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EVALUATION OF COUNTRIES' SUSTAINABLE DEVELOPMENT PERFORMANCES USING HYBRID LOPCOW-PIV TECHNIQUES

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ABSTRACT

With the changing world conditions, many environmental and social risks have preceded economic risks. Accordingly, many economic variables have begun to be evaluated together with the concept of sustainability. Undoubtedly, the most important and inclusive of these is sustainable development. It has emerged as a necessity to evaluate the concepts of development and growth for economies and whether they are sustainable. The aim of this study is to analyze the sustainable development performance of countries. For the present purpose, performance evaluation was made on a total of eight criteria, including environmental, social, governance, financial and economic, which are thought to be effective on the sustainability performance of countries. 167 countries whose data can be accessed for the year 2020 were included in the analysis. In the study, a hybrid model was applied by combining the LOPCOW (Logarithmic Percentage Change Oriented Objective Weighting) method to determine the importance levels of eight criteria and the PIV (Proximity Indexed Value) method to rank the sustainable development performance of countries. The results revealed that Luxembourg, Switzerland, and Ireland are the countries with the best sustainable development performance. It has been deduced that besides economic indicators, other factors such as environmental, social, and management performances are important in measuring the sustainable development performance of countries.

Keywords: *Sustainability, Sustainable Development, Multi-Criteria Decision-Making Methods.*

Jel Codes: *Q01, Q56, C44.*

1. INTRODUCTION

The concept of sustainable development has evolved to an approach that focuses on environmental issues and economic development, over time, including social issues and aiming for a balance between these three dimensions (Aras et al., 2018a: 48). However, different economic evaluations have caused differences in the perspective of the concept of sustainable development.

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Comprehensive evaluations of sustainable development focus on the concept of sustainable development with five dimensions, economic, social, financial, environmental, and managerial (Aras and Crowther, 2008: 438; Aras et al., 2018b).

The concept of sustainability became more common after the Brundtland Report (1987) and was discussed extensively at the United Nations Conference on Environment and Development. It has been pointed out that indicators such as gross national product, resources owned, or pollution level, which are already widely used as sustainability indicators, are insufficient. It was emphasized that more comprehensive sustainable development indicators should be developed within the framework of methods that consider and evaluate the interaction between different sectoral, environmental, demographic, social, and developmental parameters to make healthier sustainability decisions (United Nations, 1992: 346). Such indicators aim to evaluate the long-term effects of current decisions and behaviors and monitor progress in line with the sustainable development goal (Candice, 2005: 2).

Although the issue of sustainability is a newer concept for developing countries compared to developed countries, it is an issue that developing countries frequently face with the help of globalization through channels such as regulations in financial markets and supply chain relations (Garcia-Johnson, 2000: 194). In addition, since developing countries constitute the majority of the world's population and land and continue to grow faster than developed countries (Kearney, 2012: 162), their importance for global sustainability cannot be ignored. The sustainable development performance of developing countries is important for many stakeholders worldwide, as it has a global impact on factors such as consumption of natural resources, climate change, and working conditions (Pop, 2013: 239). In this context, in this study, the sustainable development performances of developing countries are discussed within the framework of Aras et al.'s (2018b) five-dimensional sustainability performance evaluation model. It is expected that the study will differ from its counterparts in terms of the countries it deals with and the sustainability performance dimensions.

2. LITERATURE

Some studies with different performance indicators for different countries and country groups and summary information about the results obtained from the studies are presented in Table 1. According to the findings obtained from the studies examined, it was observed that the country or country groups in question took place in different rankings according to each evaluated performance indicator. However, it has been observed that some countries, such as Germany, the USA, and Australia are frequently in the first places in the rankings according to different indicators. Consideration should be given to significant changes in the ranking of countries according to the performance dimension evaluated. Thus, it is emphasized that the results of the discussed studies should be examined by considering the dimensions of performance.

Table 1. Literature Review

Author/s (year)	Country or country group	Method	Summary of findings
Hsu (2008)	Developed and developing countries	Data Envelopment Analysis (DEA)	In the study, in which country performances were evaluated regarding productivity, Indonesia and Argentina were identified as the best-performing countries.
Balešentis, et al. (2011)	European Union (EU) countries	Multiobjective Optimization by Ratio Analysis Plus the Full Multiplicative Form (MULTIMOORA)	According to the findings obtained from the study aiming to measure the welfare levels of EU countries, Ireland was found to be the EU country with the highest welfare level.
Alptekin (2015)	Türkiye and EU countries	Entropy and Technique for Order Performance by Similarity to Ideal Solution (TOPSIS)	In this study, the sustainable development performance of the countries was analyzed. Sweden took first place in the ranking of sustainable development performance, and Croatia grabbed last place. Türkiye is in twentieth place.
Antanasijević vd. (2017)	30 European countries	Preference Ranking Organization Method for Enrichment Evaluation(PROMETHEE)	In the study, the countries' sustainable development performances for 2004-2014 were analyzed. It was concluded that Czechia, Germany, and Hungary performed well.
Aksu and Gencer (2018)	OECD countries	DEA	The countries in the country group discussed were examined in the context of the environmental performance dimension. The findings show Iceland has the best environmental performance among OECD countries. Türkiye was among the countries that performed poorly.
Çakın and Ayçin (2019)	EU countries and EU candidate countries	Entropy, Multi-Objective Optimization By Ratio Analysis (MOORA) and Grey Incidence Analysis, (GIA)	The performances of the countries were evaluated in the environmental dimension. The top-performing countries were Austria, Denmark, and France.
Koca ve Tunca (2019)	G20 countries	GIA	The sustainability performance of the countries for the period of 2000-2017, which includes the crisis period, has been analyzed. The findings showed that the USA was first in the pre-crisis performance ranking but fell to the sixth rank after the crisis.
Türe (2019)	OECD countries	Entropy, GIA	In the study, in which a welfare comparison was made between countries, Iceland, Australia, and Norway were the countries with the highest welfare levels among OECD countries, while Turkey was the country with the worst performance.
Aras and Yıldırım (2020a)	G20 countries	Entropy, GIA	This study examined the ranking of countries' sustainable development performances and the relationship between environmental-social performance and GDP per capita. It has been determined that there is a positive relationship between GDP per capita and environmental-social performance. In addition, Australia, Germany, and Canada were the top-performing countries in the sustainable development performance ranking.
Aras and Yıldırım (2020b)	G20 countries	ARAS	It aims to rank the countries regarding socio-economic development in 2018. According to the study results, while Australia, Canada, and the USA were the countries with the best performance in the socio-economic development ranking, Turkey took the last place.

3. DATA, METHODOLOGY AND EMPIRICAL RESULTS

The aim of the study is to examine the sustainable development performances of countries. For this purpose, the sustainable performance of the countries with the indicators selected for 2020 was evaluated with an integrated model. 167 countries whose data can be accessed for 2020 were included in the study. In the study, evaluations were made according to the criteria of inflation, unemployment rate, GDP per capita, environmental performance index, social progress index, financial development index, rule of law index, and human development index. The criteria, the benefit/cost element for the decision maker, and the data source regarding the criteria are presented in Table 2.

Table 2. Evaluation Criteria

Sequence	Code	Criteria	Direction	Data Source
1	C1	Inflation	Min.	World Bank
2	C2	Unemployment Rate	Min.	World Bank
3	C3	GDP Per Capita	Max.	World Bank
4	C4	Environmental Performance	Max.	Yale University
5	C5	Social Progress Index	Max.	Social Progress Imperative
6	C6	Financial Development Index	Max.	IMF
7	C7	Rule of Law Index	Max.	World Bank
8	C8	Human Development Index	Max.	UNDP

An integrated model consisting of LOPCOW (Logarithmic Percentage Change-driven Objective Weighting) and PIV (Proximity Indexed Value) methods was used to analyze the sustainable development performances of the countries covered in the study. The weighting coefficients of the criteria considered with the LOPCOW method were calculated. Following this, the sustainable development performance ranking of the countries considered for 2020 was created with the PIV method.

The LOPCOW method is the newest criterion weighting method developed by Ecer and Pamucar in 2022. According to Ecer and Pamucar (2022), this method gives more acceptable results than other weighting methods. This is because they did not make a ranking among the criteria, and the significant differences between them were eliminated. The LOPCOW method has its algorithm. In this way, it is not affected by the negative values in the criteria, and weighting analysis can be made with raw data. It also eliminates the size differences between the data by taking the percentage values of the standard deviation of the mean square values of the data. The LOPCOW method consists of 4 basic stages (Işık et al., 2023). The first of these stages is the creation of the decision matrix with m alternatives and n criteria.

$$IDM = \begin{bmatrix} x_{11} & \cdots & x_{1j} & \cdots & x_{1n} \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ x_{m1} & \cdots & x_{mj} & \cdots & x_{mn} \end{bmatrix} \quad 1$$

In the next step, all the values in the decision matrix should be normalized according to the utility and cost with the linear normalization equations in equations 2 and 3.

$$r_{ij} = \frac{x_{max} - x_{ij}}{x_{mak} - x_{min}} \qquad (\text{for cost decision} - \text{making criteria}) \quad 2$$

$$r_{ij} = \frac{x_{ij} - x_{min}}{x_{mak} - x_{min}} \qquad (for \text{ benefit decision} - \text{making criteria}) \quad 3$$

In order to eliminate the dimension differences between the criteria, the percentile value (PV) for each criterion is calculated with Equation 4.

$$PV_{ij} = \left| ln \frac{\sqrt{\frac{\sum_{i=1}^{m} r_{ij}^2}{m}}}{\sigma} \right| x100 \quad 4$$

The objective weight values of the criteria (weighting coefficients) (w_j) are obtained by dividing each percentile value (PV_{ij}), obtained with the help of Equation 4 by the sum of the percentile values ($w_j = \frac{PV_{ij}}{\sum_{i=1}^{n} PV_{ij}}$). The sum of the objective weight values obtained should be equal to 1. The sum of the objective weight values obtained has to equal 1.

PIV (Proximity Indexed Value) is one of the multi-criteria decision methods developed by Mufazzal and Muzakkir (2018) to determine the most appropriate choice. This method is implemented in several different steps (Khan, vd., 2019: 244-246).

At the first stage, $A_i (i = 1,2,3, \dots, m)$, in the decision problems and $C_j (j = 1,2,3, \dots, m)$, which is the decision criterion, are determined. In the second step, the decision matrix of the alternatives is created. The decision matrix (Y) of the alternatives is created. Decision matrix with $i = 1,2, \dots, m$ and $j = 1,2, \dots, n$ is shown in equation 5.

$$Y = [Y_{ij}]_{mxn} = \begin{bmatrix} Y_{11} & Y_{12} & \cdots & Y_{1j} & \cdots & Y_{1n} \\ Y_{21} & Y_{22} & \cdots & Y_{2j} & \cdots & Y_{2n} \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ Y_{i1} & Y_{i2} & \cdots & Y_{ij} & \cdots & Y_{in} \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ Y_{m1} & Y_{m2} & \cdots & Y_{mj} & \cdots & Y_{mn} \end{bmatrix} \quad 5$$

Y_{ij}, j. represents the alternative performance value of the criterion. m represents the number of alternatives, and n is the number of criteria. In the next step, the decision matrix created is normalized. After the alternative decision matrix is created, the normalized decision matrix is obtained by using Equation 6.

$$R_i = \frac{Y_i}{\sqrt{\sum_{i=1}^{m} Y_i^2}} \quad (6)$$

In the fourth step, $v_i = w_j x R_i$ is obtained by multiplying the obtained R_i values with the weights of the criteria (w_j). In the fifth step, the weighted proximity index (u_i) is calculated, as shown in Equation 7.

$$u_i = \begin{cases} v_{max} - v_i & \text{if the benefit criteria} \\ v_i - v_{min} & \text{if the cost criteria} \end{cases} \quad (7)$$

In the next step, overall proximity values are calculated. The sum of the u_i values shows the general affinity values ($d_i = \sum_{j=1}^{n} u_i$). In the last step, the obtained d_i values are evaluated. The minimum d_i value showing the smallest deviation indicates the best alternative. The maximum d_i value shows the highest deviation, that is, the worst alternative. Therefore, evaluations are made by ordering the d_i values from smallest to largest.

The importance levels of the criteria used in the first stage of the integrated model applied in the study were obtained by using the LOPCOW method. The weight values for the criteria for 167 countries analyzed using 2020 data are presented in Table 3.

Table 3. Standard Deviations, PV Values, and LOPCOW Weighting Coefficients

	C1	C2	C3	C4	C5	C6	C7	C8
Standard Deviation (σ)	0,077	0,151	0,224	0,217	0,240	0,253	0,287	0,297
Percentile Value (PV_{ij})	0,297	28,314	63,499	20,154	3,693	36,346	30,549	23,957
Weighting Coefficients (w_j)	0,001	0,136	0,307	0,097	0,017	0,175	0,147	0,115

In order to evaluate the sustainable development performances of the countries, the PIV method was applied, and the performance rankings of the countries were obtained. Related findings are presented in Appendix Table 1. These results show that Luxembourg, Switzerland, and Ireland are in the first three places in the sustainable development performance of countries. Syria, Sudan, and Libya countries are at the bottom of the ranking regarding sustainable development performance. As a result of the analysis made according to 8 criteria, Türkiye ranked 72nd among 167 countries.

4. CONCLUSION

The sustainable development performances of countries have become more important as a result of the changing world perspective. Social and environmental risks due to global problems such as climate change, declining natural resources, biological threats, epidemics, population growth, and migration have brought the concept of sustainability to the fore in the economy. Sustainable development performance for countries is a criterion examined in different dimensions. Sustainable development performance is measured with different criteria in environmental, social, managerial, and

economic dimensions. These dimensions and criteria discussed are the main points in which scientific studies on sustainable development differ. In cases with many criteria and alternatives, multi-criteria decision-making methods are used for purposes such as ranking and decision-making. Multi-criteria decision-making methods constitute the basic methodology of many studies examining environmental development performance.

In this study, the sustainable development performances of 167 countries are discussed within the framework of Aras et al.'s (2018b) five-dimensional sustainability performance evaluation model. The study analyzed 2020 data for eight criteria, including inflation, unemployment rate, GDP per capita, environmental performance index, social progress index, financial development index, rule of law index, and human development index. An integrated model consisting of LOPCOW and PIV methods was used to analyze the sustainable development performances of the 167 countries. The weights of the criteria were determined by the LOPCOW method. Accordingly, the highest weight value belongs to the GDP per capita criterion. The inflation criterion, on the other hand, has the lowest weight value. With the findings obtained by the PIV method, the sustainable development performance of the countries was ranked. Regarding performance, Luxembourg ranks first, Switzerland second, and Ireland third. Libya, Sudan, and Syria are the three worst-performing countries. Türkiye ranks 72nd in the sustainable development performance ranking. When the performance ranking obtained from the study is examined, findings consistent with the literature are observed. Implications for the countries ranking first in performance Balešentis et al. (2011), Çakın and Ayçin (2019), and Antanasijević et al. (2017) are similar to studies such as. Findings regarding Turkey's sustainable development performance are similar to those of Alptekin (2015), Aksu and Gencer (2018), and Aras and Yıldırım (2020b).

One of the points to be considered in the study findings is that the European Union countries are generally among the countries with high sustainable development performance This emphasizes the importance of ensuring certain standardizations in social and economic activities in terms of sustainable development performance. In addition, it is remarkable that countries in the high-income group show high sustainable development performance. One of the reasons for this is that GDP per capita is one of the criteria used to measure performance. In addition, when considering the variables used to monitor sustainable development, such as economic, social, political, and cultural indicators, it is evident that countries in the high-income group exhibit favorable conditions that contribute to their better performance. The relationship of these other criteria with income (possibly the inverted U-shaped relationship explained by the Kuznets hypothesis) is a research proposal for subsequent studies.

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Appendix Table 1. Sustainable Development Performance Obtained by PIV Method for 2020

Rank	Country	d_i	Rank	Country	d_i
1	Luxemburg	0,0194	85	Paraguay	0,1154
2	Switzerland	0,0346	86	Burkina Faso	0,1156
3	Ireland	0,0454	87	Grenada	0,1158
4	Norway	0,0553	88	Moldova	0,1158
5	United States	0,0555	89	Georgia	0,1159
6	Denmark	0,0581	90	Argentina	0,1161
7	Singapore	0,0595	91	Malawi	0,1161
8	Australia	0,0621	92	Cambodia	0,1163
9	Sweden	0,0647	93	Dominica	0,1164
10	Netherlands	0,0653	94	Togo	0,1164
11	Iceland	0,0658	95	Fiji	0,1164
12	United Kingdom	0,0664	96	Senegal	0,1165
13	Japan	0,0673	97	Colombia	0,1167
14	Finland	0,0676	98	Philippines	0,1167
15	Germany	0,0679	99	El Salvador	0,1167
16	Austria	0,0683	100	North Macedonia	0,1168
17	Canada	0,0715	101	South Africa	0,1169
18	Belgium	0,0724	102	Pakistan	0,1173
19	Qatar	0,0730	103	Benin	0,1174
20	France	0,0732	104	Guatemala	0,1177
21	New Zealand	0,0737	105	Ecuador	0,1177
22	İsrael	0,0754	106	Bolivia	0,1178
23	Republic of Korea	0,0780	107	Oman	0,1179
24	İtaly	0,0841	108	Mozambique	0,1180
25	United Arab Emirates	0,0841	109	Burundi	0,1183
26	Malta	0,0851	110	Bangladesh	0,1184
27	Spain	0,0873	111	Iran	0,1184
28	Portugal	0,0890	112	Jordan	0,1185
29	Czechia	0,0901	113	Azerbaijan	0,1186
30	Greek Adm. of Southern Cyprus	0,0912	114	Madagascar	0,1186
31	Slovenia	0,0919	115	Belarus	0,1188
32	Brunei Darussalam	0,0939	116	Liberia	0,1189
33	Kuwait	0,0951	117	Gambia,	0,1190
34	Estonia	0,0954	118	Albania	0,1190
35	Bahrain	0,0959	119	Tunisia	0,1190
36	Malaysia	0,0967	120	Ecuador Guinea	0,1192
37	Hungary	0,0977	121	Sierra Leone	0,1193
38	Poland	0,0983	122	Belize	0,1197
39	Thailand	0,0985	123	Guyana	0,1199
40	China	0,0998	124	Chad	0,1202
41	Slovakia	0,0999	125	Honduras	0,1202
42	Saudi Arabia	0,1002	126	Ukraine	0,1203
43	Chile	0,1011	127	Papua New Guinea	0,1203
44	Croatia	0,1012	128	Guinea	0,1204
45	Lithuania	0,1016	129	Mali	0,1204
46	Latvia	0,1024	130	Tajikistan	0,1210
47	Mauritius	0,1043	131	Cent. African Rep.	0,1210
48	Greece	0,1043	132	Nepal	0,1211
49	Trinidad and Tobago	0,1049	133	Cameroon	0,1212
50	The Bahamas	0,1052	134	Angola	0,1212
51	Romania	0,1052	135	Turkmenistan	0,1213
52	Uruguay	0,1056	136	Tanzania	0,1214
53	Bulgaria	0,1060	137	Uzbekistan	0,1215
54	Barbados	0,1064	138	Zambia	0,1216
55	Brazil	0,1068	139	Timor-Leste	0,1217

56	Bhutan	0,1088	140	Mauritania	0,1218
57	Mexico	0,1089	141	Sao Tome and Principe	0,1218
58	Russia	0,1093	142	Nicaragua	0,1220
59	Jamaica	0,1099	143	Congo, Dem. Rep.	0,1224
60	Vietnam	0,1103	144	Kyrgyzstan	0,1227
61	Panama	0,1104	145	Congo	0,1231
62	India	0,1107	146	Eritrea	0,1232
63	Kazakhstan	0,1113	147	Venezuela, RB	0,1233
64	Botswana	0,1115	148	Armenia	0,1235
65	Peru	0,1116	149	The Comoros	0,1236
66	Rwanda	0,1122	150	Gabon	0,1237
67	Namibia	0,1123	151	Myanmar	0,1242
68	Indonesia	0,1124	152	Lebanon	0,1243
69	Costa Rica	0,1132	153	Algeria	0,1251
70	Solomon Islands	0,1132	154	South Sudan	0,1262
71	Dominican Republic	0,1133	155	Haiti	0,1267
72	Türkiye	0,1135	156	Lao PDR	0,1270
73	Serbia	0,1136	157	Kiribati	0,1276
74	Cabo Verde	0,1138	158	Lesotho	0,1277
75	Surinam	0,1140	159	Vanuatu	0,1278
76	Sri Lanka	0,1141	160	Yemen, Cum.	0,1291
77	Maldives	0,1142	161	Djibouti	0,1292
78	Mongolia	0,1142	162	Kenya	0,1294
79	Niger	0,1143	163	Bosnia and Herzegovina	0,1298
80	Uganda	0,1151	164	Nigeria	0,1301
81	Egypt	0,1153	165	Libya	0,1306
82	Morocco	0,1153	166	Sudan	0,1318
83	Ghana	0,1153	167	Syria	0,1480
84	Ethiopia	0,1154			

KATKI ORANI / *CONTRIBUTION RATE*	**AÇIKLAMA / *EXPLANATION***	**KATKIDA BULUNANLAR / *CONTRIBUTORS***
Fikir veya Kavram / *Idea or Notion*	Araştırma hipotezini veya fikrini oluşturmak / *Form the research hypothesis or idea*	Asst. Prof. Yusuf KAHREMAN (Ph.D.) Asst. Prof. Muhammet KUTLU (Ph.D.)
Tasarım / *Design*	Yöntemi, ölçeği ve deseni tasarlamak / *Designing method, scale and pattern*	Asst. Prof. Yusuf KAHREMAN (Ph.D.) Asst. Prof. Muhammet KUTLU (Ph.D.)
Veri Toplama ve İşleme / *Data Collecting and Processing*	Verileri toplamak, düzenlenmek ve raporlamak / *Collecting, organizing and reporting data*	Asst. Prof. Yusuf KAHREMAN (Ph.D.) Asst. Prof. Muhammet KUTLU (Ph.D.)
Tartışma ve Yorum / *Discussion and Interpretation*	Bulguların değerlendirilmesinde ve sonuçlandırılmasında sorumluluk almak / *Taking responsibility in evaluating and finalizing the findings*	Asst. Prof. Yusuf KAHREMAN (Ph.D.) Asst. Prof. Muhammet KUTLU (Ph.D.)
Literatür Taraması / *Literature Review*	Çalışma için gerekli literatürü taramak / *Review the literature required for the study*	Asst. Prof. Yusuf KAHREMAN (Ph.D.) Asst. Prof. Muhammet KUTLU (Ph.D.)

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