_j^\sigma \cdot \omega_j}} \quad (6)$$

Step 4: Calculating Utility Functions:

The fourth step of the DNMA method involves calculating three distinct utility functions for each decision alternative. These functions provide valuable insights into the trade-offs inherent in decision-making scenarios.

First Function: Complete Compensatory Model (CCM):

The CCM assumes that a decision alternative with low performance in one criterion can be offset by strong performance in other criteria. In other words, weaknesses in some areas can be compensated for by strengths in others.

Second Function: Uncompensatory Model (UCM):

The UCM prioritizes ensuring that the chosen alternative does not exhibit significantly worse performance on any single criterion compared to other alternatives. This function essentially identifies the worst performance of the alternative across all criteria.

Third Function: Incomplete Compensatory Model (ICM):

The ICM acknowledges the practical reality of compromise in decision-making. In situations where an alternative with perfectly average performance across all criteria may not exist, the ICM identifies an alternative that strikes a balance between strong and weak areas, avoiding extreme highs and lows in performance.

Calculating CCM, UCM, and ICM Functions:

$$\text{CCM: } u_1(a_i) = \frac{\sum_{j=1}^n \tilde{\omega}_j \cdot \tilde{x}_{ij}^{1N}}{\text{maks} \tilde{x}_{ij}^{1N}} \quad (7)$$

$$\text{UCM: } u_2(a_i) = \text{maks} \tilde{\omega}_j (1 - \tilde{x}_{ij}^{1N}) / \text{maks} \tilde{x}_{ij}^{1N} \quad (8)$$

$$\text{ICM: } u_3(a_i) = \prod_j (\tilde{x}_{ij}^{2N} / \text{maks} \tilde{x}_{ij}^{2N})^{\omega_j} \quad (9)$$

Step 5: Aggregating Utility Functions and Determining Rankings (DN_i)

$$DN_i = w_1 \cdot \sqrt{\varphi \cdot \left(\frac{u_1(a_i)}{\text{maks} u_1(a_i)} \right)^2 + (1 - \varphi) \cdot \frac{m - r_1(a_i) + 1}{m}} - w_2 \cdot \sqrt{\varphi \cdot \left(\frac{u_2(a_i)}{\text{maks} u_2(a_i)} \right)^2 + (1 - \varphi) \cdot \frac{m - r_2(a_i) + 1}{m}} + w_3 \cdot \sqrt{\varphi \cdot \left(\frac{u_3(a_i)}{\text{maks} u_3(a_i)} \right)^2 + (1 - \varphi) \cdot \frac{m - r_3(a_i) + 1}{m}} \quad (10)$$

The DN_i values of decision alternatives are ranked from highest to lowest. In Equation 10, $r_1(a_i)$ represents the rank number for the CCM function, and $r_2(a_i)$ represents the rank number for the ICM function, with the highest value being in the first place. $r_3(a_i)$ represents the rank number for the UCM function, with the lowest value being in the first place. (φ) denotes the relative importance of utility functions and ranges between '0' and '1' ($\varphi \in [0,1]$). The method's developers have emphasized that the value of (φ) could be 0.5. w_1, w_2 and w_3 represent the degrees of importance (weights) of the CCM, UCM, and ICM utility functions, respectively, and the sum of criterion weights should be '1' ($w_1 + w_2 + w_3 = 1$). The values of w_1, w_2 and w_3 can be determined by the decision maker depending on the risk situations. These weights can be established in three scenarios based on the overall performance or worst performance of decision alternatives.

In the first scenario, decision makers may allocate the highest weight to the CCM if they prioritize the comprehensive performance of decision alternatives or if most alternatives perform well across various criteria.

In the second scenario, if decision makers aim to avoid risks or ensure that selected alternatives do not perform poorly across specific criteria, they may assign the highest weight to the UCM.

In the third scenario, if decision makers seek to evaluate both comprehensive performance and risks, they may assign the highest weight to the ICM.

Weights can also be determined using linear and vector normalization techniques. If linear normalization is deemed more efficient and effective, larger weights can be assigned to the CCM and UCM. Otherwise, the largest weight is allocated to the ICM utility function.

Within the scope of the research, it can be understood from the decision matrix values that each country demonstrates both good and poor performance according to different criteria. Consequently, due to the fact that some countries exhibit poor performance on certain criteria while others excel, the highest weight was assigned to UCM ($w_{UCM} = 0.8$), while lower weights were allocated to CCM and ICM ($(w_{CCM} = 0.1 \text{ and } w_{ICM} = 0.1)$), respectively. Additionally, the relative importance of the countries' benefit values (ϕ) has been set at 0.5, as explained in the DNMA literature.

RESULTS

Computational Analysis

In the study, the health performance values of the G7 countries, as indicated in Table 2, were calculated using the LPI-HI-based DNMA method by following the steps from Equation 1 to Equation 12. The calculated health performance values were then ranked accordingly. The health performance values and rankings of the measured countries are presented in Table 4.

Table 4. Health Performance Values and Rankings of Countries Within the Scope of the DNMA Method

Countries	GPI-HI based DNMA Score	Rank
Canada	0,4143	3
France	0,8057	1
Germany	0,3432	6
Italy	0,3810	4
Japan	0,0003	7
UK	0,7159	2
USA	0,3612	5
Mean	0,4314	----

Upon examining Table 4, the health performance rankings of the countries are as follows: France, the UK, Canada, Italy, the USA, Germany, and Japan. Additionally, as shown in Table 4, France and the UK stand out for having significantly higher health performance, while Japan exhibits notably lower

performance compared to the other countries. Furthermore, within the DNMA method, the average health performance value was calculated, and it was observed that only France and the UK have health performance values above this average.

Sensibility Analysis

In this study, a sensitivity analysis was performed to evaluate the methodological robustness of the LPI-HI-based DNMA approach. In the context of MCDM, sensitivity analysis involves applying various weighting techniques to a single dataset. This approach allows for a comparative assessment of the resulting values and rankings of decision alternatives' performance. Differences in the performance rankings of the identified decision alternatives are expected, which would underscore the sensitivity of the selected weight coefficient calculation method. Such variations are anticipated when comparing the performance rankings of decision alternatives derived from the application of different method (58). In this context, the weight values of the LPI-HI (criteria) for each country were first determined using objective criteria weighting methods, including ENTROPY, CRITIC, SD, SVP, MEREC, and LOPCOW. The values calculated by these methods are presented in Table 5.

Following the sensitivity analysis, the health performance of the G7 countries was assessed using the DNMA method based on ENTROPY, CRITIC, SD, SVP, MEREC, and LOPCOW. The calculated values and rankings are presented in Table 6.

Upon examining Table 4 and Table 6 together, it is observed that the health performance rankings of the countries determined using the LPI-HI-based DNMA method differ from those obtained using the DNMA methods based on ENTROPY, CRITIC, SD, SVP, MEREC, and LOPCOW. Consequently, these results indicate that the LPI-HI-based DNMA method is sensitive to measuring the health performance of G7 countries within the LPI-HI framework.

Table 5. Criteria Weights

LPI-H Criteria	ENTROPY		CRITIC		SD		SVP		MEREC		LOPCOW	
	Sco.	R.	Sco.	R.	Sco.	R.	Sco.	R.	Sco.	R.	Sco.	R.
LPI-H1	0,888	1	0,112	4	0,157	4	0,768	1	0,178	3	0,139	5
LPI-H1	0,005	5	0,348	1	0,181	2	0,016	5	0,184	2	0,179	3
LPI-H1	0,028	3	0,187	2	0,155	5	0,065	3	0,376	1	0,105	6
LPI-H1	0,067	2	0,110	5	0,141	6	0,116	2	0,148	4	0,216	1
LPI-H1	0,008	4	0,135	3	0,178	3	0,020	4	0,043	6	0,148	4
LPI-H1	0,004	6	0,108	6	0,188	1	0,015	6	0,071	5	0,213	2
Sco.: Score R.: Rank												

Table 6. Health Performance Values of G7 Countries According to ENTROPY, CRITIC, SD, SVP, and MEREC-based DNMA Methods

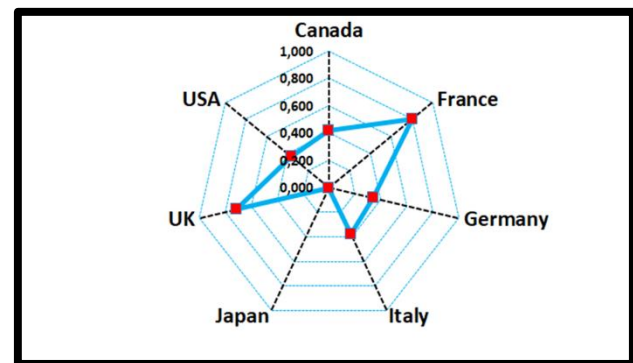
LPI-H Criteria	ENTROPY		CRITIC		SD	
	Score	Rank	Score	Rank	Score	Rank
Canada	0,095	5	0,363	5	0,409	5
France	0,138	3	0,716	2	0,617	2
Germany	0,131	4	0,460	4	0,421	4
Italy	0,193	2	0,278	6	0,389	6
Japan	0,348	1	0,043	7	0,038	7
UK	0,070	6	0,775	1	0,633	1
USA	0,016	7	0,617	3	0,465	3
LPI-H Criteria	SVP		MEREC		LOPCOW	
	Score	Rank	Score	Rank	Score	Rank
Canada	0,151	5	0,182	6	0,517	4
France	0,198	3	0,522	3	0,670	1
Germany	0,194	4	0,536	2	0,471	5
Italy	0,287	1	0,185	5	0,544	3
Japan	0,205	2	-0,026	7	0,034	7
UK	0,122	6	0,557	1	0,622	2
USA	0,061	7	0,385	4	0,458	6

Comparative Analysis

The comparative analysis evaluates the relationships and rankings of the proposed method in comparison to other techniques used for calculating MCDM methods. The proposed approach should demonstrate credibility and reliability alongside other methodologies, while also showing a favorable and statistically significant correlation with various MCDM methods (59). In this context, the health performance of G7 countries was measured using various MCDM methods (ARAS, WASPAS, GRA, MARCOS, TOPSIS) with distinct technical characteristics commonly utilized in the literature. The measured values and rankings are presented in Table 7.

When examining Table 4 and Table 7 together, it is observed that the health performance rankings of

countries determined by the LPI-HI-based DNMA method differ from those identified using other LPI-HI-based the other MCDM methods. The positions of LPI-HI-based DNMA and other LPI-HI-based MCDM methods are illustrated in Figures 1, 2, and 3.

**Figure 1.** Position of LPI-HI based DNMA Method**Table 7.** Health Performance Scores of G7 Countries According to LPI-HI Based The Other MCDM Methods

LPI-H Criteria	ARAS		WASPAS		GRA		MARCOS		TOPSIS	
	Sco.	R.	Sco.	R.	Sco.	R.	Sco.	R.	Sco.	R.
Canada	0,863	6	0,876	6	0,492	6	0,640	6	0,352	6
France	0,910	2	0,921	2	0,612	2	0,681	2	0,587	2
Germany	0,892	4	0,905	4	0,594	3	0,661	4	0,478	4
Italy	0,988	1	0,987	1	0,900	1	0,738	1	0,860	1
Japan	0,797	7	0,804	7	0,365	7	0,586	7	0,103	7
UK	0,907	3	0,915	3	0,568	4	0,673	3	0,584	3
USA	0,874	5	0,886	5	0,512	5	0,647	5	0,404	5

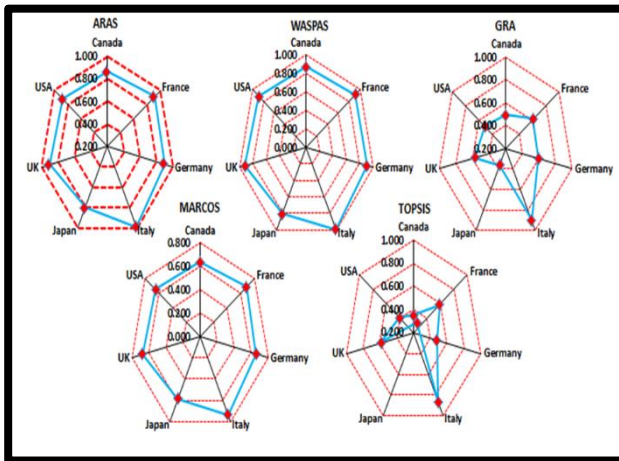


Figure 2. Position of LPI-HI based The Other MCDM Methods-1

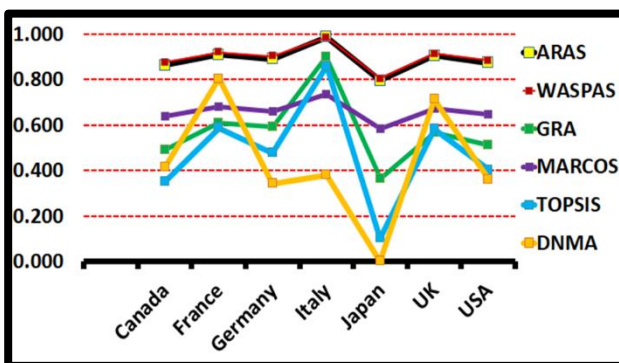


Figure 3. Position of LPI-HI based The Other MCDM Methods-2

When Figures 1, 2, and 3 are evaluated together, it is observed that the fluctuations in the increase and decrease of performance values by country, as determined by the LPI-HI-based DNMA method, are generally consistent with those identified by other LPI-HI-based MCDM methods. Therefore, based on this evaluation, it can be inferred that the health performance values of countries measured by the LPI-HI-based DNMA method are positively correlated with those determined by other LPI-HI-based MCDM methods.

In Walters' (60) study, Keshavarz-Ghorabae et al. (59) reported that a Pearson correlation coefficient between 0.400 and 0.600 between the MEREC method and other methods (SD, ENTROPY, and CRITIC) suggests a moderate relationship between the variables. In this context, the Pearson correlation values between the health performance scores of

Table 8. Correlation Scores

Method/ Method	WASPAS	GRA	MARCOS	TOPSIS	ARAS
DNMA	0,569*	0,343*	0,554*	0,590*	0,531*

**p<.01; *p<.05

countries measured by the LPI-HI-based DNMA method and those calculated using other LPI-HI-based MCDM methods are presented in Table 8.

When examining Table 8, it is evident that the health performance values of countries measured by the LPI-HI-based DNMA method have positive and significant ($p<.05$) correlations with the health performance values of countries calculated by other LPI-HI-based MCDM methods. Therefore, based on these results, the LPI-HI-based DNMA method can be considered credible and reliable in measuring the health performance of G7 countries within the scope of LPI-HI.

Simulation Analysis

To evaluate the robustness and stability of the proposed method's outcomes, a simulation analysis will be performed. This will involve creating various scenarios by applying different values to the decision matrices. A dependable method should show increasing divergence in its results compared to other MCDM methods as the number of scenarios grows. Additionally, the average variance of MCDM methods determined by the proposed method across the scenarios should be significantly higher than that of at least one other MCDM method. This would demonstrate the proposed method's superior ability to distinguish the relative importance of criteria. Lastly, the analysis should ensure consistency in the variance of MCDM methods across all methods within each individual scenario (59). In this context, Table 9 displays the correlation coefficients between the LPI-HI-based DNMA method and other LPI-HI-based MCDM methods, calculated using the first 10 scenarios from the simulation analysis.

Table 9 categorizes the 10 scenarios into two groups. The first group comprises the initial 3 scenarios, while the second group includes the remaining ones. As observed from Table 8, the correlation values between the LPI-HI-based DNMA method and other methods decrease as the number of scenarios increases. This trend is depicted in Figure 4.

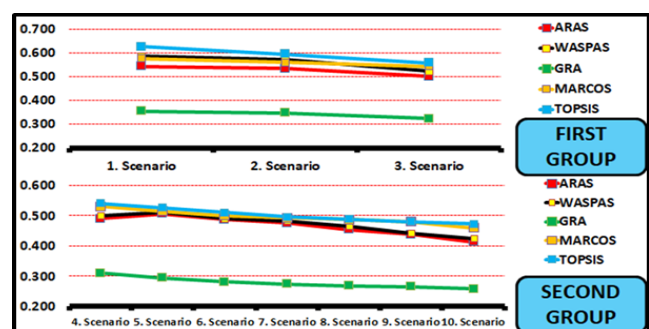


Figure 4. Correlation Positions of LPI-HI-based DNMA Among Other LPI-HI-based MCDM Methods

Table 9. Correlation Values between the LPI-H-based DNMA Method and Other MCDM Methods in Scope of Scenarios

Methods	ARAS	WASPAS	GRA	MARCOS	TOPSIS
1. Scenario	0,542*	0,585*	0,355*	0,575*	0,625*
2. Scenario	0,534*	0,571*	0,348*	0,560*	0,595*
3. Scenario	0,500*	0,523*	0,323	0,542*	0,558*
Methods	ARAS	WASPAS	GRA	MARCOS	TOPSIS
4. Scenario	0,490*	0,500*	0,310	0,530*	0,541*
5. Scenario	0,505*	0,512*	0,295	0,515*	0,526*
6. Scenario	0,487*	0,490*	0,281	0,500*	0,510*
7. Scenario	0,475*	0,482*	0,274	0,492*	0,496*
8. Scenario	0,453*	0,465*	0,269	0,487*	0,489*
9. Scenario	0,438*	0,442*	0,265	0,479*	0,480*
10. Scenario	0,413*	0,425*	0,259	0,460*	0,472*

**p<.01; *p<.05

Upon examining Figure 4, it becomes evident that the LPI-HI-based DNMA method shows increasing divergence and separation from other LPI-HI-based MCDM methods as the number of scenarios increases. This observation indicates that the distinctive features of the LPI-HI-based DNMA method become more pronounced with the rise in scenarios. To delve deeper into the simulation results, an Analysis of Means (ANOM) for variances, specifically the Levene statistic (ADM), was employed. This technique evaluates the consistency of variances in the criterion weights assigned by the LPI-HI-based DNMA method across various scenarios. It provides a visual representation to assess the homogeneity of variances. This graphical output consists of three critical elements: a central line depicting the overall mean ADM, bordered by upper decision limits (UDL) and lower decision limits (LDL). If the standard deviation of a particular group (cluster) falls outside these decision limits, it signifies a statistically significant deviation from the mean ADM,

indicating heterogeneity in variances. Conversely, when the standard deviations of all groups remain within the UDL and LDL boundaries, it confirms the homogeneity of variances (59). In the context of this analysis, the variance values for the performance scores of countries, as evaluated by the LPI-HI-based DNMA method, were calculated for each scenario. These variance values for the different methods within each scenario are subsequently presented in Table 10.

An examination of Table 10 reveals that the LPI-HI-based DNMA method exhibits a higher average variance across the analyzed scenarios compared to the other LPI-HI-based MCDM methods. This observation suggests that the LPI-HI-based DNMA method possesses a stronger ability to discriminate between criteria, potentially leading to a more nuanced differentiation in performance scores. To further elucidate this finding, a visual representation of the ADM analysis for the LPI-HI-based DNMA method across the scenarios is provided in Figure 5.

Table 10. Variance Values of MCDM Methods across Scenarios

Methods	DNMA	ARAS	WASPAS	GRA	MARCOS	TOPSIS
1. Scenario	0,0621	0,0028	0,0242	0,0023	0,0481	0,0033
2. Scenario	0,0632	0,0031	0,0251	0,0021	0,0474	0,0031
3. Scenario	0,0588	0,0026	0,0238	0,0017	0,0471	0,0028
4. Scenario	0,0577	0,0023	0,0218	0,0017	0,0464	0,0026
5. Scenario	0,0549	0,0021	0,0182	0,0015	0,0459	0,0025
6. Scenario	0,0529	0,0019	0,0173	0,0015	0,0455	0,0021
7. Scenario	0,0513	0,0016	0,0169	0,0014	0,0451	0,0019
8. Scenario	0,0482	0,0014	0,0157	0,0014	0,0449	0,0019
9. Scenario	0,0479	0,0013	0,0142	0,0013	0,0448	0,0018
10. Scenario	0,0471	0,0011	0,0139	0,0012	0,0446	0,0017
Mean	0,0544	0,0020	0,0191	0,0016	0,0460	0,0024

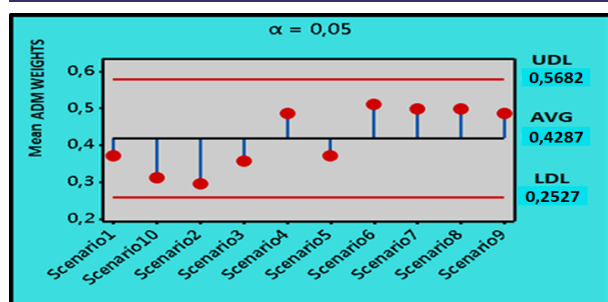


Figure 5. ADM Visual

Figure 5 portrays a homogenous band for the calculated ADM values across all scenarios. Notably, all values reside within the pre-established Upper Decision Limit (UDL) and Lower Decision Limit (LDL). This observation indicates consistent variances in weights across the scenarios. Levene's Test, with its key statistics presented in Table 11, further strengthens this finding.

Table 11. Levene's Test

Levene Statistic	df1	df2	Sig.(p)
0,256	2	10	0,178
p* < .05			

Table 11's Levene Statistic of 0,256, with a p-value exceeding 0.05 ($p = 0,178 > 0,05$), confirms homogeneous variances. This validates the robustness and stability of the LPH-HI based DNMA method in evaluating countries' health performance within the Legatum Prosperity Index-Health Indicators framework.

DISCUSSION

Upon reviewing the literature, Legatum Institute (26) ranked the health performances of G7 countries based on the LPI-HI as Japan, Germany, Italy, France, Canada, the UK, and the USA. In the current study, however, the ranking of health performances was found to be France, the UK, Canada, Italy, the USA, Germany, and Japan. Additionally, in the Legatum Institute (26) study, countries with below-average health performance were identified as Canada, the UK, and the USA. In contrast, the current study observed below-average health performance in Canada, Italy, the USA, Germany, and Japan. Considering the findings of both studies, it is evident that the health performance rankings of the countries differ from each other, and Canada is the only country with below-average health performance in both studies. Methodologically, it was assessed that the LPI-HI-based DNMA technique used in the current study is significantly different from the LPI-HI technique.

On the other hand, in Yigit's (40) study, using 2019 data and the TOPSIS method, the countries with health performance above the average were identified as Italy, Japan, the UK, France, and Germany. In the study by Durur and Turgut (46), using 2023 data and the PROMETHEE method, the countries with health performance above the average were Japan, Italy, Canada, Germany, and the UK. Additionally, considering the data from the current study, it has been observed that the UK's health performance is above average. Therefore, it can be concluded that the UK has a certain potential for health performance.

This study makes a significant contribution to the literature by evaluating the health performance of G7 countries using the LPI-HI-based DNMA method. Unlike other MCDM methods, the DNMA method integrates precision, comparative analysis, and simulation analysis into a comprehensive methodological framework for assessing health performance. Furthermore, the correlation analyses of the method reinforce the reliability and validity of DNMA, offering a fresh perspective in the literature. The findings of this study demonstrate that the DNMA method, with its higher variance compared to other methods, reveals distinct differences in the health performance rankings of countries. This indicates that the method is more effective at capturing the finer details of health performance and provides a robust tool for more advanced analyses.

From a practical standpoint, the study identifies that the health performance of Canada, Italy, the United States, Germany, and Japan falls below the average, highlighting areas that require urgent attention in their health policies. On the other hand, the performance of the United Kingdom exceeds the average, positioning it as a model for other G7 countries to emulate in terms of health policy. Additionally, the methodological framework developed in this study has the potential for application beyond the G7, offering a universal analysis tool that can be extended to other country groups such as BRICS, OECD, and ASEAN, thus contributing to global health policy analysis.

In conclusion, this study not only underscores the applicability of the LPI-HI-based DNMA method in health performance analysis but also provides significant insights for both academic literature and policymakers. The findings serve as a strategic guide, with the potential to influence future health policy decisions at both national and international levels.

The study suggests that G7 countries should prioritize policy interventions in areas related to health policy. These areas, scoring above the average, present the greatest potential for improvement in health and contribution to the global economy and health. Additionally, G7 countries like the Canada, Italy, USA, Germany ve Japan, whose health performance falls below the average, should demonstrate significant advancements in this area. This progress would contribute positively to both global health and economy. Future research could broaden its scope to include not only G7 countries but also nations belonging to other international economic organizations (e.g., G20, BRICS, OECD, ASEAN, APEC). This wider analysis would offer a more comprehensive understanding of health performance in global framework. Methodologically, future studies could explore a wider range of MCDM methods to assess climate change performance. Examples include EDAS, CODAS, RAFSI, SECA, OPA, and others. By comparing the rankings generated by these methods, researchers could gain a more nuanced understanding of country performance.

CONCLUSION

The first phase of the study involved measuring the health performance of various countries using the LPI-HI based DNMA method. The obtained performance scores were then employed to rank the countries. This ranking, based on the LPI-HI based DNMA method, placed France, UK, Canada, Italy, USA, Germany and Japan in descending order. Furthermore, an analysis of the average climate change performance across all countries was conducted using the LPI-HI based DNMA method. This analysis revealed that only France and UK demonstrated climate change performance above the average level.

The second stage of the study involved a series of analyses within the management scope to evaluate the countries' health performances based on the LPI-Health criteria using the LPI-HI based DNMA method. These analyses included sensitivity analysis, comparative analysis, and simulation analysis.

Focusing on the sensitivity analysis, the rankings generated by the LPI-HI based DNMA method for countries' health performance diverged from those obtained using the other LPI- LPI-HI based MCDM (ARAS, WASPAS, GRA, MARCOS, TOPSIS) methods. This observation suggests that the LPI-HI based DNMA method exhibits sensitivity in

measuring countries' health performances within the context of the LPI-HI. The comparative analysis revealed that the rankings generated by the LPI-HI based DNMA method for countries' health performance differed from those produced by other LPI-HI based MCDM methods, including ARAS, WASPAS, GRA, MARCOS, and TOPSIS. However, a significant finding emerged. Despite the ranking discrepancies, the climate change performance values measured by the LPI-HI based DNMA method exhibited positive and statistically significant correlation with those obtained using all other LPI-HI based MCDM methods. This significant correlation suggests that the LPI-HI based DNMA method provides credible and reliable results when measuring countries' health performance within the LPI-HI framework. The simulation analysis comprised two key observations. First, as the number of analyzed scenarios (represented by different decision matrices) increased from 1 to 10, a decreasing trend was observed in the correlation coefficient between the health performance values obtained using the LPI-HI based DNMA method and those calculated by other LPI-HI based MCDM methods. Second, the analysis compared the average variance values of the LPI-HI based DNMA method with those of other LPI-HI based MCDM methods across the 10 scenarios. This comparison revealed that the average variance value produced by the LPI-HI based DNMA method was higher than those generated by the LPI-HI based ARAS, WASPAS, GRA, MARCOS, and TOPSIS methods. Finally, the simulation analysis incorporated an ADM analysis, which confirmed the homogeneity of variances. This finding suggests that the LPI-HI based DNMA method exhibits stability and robustness in measuring countries' health performances within the LPI-HI context.

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