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PERFORMANCE EVALUATION OF G7 COUNTRIES IN TERMS OF PATENT APPLICATIONS

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Abstract: A patent is a legal right granted by a patent authority that gives the inventor or assignee exclusive rights to produce, use, sell and distribute an invention for a specified period of time. Patent acquisition offers numerous advantages related to the protection of inventions, enhancement of competitiveness, attraction of investors, generation of income, support for innovation, market expansion, and improvement of brand reputation for the individual or entity that holds the patent. Given the significance of the patent concept, the performance of the G7 countries regarding patent acquisition is handled as multi-criteria decision-making (MCDM) problem in this research. In the evaluation made over the total number of patent applications submitted over nine different technological domains between 2000-2020, the criteria weights were determined by MAXimum of Criterion (MaxC), Modified Preference Selection Index (MPSI) and LOgarithmic Percentage Change-driven Objective Weighting (LOPCOW) methods. By using these criteria weights which are combined with the Bonferroni Mean Operator, the MUltiple-TRIangles ScenarioS (MUTRISS) method was utilised for the performance rankings of G7 countries in terms of patent acquisition. As a result of the study, the success ranking of G7 countries in terms of patent applications was determined as USA, Japan, Germany, UK, France, Canada and Italy.

Keywords: Patent, G7 countries, MaxC, MPSI, LOPCOW, MUTRISS

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1. Introduction

Intellectual property rights are widely acknowledged as fundamental components of the contemporary economic system. These rights are designed to foster economic and social development by safeguarding the innovative ideas and creative expressions of individuals and organizations. Within this framework, the patent system serves as a crucial instrument that empowers inventors to legally protect their innovations. Patents confer upon the owner of an invention the exclusive rights to produce, utilize, sell, or import the invention for a specified duration. These rights serve to reward the inventive contributions of individuals while simultaneously promoting the dissemination of technology and knowledge (WIPO, 2016). Furthermore, the patent system plays a pivotal role in fostering innovative ecosystems on a local and global scale, thereby contributing to economic growth, augmenting research and development investments, and facilitating the transfer of technology (Maskus, 2000). The concept of patents has evolved significantly over historical periods and has been addressed through various approaches within different legal systems. In contemporary contexts, patents extend beyond technological inventions; they are applicable across a diverse array of fields, including biotechnology, software, and business methods. This expansion necessitates a comprehensive examination of the legal, economic, and ethical dimensions associated with the concept of patents (Granstrand, 1999). Obtaining a patent for an invention significantly contributes to several key areas, including the provision of a competitive advantage (Granstrand, 1999), the encouragement of research and development (R&D) and innovation activities (Maskus, 2000), the facilitation of technology transfer and collaborative efforts (WIPO, 2016), the enhancement of opportunities to attract investors (Hall and Harhoff, 2012), and the establishment of a robust position in the global market (WIPO, 2016). The World Intellectual Property Organization (WIPO), the United States Patent and Trademark Office (USPTO), and the European Patent Office (EPO) are prominent institutions through which patent applications may be submitted on a global scale. WIPO is the global organisation that coordinates applications filed under the Patent Cooperation Treaty (PCT), which provides patent protection in more than one country with a single application (WIPO, 2016). USPTO is the authoritative entity responsible for the processing of patent and trademark applications within the United States while playing a crucial role, particularly in regions characterized by significant levels of technological innovation (USPTO, 2024). Operating with the aim of offering a common patent protection in European countries, the EPO facilitates the acquisition of valid patents in countries that are parties to the European

Patent Convention (EPC) (EPO, 2024). On a more local scale, the African Regional Intellectual Property Organization (ARIPO, 2024), the Gulf Cooperation Council Patent Office (GCCPO, 2024) and the Turkish Patent and Trademark Office (TURKPATENT, 2024) are other organisations that provide patent protection. The G7 countries, formally referred to as The Group of Seven, originated in the 1970s as an informal forum aimed at addressing economic challenges and coordinating policy responses among the world's major industrial powers. This initiative emerged during a period characterized by oil crises, financial instability, and increasing concerns regarding international economic governance. Initially organized as the Group of Six (G6) with the participation of France, West Germany, Italy, Japan, the United Kingdom, and the United States (Putnam & Bayne, 1984, p. 20), the group subsequently evolved into the G7 format with the inclusion of Canada in the following years (Bayne, 2000, p. 33). According to the International Monetary Fund's (IMF) World Economic Outlook, the combined nominal GDP of the G7 in 2023 was estimated at $45 trillion, while global GDP was about $104 trillion. This brings the G7's share to about 43 per cent of the world's total nominal GDP (IMF, 2024). As of 2023, the total exports of products from G7 countries amounted to $6,844,219,136, while the corresponding figure for all countries globally reached $23,651,975,102. These data indicate that the export volume from G7 countries constitutes approximately 29% of the total world export volume (TradeMap, 2024). These data illustrating the economic dominance of the G7 countries at the global level are undoubtedly indicative of a systematic and non-coincidental phenomenon. The support provided by these countries in areas such as education, research and development, innovation, and entrepreneurship has facilitated their attainment of a more elevated economic status in comparison to other nations. In addition to these factors, one of the primary indicators is unequivocally the volume of patent applications that safeguard the inventions of individuals or organizations. The number of patent applications serves as a significant indicator for these countries in sustaining their economic superiority, reflecting the tangible outcomes of their investments in education, research and development, innovation, and entrepreneurship. In light of the information presented regarding the significance of the concept of patents and the G7 countries so far, this study seeks to analyse the performance of G7 nations in relation to the volume of patent applications submitted. The ranking of the G7 countries - comprising Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States - is determined by considering the total number of applications submitted to EPO, WIPO and USPTO during the 21-year period from 2000 to 2020 and by referring 9 different technology domains described by the Organisation for Economic Co-operation and Development (OECD). Therefore, this study is handled as a multi-criteria decision-making problem (MCDM), where the G7 countries serve as alternatives and the OECD technology domains are employed as criteria. The weights of OECD technology domains were determined separately by three different objective criteria weighting methods consisting of MaxC, MPSI and LOPCOW. The results obtained from these methods were subsequently integrated through the Bonferroni Mean Operator, resulting in a consensus solution. In addition, the performance rankings of G7 countries with respect to patents were established utilizing the MUTRISS method. Finally, three sensitivity analyses were conducted to assess the reliability of the results obtained from the MUTRISS method. In the Introduction section of the study, a detailed explanation regarding the significance of the patent concept and its relevance to the G7 countries is provided. The methodologies utilized in the study are delineated comprehensively in the second section, while the implementation phase, which includes the determination of criteria weights, the ranking of alternatives, and the sensitivity analysis, is discussed in the third section. In the fourth and fifth section of the study, results and discussion about the findings are presented.

2. Materials and Methods

This study aims to evaluate the performance rankings of G7 countries in terms of patent applications by analysing the total number of applications submitted to the EPO, WIPO, and USPTO from 2000 to 2020. The data that underpin the analysis were sourced from the OECD (2024) database. Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States, which are among the G7 countries, were included as alternatives in this multi-criteria decision-making problem. On the other hand, patent applications submitted within the designated OECD technology domains—namely Biotechnology $(BT)(C_1)$, Information and Communication Technologies $(ICT)(C_2)$, Nanotechnology $(NT)(C_3)$, Technologies Related to Artificial Intelligence $(TRAI)(C_4)$, Medical Technology $(MT)(C_5)$, Pharmaceuticals $(PHR)(C_6)$, Environmental Technologies $(ENV)(C_7)$, Climate Change Adaptation Technologies $(CCAT)(C_8)$, and the Sustainable Ocean Economy $(SOE)(C_9)$—were evaluated as benefit oriented criteria. Introduced in 2024 by Gligorić et al. (2024) the MaxC method is an objective criterion weighting approach that aims to identify the maximum criteria values in the initial decision matrix. The prominent features of the method are that it does not require complex mathematical operations, is easy and comprehensible while providing consistent and reliable results. The MPSI approach, derived by the modification applied to the Preference Selection Index (PSI) method (Maniya and Bhatt, 2010), was introduced to the literature in 2022 by Gligoric et al. (2022). This objective criteria weighting method, which is not time-consuming and includes simple and straightforward calculation steps, takes into account the Euclidean distance unlike the MaxC method. On the other hand, introduced in 2022 by Ecer and Pamucar (Ecer and Pamucar, 2022), the objective LOPCOW method addresses the gap caused by data size, produces more reasonable weights and enables the use of positive and negative values in the same decision matrix. Since it would not be an appropriate approach to assess the significance level of OECD technology domains based on personal judgments which require the application of subjective methods, and due to their aforementioned strengths, these three objective criteria weighting methods were favoured. In order to consolidate the results obtained from these three methods, Bonferroni Mean Operator (Bonferroni, 1950) was employed.

Introduced in 2023 by Zakeri et al. (Zakeri et al., 2023), the MUTRISS method is an approach based on the area calculation of irregular polygons consisting of multiple triangles that arise after normalisation. The polygon with the largest area among them is considered as the best alternative. This method, which is relatively recent and has not been widely implemented across numerous applications, offers significant convenience to researchers in terms of evaluation by visually representing the areas of polygons. In the last stage of the study, three sensitivity analysis were conducted to evaluate the stability of the ranking method including a comparative analysis conducted by utilizing five distinct traditional multi-criteria decision-making techniques. A comprehensive summary of all methods employed throughout the study is presented in Figure 1.

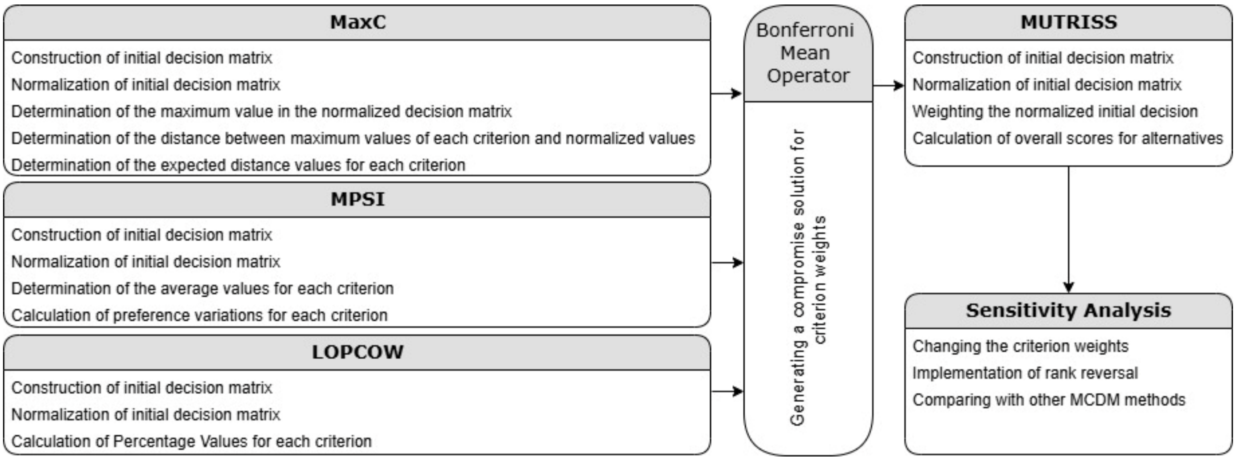

Figure 1. Flowchart of the research.

2.1. MaxC Method

Step 1: Construction of initial decision matrix.

The initial decision matrix is constructed by equation 1 where m represents the number of alternatives and n represents the number of criterion.

$$X_{ij} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \vdots & \vdots & \dots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \tag{1}$$

Step 2: Normalization of initial decision matrix.

Initial decision matrix is normalized in linear form by equation 2.

$$r_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}} \tag{2}$$

Step 3: Determination of the maximum value in the normalized decision matrix.

The alternative with the highest normalized value under each criterion is determined using equation 3.

$$r_j^* = \max\left(r_{ij} | 1 \le j \le n|\right), \forall i \in [1, m] \tag{3}$$

Step 4: Determination of the distance between maximum values of each criterion and normalized values.

The distance of each value in the normalised matrix from the maximum value determined in the previous step is calculated using equation 4.

$$d_{ij} = r_j^* - r_{ij}, \forall i \in [1, m], \forall j \in [1, n] \tag{4}$$

Step 5: Determination of the expected distance values for each criterion.

The expected distance of each criterion is determined by averaging the distances determined in the previous step with equation 5.

$$E_j = \frac{\sum_{i=1}^{m} d_{ij}}{m}, \forall j \in [1, n] \tag{5}$$

Step 6: Calculation of criterion weights.

The final weights of the criteria are computed by equation 6.

$$\omega_j = \frac{E_j}{\sum_{j=1}^{n} E_j} \tag{6}$$

2.2. MPSI Method

Step 1: Construction of initial decision matrix.

The initial decision matrix is constructed by equation 7 where m represents the number of alternatives and n represents the number of criterion.

$$X_{ij} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \vdots & \vdots & \dots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \tag{7}$$

Step 2: Normalization of initial decision matrix.

Initial decision matrix is normalized in linear form by equations 8 or 9 according to the type of criterion.

$$r_{ij} = \frac{x_{ij}}{\max\limits_{j} x_{ij}}; for\ benefit\ criterion \tag{8}$$

$$r_{ij} = \frac{\min_j x_{ij}}{x_{ij}};\, for\ cost\ criterion \tag{9}$$

Step 3: Determination of the average values for each criterion.

The average values for each criterion in the normalized decision matrix is determined by equation 10.

$$\vartheta_j = \frac{\sum_{i=1}^{m} r_{ij}}{m}, \forall j \in [1, n] \tag{10}$$

Step 4: Calculation of preference variations for each criterion.

The preference variations for each criterion are calculated in the form of Euclidean distance by equation 11.

$$\mathcal{P}_j = \sum_{i=1}^{m} \left(r_{ij} - \vartheta_j\right)^2, \forall j \in [1, n] \tag{11}$$

Step 5: Calculation of criterion weights.

The final weights of the criteria are computed by equation 12.

$$\omega_j = \frac{\mathcal{P}_j}{\sum_{j=1}^{n} \mathcal{P}_j} \tag{12}$$

2.3. LOPCOW Method

Step 1: Construction of initial decision matrix.

The initial decision matrix is constructed by equation 13 where m represents the number of alternatives and n represents the number of criterion.

$$X_{ij} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \vdots & \vdots & \dots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \tag{13}$$

Step 2: Normalization of initial decision matrix.

Initial decision matrix is normalized in linear form by equation 14 or 15 according to the type of criterion.

$$r_{ij} = \frac{x_{ij} - \min_j x_{ij}}{\max_j x_{ij} - \min_j x_{ij}};\, for\ benefit\ criterion \tag{14}$$

$$r_{ij} = \frac{\max_j x_{ij} - x_{ij}}{\max_j x_{ij} - \min_j x_{ij}};\, for\ cost\ criterion \tag{15}$$

Step 3: Calculation of percentage values for each criterion. Calculation of Percentage Values for each criterion is realised by means of equation 16 where б represents standard deviation.

$$\mathcal{PV}_j = \left| \ln \left(\frac{\sqrt{\frac{\sum_{i=1}^{m} r_{ij}^2}{m}}}{б} \right) * 100 \right| \tag{16}$$

Step 4: Calculation of criterion weights.

The final weights of the criteria are computed by equation 17.

$$\omega_j = \frac{\mathcal{PV}_j}{\sum_{j=1}^{n} \mathcal{PV}_j} \tag{17}$$

2.4. Bonferroni Mean Operator

Bonferroni Mean Operator, which aims to generate a compromise solution for criterion weights obtained by different methods, is implemented by equation 18 (Bonferroni, 1950).

$$BM^{r,s}(x_1, x_2, \dots, x_n) = \left[\frac{1}{n(n-1)} \sum_{i,j=1}^{n} x_i^r x_j^s\right]^{\frac{1}{r+s}};\ i \neq j \tag{18}$$

The parameter n indicates the number of methods employed and $r \geq 0, s \geq 0$ represent the parameters of stabilization.

2.5. MUTRISS Method

Step 1: Construction of initial decision matrix.

The initial decision matrix is constructed by equation 19 where m represents the number of alternatives and n represents the number of criterion.

$$X_{ij} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \vdots & \vdots & \dots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \tag{19}$$

Step 2: Normalization of initial decision matrix.

Initial decision matrix is normalized in linear form by equations 20 or 21 according to the type of criterion.

$$r_{ij} = \frac{x_{ij}}{\max_j x_{ij}};\, for\ benefit\ criterion \tag{20}$$

$$r_{ij} = \frac{\min_j x_{ij}}{x_{ij}};\, for\ cost\ criterion \tag{21}$$

Step 3: Weighting the normalized initial decision matrix.

The normalized initial decision matrix is weighted by equation 22.

$$W_{ij} = \omega_j . r_{ij} \tag{22}$$

Step 4: Calculation of overall scores for alternatives.

The overall score of each alternative is calculated by equation 23 based on the area it occupies on its own polygon.

$$A_i = \left[\left(\sum_{j=1}^{n} W_{ij} * W_{i(j+1)}\right) + (W_1 * W_n)\right] * sin\left(\frac{360}{n} * 0{,}5\right);\ j + 1 \leq n \tag{23}$$

The alternative with the greatest area will be assigned the primary position.

2.6. Sensitivity Analysis

The sensitivity analysis for the employed multi-criteria decision-making method was conducted utilizing equation 24 across 50 distinct scenarios, wherein the weight of the most significant criterion was systematically diminished by 1% and subsequently by 2% (Pamucar et al., 2021).

$$w_n : (1 - w_D) = w_n^* : (1 - w_D^*) \tag{24}$$

In the equation, w_D represents the original weight of the most dominant criterion, w_D^* denotes the adjusted weight of the most dominant criterion, w_n signifies the original weight of the nth criterion, and w_n^* indicates the adjusted weight of the nth criterion. The alternating order of G7 countries will be restructured based on the A_i values derived from each revised criterion weight.

Introducing new alternatives to the previously ranked options or producing new results by systematically eliminating alternatives from the bottom of the ranking, is another sensitivity analysis method acknowledged in the literature (Žižović et al., 2020).

In addition to the these sensitivity analysis conducted, a comparative analysis was performed utilizing the ranking results obtained from the ARAS (Zavadskas and Turskis, 2010), MAUT (Keeney et al., 1979), WEDBA (Rao et al., 2012), CODAS (Keshavarz-Ghorabaee et al., 2016), and EDAS (Ghorabaee et al., 2015) methods.

3. Results

The initial decision matrix for the MaxC, MPSI, and LOPCOW methods utilized in the criteria weighting, as well as the MUTRISS method employed in the ranking of alternatives, was established through Equations (1), (7), (13), and (19). The pertinent data pertaining to the G7 countries, considered as alternatives, alongside the OECD technology domains serving as criteria, are summarized in Table 1. Equations (1) through (17) were employed for the MaxC, MPSI, and LOPCOW objective criterion weighting methods, respectively. Table 2 presents the results of the criterion weights derived from these three methodologies. Exemplary calculations conducted during the implementation of these three objective criteria weighting methods are presented as follows.

Table 1. Initial decision matrix

	BT	ICT	NT	TRAI	MT	PHR	ENV	CCAT	SOE
Canada	20764	91942	2351	5526	20388	21464	30871	4111	877
France	31792	106557	4298	4030	28042	32327	60440	6090	1637
Germany	55290	198499	7229	9051	81200	55224	159813	12039	2166
Italy	10807	26583	1086	1064	16798	17389	23548	2541	617
Japan	75357	771955	24316	32737	116889	63009	286429	12216	3132
UK	33977	109550	3558	6491	37707	39171	45482	6279	1867
USA	426326	1643783	55448	111051	577736	424210	475457	70517	9864

Table 2. Results of the criterion weights derived from three methods

	ω_1	ω_2	ω_3	ω_4	ω_5	ω_6	ω_7	ω_8	ω_9
MAXC	0.1273	0.1037	0.1054	0.1278	0.1288	0.1269	0.0742	0.1193	0.0867
MPSI	0.1098	0.1191	0.1168	0.1159	0.1117	0.1088	0.1161	0.1069	0.0949
LOPCOW	0.0799	0.1339	0.1277	0.0937	0.0697	0.0602	0.1917	0.0845	0.1586

MaxC Method:

$$r_{11} = \frac{20{,}764}{20{,}764 + \cdots + 426{,}326} = 0.0317$$

$$r_1^* = \max(0.0317, \ldots, 0.6516) = 0.6516$$

$$d_{11} = 0.6516 - 0.0317 = 0.6198$$

$$E_1 = \frac{0.6198 + \cdots + 0.000}{7} = 0.5087$$

$$\omega_1 = \frac{0.5087}{0.5087 + \cdots + 0.3465} = 0.1273$$

MPSI Method:

$$r_{11} = \frac{20{,}764}{426{,}326} = 0.0487$$

$$\vartheta_1 = \frac{0.0487 + \cdots + 1.000}{7} = 0.2193$$

$$\mathcal{P}_1 = (0.0487 - 0.2193)^2 + \cdots + (1.000 - 0.2193)^2 = 0.7265$$

$$\omega_1 = \frac{0.7265}{0.7265 + \cdots + 0.6275} = 0.1098$$

LOPCOW Method:

$$r_{11} = \frac{20{,}764 - 10{,}807}{426{,}326 - 10{,}807} = 0{,}0240$$

$$\mathcal{PV}_1 = \left| \ln\left(\frac{\sqrt{\frac{0.0240^2 + \cdots + 1.000^2}{7}}}{\sqrt{\frac{(0.0240 - 0.1989)^2 + \cdots . + (1.000 - 0.1989)^2}{7-1}}} \right) * 100 \right| = 7.7506$$

$$\omega_1 = \frac{7.7506}{7.7506 + \cdots + 15.3834} = 0.0799$$

Bonferroni Mean Operator:

Utilizing the Bonferroni Mean Operator, as delineated in equation 18), a compromise solution was derived from the results generated by all three objective criteria weighting methods as $\omega_1 = 0.1048$, $\omega_2 = 0.1186$, $\omega_3 = 0.1165$, $\omega_4 = 0.1120$, $\omega_5 = 0.1019$, $\omega_6 = 0.0966$, $\omega_7 = 0.1226$, $\omega_8 = 0.1031$ and $\omega_9 = 0.1111$.

An exemplary application of the Bonferroni Mean Operator for the first criterion is as follows;

$$\omega_1 = \left[\frac{1}{3(3-1)} . (0.1273 * 0.1098 + 0.1273 * 0.0799 + \cdots + 0.0799 * 0.1273 + 0.0799 * 0.1098\right]^{\frac{1}{1+1}} = 0.1048$$

These compromised criterion weights obtained with

Bonferroni Mean Operator demonstrate that, although there is no significant difference among them, their order of importance is as $\omega_7 > \omega_2 > \omega_3 > \omega_4 > \omega_9 > \omega_1 > \omega_8 > \omega_5 > \omega_6$.

MUTRISS Method:

The initial decision matrix utilized during the weighting of criteria, as presented in Table 1, was employed similarly in the MUTRISS method for ranking the G7 countries. This initial decision matrix was normalized using equation 20, and subsequently weighted according to equation 22. In the final stage of the methodology, the overall score for each alternative presented in Table 3 was computed using equation 23.

Table 3. Overall scores and orders of G7 countries

Country	Overall Score	Order
Canada	0,0001055	6
France	0,0002521	5
Germany	0,0009210	3
Italy	0,0000378	7
Japan	0,0032781	2
UK	0,0002756	4
USA	0,0347445	1

Exemplary calculations performed at each step of the MUTRISS method utilized in the patent success rankings of G7 countries are presented as follows.

$$r_{11} = \frac{20,764}{426,326} = 0.0487$$

$$W_{11} = 0.1048 * 0.0487 = 0.0051$$

$$A_1 = [(0.0051 * 0.0066 + 0.0066 * 0.0049 + \cdots + 0.0060 * 0.0099) + (0.0051 * 0.0099)] * sin\left(\frac{360}{9} * 0,5\right) = 0.0001055$$

These overall score values represent the area of the resulting polygon for each G7 country, and the corresponding polygons are visualized as follows in Figure 2.

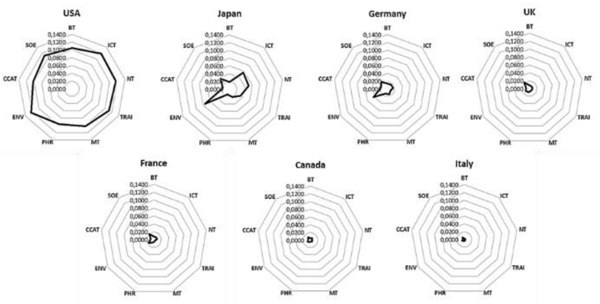

Figure 2. Areas of each polygons.

According to the results of the sorting operation carried out with the MUTRISS method, the success orders of G7 countries in terms of patent applications were emerged as the USA, Japan, Germany, the UK, France, Canada, and Italy.

The robustness of the ranking derived from the application of the MUTRISS method is corroborated by the sensitivity analysis conducted utilizing equation 24). In this methodology, the weight assigned to the criterion with the highest value was progressively diminished, while concurrently, the weights of the other criteria were correspondingly augmented. Criteria weights have been modified across fifty distinct scenarios, and this variation is illustrated in Figure 3.

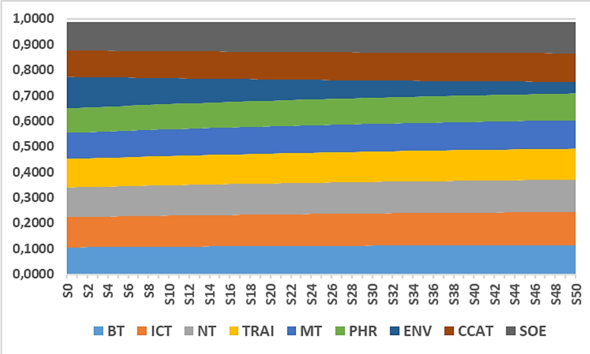

Figure 3. Observed changes in criterion weights.

In conjunction with the alteration in criterion weights, the observed changes in the ranking of G7 countries are illustrated in Figure 4.

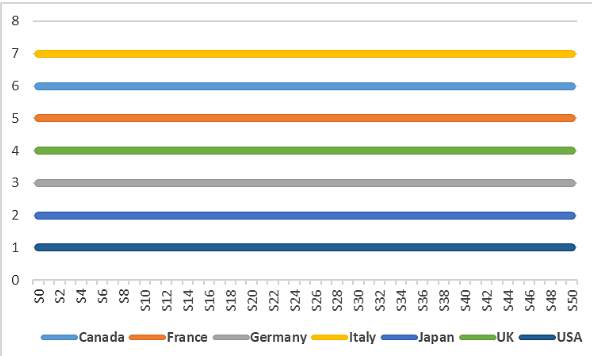

Figure 4. Observed changes in the order of G7 countries

Figure 4 illustates that the alterations in the criteria weights did not influence the ranking of the G7 countries. The newly derived rankings, which were obtained by sequentially excluding the lowest-performing countries from the alternatives, are illustrated in Figure 5.

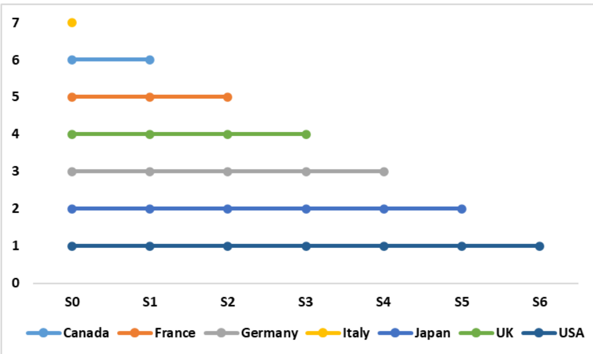

Figure 5. Resilience of the method to the rank reversal problem.

Figure 5 illustrates that the implemented method exhibits considerable resilience to the rank reversal problem. Furthermore, the analysis conducted using the ARAS, MAUT, WEDBA, CODAS, and EDAS methods, by employing identical criteria weights, yielded results consistent with those obtained through the MUTRISS method. The results are illustrated in Figure 6.

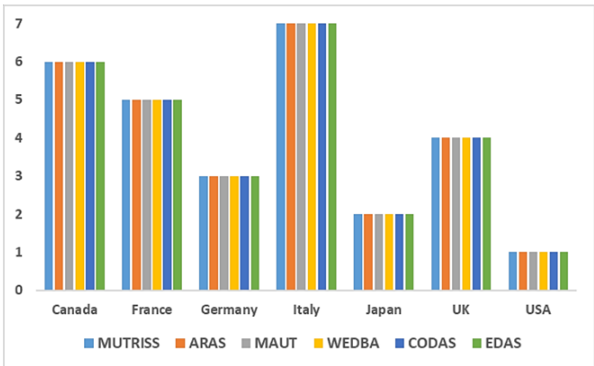

Figure 6. Comparison with other MCDM methods.

4. Discussion

In this research, the publications presented within the scope of the literature review, were analysed from two distinct perspectives: the analyses grounded in the patent data of G7 countries, and the methodological approaches employed in the study. To analyse and compare the civil remedies available for patent infringement across the G7 countries, Coury (2003) conducted a study that focused on injunctions, damages, descriptions and seizures, and criminal penalties. In their study, Archibugi and Filippetti (2010) offer significant insights regarding patent and broader intellectual property rights policies in G7 countries, cautioning against an excessive focus on intellectual property rights protection and underscoring the necessity for more comprehensive innovation and competitiveness policies. Investigating the dynamic relationship between the increase in the number of patents and GDP growth in G7 economies, Josheski and Koteski (2011) demonstrated a positive long-run association between quarterly increases in patents and quarterly GDP growth, employing the Autoregressive Distributed Lag (ARDL) model. By analysing the patent distributions in OECD countries, including the G7 nations, O'Neale and Hendy (2012) suggested that the distribution of patents generally adheres to a power law across nations, with variations that offer insights into the innovation ecosystems of each country. Kurt et al. (2018) conducted an analysis of the variables influencing patent output in G7 countries using panel data econometric techniques where the findings identified the key determinants as the share of R&D expenditures in GDP, GDP per capita, and the number of researchers, respectively. In their study, Çütçü and Bozan (2019) sought to ascertain the relationship between innovation and economic growth through panel data analysis, specifically examining Research and Development (R&D) expenditures and patent applications in G7 countries. The findings of their analyses indicated the presence of a long-run relationship between innovation and economic growth. Stolpe (2022) conducted a study advocating for the G7 countries to initiate patent buyouts as a means of ensuring equitable access to COVID-19 vaccines, both domestically and internationally among G7 nations. To investigate the relationship between innovation indicators and the international trade performance of G7 countries, Aktaş (2022) incorporated variables such as the number of patent applications in the analysis. A comprehensive summary of the literature regarding the methods employed in multi-criteria decision-making problems, which are also incorporated in this study, is presented in Table 4.

Table 4. Similar studies pertaining to the methodologies employed in this research

Method	Author	Subject
MaxC	Z. Gligorić et al. (2024)	Deep learning software selection
MPSI	M. Gligorić et al. (2022)	Support system selection
	Çelebi Demirarslan et al. (2024)	Ranking the quality of life indices by year in Asian countries
	Kara et al. (2024)	Benchmarking the supply chain performance of countries
	Biswas et al. (2024)	Comparing online shopping platforms
	Araujo et al. (2024)	Selection of SUV vehicles
	Torres et al. (2024)	Selection of unmanned aerial vehicle systems
LOPCOW	Ecer & Pamucar (2022)	Determination of corporate sustainability performances
	Rong et al. (2023)	Risk assessment of R&D projects
	Chatterjee et al. (2024)	Selection of collaborative robots
	Setiawansyah & Sulistiyawati (2024)	Selection of right tutor
	Dhruva et al. (2024)	Selection of suitable cloud vendors for health centre
	Sumanto et al. (2024)	Supplier selection in supply chain management
	Setiawan & Pasaribu (2024)	Selection of indoor working space
	Lukic (2024)	Performance positioning of trade in Serbia
	Pramuditya et al. (2024)	Selection of sports equipment suppliers
MUTRISS	Zakeri et al. (2023)	Material selection

While there exists a range of publications focusing on patent-related econometric analyses of G7 countries, the primary contribution of this study to the literature lies in the novel approach of addressing this issue as a multi-criteria decision-making problem for the first time. Furthermore, the establishment of consensus criteria weights through the integration of objective criteria weighting methods, including MaxC, MPSI, and LOPCOW, is regarded as a supplementary contribution. In future research, it is advisable to incorporate complementary indicators such as patent citation rates, R&D expenditures, the number of R&D personnel, and innovation outputs within specific sectors to enrich the analyses. Expanding the scope beyond the G7 countries to include emerging economies could yield a more comprehensive understanding of global innovation dynamics. The findings of this research offer meaningful observations regarding the G7 nations patent application performance, evaluated through the MUTRISS approach. The analysis revealed the success order of the G7 nations as follows: the USA, Japan, Germany, the UK, France, Canada, and Italy. The discrepancies in innovation capabilities, research and development funding, and intellectual property generation among the leading economies are underscored by this ranking. The dominant position of the United States in the ranking underscores its robust innovation ecosystem, which is bolstered by substantial investments in R&D activities, highly skilled labour force, and well-established legal and financial frameworks for patent protection. Similarly, Japan's second-place ranking reflects its strong emphasis on technological advancements, particularly in fields such as electronics, robotics, and automotive engineering. Germany, ranking third, exemplifies the strength of its industrial base and commitment to engineering excellence, particularly in sectors such as machinery and automotive technologies.

On the other hand, nations such as the United Kingdom and France, despite their commendable performance, are somewhat eclipsed by the leading three countries. Their rankings may be indicative of divergent national priorities, including an emphasis on service-oriented economies or other domains of innovation that are not entirely encapsulated by patent application metrics. In contrast, Canada and Italy, situated in the lower rankings, may have encountered challenges such as constrained research and development budgets, reduced rates of industrial innovation, or obstacles in translating research outputs into intellectual property. Therefore, strategies aimed at enhancing investment in R&D activities, fostering collaboration between universities and industry, and providing incentives for businesses to innovate may significantly contribute to increasing patent outputs. Furthermore, improving access to funding for start-ups and small enterprises, streamlining the patent application process, and investing in education and training programs to cultivate a skilled workforce in critical innovation sectors represent additional effective approaches. By implementing these targeted initiatives, policymakers can endeavour to strengthen their nations' innovation ecosystems, thereby driving economic growth and enhancing global competitiveness. While the MUTRISS method offers a comprehensive framework for ranking G7 countries, it is crucial to acknowledge the limitations inherent in this study. The dependence on patent application data exclusively may result in the oversight of other significant dimensions of innovation, including quality, commercialization success, and socio-economic impact. Furthermore, external factors such as global economic fluctuations, trade policies, and cultural attitudes toward innovation may affect patent activity which are not encompassed within the scope of this analysis.

5. Conclusion

This study contributes to the understanding of comparative patent performance, providing valuable insights for policymakers and stakeholders seeking to strengthen national innovation ecosystems. The findings highlight the varying degrees of innovation efficiency among G7 nations, suggesting that policy interventions tailored to enhancing patent quality, fostering R&D collaboration, and improving technology transfer could assist lower-ranked countries in bridging the gap. Furthermore, the study underscores the role of patents as a critical driver of technological advancement and economic competitiveness.

Author Contributions

The percentages of the author' contributions are presented below. The author reviewed and approved the final version of the manuscript.

	S.D.
C	100
D	100
S	100
DCP	100
DAI	100
L	100
W	100
CR	100
SR	100
PM	100
FA	100

C=Concept, D= design, S= supervision, DCP= data collection and/or processing, DAI= data analysis and/or interpretation, L= literature search, W= writing, CR= critical review, SR= submission and revision, PM= project management, FA= funding acquisition.

Conflict of Interest

The authors declared that there is no conflict of interest.

Ethical Consideration

Ethics committee approval was not required for this study because of there was no study on animals or humans.

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