Multi-Criteria Assessment of Better Life via TOPSIS and MOORA Methods

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Abstract

OECD Better Life Index is an important indicator for countries well-being. OECD collects the data from countries and compiles its index which gives more details about people daily life. In this way people can compare the life standards of the countries under 11 different topics. In this study, better life is assessed with TOPSIS and MOORA methods which are the multi-criteria decision making methods. Methods are applied to 36 alternative countries and 24 criteria in the OECD Better Life Index data. Thus we have alternative better life ranks according to methods.

Keywords: TOPSIS; MOORA; Multi-criteria decision making; better life; OECD

Introduction

OECD (The Organisation for Economic Co-operation and Development) is an organization which was officially born on 1961. Today, it has 34 member countries worldwide regularly turn to one another to identify problems, discuss and analyse them, and promote policies to solve them (OECD-history, online). Its mission is to promote policies that will improve the economic and social well-being of people around the world. In this way it provides a forum in which governments can work together to share experiences and seek solutions to common problems. It looks at issues that directly affect everyone's daily life, such as; taxes and social security expenditures, leisure time. It compares different countries' school system show they are readying their young people for modern life, and pension system show they will look after their citizens in old age(OECD-about, online). OECD releases "Better Life index". People can compare well-being across countries by this index, based on 11 topics the OECD has identified as essential which are in the areas of material living conditions and quality of life (OECD-better life, online).

There are several studies in literature review which are about TOPSIS and MOORA methods. Some of them are as following. Jahanshahloo, Lotfi and Izadikhah (2006) give the extension of the TOPSIS method for decision-making problems with fuzzy data.Lotfi, Fallahnejad and Navidi (2011) rank efficient units in data envelopment analysis by using TOPSIS method. El-Santawy and Ahmed (2012) give an information entropy weighting method combined to TOPSIS approach for ranking consulting firms. Barros and Wanke (2015) make analysis of African airlines efficiency with two-stage TOPSIS and neural networks. Lourenzutti and Krohling (2016) use a generalized TOPSIS method for group decision making with heterogeneous information in a dynamic environment. Ramesh, Viswana than and Ambika (2016) use grey relational analysis, TOPSIS and RSA techniques for measurement and optimization of surface roughness and tool wear. For predicting efficiency in Malaysian Islamic banks,Wanke, Azad and Barros (2016) use two-stage TOPSIS and neural networks approach. Brauers and Zavadskas (2006) give the MOORA method and its application to privatization in a transition economy. Brauers, Zavadskas, Peldschus and Turskis (2008) apply MOORA method for multi-objective optimization of road design alternatives. Brauers, Zavadskas, Turskis and Vilutienė (2008) use MOORA method multi-objective contractor's ranking. Kalibatas and Turskis (2008) makemulti-criteria evaluation of inner climate with MOORA method. Brauers, Ginevičius and Podvezko (2010) use MOORA method for considering multiple objectives of regional development in Lithuania.

Chakraborty(2011) use MOORA method for decision making in manufacturing environment. Karande and Chakraborty (2012)apply MOORA method for materials selection.Görener, Dinçer and Hacıoğlu (2013) select bank branch location by M OORA method. In this study, 36 countries, OECD countries as well as Russia and Brazil, are assessed by TOPSIS and MOORA methods according to Better Life Index data of OECD. The paper is organized in the following way: Firstly methods are defined, secondly the methods are applied and lastly the results are given, compared and reviewed.

2. Methods

In this section the TOPSIS and MOORA methods are presented. Consider the evaluation matrix (decision matrix) consisting of *m* alternatives and *n* criteria in both methods. Let $A = \{A_1, A_2, \dots, A_m\}$ be a set of *m* alternatives and $C = \{C_1, C_2, \dots, C_n\}$ be the set of *n* criteria. $x_{ij}$is the rating of alternative A_i with respect to criterion C_j. $W = \{w_1, w_2, \dots, w_n\}$be the set of weights of criteria. (El-Santawy& Ahmed, 2012;Jahanshahloo, Lotfi, & Izadikhah, 2006)

2.1. The TOPSIS Method

The TOPSIS method is described in the following steps (Wanke, Azad, & Barros, 2016; Ramesh, Viswanathan, &Ambika, 2016; Lourenzutti & Krohling, 2016; Barros & Wanke, 2015; Lotfi, Fallahnejad, & Navidi, 2011):

Step 1: The evaluation (decision) matrix $(x_{ij})_{mxn}$ consisting of *m* alternatives and *n* criteria is developed.

Step 2: Decision matrix $(x_{ij})_{mxn}$ is normalized to a regulated matrix $(r_{ij})_{mxn}$.

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \quad (1)$$

Step 3: Calculate the weighted normalized decision matrix $V = (v_{ij})_{mxn}$;

$$v_{ij} = w_j . r_{ij} \quad (2)$$

wherew_j is the weight of the criterion *j* and $\sum_{j=1}^{n} w_j = 1$.

Step 4: The positive ideal solution (PIS), A^+, and the negative ideal solution (NIS), A^-, define for each criterion. Usually $A^+ = max\{v_1^+, v_2^+, \cdots, v_n^+\}$ and $A^- = min\{v_1^-, v_2^-, \cdots, v_n^-\}$ for benefit criteria, $A^+ = min\{v_1^+, v_2^+, \cdots, v_n^+\}$ and $A^- = max\{v_1^-, v_2^-, \cdots, v_n^-\}$ for cost criteria.

Step 5: Calculate the separation measures for each alternative. Measuring the distance of alternatives from positive and negative ideal solutions.

$$S_i^+ = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^+\right)^2}, \qquad i = 1,2, \dots, m \quad (3)$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2}, \qquad i = 1,2, \dots, m \quad (4)$$

Step 6: Calculate the closeness coefficients to the ideal solution.

$$CC_i = \frac{S_i^-}{S_i^* + S_i^-}, \quad (0 \le CC_i \le 1, i = 1,2, \dots, m) \quad (5)$$

Rank the alternatives according to CC_i. The higher value of CC_i, indicates a better alternative A_i.

2.2. The MOORA Method

The MOORA method starts with an evaluation (decision) matrix $(x_{ij})_{mxn}$ consisting of *m* alternatives and *n* criteria is developed. The MOORA method consists of two parts: the ratio system and the reference point approach (Brauers, Ginevičius, & Podvezko, 2010).

2.2.1 The Ratio System

The ratio system as a part of MOORA is referred to in which each response of an alternative on a criterion is compared to a denominator, the square root of the sum of squares of each alternative per objective, which is representative for all alternatives concerning that criterion (objective) (Chakraborty, 2011). This ratio can be defined as;

$$x_{ij}^* = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \tag{6}$$

x_{ij}^*:dimensionless number representing the normalized response of *i-th* alternative on *j-th* criterion (objective). $x_{ij}^* \in [0,1]$. However, sometimes the interval could be $[-1,1]$ instead of $[0,1]$ (Brauers, Zavadskas, Turskis, & Vilutienė, 2008).

For optimization, these normalized responses are added in case of maximization and subtracted in case of minimization (Görener, Dinçer, & Hacıoğlu, 2013).

$$y_i^* = \sum_{j=1}^{g} x_{ij}^* - \sum_{j=g+1}^{n} x_{ij}^* \tag{7}$$

$j = 1,2, \dots, g$; as the objectives to be maximized,
$j = g + 1, g + 2, \dots, n$; as the objectives to be minimized,
An ordinal ranking of the y_i^* shows the final preference.

2.2.2 The Reference Point Approach

The reference point approach starts from the ratio found in formula (6). The highest co-ordinate per objective of all the candidate alternatives is chosen as reference point for maximization. For minimization, the lowest co-ordinate is chosen (Brauers & Zavadskas, 2006).

The Tchebycheff Min-Max metric uses for measure the distance between the alternatives and the reference point(Brauers & Zavadskas, 2006);

$$min_i\{max_j|r_j - x_{ij}^*|\} \tag{8}$$

$i = 1,2, \dots, m$: are the alternatives,
$j = 1,2, \dots, n$: are the criteria (objectives),
r_j:the*j-th* objective reference point.

2.2.3 Significance Coefficient

Since some criteria (objectives) are more important than others in some cases, it could be multiplied with its corresponding weights (significance coefficient) (Chakraborty, 2011). In that case; formula (9) uses instead of formula (7) and formula (10) uses instead of formula (8) (Brauers, Zavadskas, Peldschus, &Turskis, June 26-29, 2008).

$$y_i^* = \sum_{j=1}^{g} w_j x_{ij}^* - \sum_{j=g+1}^{n} w_j x_{ij}^* \tag{9}$$

$$min_i\{max_j|w_j r_j - w_j x_{ij}^*|\} \tag{10}$$

3. Application and Results

3.1 Data Set

Data set is obtained from OECD Better Life Index (OECD better life data,online). There are 24 criteria at the Table1 which are related with 11 topics such as; Housing, Income, Jobs, Community, Education, Environment, Civic Engagement, Health, Life Satisfaction, Safety and Work-Life Balance. 34 OECD member countries plus Brazil and Russia, totally 36 countries are alternatives. Alternatives rank with TOPSIS and MOORA methods.

Criteria one and two (C1 and C2) are under the topic of Income. The first criterion (C1), household net adjusted disposable income represents the money obtainable to a household for spending on goods or services. It is the amount of money that a household earns, or gains, each year after taxes and transfers, latest available year. Criterion two (C2) is household net financial wealth. It defines as the sum of their overall financial assets minus liabilities, latest available year (OECD-better life, income, online).

Criteria C3(Rooms per person), C17(Dwellings without basic facilities) and C18(Housing expenditure) are under the topic of Housing. The criterion, rooms per person, is about average number of rooms shared per person in a dwelling, latest available year. It indicates whether residents are living in crowded conditions which may cause a negative impact on physical and mental health, relations with others, and children's development. In addition, criterion C3 is related with criterion C17, because dense living conditions are often a sign of inadequate water and sewage supply. The criterion C18 represents the housing costs such as rent, gas, electricity, water, furniture and repairs. It may represent the largest single expenditure for many individuals and families. Housing expenditure criterion is the ratio of housing costs on gross adjusted disposable income of the households, latest available year (OECD-better life, housing, online).

Criteria C4 (Employment rate), C5 (Personal earnings), C19 (Job security) and C20 (Long-term unemployment rate) are under the topic of Jobs. The criterion employment rate indicates the percentage of people, aged 15 to 64, currently in a paid job, latest available year. Personal earnings are average personal annual earnings per full time employee, latest available year. Earnings; represent the main source of income for most households and may also suggest how fairly work is remunerated by analyzing it. Job security is another essential factor of employment quality. C19, job security criterion represents workers chance of losing their job, latest available year. Long-term unemployment rate is the percentage of people, aged 15 to 64, whoare currently not working but have been actively searching a job for over a year, latest available year. In addition, it can have a large negative effect on feelings of well-being and self-worth, and result in a loss of skills, further reducing employability (OECD-better life, jobs, online).

Criterion C6 (Quality of support network) is under the topic of Community. It indicates the percentage of people who have friends or relatives to depend on in case of need. A strong social network, or community, has important role. It can provide emotional support during both good and bad times as well as access to jobs, services and other material opportunities (OECD-better life, community, online).

Criteria C7 (Educational attainment), C8(Student skills), C9 (Years in education) is under the topic of Education. Education is really important topic for individuals. It can help people to improve their lives in such areas as health, civic participation, political interest and happiness. Educational attainment indicates the percentage of people, age 25 to 64, having at least an upper-secondary (high school) degree, latest available year. Students skills criterion indicates average performance of students age 15, according to Programme for International Student Assessment (PISA). Criterion, years in education, indicates average duration of formal education in which a five-year old child can expect to enroll during his/her lifetime until the age of 39(OECD- better life, education, online). Criteria C10 (Water quality) and C21 (Air pollution) are under the topic of environment. The quality of environment which has directly affects the quality of people's lives. Criterion water quality represents the percentage of people reporting to be satisfied with the quality of local water. Criterion air pollution is average concentration of particulate matter (PM10) in cities populations larger than 100000, measured in micrograms per cubic meter, latest available year (OECD- better life, environment, online).

Criteria C11 (Consultation on rule-making) and C12 (Voter turnout) are under the topic of "Civic Engagement". Criterion C11, "Consultation on rule-making", indicates level of governmental transparency when drafting regulations, latest available year. Criterion C12, "Voter turnout", represents the percentage of registered voters who voted during recent elections, latest available year (OECD- better life, civic-engagement, online). Criteria C13 (Life expectancy) and C14 (Self-reported health) are under the topic of "Health". Criterion "Life expectancy" is about average number of years a person expects to live, latest available year. Criterion "Self-reported health" is related to the percentage of people reporting their health to be "good or very well", latest available year (OECD-better life, health, online).

Criterion C15 is "Life satisfaction" which is under the topic, same name, "Life satisfaction". It indicates average self-evaluation of life satisfaction, on a scale from0 to 10 (OECD- better life, life satisfaction, online).

Criteria C22 (Assault rate) and C23 (Homicide rate) are under the topic of “Safety”. Criterion C22, “Assault rate”, is about the percentage of people who report having been assaulted in the previous year. Criterion C23, “Homicide rate”, represents average number of reported homicides per 100000 people, latest available year (OECD- better life, safety, online).

Criteria C16 (Time devoted to leisure and personal care) and C24 (Employees working very long hours) are under the topic of “Work-Life Balance”. Criterion C16, time devoted to leisure and personal care, indicates average number of minutes per day spent on leisure and personal care, including sleeping and eating. Criterion C24, employees working very long hours, represents the percentage of employees working fifty hours or more a week on average, latest available year (OECD- better life, wok-life balance, online). There are 36 alternatives which are consisted of OECD countries as well as Brazil and Russia. They are shown at the Table2.

3.2. Assessment of Better Life

The TOPSIS and MOORA methods are applied to better life index data. Because of we assume that any of the criteria is not more significant than any other criteria, weights are not use. Calculation steps write with Java. The Java codes run in the computer with Intel(R) Core(TM) i7-4770 CPU 3.40GHz and 8Gb RAM. CPU time takes93 milliseconds for TOPSIS and 93 milliseconds for MOORA (ratio approach and reference point) methods. Normalized matrix, ideal solutions for TOPSIS method and reference points for MOORA – Reference point approach method are given at the Table 3. Deviations from references points are given at the Table 4. The separation measures of each alternative and closeness coefficients to the ideal solution for TOPSIS method and MOORA ratio system and reference point approach results are shown at the Table 5. Rankings of the methods are given and compared at the Table5.

4. Conclusion

The TOPSIS, MOORA Ratio System and MOORA Reference Point Approach methods are used for ranking countries. These methods give ideas about the better life country ranking. There are some differences between rankings of the countries according to methods. In spite of the changes in the ranking, some countries usually dominate the top of the rankings. United States and Switzerland dominate first two rows of the ranking list for each of the three methods. United States, Switzerland and Canada dominate first three rows of the ranking list for TOPSIS and MOORA- Ratio System methods.

United States is the first alternative to the both TOPSIS and MOORA- Ratio System methods which is at the second order of the MOORA- Reference Point Approach results. Thus it can say that United States is the best country of the better life ranking. Switzerland is the second alternative to the TOPSIS method, third alternative of the MOORA-Ratio System and the first better life country according to MOORA - Reference Point Approach results. Canada is the third better life country according to TOPSIS method, second for MOORA-Ratio System method and fifth for MOORA- Reference Point Approach method. Luxembourg is the fourth alternative country according to TOPSIS method and seventh alternative for MOORA- Ratio System method, sixth alternative for MOORA- Reference Point Approach results. Sweden is the fifth better life country according to TOPSIS and fourth to MOORA- Ratio System method. It is eighth alternative to MOORA- Reference Point Approach results. These countries can be examples to the top of the ranking list.

Mexico is the thirty-sixth alternative county to the TOPSIS and MOORA- Ratio System methods and it is at the thirty-fifth order to the MOORA- Reference Point Approach results. Brazil is the thirty-fifth alternative country according to TOPSIS, thirty-fourth alternatives to MOORA- Ratio System method, thirty-sixth alternative to MOORA- Reference Point Approach results.

If weights use for criteria, some criteria will be more important than others. So according to weights, the importance of the criteria, ranking may be different. In future studies, researchers can determine their weights and apply to criteria. Thus new better life assessments can create.

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Table 1: List of Criteria

		Criteria Situation	
		TOPSIS	MOORA
C1	Household net adjusted disposable income	Benefit	Max
C2	Household net financial wealth	Benefit	Max
C3	Rooms per person	Benefit	Max
C4	Employment rate	Benefit	Max
C5	Personal earnings	Benefit	Max
C6	Quality of support network	Benefit	Max
C7	Educational attainment	Benefit	Max
C8	Student skills	Benefit	Max
C9	Years in education	Benefit	Max
C10	Water quality	Benefit	Max
C11	Consultation on rule-making	Benefit	Max
C12	Voter turnout	Benefit	Max
C13	Life expectancy	Benefit	Max
C14	Self-reported health	Benefit	Max
C15	Life satisfaction	Benefit	Max
C16	Time devoted to leisure and personal care	Benefit	Max
C17	Dwellings without basic facilities	Cost	Min
C18	Housing expenditure	Cost	Min
C19	Job security	Cost	Min
C20	Long-term unemployment rate	Cost	Min
C21	Air pollution	Cost	Min
C22	Assault rate	Cost	Min
C23	Homicide rate	Cost	Min
C24	Employees working very long hours	Cost	Min

Table 2 : List of Alternatives

A1	Australia	A19	Korea
A2	Austria	A20	Luxembourg
A3	Belgium	A21	Mexico
A4	Canada	A22	Netherlands
A5	Chile	A23	New Zealand
A6	Czech Republic	A24	Norway
A7	Denmark	A25	Poland
A8	Estonia	A26	Portugal
A9	Finland	A27	Slovak Republic
A10	France	A28	Slovenia
A11	Germany	A29	Spain
A12	Greece	A30	Sweden
A13	Hungary	A31	Switzerland
A14	Iceland	A32	Turkey
A15	Ireland	A33	United Kingdom
A16	Israel	A34	United States
A17	Italy	A35	Brazil
A18	Japan	A36	Russia

Table 3: Normalized matrix, ideal solutions for TOPSIS method and reference points for MOORA – Reference point approach method

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24
	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MAX	MIN	MIN	MIN	MIN	MIN	MIN	MIN	MIN
	Benefit	Benefit	Benefit	Benefit	Benefit	Benefit	Benefit	Benefit	Benefit	Benefit	Benefit	Benefit	Benefit	Benefit	Benefit	Benefit	Cost	Cost	Cost	Cost	Cost	Cost	Cost	Cost
A1	0.209	0.154	0.224	0.180	0.220	0.171	0.164	0.172	0.184	0.182	0.232	0.218	0.171	0.204	0.184	0.161	0.041	0.159	0.127	0.035	0.101	0.076	0.021	0.190
A2	0.206	0.162	0.155	0.180	0.197	0.165	0.179	0.168	0.162	0.188	0.157	0.176	0.169	0.166	0.173	0.162	0.037	0.166	0.103	0.038	0.210	0.123	0.010	0.103
A3	0.187	0.272	0.214	0.155	0.209	0.175	0.156	0.171	0.180	0.174	0.099	0.208	0.168	0.178	0.173	0.176	0.074	0.166	0.132	0.124	0.163	0.239	0.029	0.062
A4	0.194	0.220	0.243	0.180	0.204	0.171	0.192	0.176	0.163	0.182	0.232	0.143	0.170	0.214	0.184	0.159	0.007	0.166	0.169	0.029	0.116	0.047	0.039	0.053
A5	0.096	0.057	0.117	0.155	0.096	0.160	0.123	0.147	0.157	0.146	0.044	0.115	0.165	0.142	0.168	0.161	0.349	0.143	0.117	0.051	0.357	0.249	0.115	0.209
A6	0.122	0.056	0.136	0.170	0.089	0.158	0.199	0.168	0.172	0.170	0.150	0.138	0.163	0.144	0.163	0.168	0.033	0.206	0.109	0.100	0.124	0.101	0.021	0.095
A7	0.175	0.144	0.185	0.182	0.210	0.176	0.169	0.168	0.184	0.188	0.155	0.206	0.167	0.173	0.189	0.180	0.033	0.190	0.148	0.057	0.116	0.141	0.008	0.027
A8	0.100	0.025	0.146	0.170	0.082	0.165	0.195	0.177	0.166	0.158	0.073	0.150	0.160	0.130	0.141	0.167	0.301	0.151	0.138	0.122	0.070	0.199	0.126	0.045
A9	0.185	0.061	0.185	0.172	0.174	0.176	0.184	0.178	0.187	0.188	0.199	0.162	0.169	0.156	0.186	0.167	0.022	0.174	0.183	0.055	0.116	0.087	0.037	0.048
A10	0.191	0.158	0.175	0.160	0.175	0.162	0.158	0.168	0.156	0.164	0.077	0.187	0.171	0.161	0.163	0.172	0.019	0.166	0.172	0.128	0.093	0.181	0.016	0.110
A11	0.207	0.163	0.175	0.182	0.190	0.175	0.186	0.173	0.173	0.190	0.099	0.169	0.169	0.156	0.176	0.171	0.004	0.166	0.082	0.076	0.124	0.130	0.013	0.071
A12	0.123	0.047	0.117	0.122	0.111	0.154	0.147	0.157	0.177	0.138	0.144	0.150	0.169	0.178	0.121	0.167	0.026	0.198	0.323	0.588	0.210	0.134	0.042	0.083
A13	0.102	0.043	0.107	0.145	0.091	0.162	0.177	0.164	0.167	0.154	0.174	0.145	0.157	0.137	0.123	0.168	0.178	0.159	0.151	0.163	0.116	0.130	0.034	0.043
A14	0.159	0.139	0.146	0.205	0.243	0.178	0.153	0.163	0.188	0.194	0.113	0.190	0.173	0.185	0.189	0.164	0.015	0.190	0.109	0.038	0.140	0.098	0.008	0.166
A15	0.158	0.102	0.204	0.150	0.216	0.178	0.162	0.174	0.167	0.160	0.199	0.164	0.169	0.197	0.176	0.170	0.007	0.151	0.156	0.268	0.101	0.094	0.021	0.057
A16	0.146	0.172	0.117	0.167	0.125	0.162	0.184	0.160	0.150	0.136	0.055	0.159	0.171	0.192	0.186	0.162	0.138	0.166	0.132	0.025	0.163	0.231	0.060	0.217
A17	0.167	0.178	0.136	0.140	0.150	0.167	0.123	0.165	0.160	0.142	0.110	0.176	0.172	0.159	0.151	0.168	0.041	0.190	0.156	0.222	0.163	0.170	0.018	0.050
A18	0.173	0.281	0.175	0.180	0.154	0.165	0.203	0.182	0.155	0.170	0.161	0.124	0.174	0.072	0.148	0.167	0.238	0.174	0.064	0.053	0.186	0.051	0.008	0.301
A19	0.129	0.094	0.136	0.160	0.158	0.134	0.177	0.183	0.166	0.156	0.230	0.178	0.170	0.084	0.146	0.164	0.156	0.127	0.085	0.000	0.233	0.076	0.029	0.254
A20	0.258	0.200	0.194	0.165	0.244	0.162	0.169	0.165	0.143	0.172	0.133	0.213	0.170	0.173	0.173	0.169	0.004	0.166	0.114	0.057	0.093	0.155	0.010	0.047
A21	0.087	0.029	0.097	0.152	0.070	0.143	0.080	0.140	0.137	0.134	0.199	0.148	0.156	0.159	0.168	0.155	0.156	0.166	0.130	0.003	0.233	0.463	0.612	0.390
A22	0.185	0.253	0.194	0.185	0.207	0.167	0.158	0.175	0.178	0.184	0.135	0.176	0.170	0.183	0.184	0.173	0.000	0.151	0.119	0.077	0.233	0.177	0.024	0.006
A23	0.158	0.092	0.233	0.182	0.155	0.175	0.160	0.171	0.172	0.178	0.227	0.180	0.170	0.216	0.184	0.166	0.007	0.182	0.135	0.024	0.085	0.080	0.031	0.188
A24	0.222	0.029	0.194	0.187	0.219	0.175	0.177	0.167	0.170	0.188	0.179	0.183	0.170	0.183	0.186	0.174	0.011	0.135	0.082	0.010	0.124	0.119	0.016	0.038
A25	0.118	0.035	0.107	0.150	0.099	0.169	0.195	0.175	0.175	0.158	0.239	0.129	0.161	0.139	0.146	0.159	0.119	0.166	0.193	0.120	0.256	0.051	0.024	0.100
A26	0.133	0.101	0.155	0.152	0.103	0.160	0.082	0.164	0.167	0.172	0.144	0.136	0.168	0.111	0.128	0.167	0.033	0.151	0.228	0.291	0.140	0.206	0.029	0.130
A27	0.116	0.028	0.107	0.150	0.088	0.167	0.199	0.159	0.155	0.162	0.146	0.138	0.159	0.159	0.153	0.168	0.022	0.206	0.146	0.302	0.101	0.108	0.031	0.095
A28	0.128	0.060	0.146	0.157	0.139	0.167	0.184	0.168	0.175	0.176	0.227	0.122	0.168	0.156	0.143	0.164	0.019	0.159	0.146	0.165	0.202	0.141	0.010	0.076
A29	0.149	0.080	0.185	0.140	0.152	0.176	0.119	0.165	0.167	0.142	0.161	0.162	0.172	0.173	0.163	0.180	0.004	0.174	0.471	0.414	0.186	0.152	0.016	0.080
A30	0.193	0.195	0.165	0.185	0.178	0.171	0.190	0.162	0.183	0.190	0.241	0.201	0.171	0.195	0.181	0.169	0.000	0.159	0.172	0.044	0.078	0.184	0.018	0.015
A31	0.222	0.353	0.175	0.200	0.236	0.178	0.186	0.174	0.164	0.192	0.186	0.115	0.173	0.195	0.189	0.168	0.000	0.174	0.079	0.047	0.155	0.152	0.013	0.091
A32	0.093	0.011	0.107	0.125	0.074	0.160	0.073	0.156	0.156	0.124	0.121	0.206	0.156	0.163	0.141	0.150	0.472	0.166	0.215	0.076	0.272	0.181	0.031	0.553
A33	0.179	0.197	0.185	0.177	0.179	0.169	0.169	0.169	0.156	0.176	0.254	0.155	0.169	0.178	0.171	0.166	0.007	0.182	0.138	0.089	0.101	0.069	0.008	0.172
A34	0.274	0.472	0.233	0.167	0.245	0.167	0.192	0.166	0.163	0.170	0.183	0.159	0.164	0.211	0.181	0.160	0.004	0.143	0.156	0.061	0.140	0.054	0.136	0.153
A35	0.077	0.022	0.155	0.167	0.075	0.167	0.097	0.135	0.155	0.144	0.088	0.185	0.154	0.166	0.176	0.168	0.249	0.166	0.122	0.063	0.140	0.285	0.667	0.141
A36	0.128	0.011	0.087	0.172	0.091	0.167	0.203	0.162	0.152	0.112	0.055	0.152	0.147	0.089	0.151	0.168	0.561	0.087	0.106	0.054	0.116	0.137	0.335	0.002
Positive ideal solutions(TOPSIS):	**0.274**	**0.472**	**0.243**	**0.205**	**0.245**	**0.178**	**0.203**	**0.183**	**0.188**	**0.194**	**0.254**	**0.218**	**0.174**	**0.216**	**0.189**	**0.180**	**0.000**	**0.087**	**0.064**	**0.000**	**0.070**	**0.047**	**0.008**	**0.002**
Negative ideal solutions(TOPSIS):	**0.077**	**0.011**	**0.087**	**0.122**	**0.070**	**0.134**	**0.073**	**0.135**	**0.137**	**0.112**	**0.044**	**0.115**	**0.147**	**0.072**	**0.121**	**0.150**	**0.561**	**0.206**	**0.471**	**0.588**	**0.357**	**0.463**	**0.667**	**0.553**
Reference points(MOORA):	**0.274**	**0.472**	**0.243**	**0.205**	**0.245**	**0.178**	**0.203**	**0.183**	**0.188**	**0.194**	**0.254**	**0.218**	**0.174**	**0.216**	**0.189**	**0.180**	**0.000**	**0.087**	**0.064**	**0.000**	**0.070**	**0.047**	**0.008**	**0.002**

Table4: Deviations from reference point

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24
A1	0.065	0.318	0.019	0.025	0.026	0.007	0.039	0.010	0.004	0.012	0.022	0.000	0.002	0.012	0.005	0.018	0.041	0.071	0.064	0.034	0.031	0.029	0.013	0.188
A2	0.067	0.311	0.087	0.025	0.049	0.013	0.024	0.014	0.027	0.006	0.097	0.042	0.005	0.050	0.015	0.018	0.037	0.079	0.040	0.038	0.140	0.076	0.003	0.101
A3	0.086	0.201	0.029	0.050	0.036	0.004	0.048	0.011	0.009	0.020	0.155	0.009	0.006	0.038	0.015	0.004	0.074	0.079	0.069	0.124	0.093	0.192	0.021	0.060
A4	0.079	0.252	0.000	0.025	0.041	0.007	0.011	0.007	0.025	0.012	0.022	0.075	0.004	0.002	0.005	0.020	0.007	0.079	0.106	0.028	0.047	0.000	0.031	0.051
A5	0.178	0.415	0.126	0.050	0.149	0.019	0.080	0.036	0.031	0.048	0.210	0.103	0.009	0.074	0.020	0.018	0.349	0.055	0.053	0.050	0.287	0.202	0.107	0.207
A6	0.152	0.416	0.107	0.035	0.157	0.020	0.004	0.014	0.016	0.024	0.104	0.080	0.010	0.072	0.025	0.012	0.033	0.119	0.045	0.099	0.054	0.054	0.013	0.092
A7	0.098	0.328	0.058	0.022	0.035	0.002	0.035	0.015	0.004	0.006	0.099	0.012	0.006	0.043	0.000	0.000	0.033	0.103	0.085	0.057	0.047	0.094	0.000	0.025
A8	0.173	0.447	0.097	0.035	0.163	0.013	0.009	0.005	0.022	0.036	0.181	0.068	0.014	0.086	0.048	0.013	0.301	0.063	0.074	0.122	0.000	0.152	0.118	0.043
A9	0.089	0.412	0.058	0.032	0.071	0.002	0.019	0.004	0.001	0.006	0.055	0.056	0.005	0.060	0.003	0.013	0.022	0.087	0.119	0.055	0.047	0.040	0.029	0.046
A10	0.083	0.314	0.068	0.045	0.070	0.017	0.045	0.014	0.032	0.030	0.177	0.030	0.002	0.055	0.025	0.008	0.019	0.079	0.109	0.127	0.023	0.134	0.008	0.108
A11	0.067	0.309	0.068	0.022	0.055	0.004	0.017	0.009	0.015	0.004	0.155	0.049	0.005	0.060	0.013	0.008	0.004	0.079	0.019	0.075	0.054	0.083	0.005	0.069
A12	0.151	0.425	0.126	0.082	0.134	0.024	0.056	0.026	0.011	0.056	0.110	0.068	0.005	0.038	0.068	0.013	0.026	0.111	0.260	0.587	0.140	0.087	0.034	0.081
A13	0.172	0.429	0.136	0.060	0.154	0.017	0.026	0.019	0.021	0.040	0.080	0.073	0.017	0.079	0.065	0.011	0.178	0.071	0.087	0.163	0.047	0.083	0.026	0.041
A14	0.115	0.333	0.097	0.000	0.003	0.000	0.050	0.020	0.000	0.000	0.141	0.028	0.000	0.031	0.000	0.016	0.015	0.103	0.045	0.037	0.070	0.051	0.000	0.164
A15	0.115	0.370	0.039	0.055	0.030	0.000	0.041	0.009	0.021	0.034	0.055	0.054	0.005	0.019	0.013	0.010	0.007	0.063	0.093	0.268	0.031	0.047	0.013	0.055
A16	0.127	0.301	0.126	0.037	0.120	0.017	0.019	0.023	0.038	0.058	0.199	0.059	0.003	0.024	0.003	0.018	0.138	0.079	0.069	0.025	0.093	0.184	0.052	0.215
A17	0.107	0.294	0.107	0.065	0.095	0.011	0.080	0.018	0.029	0.052	0.144	0.042	0.002	0.058	0.038	0.012	0.041	0.103	0.093	0.221	0.093	0.123	0.010	0.047
A18	0.101	0.191	0.068	0.025	0.091	0.013	0.000	0.001	0.033	0.024	0.093	0.094	0.000	0.144	0.040	0.013	0.238	0.087	0.000	0.053	0.116	0.004	0.000	0.299
A19	0.145	0.378	0.107	0.045	0.087	0.045	0.026	0.000	0.022	0.038	0.024	0.040	0.004	0.132	0.043	0.016	0.156	0.040	0.021	0.000	0.163	0.029	0.021	0.251
A20	0.016	0.272	0.049	0.040	0.001	0.017	0.035	0.018	0.045	0.022	0.121	0.005	0.004	0.043	0.015	0.011	0.004	0.079	0.050	0.057	0.023	0.108	0.003	0.045
A21	0.187	0.443	0.146	0.052	0.175	0.035	0.123	0.042	0.051	0.060	0.055	0.070	0.018	0.058	0.020	0.024	0.156	0.079	0.066	0.002	0.163	0.416	0.605	0.388
A22	0.089	0.220	0.049	0.020	0.038	0.011	0.045	0.008	0.010	0.010	0.119	0.042	0.004	0.034	0.005	0.007	0.000	0.063	0.056	0.076	0.163	0.130	0.016	0.004
A23	0.116	0.381	0.010	0.022	0.090	0.004	0.043	0.011	0.016	0.016	0.027	0.037	0.004	0.000	0.005	0.013	0.007	0.095	0.072	0.024	0.016	0.033	0.024	0.186
A24	0.052	0.444	0.049	0.017	0.026	0.004	0.026	0.015	0.018	0.006	0.075	0.035	0.004	0.034	0.003	0.006	0.011	0.048	0.019	0.010	0.054	0.072	0.008	0.036
A25	0.156	0.437	0.136	0.055	0.147	0.009	0.009	0.007	0.013	0.036	0.015	0.089	0.013	0.077	0.043	0.021	0.119	0.079	0.130	0.120	0.186	0.004	0.016	0.098
A26	0.141	0.371	0.087	0.052	0.142	0.019	0.121	0.018	0.021	0.022	0.110	0.082	0.006	0.106	0.060	0.012	0.033	0.063	0.164	0.291	0.070	0.159	0.021	0.128
A27	0.158	0.444	0.136	0.055	0.157	0.011	0.004	0.024	0.033	0.032	0.108	0.080	0.015	0.058	0.035	0.012	0.022	0.119	0.082	0.302	0.031	0.061	0.024	0.093
A28	0.146	0.413	0.097	0.047	0.106	0.011	0.019	0.014	0.013	0.018	0.027	0.096	0.006	0.060	0.045	0.016	0.019	0.071	0.082	0.164	0.132	0.094	0.003	0.074
A29	0.125	0.392	0.058	0.065	0.094	0.002	0.084	0.018	0.021	0.052	0.093	0.056	0.001	0.043	0.025	0.000	0.004	0.087	0.408	0.414	0.116	0.105	0.008	0.078
A30	0.081	0.277	0.078	0.020	0.068	0.007	0.013	0.020	0.005	0.004	0.013	0.016	0.003	0.022	0.008	0.011	0.000	0.071	0.109	0.043	0.008	0.137	0.010	0.013
A31	0.052	0.120	0.068	0.005	0.009	0.000	0.017	0.008	0.024	0.002	0.068	0.103	0.001	0.022	0.000	0.012	0.000	0.087	0.016	0.046	0.085	0.105	0.005	0.089
A32	0.181	0.462	0.136	0.080	0.172	0.019	0.130	0.027	0.032	0.070	0.133	0.012	0.018	0.053	0.048	0.030	0.472	0.079	0.151	0.075	0.202	0.134	0.024	0.551
A33	0.095	0.275	0.058	0.027	0.066	0.009	0.035	0.013	0.032	0.018	0.000	0.063	0.005	0.038	0.018	0.014	0.007	0.095	0.074	0.088	0.031	0.022	0.000	0.170
A34	0.000	0.000	0.010	0.037	0.000	0.011	0.011	0.017	0.025	0.024	0.071	0.059	0.009	0.005	0.008	0.020	0.004	0.055	0.093	0.061	0.070	0.007	0.128	0.151
A35	0.197	0.450	0.087	0.037	0.171	0.011	0.106	0.047	0.033	0.050	0.166	0.033	0.020	0.050	0.013	0.012	0.249	0.079	0.058	0.063	0.070	0.239	0.660	0.139
A36	0.146	0.461	0.155	0.032	0.154	0.011	0.000	0.021	0.036	0.082	0.199	0.066	0.027	0.127	0.038	0.012	0.561	0.000	0.042	0.054	0.047	0.090	0.327	0.000

Table 5: Results of the methods

	TOPSIS				MOORA - Ratio System		MOORA - Reference Point Approach	
Country	S_i^+	S_i^-	CC_i	TOPSIS Rank	Ratio System (y_i^*)	Ratio System Rank	Reference Point Approach $max_j\|r_j - x_{ij}^*\|$	Reference Point Approach Rank $min_i\{max_j\|r_j - x_{ij}^*\|\}$
Australia	0.399	1.277	0.762	8	2.282	5	0.318	15
Austria	0.417	1.264	0.752	11	1.974	15	0.311	13
Belgium	0.403	1.210	0.750	12	1.906	16	0.201	3
Canada	0.322	1.332	0.805	3	2.399	2	0.252	5
Chile	0.791	0.975	0.552	31	0.459	33	0.415	25
Czech Republic	0.548	1.230	0.692	21	1.577	20	0.416	26
Denmark	0.412	1.286	0.757	10	2.129	8	0.328	16
Estonia	0.686	1.066	0.608	29	1.054	28	0.447	31
Finland	0.479	1.269	0.726	16	2.005	14	0.412	22
France	0.472	1.205	0.719	17	1.713	18	0.314	14
Germany	0.407	1.288	0.760	9	2.088	10	0.309	12
Greece	0.857	1.043	0.549	32	0.616	32	0.587	34
Hungary	0.607	1.141	0.653	26	1.242	26	0.429	27
Iceland	0.455	1.268	0.736	14	2.018	13	0.333	17
Ireland	0.506	1.220	0.707	18	1.891	17	0.370	18
Israel	0.557	1.122	0.668	24	1.310	25	0.301	11
Italy	0.506	1.171	0.698	19	1.453	23	0.294	9
Japan	0.522	1.181	0.694	20	1.609	19	0.299	10
Korea	0.573	1.185	0.674	23	1.505	22	0.378	20
Luxembourg	0.355	1.316	0.788	4	2.256	7	0.272	6
Mexico	1.036	0.841	0.448	36	-0.099	36	0.605	35
Netherlands	0.370	1.290	0.777	6	2.117	9	0.220	4
New Zealand	0.472	1.273	0.729	15	2.087	11	0.381	21
Norway	0.474	1.332	0.738	13	2.266	6	0.4438	29
Poland	0.611	1.167	0.656	25	1.323	24	0.437	28
Portugal	0.634	1.080	0.630	28	1.036	29	0.371	19
Slovak Republic	0.649	1.152	0.640	27	1.241	27	0.4443	30
Slovenia	0.550	1.202	0.686	22	1.563	21	0.413	23
Spain	0.766	1.086	0.586	30	0.988	30	0.414	24
Sweden	0.366	1.315	0.782	5	2.301	4	0.277	8
Switzerland	0.274	1.336	0.830038	2	2.392	3	0.120	1
Turkey	0.984	0.924	0.484	34	0.049	35	0.551	32
United Kingdom	0.394	1.271	0.764	7	2.082	12	0.275	7
United States	0.268	1.311	0.830398	1	2.463	1	0.151	2
Brazil	0.959	0.880	0.478	35	0.298	34	0.660	36
Russia	0.890	1.019	0.534	33	0.647	31	0.561	33