Which OECD Countries Are Advantageous in Fight Against COVID-19?

Aslı ÇALIŞ BOYACI*[1]

*[1] Ondokuz Mayıs University, Faculty of Engineering, Department of Industrial Engineering, SAMSUN

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Abstract: COVID-19 outbreak has changed daily lives deeply, has fallen economies into recession, and has put social life and public health under unprecedented pressure. In this study, it is aimed to evaluate the performances of OECD countries in combating COVID-19 and to develop strategies for preventing or controlling a similar epidemic in the future. To this end, MCDM methods are used to evaluate the countries according to the criteria which are number of confirmed cases per one million population, number of deaths per one million population, number of doctors per 1000 population, number of nurses per 1000 population, number of hospital beds per 1000 population, and health spending share. SWARA method is employed to determine the criteria weights. Countries are ranked using TOPSIS, COPRAS, and ARAS methods according to the weights obtained by SWARA. Borda Count Data Fusion technique is used for integrated ranking. Japan is the first alternative according to all rankings and Chile is the last.

COVID-19 ile Mücadelede Hangi OECD Ülkeleri Avantajlı?

Anahtar Kelimeler
COVID-19,
OECD Ülkeleri,
ÇKKV

Öz: COVID-19 salgını günlük hayatı derinden değiştirmiş, ekonomileri durgunluğa sürüklemiş, sosyal hayatı ve halk sağlığını benzeri görülmemiş bir baskı altına almıştır. Bu çalışmada, OECD ülkelerinin COVID-19 ile mücadeledeki performanslarının değerlendirilmesi ve gelecekte benzer bir salgının önlenmesi veya kontrol altına alınması için stratejilerin geliştirilmesi amaçlanmaktadır. Bu amaçla, ÇKKV yöntemleri kullanılarak OECD ülkeleri, bir milyon kişi başına doğrulanmış vaka sayısı, bir milyon kişi başına ölüm sayısı, bin kişiye düşen hekim sayısı, bin kişiye düşen hemşire sayısı, bin kişiye düşen hastane yatağı sayısı ve sağlık harcamalarının GSYİH içindeki payı kriterlerine göre değerlendirilmektedir. Kriterlerin ağırlıklarını belirlemek için SWARA yöntemi kullanılmaktadır. SWARA ile elde edilen ağırlıklar doğrultusunda ülkeler TOPSIS, COPRAS ve ARAS yöntemleri ile sıralanmaktadır. Bütünleşik sıralama için bir veri birleştirme tekniği olan Borda Sayım yöntemi kullanılmaktadır. Japonya elde edilen tüm sıralamalarda ilk sırada, Şili ise son sırada yer almaktadır.

***İlgili Yazar:** asli.calis@omu.edu.tr

1. Introduction

In late 2019, it was reported that there were many pneumonia patients with unknown causes in a seafood market in Wuhan city, Hubei province, China. In January 2020, the World Health Organization (WHO) first announced that the cause of these complaints was a new type of coronavirus (2019-nCoV). The outbreak spread to many countries, especially in Asian countries, after China, and reached an international dimension affecting the whole world. As a result, WHO accepted this outbreak as an international public health problem. In February 2020, the outbreak was named COVID-19 pandemic by WHO [1, 2].

COVID-19 continues to cause great harm to individuals, families, communities, and societies around the world. This pandemic has changed daily lives deeply, has fallen economies into recession, and has put social life and public health under unprecedented pressure [3].

The spread of COVID-19 on a global scale collapses the health systems of some of the countries and causes economic disruption. In this study, it is aimed to evaluate the performances of OECD countries in combating COVID-19 and to develop strategies for preventing or controlling a similar epidemic in the future. Multi-criteria decision making (MCDM) methods are used to evaluate the countries according to the criteria which are number of confirmed cases per one million population, number of deaths per one million population, number of doctors per 1000 population, number of nurses per 1000 population, number of hospital beds per 1000 population, and health spending share. Firstly, SWARA (Step-wise Weight Assessment Ratio Analysis) method is employed to determine the criteria weights. Then the countries are ranked using TOPSIS (Technique for Order Preference by Similarity to Ideal Solution), COPRAS (Complex Proportional Assessment), and ARAS (Additive Ratio Assessment) methods according to the weights obtained by SWARA. Finally, Borda Count Data Fusion technique is used for integrated ranking.

In the literature, MCDM methods have been applied in several areas related to COVID-19 outbreak such as helping doctors hasten treatment [4], selecting an antivirus mask [5], medicine selection for the patients [6], analyzing the barriers for implementation of public health and social measures [7], risk assessment [8, 9], evaluation of the challenges of digital health intervention adoption [10], evaluation of urban epidemic situation [11], capacity evaluation of diagnostic tests [12], evaluation of the impact of the epidemic on supply chain performance [13], evaluation of the pandemic intervention strategies [14], emergency decision making for treatment of the patients [15], determining the priority groups for the vaccine [16], identification of dominant risk factor [17], selection of the best healthcare waste disposal techniques [18], implication for green economic recovery [19].

The most relevant streams of research were reviewed and no studies using the SWARA, TOPSIS, COPRAS, ARAS, and Borda Count methods for the evaluation of OECD countries in combating COVID-19 were found. This study is expected to fill this gap.

2. Material and Method

In this study, decision models consisting of SWARA, TOPSIS, COPRAS, ARAS, and Borda Count methods were used to evaluate the performances of OECD countries in combating COVID-19 and to develop strategies. SWARA was employed to determine the criteria weights. The rankings were obtained using TOPSIS, COPRAS, and ARAS methods. The final ranking was attained by Borda Count method. This section explains these five methods.

2.1. SWARA method

SWARA method was presented by Keršulienė et al. in 2010 for evaluating the weights of the criteria. Unlike other multi-criteria methods, SWARA method can value the criteria weights as one weight of criterion is higher or lower significant than the other criterion [20]. SWARA method has the following steps [20, 21]:

Step 1: Sort the criteria in descending order based on their significances.
Step 2: Determine the relative importance of criterion j in relation to the previous (j-1) criterion, starting from the second criterion. This ratio is called the comparative importance of average value, (s_j).
Step 3: Determine the coefficient (k_j) using Equation (1).

$$k_j = \begin{cases} 1 & j = 1 \\ s_j + 1 & j > 1 \end{cases} \tag{1}$$

Step 4: Determine the recalculated weight (q_j) using Equation (2).

$$q_j = \begin{cases} 1 & j = 1 \\ \dfrac{q_{j-1}}{k_j} & j > 1 \end{cases} \quad (2)$$

Step 5: Determine the relative weights of the criteria using Equation (3).

$$w_j = \frac{q_j}{\sum_{k=1}^{n} q_k} \quad (3)$$

2.2. TOPSIS method

TOPSIS method was presented by Hwang and Yoon [22]. The basic principle of the TOPSIS method is that the chosen alternative has the shortest distance to the ideal solution and the farthest distance to the negative ideal solution. TOPSIS method has the following steps [23]:

Step 1: The first step of TOPSIS is decision-making matrix forming. Any problem to be solved is indicated by the following preferences matrix shown in Equation (4) for applicable alternatives (rows) rated by n criterion (s):

$$D = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2n} \\ \cdot & \cdot & \cdots & \cdot \\ \cdot & \cdot & \cdots & \cdot \\ \cdot & \cdot & \cdots & \cdot \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (4)$$

Where *m* represents the number of alternatives and *n* represents the number of criteria describing each alternative. In the decision matrix, x_{ij} is the value that represents the performance value of the alternative *i* in terms of the criterion *j*.

Step 2: Normalize the decision matrix using Equation (5).

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad (i = 1, \ldots, m;\ j = 1, \ldots, n) \quad (5)$$

Step 3: Form the weighted normalized decision matrix using Equation (6).

$$V = v_{ij} = w_j \times r_{ij} \qquad (i = 1, \ldots, m;\ j = 1, \ldots, n) \quad (6)$$

Step 4: Determine the ideal and negative-ideal solutions using Equation (7) and Equation (8).

$$A^* = \{v_1^*, v_2^*, \ldots, v_n^*\} = A^* = \left\{\left(\max_i v_{ij} \mid j \in J'\right), \left(\min_i v_{ij} \mid j \in J''\right)\right\} \quad (7)$$

$$A^{-}=\left\{v_1^{-},v_2^{-},\ldots,v_n^{-}\right\}=A^{-}=\left\{\left(\min_i v_{ij}\,\middle|\,j\in J'\right),\left(\max_i v_{ij}\,\middle|\,j\in J''\right)\right\} \quad (8)$$

where, J' is related to benefit criteria and J'' is related to cost criteria.

Step 5: Calculate the separation of each alternative from the ideal solution using Equation (9) and the separation from the negative-ideal solution using Equation (10).

$$S_i^{*}=\sqrt{\sum_{j=1}^{n}\left(v_{ij}-v_j^{*}\right)^2} \quad (i=1,\ldots,m) \quad (9)$$

$$S_i^{-}=\sqrt{\sum_{j=1}^{n}\left(v_{ij}-v_j^{-}\right)^2} \quad (i=1,\ldots,m) \quad (10)$$

Step 6: Calculate the relative closeness (C_i^{*}) to the perfect solution using Equation (11).

$$C_i^{*}=\frac{S_i^{-}}{S_i^{-}+S_i^{*}} \qquad 0\le C_i^{*}\le 1 \qquad i=1,\ldots,m \quad (11)$$

Step 7: Rank the preference order.

2.3. COPRAS method

COPRAS method was presented by Zavadskas et al. [24, 25]. COPRAS uses uses a stepwise ranking and evaluating procedure of the alternatives in terms of significance and utility degree [26]. The alternatives are described using values of discrete indices in COPRAS method. COPRAS can be easily applied to problems involving complex criteria and a large number of alternatives. COPRAS method has the following steps [27, 28]:

Step1: Form the decision-making matrix using Equation (4).

Step 2: Convert the decision matrix to a normalized decision matrix with the help of Equation (12).

$$x_{ij}^{*}=\frac{x_{ij}}{\sum_{i=1}^{m}x_{ij}} \qquad \forall j=1,2,\ldots,n \quad (12)$$

Step 3: Develop the weighted normalized decision matrix D', consisting of the elements d_{ij}, using Equation (13). This step aims to obtain weighted dimensional values from comparative indexes.

$$D'=d_{ij}=x_{ij}^{*}\times w_j \quad (13)$$

Step 4: Calculate the sums of the weighted normalized indexes. It is better to have lower values of minimizing indexes (S_{-i}) and to have higher values of maximizing indexes (S_{+i}). The sums are calculated by using Equation (14) and Equation (15).

$$S_{+i}=\sum_{j=1}^{k}d_{ij} \qquad j=1,2,\ldots,k \quad (14)$$

$$S_{-i}=\sum_{j=k+1}^{n}d_{ij} \qquad j=k+1,k+2,\ldots,n \quad (15)$$

Step 5: For each alternative, determine the Relative Significance (Q_i) by using the Equation (16). The greater the Q_i , the higher the efficiency/priority of the alternative.

$$Q_i = S_{+i} + \frac{\sum_{i=1}^{m} S_{-i}}{S_{-i}.\sum_{i=1}^{m} \frac{1}{S_{-i}}} \quad \forall i = 1,2,...,m \tag{16}$$

Step 6: Determine the priority. Quantitative utility (U_i) for the alternatives gives an absolute prioritization and is calculated using Equation (17) as follows:

$$U_i = \left[\frac{Q_i}{Q_{\max}} \right] \times 100\% \tag{17}$$

where ($Q_{\max}$) is the maximum relative significance value. The candidate alternatives' utility values range from 0% to 100% [29].

2.4. ARAS method

ARAS method was submitted by Zavadskas and Turskis for the solution of MCDM problems in 2010. In ARAS method, a utility function value that determines the complicated relative efficiency of a feasible alternative is directly proportional to the comparative impact of the main criteria values and weights. ARAS method has the following steps [30]:

Step 1: Form the decision-making matrix using Equation (18).

$$X = \begin{bmatrix} x_{01} & \cdots & x_{0j} & \cdots & x_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{i1} & \cdots & x_{ij} & \cdots & x_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mj} & \cdots & x_{mn} \end{bmatrix} \quad i = 0,1,2,...,m; \; j = 1,2,...,n \tag{18}$$

In the decision matrix, x_{ij} represents the performance value of the alternative *i* in terms of the criterion *j*, and x_{0j} is the optimal value of criterion *j*.

In the decision problem, if the optimal value of criterion *j* is not known Equation (19) and Equation (20) are used.

$$x_{0j} = \max_i x_{ij}, \; if \; \max_i x_{ij} \; is \; preferable \tag{19}$$

$$x_{0j} = \min_i x_{ij}^*, if \; \min_i x_{ij}^* \; is \; preferable \tag{20}$$

Step 2: Normalize all initial criteria values. The normalized matrix X' is as follows:

$$X' = \begin{bmatrix} x'_{01} & \cdots & x'_{0j} & \cdots & x'_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x'_{i1} & \cdots & x'_{ij} & \cdots & x'_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x'_{m1} & \cdots & x'_{mj} & \cdots & x'_{mn} \end{bmatrix} \quad i = 0,1,2,...,m; \; j = 1,2,...,n \tag{21}$$

The criteria whose preferred values are maximum are normalized using Equation (22).

$$x'_{ij} = \frac{x_{ij}}{\sum_{i=0}^{m} x_{ij}} \tag{22}$$

The criteria whose preferred values are minimum are normalized using Equation (23).

$$x_{ij} = \frac{1}{x^*_{ij}};\ x'_{ij} = \frac{x_{ij}}{\sum_{i=0}^{m} x_{ij}} \tag{23}$$

Step 3: Form the normalized-weighted matrix $\widehat{X}$ as Equation (24). The criteria can be assessed with weights $0 < w_j < 1$. The sum of the weights w_j is limited as in Equation (25). The normalized-weighted values of the criteria $\widehat{x}_{ij}$ are calculated using Equation (26).

$$\widehat{X} = \begin{bmatrix} \widehat{x}_{01} & \cdots & \widehat{x}_{0j} & \cdots & \widehat{x}_{0n} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \widehat{x}_{i1} & \cdots & \widehat{x}_{ij} & \cdots & \widehat{x}_{in} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ \widehat{x}_{m1} & \cdots & \widehat{x}_{mj} & \cdots & \widehat{x}_{mn} \end{bmatrix} \quad i = 0,1,2,\ldots,m;\ j = 1,2,\ldots,n \tag{24}$$

$$\sum_{j=1}^{n} w_j = 1 \tag{25}$$

$$\widehat{x}_{ij} = x'_{ij} w_j; \qquad i = 0,1,2,\ldots\ldots,m \tag{26}$$

Step 4: Determine the values of the optimality function (S_i) using Equation (27).

$$S_i = \sum_{j=1}^{n} \widehat{x}_{ij},\ i = 0,1,\ldots,m \tag{27}$$

The best result has the greatest value and the worst result has the smallest value. The greater the value of the optimality function S_i, the more efficient the alternative.

Step 5: Calculate the utility degree K_i of the alternatives using Equation (28). The degree of the alternative utility is defined by a comparison of the variant with the best S_0. K_i is in the interval [0,1] and can be ordered in an increasing sequence.

$$K_i = \frac{S_i}{S_0},\ i = 0,1,\ldots,m \tag{28}$$

2.5. Borda Count method

Borda Count method was submitted by Borda in 1784 [31]. The method orders the alternatives according to the rankings created by more than one method and offers a single ranking [32]. Borda scores (b_i) of the alternatives for each criterion is determined by Equation (29) [33].

$$b_i = \sum_k \left(N - r_{ik}\right) \tag{29}$$

where, N is the number of alternatives and r_{ik} is the rank of alternative i under criterion k. In the Borda Count method, a score of zero is assigned to the least preferred alternative of the decision maker, and a score of (N-1) is assigned to the most preferred alternative, and the Borda scores are obtained [34].

3. Results

In this study, it is aimed to evaluate the performances of OECD countries in combating COVID-19 using MCDM methods. In this respect, firstly an expert team consisting of three staff working in the pandemic hospitals in different regions of Turkey was built. Then the criteria were determined by the experts as follows:

Criterion 1 (C_1): Number of confirmed cases per one million (1M) population,
Criterion 2 (C_2): Number of deaths per 1M population,
Criterion 3 (C_3): Number of doctors per 1000 population,
Criterion 4 (C_4): Number of nurses per 1000 population,
Criterion 5 (C_5): Number of hospital beds per 1000 population,
Criterion 6 (C_6): Health spending share (As a % of Gross Domestic Product).

The values for C_1, and C_2 were obtained from ISC COVID-19 Visualizer on 25 June 2020 [35]. The values for C_3, C_4, C_5, and C_6 were obtained from 'Health at a Glance 2019' [36].

In light of the above information, the decision matrix was formed for 36 OECD member countries in the relevant year as in Table 1.

Table 1. The decision matrix

	C_1	C_2	C_3	C_4	C_5	C_6
Australia	294.9	4.0	3.7	11.7	3.8	9.3
Austria	1,937.4	76.9	5.2	6.9	7.4	10.3
Belgium	5,254.5	838.9	3.1	11.0	5.7	10.4
Canada	2,701.6	224.0	2.7	10.0	2.5	10.7
Chile	13,118.0	235.7	2.5	2.7	2.1	8.9
Czech Republic	994.6	31.7	3.7	8.1	6.6	7.5
Denmark	2,177.9	104.1	4.0	10.0	2.6	10.5
Estonia	1,494.9	52.0	3.5	6.2	4.7	6.4
Finland	1,293.5	59.0	3.2	14.3	3.3	9.1
France	2,470.6	455.3	3.2	10.5	6.0	11.2
Germany	2,301.8	107.3	4.3	12.9	8.0	11.2
Greece	316.8	18.2	6.1	3.3	4.2	7.8
Hungary	425.9	59.6	3.3	6.5	7.0	6.6
Iceland	5,345.2	29.3	3.9	14.5	3.1	8.3
Ireland	5,142.2	348.3	3.1	12.2	3.0	7.1
Israel	2,503.1	35.6	3.1	5.1	3.0	7.5
Italy	3,950.1	573.5	4.0	5.8	3.2	8.8
Japan	142.1	7.6	2.4	11.3	13.1	10.9
Korea	244.5	5.5	2.3	6.9	12.3	8.1
Latvia	589.0	15.9	3.2	4.6	5.6	5.9
Lithuania	662.7	28.7	4.6	7.7	6.6	6.8
Luxembourg	6,602.5	175.7	3.0	11.7	4.7	5.4
Mexico	1,484.6	181.3	2.4	2.9	1.4	5.5
Netherlands	2,906.6	355.8	3.6	10.9	3.3	9.9
New Zealand	314.4	4.6	3.3	10.2	2.7	9.3
Norway	1,618.1	45.7	4.7	17.7	3.6	10.2
Poland	867.2	36.9	2.4	5.1	6.6	6.3
Portugal	3,933.0	151.3	5.0	6.7	3.4	9.1
Slovak Republic	294.3	5.1	3.4	5.7	5.8	6.7
Slovenia	741.2	52.4	3.1	9.9	4.5	7.9
Spain	6,284.5	605.8	3.9	5.7	3.0	8.9
Sweden	6,023.9	511.0	4.1	10.9	2.2	11.0
Switzerland	3,625.3	226.2	4.3	17.2	4.5	12.2
Turkey	2,254.8	59.3	1.9	2.1	2.8	4.2
United Kingdom	4,510.6	632.3	2.8	7.8	2.5	9.8
United States	7,327.5	373.1	2.6	11.7	2.8	16.9

3.1. Determination of the criteria weights using SWARA method

In this subsection weights of the criteria were obtained using the SWARA method. In this context, firstly the experts sorted the criteria in descending order based on their significances. Then, the comparative importance of average value (s_j) was obtained as in Table 2. Finally, the weights of the criteria were obtained as in Table 3. As shown in Table 3, C_1 (number of confirmed cases per 1M population) is the most significant criterion affecting the evaluation process with weight of 0.294, while C_2 (number of deaths per 1M population) has the least important with 0.103.

Table 2. The comparative importance of average values

Rank	Expert 1		Expert 2		Expert 3	
	C_j	s_j	C_j	s_j	C_j	s_j
1	C_1	-	C_1	-	C_5	-
2	C_2	0.90	C_6	0.60	C_3	0.95
3	C_6	0.40	C_4	0.20	C_1	0.90
4	C_5	0.35	C_3	0.70	C_4	0.85
5	C_3	0.50	C_2	0.45	C_6	0.75
6	C_4	0.20	C_5	0.40	C_2	0.55

Table 3. Weights of the criteria

C_j	Expert 1	Expert 2	Expert 3	**Final**
	w_j	w_j	w_j	$\mathbf{w_j}$
C_1	0.397	0.355	0.131	**0.294**
C_2	0.209	0.075	0.026	**0.103**
C_3	0.074	0.109	0.248	**0.144**
C_4	0.061	0.185	0.071	**0.106**
C_5	0.110	0.054	0.484	**0.216**
C_6	0.149	0.222	0.040	**0.137**

3.2. Ranking the alternatives using TOPSIS, COPRAS, ARAS, and Borda Count methods

The alternatives were ranked using SWARA based TOPSIS, COPRAS, and ARAS methods in this subsection. Then the final ranking was obtained using Borda Count method as in Table 4, and Figure 1. When the results are evaluated, Japan is the first alternative according to all rankings and Korea is the second. According to the final ranking obtained by Borda Count method, Korea is followed by Slovak Republic and Australia, respectively. Moreover, Chile is the last according to the final ranking. Chile is preceded by Spain.

Table 4. The rankings

Countries	SWARA & TOPSIS Rank	Borda Score	SWARA & COPRAS Rank	Borda Score	SWARA & ARAS Rank	Borda Score	Total Borda Score	**Borda Rank**
Australia	11	25	3	33	3	33	91	**4**
Austria	6	30	13	23	12	24	77	**12**
Belgium	31	5	20	16	20	16	37	**21**
Canada	23	13	27	9	28	8	30	**25**
Chile	36	0	36	0	36	0	0	**36**
Czech Republic	7	29	10	26	11	25	80	**11**
Denmark	19	17	21	15	22	14	46	**20**
Estonia	16	20	19	17	19	17	54	**19**
Finland	17	19	17	19	17	19	57	**16**
France	18	18	18	18	18	18	54	**18**
Germany	3	33	11	25	10	26	84	**8**
Greece	12	24	6	30	6	30	84	**7**
Hungary	5	31	8	28	7	29	88	**6**
Iceland	28	8	23	13	21	15	36	**23**
Ireland	30	6	30	6	31	5	17	**31**
Israel	21	15	29	7	29	7	29	**26**
Italy	27	9	31	5	30	6	20	**30**
Japan	1	35	1	35	1	35	105	**1**
Korea	2	34	2	34	2	34	102	**2**
Latvia	10	26	9	27	9	27	80	**10**
Lithuania	4	32	7	29	8	28	89	**5**
Luxembourg	32	4	26	10	27	9	23	**28**
Mexico	24	12	35	1	34	2	15	**32**
Netherlands	22	14	25	11	24	12	37	**22**
New Zealand	15	21	5	31	5	31	83	**9**
Norway	14	22	15	21	14	22	65	**15**
Poland	9	27	14	22	15	21	70	**14**
Portugal	26	10	24	12	25	11	33	**24**
Slovak Republic	8	28	4	32	4	32	92	**3**
Slovenia	13	23	12	24	13	23	70	**13**
Spain	34	2	32	4	32	4	10	**35**
Sweden	33	3	28	8	26	10	21	**29**
Switzerland	20	16	16	20	16	20	56	**17**
Turkey	25	11	34	2	35	1	14	**33**
United Kingdom	29	7	33	3	33	3	13	**34**
United States	35	1	22	14	23	13	28	**27**

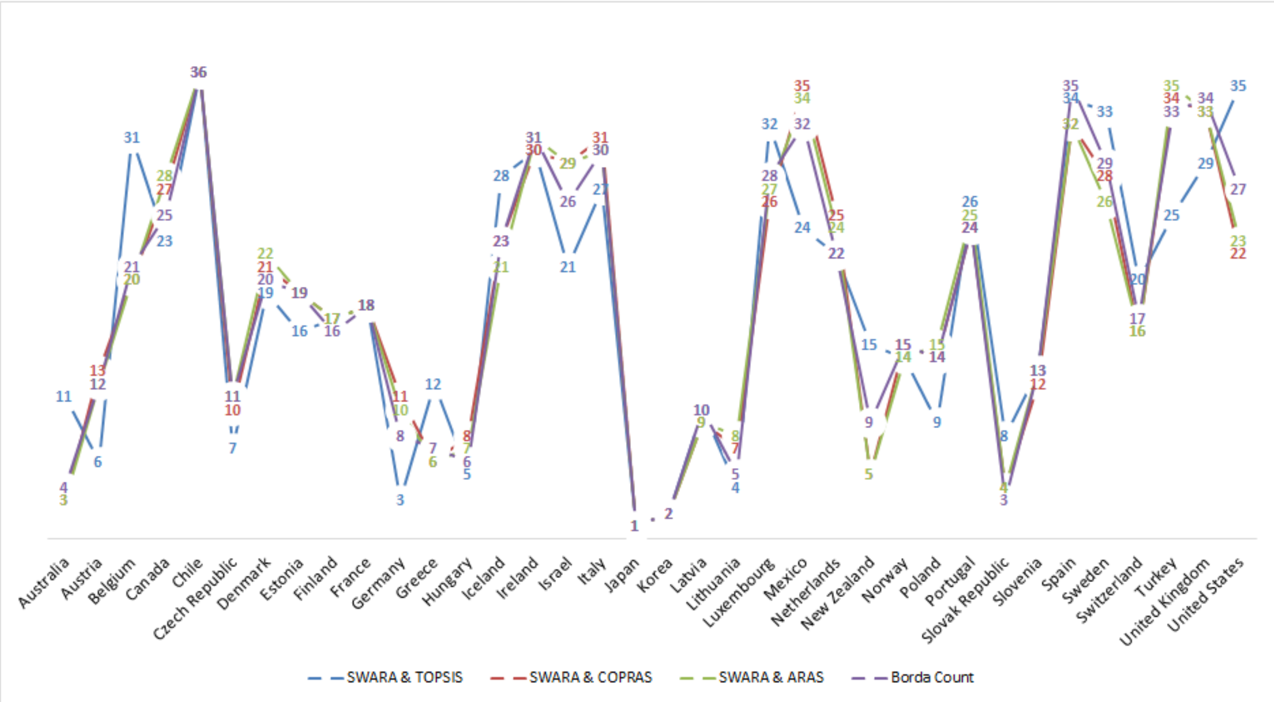

Figure 1. The rankings of the alternatives

4. Discussion and Conclusion

In this study, OECD countries were evaluated by the MCDM methods according to the specified criteria in combating COVID-19. First, the weights of the criteria were determined according to the expert opinions with the help of SWARA. Then 36 countries were ranked using TOPSIS, COPRAS, and ARAS methods. The final rankings were obtained by Borda Count method. The main advantage of the proposed method is that it allows decision-makers to approach complex decision-making problems with a highly methodological basis for decision support.

According to the SWARA method, C_1 (number of confirmed cases per 1M population) was the most significant criterion affecting the evaluation process with weight of 0.294. Some of the countries were caught unprepared by COVID-19, and they were late to fight the virus. This is an important factor in the high number of confirmed cases. The number of confirmed cases can be reduced by some strategies for preventing or controlling COVID-19 such as the use of masks, complying with social distancing and hygiene rules, travel and transportation restrictions, temporary closure of places where people are located, isolation, and quarantine. C_2 (number of deaths per 1M population) had the least importance with 0.103 according to the SWARA. In the coronavirus crisis, it is a fact that the regions with lower values of welfare, and weak healthcare systems are more disadvantaged. However, there are different factors that affect the number of deaths. The most important of these is the age factor. Studies have determined that COVID-19 may have more serious mortality in people aged 65 and over. For example, Germany, despite being more advantageous than Turkey according to C_3 (number of doctors per 1000 population), C_4 (number of nurses per 1000 population), C_5 (number of hospital beds per 1000 population), C_6 (health spending share), and although C_1 (number of confirmed cases per 1M population) is similar for the two countries, the mortality rate in Turkey is much lower than in Germany. At this stage, the low share of the 65 and older population in the total population in Turkey, and treatment methods are some of the advantages of Turkey in combating COVID-19.

After the criteria weights were obtained, the alternatives were ranked using SWARA-based TOPSIS, COPRAS, and ARAS methods. Then the final ranking was obtained using Borda Count method. Japan is the most advantageous country among OECD countries in the fight against COVID-19 according to all rankings and Korea is the second. According to the final ranking, Korea is followed by Slovak Republic and Australia, respectively. Chile is scored lowest. Chile is preceded by Spain and United Kingdom.

For future work, the performance of the countries may be evaluated by including criteria such as the median age, and the ratio of the population with chronic disease in the total population.

References

[1] World Health Organization (WHO). 2020a. Novel Coronavirus (2019-nCoV): Situation Report, 11.

[2] Türkiye Bilimler Akademisi (TÜBA). 2020. COVID-19 Pandemi Değerlendirme Raporu, Ankara.

[3] World Health Organization (WHO), 2020b. COVID-19 Strategy Update, 14 April 2020.

[4] Albahri, O. S., Al-Obaidi, J. R., Zaidan, A. A., Albahri, A. S., Zaidan, B. B., Salih, M. M., Qays, A., Dawood, K. A., Mohammed, R. T., Abdulkareem, K. H., Aleesa, A. M., Alamoodi, A. H., Chyad, M. A., Zulkifli, C. Z. 2020. Helping doctors hasten COVID-19 treatment: Towards a rescue framework for the transfusion of best convalescent plasma to the most critical patients based on biological requirements via ml and novel MCDM methods. Comput. Meth. Prog. Bio., 196, 105617.

[5] Yang, Z., Li, X., Garg, H., Qi, M. 2020. Decision support algorithm for selecting an antivirus mask over COVID-19 pandemic under spherical normal fuzzy environment. Int. J. Environ. Res. Public Health, 17, 3407.

[6] Ren, Z., Liao, H., Liu, Y. 2020. Generalized Z-numbers with hesitant fuzzy linguistic information and its application to medicine selection for the patients with mild symptoms of the COVID-19. Comput. Ind. Eng., 145, 106517.

[7] Maqbool, A., Khan, N. Z. 2020. Analyzing barriers for implementation of public health and social measures to prevent the transmission of COVID-19 disease using DEMATEL method. Diabetes Metab. Syndr., 14, 887-892.

[8] Sangiorgio, V., Parisi, F. 2020. A multicriteria approach for risk assessment of Covid-19 in urban district Lockdown. Saf. Sci., 130,104862.

[9] Majumder, P., Biswas, P., Majumder, S. 2020. Application of new TOPSIS approach to identify the most significant risk factor and continuous monitoring of death of COVID-19. Electron. J. Gen. Med., 17(6), em234.

[10] Mardani, A., Saraji, M. K., Mishra, A. R., Rani, P. 2020. A novel extended approach under hesitant fuzzy sets to design a framework for assessing the key challenges of digital health interventions adoption during the COVID-19 outbreak. Appl. Soft Comput., 96, 106613.

[11] Wu, W., Xu, Z. 2020. Hybrid TODIM method with crisp number and probability linguistic term set for urban epidemic situation evaluation. Complexity, 1-11.

[12] Sayan, M., Sarigul Yildirim, F., Sanlidag, T., Uzun, B., Uzun Ozsahin, D., Ozsahin, I. 2020. Capacity evaluation of diagnostic tests for COVID-19 using multicriteria decision-making techniques. Computational and Mathematical Methods in Medicine, 1-8.

[13] Grida, M., Mohamed, R., Zaied, A. N. H. 2020. Evaluate the impact of COVID-19 prevention policies on supply chain aspects under uncertainty. Transportation Research Interdisciplinary Perspectives, 8,100240.

[14] Samanlioglu, F., Kaya, B. E. 2020. Evaluation of the COVID-19 pandemic intervention strategies with hesitant F-AHP. Journal of Healthcare Engineering, 1-11.

[15] Chai, J., Xian, S., Lu, S. 2020. Z-uncertain probabilistic linguistic variables and its application in emergency decision making for treatment of COVID-19 patients. Int. J. Intell. Syst., 1-41.

[16] Hezam, I. M., Nayeem, M. K., Foul, A., Alrasheedi, A. F. 2021. COVID-19 Vaccine: A neutrosophic MCDM approach for determining the priority groups. Results in Physics, 20, 103654.

[17] Ghorui, N., Ghosh, A., Mondal, S. P., Bajuri, M. Y., Ahmadian, A., Salahshour, S., Ferrara, M. 2021. Identification of dominant risk factor involved in spread of COVID-19 using hesitant fuzzy MCDM methodology. Results in Physics 21, 103811.

[18] Manupati, V. K., Ramkumar, M., Baba, V., Agarwal, A. Selection of the best healthcare waste disposal techniques during and post COVID-19 pandemic era. Journal of Cleaner Production, 281, 125175.

[19] Shah, S. A. A., Longsheng, C., Solangi, Y.A., Ahmad, M., Ali, S. 2021. Energy trilemma based prioritization of waste-to-energy technologies: Implications for post-COVID-19 green economic recovery in Pakistan. Journal of Cleaner Production, 284, 124729.

[20] Keršulienė, V., Zavadskas, E. K., Turskis, Z. 2010. Selection of rational dispute resolution method by applying new step-wise weight assessment ratio analysis (SWARA). Journal of Business Economics and Management, 11(2), 243–258.

[21] Stanujkic, D., Karabasevic, D., Zavadskas, E. K. 2015. A Framework for the selection of a packaging design based on the SWARA method. Inzinerine Ekonomika-Engineering Economics, 26(2), 181–187.

[22] Hwang, C. L., Yoon, K. 1981. Multiple Attribute Decision Making. Lecture Notes in Economics and Mathematical Systems. Springer-Verlag, Berlin.

[23] Opricovic, S., Tzeng, G. H. 2004. Compromise solution by MCDM methods: A comparative analysis of VIKOR and TOPSIS. Eur. J. Oper. Res., 156, 445-455.

[24] Zavadskas, E. K., Kaklauskas, A., Sarka, V. 1994. The new method of multicriteria complex proportional assessment of projects. Technological and Economic Development of Economy, 1(3),131-139.

[25] Zavadskas, E. K., Kaklauskas, A. 1996. Systemotechnical evaluation of buildings (Pastatų sistemotechninis įvertinimas). Vilnius: Tech. 280. (in Lithuanian).

[26] Zavadskas, E. K., Kaklauskas, A., Turskis, Z., Tamošaitienė, J. 2008. Selection of the Effective Dwelling House Walls by Applying Attributes Values Determined at Intervals. Journal of Civil Engineering and Management, 14(2), 85-93.

[27] Kaklauskas, A., Zavadskas, E.K., Naimavicienė, J., Krutinis, M., Plakys, V. Venskus, D.,2010. Model for a complex analysis of intelligent built environment. Autom. Constr., 19, 326-340.

[28] Kildienė, S., Kaklauskas, A. Zavadskas E.K. 2011. COPRAS based comparative analysis of the European country management capabilities within the construction sector in the time of crisis. J. Bus. Econ. Manag., 12(2), 417-434.

[29] Chatterjee, P., Athawale V. W., Chakraborty, S. 2011. Materials selection using complex proportional assessment and evaluation of mixed data methods. Mater. Des., 32, 851-860.

[30] Zavadskas, E. K., Turskis, Z. 2010. A new Additive Ratio Assessment (ARAS) method in multicriteria decision-making. Technol. Econ. Dev. Econ., 16, 159-172.

[31] Borda, J. C. 1784. Mémoire sur les élections au scrutin. Histoire de l'Académie royale des sciences, Paris.

[32] Lamboray, C. 2007. A comparison between the prudent order and the ranking obtained with Borda's, Copeland's, Slater's and Kemeny's rules. Math. Soc. Sci., 54, 1-16.

[33] Lansdowne, Z. F., Woodward, B. S. 1996. Applying the Borda ranking method. Air Force Journal of Logistics, 20(2), 27-29.

[34] Ömürbek, N., Urmak Akçakaya, E. D. 2018. Analysis of the aviation companies on the FORBES 2000 list with the ENTROPY, MAUT, COPRAS and SAW methods. Suleyman Demirel University the Journal of Faculty of Economics and Administrative Sciences, 23(1), 257-278.

[35] ISC, 2020. https://maps.isc.gov.ir/covid19/#/world, Retrieved 2020, June 25.

[36] OECD. 2019. Health at a Glance 2019: OECD Indicators, OECD Publishing, Paris, https://doi.org/10.1787/4dd50c09-en.