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A DATA-DRIVEN MULTI-CRITERIA DECISION SUPPORT MODEL FOR ANALYZING SCIENTIFIC DEVELOPMENT OF OECD COUNTRIES

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Abstract: *In the global science ecosystem, countries' academic outputs are a key determinant of their strategic development level. The aim of this study is to examine the development dynamics of higher education systems over a period of approximately thirty years using integrated decision analytics. The scientific dynamics of OECD countries between 1996 and 2024 were analyzed using integrated LODECI and RAWEC methods based on the SCIMAGO database. The study compares long-term trends with current data from 2024 from a comparative perspective. The criterion weighting analysis conducted with LODECI determined that the Citations criterion is the most important determinant of academic competitiveness. This finding shows that the positioning of higher education institutions at the national and international levels is shaped in the context of scientific impact and productivity, beyond mere quantity. Countries were ranked according to their performance by integrating the weights into the RAWEC method. This study, which synthesizes innovative MCDM methods with long-term data, offers a unique methodological framework for analyzing countries' scientific development.*
Keywords: *MCDM, LODECI, RAWEC, Global Science Ecosystem, OECD.*

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1. Introduction

The production, application, and sharing of scientific knowledge, along with the impact it creates on a global scale, has become an important measure of countries' intellectual and technological dominance in today's world. The evaluation of scientific outputs in terms of quality and quantity has become a critical area of analysis that determines countries' innovation capacities and future strategic positions, going beyond academic endeavors. In this context, measuring scientific productivity from a multidimensional perspective is directly linked to sustainable development goals and the vision of a knowledge-based economy.

Universities, which form the basis of the higher education system, are strategic actors in the production, dissemination, and transformation of knowledge into social benefit, in addition to preparing individuals for professional life and ensuring social transformation. Therefore, academic studies produced within universities are concrete indicators of knowledge-based

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development, along with academic competitiveness. Academic publications, described as the most fundamental outputs of scientific production, are evaluated in a multidimensional manner, both quantitatively and qualitatively, based on factors such as the number of publications, the number of citations, contribution to the field, and impact factor. However, the analysis of this complex and multi-variable structure should be evaluated within a systematic and verifiable framework, free from subjective judgments. At this point, multi-criteria decision-making (MCDM) models provide a strong methodological infrastructure for the objective measurement of scientific performance (Belton & Stewart, 2002; Zavadskas & Turskis, 2011).

Today, the institutional quality and academic success of higher education institutions are largely associated with their research performance (Maral, 2024). Various ranking systems that measure scientific contribution in higher education, such as SCIMAGO, URAP, NTU, and Leiden, embody the competitive nature of the academic ecosystem (Lukic & Tumbas, 2019). These platforms generally measure and rank scientific indicators such as publication quantity and citation counts, evaluating the measurement indicators in a single composite score. Among these systems, Scimago Journal Rank (SCJR) stands out as a platform that provides scientific indicators based on data from the Scopus database. With data from 239 countries covering more than 34,100 titles, the platform offers the opportunity to compare and analyze countries in terms of academic performance and provides innovative solutions to improve scientific visibility and knowledge management (https://www.scimagojr.com/aboutus.php). The main objective of this study is to analyze the scientific publication production capacities of OECD countries using SCIMITAR methods. Based on data provided by SCJR covering the years 1996-2024, OECD countries are evaluated over a period of approximately thirty years in terms of document numbers, citable documents, citations, self-citations, citations per document, and h-index parameters. Furthermore, the study aims to identify the current status within the existing scientific hierarchy based on the 2024 data. The primary motivation of the study is to seek a data-driven analytical answer to the question: "Which is more decisive on the global scientific stage: the accumulation of the past or the momentum of the present?".

The presence of outliers in scientific measurement data and the complex interactions between criteria necessitate a methodologically robust and stable ranking approach. In this context, the LODECI-RAWEC method, which considers criterion interactions in the criterion weighting process, was preferred. The criteria weights obtained were integrated into the RAWEC MCDM method to rank OECD countries according to their academic performance. This integrated LODECI-RAWEC model provides an objective and systematic evaluation framework that is unaffected by changes in the data.

This study consists of four sections, ranging from the establishment of the theoretical basis to the application and evaluation stages. Following the introduction, the literature review section systematically examines the LODECI and RAWEC methods in the MCDM literature, academic performance processes, and global university rankings with SCIMAGO. This section outlines the study's contribution to the literature and the theoretical framework within which it was conducted. The methods section details the implementation stages of the LODECI and RAWEC MCDM methods, which form the backbone of the study. The next section, which examines OECD countries using data from the SCIMAGO database, is followed by the results and discussion section.

2. Literature review

Numerous studies in the literature have focused on the issue of measuring scientific productivity. Dill & Soo (2005) conducted a comparative analysis of university rankings in Australia, Canada, the United Kingdom, and the United States and concluded that these countries

are similar in terms of academic quality. According to the results of a study on the components of academic performance, a positive relationship was found between research quality and teaching quality (Cadez et al., 2017). An analysis of 50 Latin American universities based on data from the Shanghai Ranking, QS World University Ranking, SCIMAGO, and Web Ranking of Universities-Webometrics placed Brazil in the leading position (Torres-Samuel et al., 2018). Forty-eight Turkish universities were examined using DEA (data envelopment analysis) with URAP and TUBITAK input-output data, and a structural inefficiency was observed in the capacity of universities to transform the results of their academic work into real-life socio-economic applications (Kızılaslan et al., 2026).

Multi-criteria decision-making (MCDM) methods are one of the most important areas of operations research and are growing rapidly. This rapid development continues with numerous methods such as AHP, TOPSIS, TODIM, MOORA, SWARA, EDAS, and others (Stanujkic et al., 2017). MCA methods produce more precise, objective, and reliable results compared to traditional methods, thanks to their criterion weighting mechanisms and hierarchical ranking capabilities. In a study where criteria affecting the quality of e-learning materials were identified using the PIPRECIA method, learning materials were found to be the most important criterion (Jocić et al., 2020). The SWARA method was used as an effective tool in determining personnel selection criteria (Popović et al., 2021). SWARA methods, which can be used to determine criterion weights, have been the subject of many applications in various fields. In the personnel evaluation process, DELPHI and SWARA were used (Karabasevic et al., 2017).

The nature and multidimensionality of scientific measurement necessitates the evaluation of this process using MCDM approaches (Keenan, 2024; Maral, 2024; Kurniadi et al., 2026). AHP methods produce more accurate, objective, and reliable results compared to traditional methods due to their criterion weighting mechanisms and hierarchical ranking capabilities. The literature shows an increasing frequency of use of AHP techniques in the evaluation of higher education institutions. Gül & Yücesan (2022) evaluated the performance of 189 Turkish universities using the BMW-TOPSIS method with TUBİTAK institutional indicators. Ayyıldız et al. (2023) evaluated universities using a student perspective-focused hierarchical clustering analysis by integrating the IVN-AHP and VIKOR methods. In a study comparing the SAW technique used in the QS World ranking with the TOPSIS MCDM method, it was found that methodological differences led to significant variations in the ranking (Vrat, 2026). Dündar et al. (2024) examined 19 G20 countries using the Fuzzy SWARA and CODAS methods within the framework of SCIMAGO journal and country rank 1996-2022 data and ranked the top five countries. Şimşek (2024) evaluated the university ranking based on URAP data using the LOPCOW-RAWEC methods and made recommendations to stakeholders. Kahreman (2024) analyzed the G8 countries using the LOPCOW-ARLON methods and concluded that the countries' governance performance and happiness performance were very close to each other.

In the literature review conducted using the LODECI and RAWEC methods, which are the analysis methods of the study, it was observed that these methods were used in a limited number of studies. Pala et al. (2024) weighted the financial indicators of companies operating in the cement sector using LODECI and evaluated their performance using CRADIS. Macit (2025) evaluated G20 countries in terms of climate change performance using the LODECI, SWI, and RAWEC methods. LODECI-ARLON (Demirhan et al., 2025) was used to evaluate the performance of commercial banks traded on BIST, LODECI-CORASO (Tufan & Ulutaş, 2026) was used for supplier selection in the food sector, and LODECI-MAXC-DEPART methods were used to analyze wall coverings for energy-efficient buildings. (Balo et al., 2025), and the integrated use of LODECI-REF methods in the selection of rechargeable upright vacuum cleaners (Orakçı, 2025) are examples of research conducted using the LODECI method.

The RAWEC method has found application in different disciplines in the literature for optimizing multi-criteria decision-making methods. The integrated use of LWAW and RAWEC methods in the selection of distribution centers (Puška et al. 2024), analyzing sustainable development performance through the integration of SIWEC-M and RAWEC methods (Ulutaş & Demirbaş, 2025), and applying LOPCOW-RAWEC methods in evaluating the top ten universities in Vietnam (Do, 2024) are recent studies that confirm the effectiveness of the method. Furthermore, the inclusion of SIWEC-RAWEC methods in macro-scale decision problems such as railway infrastructure planning (Badi et al., 2026) demonstrates that the method produces consistent results in complex processes.

As seen in the literature review, the LODECI and RAWEC methods are newly developed methods with limited use in the literature. The LODECI method enables the effective analysis of contrasts between different criteria and ensures that weights are determined in a balanced and consistent manner (Demirhan et al., 2025). The RAWEC method, on the other hand, offers computational ease in complex decision problems and provides decision-makers with the advantage of ranking within a rational hierarchy. In a comprehensive systematic literature review of the SCIMAGO database, no study was found that addressed the LODECI and RAWEC methods with an integrated approach. In this context, the present study aims to contribute to the literature by offering methodological diversity as well as a unique and innovative perspective on decision-making processes. The size of the charts, images, schemes and attachments should be customized to fit the page's format and margins. The same applies to the size of the fonts in the table, so that they can clearly and completely appear on one page. Breaks are not allowed.

3. Methodology

This section details the LODECI and RAWEC MCDM methods and the application stages of these methods.

3.1. LODECI

The LODECI method, a reconciling approach between the Entropy and MEREC MCDM methods, was introduced to the literature by Pala in 2024. The steps of the method are presented in Table 1.

Table 1. LODECI method implementation steps

Step	Process/formulation		Process description
1	$X=\left[x_{ij}\right]_{nxm}$	(1)	*An initial decision matrix is created.*
2	$b_{ij}=\frac{x_{ij}}{\max(x_{ij})}$, j benefit $b_{ij}=1-\frac{x_{ij}}{\max(x_{ij})}$, j cost	(2)	*The decision matrix is normalized according to the criterion structure using Equation (2).*
3	$SD_{ij}=max\{\left\|b_{ij}-b_{rj}\right\|\}r\neq i$	(3)	*The deviation values of the normalized values are calculated using Equation (3).*
4	$LSD_j=ln(1+\frac{\sum_{i=1}^{m}SD_{ij}}{m})$	(4)	*The logarithmic deviation value is calculated for each*

			criterion using Equation (4).
5	$w_j = \frac{LSD_j}{\sum_{i=1}^{n} LSD_j}$	(5)	*The criterion weights are calculated using Equation (5).*

3.2. RAWEC

The steps of the method proposed by Puška et al. (2024) for ranking alternatives are presented in Table 2.

Table 2. RAWEC method implementation steps

Step	Process/formulation		Process description
1	$X = \begin{matrix} A_1 \\ A_2 \\ A_3 \\ . \\ A_4 \end{matrix} \begin{bmatrix} C_1 & C_2 & \dots & C_n \\ x_{11} & x_{12} & \dots & x_{1n} \\ x_{11} & x_{22} & \dots & x_{2n} \\ . & . & . & . \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix}$	(6)	*An initial decision matrix is created.*
2	$n_{ij} = \frac{x_{ij}}{x_j max}$, $n_{ij}' = \frac{x_j\, min}{x_{ij}}$ $(benefit\ criterion)$ $n_{ij} = \frac{x_j min}{x_{ij}}$, $n_{ij}' = \frac{x_{ij}}{x_j max}$ $(cost\ criterion)$	(7)	*The decision matrix is doubly normalized according to the criterion structure using Equation (7).*
3	$v_{ij} = \sum_{i=1}^{n} w_j . (1 - n_{ij})$ $v_{ij}' = \sum_{i=1}^{n} w_j . (1 - n_{ij}')$	(8) (9)	*Deviations from the criterion weights are calculated using Equations (8-9).*
4	$Q_i = \frac{v_{ij}' - v_{ij}}{v_{ij}' + v_{ij}}$	(10)	*The value of the RAWEC method $(Q)_i$ is calculated.*

4. Analysis of OECD countries using the LODECI-RAWEC integrated approach

This study analyzes data from SCIMAGO using indicators such as documents, citable documents, citations, self-citations, citations per document, and h-index, as well as multi-criteria decision-making methods like LODECI and RAWEC. The first stage of the study measures the long-term scientific stability and academic performance of 38 OECD member countries (United States, United Kingdom, Germany, Japan, France, Italy, Canada, Australia, Spain, South Korea, Netherlands, Switzerland, Poland, Turkey, Sweden, Belgium, Denmark, Austria, Israel, Portugal, Mexico, Norway, Czech Republic, Finland, Greece, New Zealand, Ireland, Hungary, Chile, Colombia, Slovakia, Slovenia, Lithuania, Estonia, Latvia, Luxembourg, Iceland, and Costa Rica) using cumulative data covering the period 1994-2024. The second stage evaluates current competitiveness based on updated data from 2024 and examines the discrepancies between these two time periods. The criteria used in the analysis, their corresponding codes, and the optimization aspects of these criteria are presented in Table 3.

Table 3. Criteria, codes, and specifications

Criterion name	Criterion code	Definition	Optimization direction
Documents	CR1	Total number of published scientific documents	Benefit
Citable documents	CR2	Number of documents eligible for citation	Benefit
Citations	CR3	Total number of citations received	Benefit
Self-citations	CR4	Citations made by authors to their own work	Cost
Citations per document	CR5	Average number of citations per document	Benefit
H-index	CR6	Index showing the scientific productivity and impact of the country	Benefit

The initial decision matrix for the LODECI and RAWEC methods, created based on data from the SCIMAGO database covering the period 1994-2024, is presented in Table 4.

Table 4. Initial decision matrix (1996-2024)

Countries	Criteria					
	CR1	**CR2**	**CR3**	**CR4**	**CR5**	**CR6**
United States	16963549	14617353	564191398	226496389	33.26	3213
United Kingdom	5089262	4196657	158900978	31829276	31.22	2048
Germany	4328107	3931535	121470423	25987033	28.07	1797
Japan	3629428	3442416	76400180	17329253	21.05	1364
France	2919925	2677893	82008442	14588890	28.09	1604
Italy	2699911	2417621	68905437	14692274	25.52	1416
Canada	2575484	2275692	82451695	12443100	32.01	1659
Australia	2146519	1865552	65188977	11200952	30.37	1475
Spain	2119444	1935060	52225630	9921493	24.64	1303
South Korea	1717334	1660476	35304573	5800194	20.56	1004
Netherlands	1425877	1268424	53669901	6821752	37.64	1471
Switzerland	1064762	959406	40611905	4403706	38.14	1369
Poland	1031691	974258	15898395	3341450	15.41	792
Turkey	1005684	929722	15238939	2945992	15.15	647
Sweden	963743	877676	33527896	4064825	34.79	1232
Belgium	784825	708472	25838558	2702915	32.92	1134
Denmark	610489	548995	22339602	2500563	36.59	1081
Austria	594548	533998	17342330	1813045	29.17	937
Israel	543249	489626	17125142	1873165	31.52	962
Portugal	526180	474462	11887422	1689698	22.59	739
Mexico	520267	481535	8841868	1534261	16.99	641
Norway	498787	443666	14946021	1809261	29.96	896
Czech Republic	498062	474100	8643140	1453179	17.35	667
Finland	495887	452432	15592944	1846816	31.44	897
Greece	477663	427176	11486617	1426059	24.05	725
New Zealand	362719	315819	10661993	1201090	29.39	758
Ireland	334451	287951	9500687	834943	28.41	753
Hungary	287398	268428	6244226	787907	21.73	630

Chile	267237	250831	5451459	913551	20.4	555
Colombia	207998	194304	2936446	421956	14.12	436
Slovakia	173411	166065	2456922	395081	14.17	381
Slovenia	145561	136137	2975355	358200	20.44	439
Lithuania	86402	82048	1365275	184474	15.8	319
Estonia	67734	62475	1818642	198515	26.85	412
Latvia	44458	42192	643948	75432	14.48	243
Luxembourg	38619	34167	914564	63025	23.68	300
Iceland	35323	31396	1364173	103576	38.62	415
Costa Rica	23464	21550	550621	47131	23.47	252

The initial decision matrix was normalized using Equation (2) of the LODECI method. The deviation values of the normalized values were determined using Equation (3). In the next step, the logarithmic deviation values were obtained using Equation (4). The criterion weights were calculated using Equation (5) and these values are presented in Table 5.

Table 5. LODECI method criterion weights (1996-2024)

	Criteria					
	CR1	**CR2**	**CR3**	**CR4**	**CR5**	**CR6**
$\mathbf{SD_{ij}}$	0.6613	0.6599	0.6671	0.6597	0.3911	0.5469
$\mathbf{LSD_j}$	0.1844	0.1840	0.1860	0.1840	0.1091	0.1525
$\mathbf{w_j}$	0.6613	0.6599	0.6671	0.6597	0.3911	0.5469

When the criterion weights obtained using the LODECI method are examined, the Citations (CR3) criterion (0.6671) stands out as the criterion with the highest weight. This finding shows that the Citations criterion is the most decisive parameter in determining the scientific achievement levels of countries. According to the weight results, the Documents criterion (CR1) ranks second with a value very close to the Citations criterion (0.6613). Citable documents (CR2; 0.6599) and Self-citations (CR4; 0.6597) criteria, which have very similar weight values, rank third and fourth. The H-index criterion (0.5469) ranks fifth. The Citations per document (CR5) criterion emerges as the criterion with the lowest weight value.

The fact that the Citations criterion has the highest weight reveals that the scientific performance of countries is largely evaluated through impact-based indicators. While a high number of publications alone is not a sufficient indicator, the fact that these publications are cited by other researchers globally reflects the level of knowledge dissemination and academic quality. The slightly higher weighting of the "Citable Documents" criterion compared to the "Documents" criterion indicates that publications with little citation potential are given lower importance in the evaluation of academic success. This shows that simply increasing the number of publications is not enough; the real determining factor for a country's scientific competitiveness is producing high-quality work with high citation potential. The high weighting of the "Self-citations" criterion, ranking fourth, reflects the balance between scientific continuity and ethical sensitivity. Self-citations reflect the accumulation and continuity of knowledge within a country's own academic output, but an excessive level of self-citations indicates limited international scientific interaction. The lower weightings of the H-index and "Citations per document" criteria show that these values are closer to each other across countries.

The visual distribution of criterion weightings obtained using the LODECI method for the period 1996-2024 is presented in Figure 1. When the radar graph is examined, it is seen that the Citations and Documents criteria have remained at the top of the hierarchy throughout the historical period of nearly thirty years, while the Citations per Document criterion is positioned

as the parameter closest to the center (lowest weighted) in the long-term cumulative evaluation. This situation methodologically proves that publication volume and total impact level have maintained their decisive role in the historical development of academic competitiveness; however, productivity ratios have a more limited discriminatory power in the long-term weighting model.

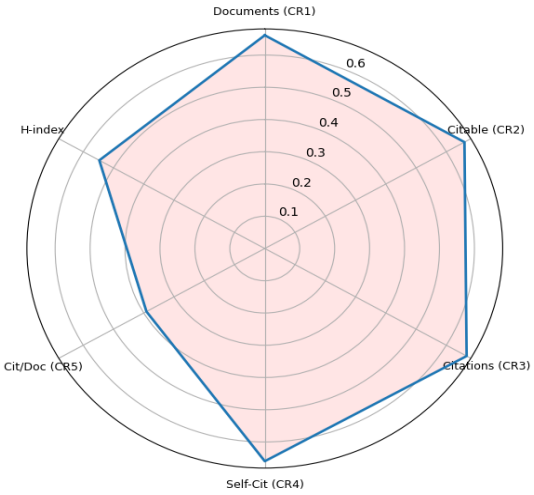

Figure 1. Radar graph of LODECI criterion weight distribution for the years 1996-2024
Source: Authors

The criterion weighting process carried out using the LODECI method reveals the fundamental dynamics determining the scientific performance of OECD countries. The findings show that academic outputs are not only quantitative but also have a primary impact on the international scientific community. In the next step of the study, the criterion weights obtained from the LODECI method were integrated into the RAWEC method, and OECD countries were ranked within the scope of SCIMAGO data. The initial decision matrix presented in Table 4 was doubly normalized with Equation (7). Deviation values from the weights were calculated with Equations (8-9), and finally, RAWEC values were calculated with Equation (10). Table 6 presents the initial results of the deviations from the criterion weights, the second results, RAWEC values, the rankings of 38 OECD countries according to their performance, and the SCIMAGO country rank.

Table 6. RAWEC method ranking results

Countries	v_{ij}	v'_{ij}	Q_i	Rank	SCIMAGO country rank
United States	0.199059	0.757497	0.583801	1	1
United Kingdom	0.653796	0.904287	0.160769	2	3
Germany	0.698499	0.900557	0.126361	3	4
Japan	0.767324	0.881913	0.06948	10	5
France	0.751445	0.906012	0.093255	5	7
Italy	0.77762	0.896821	0.071189	9	8
Canada	0.746324	0.914781	0.101413	4	9
Australia	0.775131	0.909357	0.079684	7	10
Spain	0.80307	0.894949	0.054109	12	11
South Korea	0.841572	0.875666	0.019854	18	13
Netherlands	0.773443	0.920283	0.086696	6	15
Switzerland	0.788297	0.918256	0.076153	8	16

Poland	0.88757	0.835852	-0.03001	24	17
Turkey	0.8959	0.823389	-0.04217	26	18
Sweden	0.808559	0.910289	0.059185	11	20
Belgium	0.824028	0.903269	0.045876	14	22
Denmark	0.820977	0.902702	0.047413	13	23
Austria	0.849461	0.885571	0.020813	17	24
Israel	0.842979	0.889051	0.0266	15	26
Portugal	0.880383	0.855109	-0.01456	23	27
Mexico	0.901309	0.82216	-0.04592	28	28
Norway	0.852135	0.8813	0.016825	19	30
Czech Republic	0.899144	0.825594	-0.04264	27	31
Finland	0.847713	0.884142	0.021035	16	32
Greece	0.877231	0.856432	-0.012	22	35
New Zealand	0.86237	0.86364	0.000736	20	40
Ireland	0.86325	0.858408	-0.00281	21	42
Hungary	0.889164	0.823431	-0.03838	25	46
Chile	0.898695	0.806201	-0.05425	29	47
Colombia	0.913206	0.729497	-0.11183	31	48
Slovakia	0.915168	0.703205	-0.13097	33	50
Slovenia	0.892957	0.746664	-0.08922	30	57
Lithuania	0.890817	0.612765	-0.18493	35	63
Estonia	0.858822	0.668848	-0.12436	32	68
Latvia	0.831406	0.390686	-0.36063	37	80
Luxembourg	0.780169	0.471268	-0.24684	36	84
Iceland	0.786302	0.546839	-0.17962	34	88
Costa Rica	0.737091	0.232817	-0.51992	38	96

The ranking results obtained using the RAWEC method reveal the academic productivity or qualitative impact of countries from a different perspective compared to SCIMAGO's standard ranking. In the analysis conducted specifically for 38 OECD countries, the United States maintained its academic dominance, ranking 1st in both rankings. The United Kingdom (UK) rose from 3rd in the SCIMAGO ranking to 2nd according to the results obtained from the LODECI-RAWEC methods. Although the UK lags behind China (ranked 2nd in the 1996-2024 rankings) and the US in terms of publication volume, it demonstrated superior performance in the H-index and citation/publication ratios weighted by the LODECI method. The country's citation rates, which are above the world average, highlight its impact and importance on global scientific dissemination rather than its inward-looking publishing practices. The use of objective weighting methods in performance evaluation in this study allowed for assessment under different weights, taking into account the distinctive level of each criterion within the data. When comparing the analysis results with the current results, it is seen that the top-ranked countries, the USA, UK, and Germany, have similar results to the current situation. This confirms that the academic output capacity of these countries is not based solely on quantitative size, but is also built on a qualitative, effective, and sustainable structure. Turkey, ranking 18th in the SCIMAGO standard ranking, exhibits a strong position among the top 20 countries globally. This shows that it is a strong actor in terms of academic production capacity. However, according to the analysis results obtained with the LODEC-RAWEC methods, Turkey has fallen to 28th place. This decline reveals that the quantitative size of the number of academic outputs does not correspond to the

same level in terms of global scientific impact and quality. In other words, the Turkish example proves that there is no linear relationship between the increase in the number of publications and the potential of these publications to shape the global literature. This result is a critical indicator that focusing solely on the number of publications in academic incentive and policy processes limits the qualitative development of the scientific ecosystem and its global competitiveness.
In this study, SCIMAGO country runk data were evaluated for both the years 1996-2024 and for the year 2024. Table 7 shows the initial matrix for 2024.

Table 7. Initial decision matrix (2024)

Countries	Criteria					
	CR1	CR2	CR3	CR4	CR5	CR6
United States	743884.00	636319.00	694392.00	272624.00	0.93	3213.00
United Kingdom	252604.00	211490.00	295326.00	68714.00	1.17	2048.00
Germany	206323.00	185893.00	214421.00	55661.00	1.04	1797.00
Japan	138991.00	129428.00	107928.00	27488.00	0.78	1364.00
France	125764.00	112837.00	131911.00	26277.00	1.05	1604.00
Italy	162794.00	144985.00	178188.00	53151.00	1.09	1416.00
Canada	132596.00	117420.00	149192.00	28807.00	1.13	1659.00
Australia	124941.00	109796.00	170342.00	33488.00	1.36	1475.00
Spain	126393.00	115233.00	131281.00	28769.00	1.04	1303.00
South Korea	109408.00	105406.00	124067.00	27396.00	1.13	1004.00
Netherlands	75748.00	67526.00	95552.00	17204.00	1.26	1471.00
Switzerland	58724.00	52818.00	77229.00	12859.00	1.32	1369.00
Poland	61667.00	57218.00	60130.00	13851.00	0.98	792.00
Turkey	82150.00	75868.00	81106.00	18975.00	0.99	647.00
Sweden	51897.00	47222.00	65346.00	10767.00	1.26	1232.00
Belgium	42489.00	38168.00	53342.00	8180.00	1.26	1134.00
Denmark	36594.00	32906.00	51213.00	8488.00	1.40	1081.00
Austria	34522.00	30882.00	41693.00	6418.00	1.21	937.00
Israel	27120.00	24529.00	28273.00	4855.00	1.04	962.00
Portugal	38395.00	34052.00	39749.00	6658.00	1.04	739.00
Mexico	34041.00	30788.00	24124.00	4304.00	0.71	641.00
Norway	31793.00	28437.00	37661.00	6201.00	1.18	896.00
Czech Republic	27686.00	25996.00	28920.00	4608.00	1.04	667.00
Finland	27413.00	24537.00	33963.00	5367.00	1.24	897.00
Greece	27650.00	24715.00	31755.00	5977.00	1.15	725.00
New Zealand	18758.00	16443.00	22706.00	3777.00	1.21	758.00
Ireland	22267.00	19181.00	27436.00	3665.00	1.23	753.00
Hungary	17575.00	16345.00	18746.00	3310.00	1.07	630.00
Chile	21474.00	20014.00	20045.00	4004.00	0.93	555.00
Colombia	18413.00	17025.00	13432.00	2415.00	0.73	436.00
Slovakia	10061.00	9552.00	7967.00	1503.00	0.79	381.00
Slovenia	8725.00	8042.00	9282.00	1193.00	1.06	439.00
Lithuania	6056.00	5679.00	6444.00	886.00	1.06	319.00
Estonia	4577.00	4192.00	6074.00	794.00	1.33	412.00
Latvia	3361.00	3156.00	3216.00	452.00	0.96	243.00

Luxembourg	3384.00	2996.00	4102.00	496.00	1.21	300.00
Iceland	2349.00	2090.00	3079.00	323.00	1.31	415.00
Costa Rica	1854.00	1696.00	1479.00	182.00	0.80	252.00

When examining the results of the criterion weighting analysis conducted using the LODECI method and focused on current 2024 data, the Citations (CR3) criterion (0.19) stands out as the criterion with the highest weight. This once again underscores that the number of citations is the most decisive factor in academic visibility. This criterion is followed by the Documents (CR1), Citable Documents (CR2), and Self-citations (CR4) criteria, all of which have equal weight values. As seen, the quantitative criteria have equal and high weights. This indicates that the system places importance on the volume of quantitative output and accepts productivity as a measure of success. In particular, the fact that the Self-citations criterion has a high weight of 0.18 reveals that countries or institutions are intensively using internal citation mechanisms to both maintain and improve their rankings. In contrast, the fact that the H-index criterion (0.15)—an important indicator of academic prestige—ranks fifth, while the "Citations per document" criterion (0.11) has the lowest weight, indicates that the current evaluation system focuses more on cumulative impact and numerical magnitude rather than originality.

The visual distribution of the 2024 criterion weights obtained using the LODECI method is presented in Figure 2. Upon examining the radar chart, it can be seen that the "Citations" and "Documents" criteria are located at the point farthest from the center (with the highest weights), and that a balanced yet citation-focused hierarchy among the criteria is visually evident.

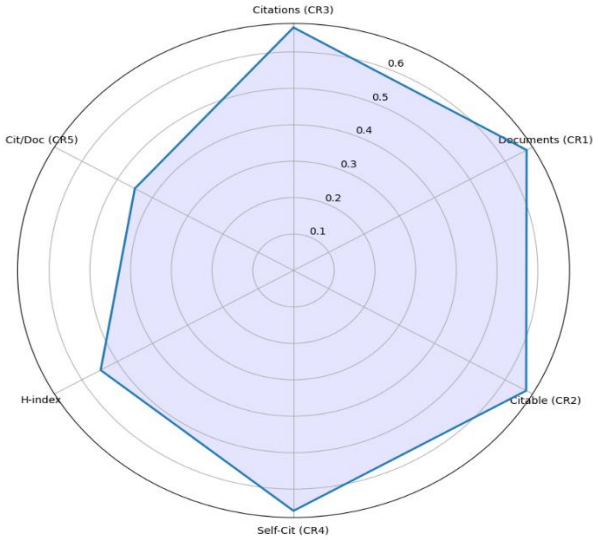

Figure 2. Radar graph of LODECI criterion weight distribution for 2024
Source: Authors

When both periods (current and cumulative) are evaluated together, it is observed that the balance between 'quality' (Citations) and 'quantity' (Documents) in measuring scientific performance exhibits a stable structure over time, but in the current period, there is a micro-level increase trend in the weights of productivity criteria such as H-index and Citations per Document. This situation confirms that although academic competitiveness has historically progressed in terms of total output and impact, the strategic importance of impact per publication and sustainable success ratios is increasing in the current conjuncture. The performance evaluation of OECD countries in 2024, by integrating the obtained weights into the RAWEC method, is presented in Table 9.

Table 9. RAWEC analysis results on the scientific performance dynamics of OECD countries and comparison with SCIMAGO ranking

Countries	v_{ij}	v'_{ij}	Q_i	Rank (2024)	Rank (1996-2024)	SCIMAGO country rank
United States	0,199059	0,719897	0,534606	1	1	1
United Kingdom	0,653796	0,865594	0,176747	2	2	3
Germany	0,698499	0,862743	0,126966	3	3	4
Japan	0,767324	0,847587	0,047521	14	10	5
France	0,751445	0,877847	0,085717	7	5	7
Italy	0,77762	0,861125	0,092904	6	9	8
Canada	0,746324	0,882616	0,099635	5	4	9
Australia	0,775131	0,888146	0,110385	4	7	10
Spain	0,80307	0,87018	0,071692	9	12	11
South Korea	0,841572	0,867771	0,059918	11	18	13
Netherlands	0,773443	0,889726	0,076494	8	6	15
Switzerland	0,788297	0,890296	0,06857	10	8	16
Poland	0,88757	0,849271	0,009398	20	24	17
Turkey	0,8959	0,84003	0,009573	19	26	18
Sweden	0,808559	0,883789	0,053932	12	11	20
Belgium	0,824028	0,878961	0,043813	15	14	22
Denmark	0,820977	0,880478	0,047787	13	13	23
Austria	0,849461	0,865512	0,024198	16	17	24
Israel	0,842979	0,848681	0,003567	21	15	26
Portugal	0,880383	0,845909	-0,00034	23	23	27
Mexico	0,901309	0,798631	-0,04907	29	28	28
Norway	0,852135	0,859796	0,016882	18	19	30
Czech Republic	0,899144	0,833002	-0,01335	26	27	31
Finland	0,847713	0,859322	0,018108	17	16	32
Greece	0,877231	0,843856	-0,00083	24	22	35
New Zealand	0,86237	0,835238	-0,00441	25	20	40
Ireland	0,86325	0,8437	0,003349	22	21	42
Hungary	0,889164	0,813345	-0,02792	27	25	46
Chile	0,898695	0,802017	-0,04308	28	29	47
Colombia	0,913206	0,74991	-0,08755	31	31	48
Slovakia	0,915168	0,702503	-0,11713	33	33	50
Slovenia	0,892957	0,734085	-0,07848	30	30	57
Lithuania	0,890817	0,656061	-0,13292	34	35	63
Estonia	0,858822	0,656839	-0,11506	32	32	68
Latvia	0,831406	0,480349	-0,26951	37	37	80
Luxembourg	0,780169	0,539851	-0,20509	35	36	84
Iceland	0,786302	0,467126	-0,24456	36	34	88
Costa Rica	0,737091	0,201554	-0,57122	38	38	96

The cross-sectional and longitudinal academic performance rankings for 2024 and 1996-2024, obtained using the LODECI method, were analyzed comparatively with SCIMAGO Country Rank (SJR) data. The findings show that countries at the peak of scientific productivity, such as the USA, the UK, and Germany, maintain their positions in the top three in both systems. This confirms the high correlation and managerial validity of the proposed model with traditional systems. However, a detailed examination of the rankings reveals that the LODECI method, unlike SJR, measures the balance between quality and quantity more accurately. It is noteworthy that countries like Turkey, which ranked 26th in the cumulative data for 1996-2024, rose to 19th place in the 2024 data alone, largely coinciding with SCImago's current position of 18th. The shifts in rankings experienced by countries such as Japan and South Korea between the cumulative and current models of LODECI reveal that the dynamic nature of the method reflects time-dependent performance changes more clearly compared to SJR; while the closeness of the results obtained by countries such as Poland, Turkey, and Sweden in the LODECI-2024 ranking to the traditional SCImago rankings scientifically confirms that this newly developed model offers a reliable and valid alternative in measuring international academic competition.

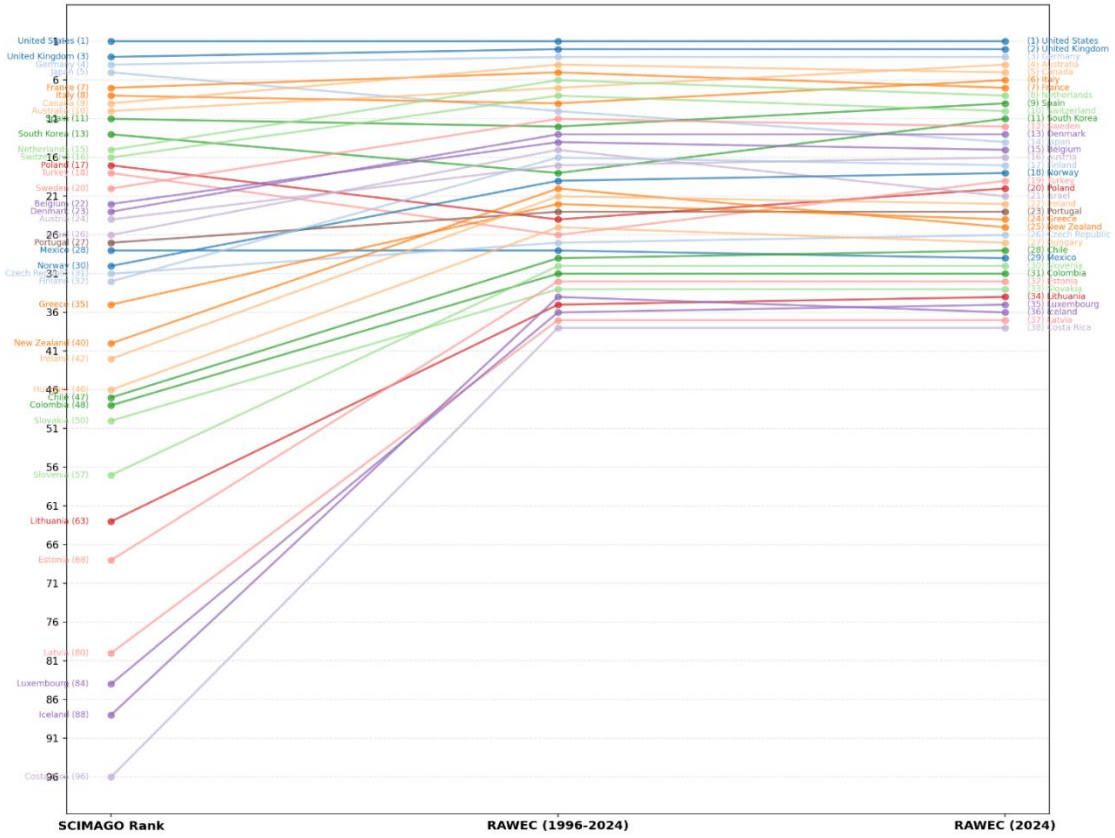

Figure 3. Ranking change analysis of OECD countries based on SCIMAGO and RAWEC models
Source: Authors

Examining the ranking change graph presented in Figure 3, it can be seen that the RAWEC (1996-2024) and RAWEC (2024) models create a more precise hierarchy by considering not only the publication volume of countries but also the qualitative impact parameters weighted by LODECI. The upward or downward movements of the lines in Figure 3 show the ranking differences of the countries between the two methods. The more sloping (vertical) a line is, the greater the change in that country's ranking. These large changes prove how different and unique

the results of the method we used (RAWEC) are compared to classical systems that only consider the number of publications.

5. Conclusion

This study aimed to demonstrate the validity and effectiveness of the LODECI-RAWEC methods in measuring the scientific production capacity and academic performance of countries. Within the scope of the study, a large-scale dataset of SCIMAGO Country Rank (SJR) data, considered a global reference, covering the years 1996-2024, and current indicators for 2024 were analyzed in detail. The importance levels (weights) of the evaluation criteria were objectively determined using the LODECI method. Both in the holistic analysis of the 1996-2024 period and specifically for 2024, the most important criterion was identified as Citations (CR3). In contrast, the Citations per document (CR5) criterion had the lowest weight. By integrating the obtained criterion weights into the RAWEC method, OECD countries were ranked according to their academic performance measures.

The OECD countries were ranked according to their performance by integrating the obtained criterion weights into the RAWEC method. Instead of directly converting criterion weights into ranking scores during the ranking phase, processing them based on efficiency has provided a dynamic performance hierarchy in the ranking of achievement. The RAWEC method has created a confirming effect in the academic ecosystem, demonstrating the superiority of quality over quantity. When the findings are examined, it is seen that countries such as the USA, the United Kingdom, and Germany have maintained their top positions. This shows that the LODECI-RAWEC integrated model produces results consistent with structures considered high-performing on a global scale and supports the validity of the model. While Turkey ranked 18th in the SCIMAGO ranking, it ranked 26th in the analysis of the 1996-2024 dataset. In the updated efficiency-focused RAWEC analysis for 2024, it ranked 19th. This shows that Turkey's recent academic outputs have gained a competitive position. Although Japan ranked 5th in the SCIMAGO ranking, it dropped to 14th place in the RAWEC-based ranking in 2024. This indicates a relative performance loss where quantitative magnitude is normalized by the efficiency coefficient. Australia, which ranked 10th in the SCIMAGO ranking, rose to 4th place in the 2024 RAWEC-based ranking, demonstrating one of the most remarkable productivity increases in the study.

The evaluation using the RAWEC method not only provides a performance score but also shows how rational the academic output capacity of countries is. Finland ranked 32nd in the SCIMAGO ranking, 17th in 2024, and 16th in the 1996-2024 period. Similarly, Sweden showed a performance of 20th in SCIMAGO, 12th in 2024, and 11th in the 1996-2024 period. This confirms that these countries have a high standard of productivity in their academic production processes. Poland and South Korea showed a negative deviation according to the current ranking. This situation can be attributed to the fact that the criterion weights determined by the LODECI method give higher importance to citation-based indicators in particular. Although these countries demonstrated strong performance in certain production indicators, their relatively lower performance in the impact and visibility-based criteria prioritized by the model resulted in a decline in their overall ranking scores. Consequently, combining the objectively determined weights of the LODECI method with the RAWEC method made it possible to evaluate the academic performance of countries not only through cumulative publication numbers but also from a dynamic productivity perspective. It reveals that the performance data for the period 1996-2024 and the current year 2024 accurately reflect changes over time and offer policymakers a more refined insight into raw data.

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