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A New Criterion Weighting in Ranking Studies: European Next Generation Liveable Countries Ranking

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Abstract

Criterion weighting is frequently used in ranking studies and multi-criteria decision-making problems where the power of the weights represents the important role of a variable. Variables with excessive weight may directly affect the ranking or selection results. In this study, a new criterion weighting method (Effect of Coefficient of Variation) based on the coefficient of variation is proposed. It is thought that the proposed method will give more balanced results, especially in the weighting of the variables with outliers. The proposed method was applied under the title of the new generation liveability index and the liveability ranking of European countries was determined. According to the ranking, Northern European countries occupy the first five places and the countries that left the former USSR and Yugoslavia occupy the last places.

Keywords*:* Criteria weighting; Liveability index; Ranking; Decision making

INTRODUCTION

Decision-making can be defined as decision-makers choosing the ones that are suitable for their purposes among different alternatives and possibilities. In intense competition conditions, decision-makers want to obtain the best alternative under the best conditions to eliminate uncertainties and provide maximum benefits. Decision-makers must carefully evaluate the criteria they come across while choosing among options, sift through alternatives with conflicting objectives, and reveal the best option. Therefore, decision-makers should be able to consider how existing resources and optimal usage conditions affect other people and elements while making their decisions.

Several decision problems involve multiple criteria and alternatives. In solving decision problems such as selection, ranking, and classification, people and businesses simultaneously consider many criteria instead of considering only one that can be effective in making sustainable decisions [1]. Considering more than one criterion allows the decision problem to be evaluated from many different perspectives. Problems related to choosing the most suitable alternative are defined as multi-criteria decision-making (MCDM). MCDM is the operation of methods and processes for the decision-maker to select, rank, or classify the best options according to concrete or abstract variables [2]. MCDM is a process that evaluates alternatives with their advantages and disadvantages by considering many criteria and attempting to determine the most suitable one among these alternatives [3].

People evaluate the alternatives they encounter during each choice according to different degrees of importance. The importance of a selection criterion relative to the other selection criteria may differ. The task of determining these differences is known as criterion weighting.

In most MCDM methods, criterion weights are used when calculating. These criteria weights play an important role in determining the priorities of alternatives. Thus, MCDM methods with different calculation rules can use these weights differently [4]. Because MCDM problems include criteria whose importance varies according to the decision-makers, preliminary information about the relative importance of the criteria facilitates the decision-making process, and this desired situation can be achieved by assigning weights to the criteria to be used. The derivation of weights is important in revealing the preferences of the decision-maker [5].

Weighting methods are generally divided into two categories: objective and subjective methods [6]. In subjective methods, the determination of criteria weights depends on the preferences of decision-makers. Some important studies on this subject include the ratio method [7], swing method [8], analytic hierarchy process (AHP) [9], direct rating (DR) method [10], point allocation (PA) method [11], Delphi method [12], and LINPAC [13]. In objective weighting methods, the preferences of decision-makers have no role in determining the criteria weights [4]. The entropy method, standard deviation (SD) method, CRITIC method [14] and maximizing deviation method [15] are the most common. In some studies, the hybrid weighting method has also been defined as a third category [16]. Hybrid methods are a combination of subjective and objective weighting methods that reflect the properties of the mentioned methods [17]. In [18] the authors stated that different weighting methods produce a different set of criteria weights, and the results of the multi-criteria decision-making methods are sensitive to criteria weights. Therefore, it is paramount to emphasize the selection of a weighting method for solving a multicriteria decision problem [4].

An index can be defined as a measure of changes in a representative set of individual data points, or a combined measure that aggregates multiple indicators. Indices summarize and rank specific observations. Thus, the researcher can evaluate the subject according to criteria such as good to bad, strong to weak, and far to close, and can make decisions in line with the research topic. Today, index ranking studies under many subject headings are frequently carried out and updated by both public and private institutions (Freedom Index, Human Development Index, Global Gender Report, Misery Index, The World Justice Project, World Happiness Index, etc.). These indices, which do not have legal and economic sanctions, are perhaps the most useful indicators for showing the status of countries, cities, or societies. Using different index calculations with different indicators, one can evaluate the current situation, make the closest assessments about the future, and establish an economic, statistical, and intellectual bridge between the past and the present in [19-23]. The general purpose of these index studies is to determine the changes in the regions over time regarding the researched subject, to follow their development, and to help evaluate their status [24].

One of the most important issues in index studies is the creation of rankings. The ranking is a question-response format used when a researcher is interested in establishing some type of priority among a set of objects. Giving weight to variables is the most used method for determining these priorities. The important thing in ranking studies is to determine the method to be used and then calculate the ranking of each observation with the help of the weights to be applied to the variables. The weighting of the variables is an intermediate factor that directly affects ranking. Generally, the ranking method weight determination involves two steps: ranking the criteria according to their importance and weighting the criteria from their ranks using one of the rank order weighting formulas [25]. It is difficult to find an answer to the first question. Each weighting method is likely to be successful for different data

structures. Second, owing to the many methods introduced in the literature, different results can be obtained, and comparisons can be made.

The concept of happiness can be defined as the goal(s) individuals aim to achieve in their lives. Happiness is achieved when both individuals and societies approach life in a balanced manner. In recent years, it has been understood that the social, political, and cultural indicators of countries, as well as economic performance, are also effective in the happiness of individuals. The concept of individual happiness also helped come up with the idea of more liveable cities and regions. The components of liveability are multiple and complex, including not only the built environment, but also social, economic, and natural factors [26]. The concept of liveability includes variables such as a healthy environment, a society free from natural disasters, and a crime-free society, as well as factors such as economic equality, an abundance of employment opportunities, the quality of education, and public services [27]. The article [28] emphasized that four important elements of a habitable zone should be urbanization and sustainable planning, water quantity and quality aspects, soil contamination and solid waste management, and air quality and urban heat islands. The concept of liveability for developing countries focuses entirely on the physical dimensions (natural and built environment, economic growth, and urban services) and sees the social and political lives of cities as a means, not an end, to achieve material results in [29-30]. Independent of all these, research on more liveable countries (regions) in the globalizing world has revealed new-generation happiness indices. These indices include factors that can increase the quality of life, such as ecological footprint and sustainable environment, as well as variables that affect human life. Different index studies have been published and evaluated under the headings of happiness or liveability in [31-36]. In almost all these studies, the effect of different variables on habitability was investigated to help determine the existence of more habitable regions.

In this study, the ranking of Europe's most liveable countries was determined using six indices and one statistical indicator. For this purpose, a new criterion weighting method was proposed for use in multi-criteria decision-making methods, and an index ranking was created with the help of seven determined variables. The names of the indicators used in the study and information on the institutions that prepared them are given in Table 1.

Table 1. Index and indicator information used in the study

Index	**Source**	**Year**
Happiness	The Sustainable Development Solutions Network [37]	2022
Corruption Perceptions	Transparency International [38]	2021
Misery Index	Steve Hanke [39]	2021
Human Development	United Nations Development Programme [40]	2021
Global Gender Report	World Economic Forum [41]	2022
Economic Freedom	The Heritage Foundation [42]	2022
Indicator	**Source**	**Year**
Life expectancy at birth	World Data Bank [43]	2022

Achieving the highest quality levels is the main goal for all companies in all industries [44]. The direction of highest quality in index rankings also differs from organization to organization. Each of these indices is an independent index calculated by different institutions, using a different number of variables. The effect of each index on the concept of liveability will be at different rates. In this study, a new criterion weighting method was

proposed to determine the effects of these ratios. The proposed method is a new criterion-weighting method based on the coefficient of variation. Unlike other weighting methods, in this method, the effect of observation values other than the calculated observation value is added to the weighting. Thus, the effect of possible outliers in the data on the significance levels of the other observations on the variable was minimized.

MATERIAL AND METHOD

The proposed criteria weighting method is named the Effect of Coefficient of Variation (ECV) and consists of the following steps.

Step 1: The sample standard deviation value was calculated for the remaining values of the series, except for each observation value for each criterion.

$$s_i = \frac{\left(\sum_{i=1}^{n} x_i^2 - x_i^2\right) - \frac{\left(\sum_{i=1}^{n} x_i - x_i\right)^2}{n-1}}{n-2} \tag{1}$$

Step 2: The arithmetic mean value was calculated for the remaining values of the series, except for each observation value for each criterion.

$$\overline{x}_i = \frac{\left(\sum_{i=1}^{n} x_i - x_i\right)^2}{n-1} \tag{2}$$

Step 3: The coefficients of variation for all observations were calculated by proportioning the calculated standard deviation and arithmetic mean values.

$$a_i = \frac{s_i}{\overline{x}_i} \tag{3}$$

Step 4: Normalization values were calculated for a matrix consisting of variables whose coefficients of variation were calculated. Normalization formulas for the benefit, cost, and optimal values are given in the literature. Minimum ordering is important because the weight method proposed here is already calculated from index values. Thus, the cost function is expressed as follows:

$$a_i^* = \frac{\max a_i(j) - a_i(j)}{\max a_i(j) - \min a_i(j)} \tag{4}$$

Step 5: Column totals were calculated for all criteria. The sum of these values was determined as the total criterion value.

$$b_t = \sum_{i=1}^{n} a_i^* \qquad t = 1, \ldots, k \tag{5}$$

Step 6: The ratio of the sum of each criterion to the total value of the criteria was determined as the criterion weight.

$$c_t = \frac{b_t}{\sum_{i=1}^{k} b_t} \qquad t = 1, \ldots, k \tag{6}$$

The criteria weights determined in step 6 are multiplied by the variable values in the raw data, and the new weighted values of all the variables are determined. By ordering the sums of these values from smallest to largest, an index ranking calculation was found.

RESULTS

In the application part, the proposed weighting method was used to determine the most liveable European countries. Accordingly, with the help of the indicators and indices given in Table 1, 45 European countries were ranked, and Europe's most liveable country ranking was created. Analyzes were performed with R for Windows (version 4.2.2).

The data and steps used in the calculation are provided in the appendix. The tables in the Appendix are the index data of seven variables of European countries, the coefficients of variation given in the proposed method for each country, the normalization calculation values, and the new index values formed by the multiplication of the suggested weight values given in Table 2 and the index data. The weight values calculated using the ECV weighting method based on the calculations provided in the Appendix are listed in Table 2.

Table 2. Weight values calculated with the ECV weighting method

Happiness	Misery	Corruption	Human Dev.	Gender	Eco.Freed.	Life Exp.
0,153789	0,128047	0,196236	0,158637	0,074535	0,127728	0,161028

Looking at the weights in Table 2, it is seen that Corruption Perceptions are variable and have the greatest impact on the liveable countries index and that the gender inequality variable has the least impact. The result of the liveable European countries ranking made with the new index values obtained by multiplying these weights with the index data is given in Table 3.

Table 3. Liveable European countries ranking with ECV weightings

Rank	Country	Rank	Country	Rank	Country
1	Finland	**16**	Spain	**31**	Montenegro
2	Switzerland	**17**	Portugal	**32**	Croatia
3	Denmark	**18**	Georgia	**33**	Turkey
4	Sweden	**19**	Malta	**34**	Romania
5	Norway	**20**	Italy	**35**	N. Macedonia
6	Luxembourg	**21**	Israel	**36**	Hungary
7	Netherlands	**22**	Slovenia	**37**	Bulgaria
8	Iceland	**23**	Lithuania	**38**	Albania
9	United Kingdom	**24**	Latvia	**39**	Serbia
10	Ireland	**25**	Cyprus	**40**	Bosnia
11	Germany	**26**	Czechia	**41**	Belarus
12	Estonia	**27**	Greece	**42**	Ukraine
13	Austria	**28**	Armenia	**43**	Azerbaijan
14	Belgium	**29**	Poland	**44**	Moldova
15	France	**30**	Slovakia	**45**	Russia

The results showed that Finland is the most liveable country in Europe. Although Finland ranks first with two times and Switzerland three times in the seven index rankings included

in the calculation, the coefficient weights are determined differently in the first two ranks. The fact that four of the top five countries were Scandinavian was also in line with the expectations of Scandinavian countries to be in the top ranks. In many positive index rankings, these countries consistently ranked at the top. Perhaps the most curious results are the identities of the countries in the last place. The fact that the countries in the last five places in the study are former USSR countries is also an indication that these countries continue to have problems adapting to globalization, even after many years. The fact that the last 15 countries in the ranking were composed of the disintegrated USSR countries or the Balkan countries, perhaps also documents that the problems of these geographies continue.

CONCLUSION

One of the most important problems in index studies is that it is not exactly known how the weights of the variables included in the calculation will be. In this study, a new weighting method is proposed for use in multi-criteria decision-making methods. In most previous weighting methods, the presence of an outlier in the data caused the outlier to have a very high criterion coefficient compared to other observations in the calculations for all data. The most important advantage of the proposed method is that it minimizes the effect of outliers on the series and allows the calculation of the effects of the remaining observations in the series in a manner similar to reality. The liveability levels of European countries were determined using the proposed weighting method. For this, six indices and one indicator used in the literature were used, and a new generation of liveable country index ranking were created. According to the results obtained, northern European countries (as expected) are seen as the most liveable countries. It is seen that 14 of the first 15 countries on the list of liveable countries are among the first 15 countries in the European per capita income ranking. It is known that a high level of well-being is a happiness enhancer. The results obtained in this study showed that other factors determined influence the concept of liveability as much as income.

The use of different indices in such ranking studies directly affects the result of the study. In addition to the indices used in this study, different results may be obtained in different studies with the use of indices such as GDP, crime, and terrorism. Since the sub-titles that make up the variables included in the study are considered to be the titles that can best reflect the concept of a liveable country, the study consists of the above-mentioned variables. Unlike the specialization of index values, such as happiness, liveability, and justice on a single subject, a mixed but strong ranking with the effects of different indices was revealed in the proposed index study. It can be said that the results obtained from the proposed ECV weighting method, including the effect of more than one index in the calculations, are quite successful.

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CONFLICT OF INTERESTS

No potential conflict of interest was reported by the author.

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Appendices

Appendix.1 Index and indicator data used in the application

Country	Happiness	Misery	Corruption	H. Dev.	Gender	Eco. Fr.	Life E.
Albania	5,199	23,8	35	0,796	0,787	66,6	76,5
Armenia	5,399	36,7	49	0,759	0,698	65,3	72
Austria	7,163	14,5	74	0,916	0,781	73,8	81,6
Azerbaijan	5,173	28,2	30	0,745	0,687	61,6	69,4
Belarus	5,821	22	41	0,808	0,75	53	72,4
Belgium	6,805	15,4	73	0,937	0,793	69,6	81,9
Bosnia	5,768	23,8	35	0,78	0,71	63,4	75,3
Bulgaria	5,371	16	42	0,795	0,74	71	71,8
Croatia	6,125	18,3	47	0,858	0,733	67,6	77,6
Cyprus	6,221	16,3	53	0,896	0,696	72,9	81,2
Czechia	6,92	15,7	54	0,889	0,71	74,4	77,7
Denmark	7,636	11,8	88	0,948	0,764	78	81,4
Estonia	6,341	17,1	74	0,89	0,733	80	77,1
Finland	7,821	12,8	88	0,94	0,86	78,3	82
France	6,687	18,4	71	0,903	0,791	65,9	82,5
Georgia	4,973	34,8	55	0,802	0,731	71,8	71,7
Germany	7,034	10,9	80	0,942	0,801	76,1	80,6
Greece	5,948	31,3	49	0,887	0,689	61,5	80,1
Hungary	6,086	14,8	43	0,846	0,699	66,9	74,5
Iceland	7,557	23,5	74	0,959	0,908	77	82,7
Ireland	7,041	12,9	74	0,945	0,804	82	82
Israel	7,364	14,4	59	0,919	0,727	68	82,3
Italy	6,467	22	56	0,895	0,72	65,4	82,9
Latvia	6,18	17,1	59	0,863	0,771	74,8	73,6
Lithuania	6,446	14,5	61	0,875	0,799	75,8	73,7
Luxembourg	7,404	14,3	81	0,93	0,736	80,6	82,6
Malta	6,447	18	54	0,918	0,703	71,5	83,8
Moldova	5,857	16,4	36	0,767	0,788	61,3	68,8
Montenegro	5,547	36,2	46	0,832	0,732	57,8	76,3
Netherlands	7,415	13	82	0,941	0,767	79,5	81,7
N. Macedonia	5,199	28,1	39	0,77	0,716	65,7	73,8
Norway	7,365	12,8	85	0,961	0,845	76,9	83,2
Poland	6,123	13,9	56	0,876	0,709	68,7	76,5
Portugal	6,016	18	62	0,866	0,766	70,8	81
Romania	6,477	18,5	45	0,821	0,698	67,1	74,2
Russia	5,459	19,9	29	0,822	0,708	56,1	69,4
Serbia	6,178	18,4	38	0,802	0,779	65,2	74,2
Slovakia	6,391	16,2	52	0,848	0,717	69,7	74,9
Slovenia	6,63	17	57	0,918	0,744	70,5	80,7

Spain	6,476	28,2	61	0,905	0,788	68,2	83
Sweden	7,384	12,7	85	0,947	0,822	77,9	83
Switzerland	7,512	8,6	84	0,962	0,795	84,2	84
Turkey	4,744	41,2	38	0,838	0,639	56,9	76
Ukraine	5,084	33,5	32	0,773	0,707	54,1	71,6
UK	6,943	22,5	78	0,929	0,78	72,7	80,7

Appendix.2 Expanded values of each variable with ECV weightings

Country	Happiness	Misery	Corruption	H. Dev.	Gender	Eco.Fr.	Life E.
Albania	0,799519	3,047508	6,868269	0,126275	0,058659	8,506709	12,3126
Armenia	0,830246	4,699309	9,615577	0,120405	0,052026	8,340662	11,60094
Austria	1,101591	1,856675	14,52148	0,145311	0,058212	9,426353	13,1366
Azerbaijan	0,795612	3,610913	5,887088	0,118184	0,051206	7,868067	11,16982
Belarus	0,895283	2,817025	8,045686	0,128178	0,055901	6,769603	11,66453
Belgium	1,046535	1,971917	14,32525	0,148643	0,059107	8,889894	13,18475
Bosnia	0,887055	3,047508	6,868269	0,123737	0,05292	8,097978	12,12544
Bulgaria	0,825986	2,048745	8,241923	0,126116	0,055156	9,068714	11,56147
Croatia	0,941989	2,343252	9,223104	0,13611	0,054634	8,634437	12,4926
Cyprus	0,956706	2,087159	10,40052	0,142138	0,051877	9,311397	13,07599
Czechia	1,06419	2,010331	10,59676	0,141028	0,05292	9,50299	12,51642
Denmark	1,174364	1,51095	17,26879	0,150388	0,056945	9,962812	13,10369
Estonia	0,975146	2,189596	14,52148	0,141187	0,054634	10,21827	12,42226
Finland	1,202784	1,638996	17,26879	0,149118	0,0641	10,00113	13,21041
France	1,028341	2,356057	13,93277	0,143249	0,058957	8,417299	13,2846
Georgia	0,764824	4,456021	10,79299	0,127227	0,054485	9,170896	11,54473
Germany	1,081768	1,395708	15,6989	0,149436	0,059703	9,720128	12,98369
Greece	0,914768	4,007858	9,615577	0,140711	0,051355	7,855294	12,90003
Hungary	0,935945	1,895089	8,438159	0,134207	0,0521	8,545027	12,00142
Iceland	1,162261	3,009095	14,52148	0,152133	0,067678	9,835084	13,31349
Ireland	1,082798	1,651801	14,52148	0,149912	0,059926	10,47373	13,20389
Israel	1,132472	1,843871	11,57794	0,145787	0,054187	8,685529	13,24534
Italy	0,994508	2,817025	10,98923	0,14198	0,053665	8,353435	13,34119
Latvia	0,950478	2,189596	11,57794	0,136903	0,057467	9,554081	11,8482
Lithuania	0,991263	1,856675	11,97041	0,138807	0,059554	9,68181	11,87099
Luxembourg	1,138654	1,831066	15,89514	0,147532	0,054858	10,29491	13,30552
Malta	0,991463	2,304838	10,59676	0,145628	0,052398	9,132578	13,49041
Moldova	0,900712	2,099964	7,064505	0,121674	0,058734	7,829749	11,0861
Montenegro	0,853037	4,635286	9,026868	0,131986	0,05456	7,382699	12,29328
Netherlands	1,140331	1,664605	16,09137	0,149277	0,057169	10,1544	13,15393
N. Macedonia	0,799549	3,598109	7,653214	0,12215	0,053367	8,391753	11,89053
Norway	1,132672	1,638996	16,68008	0,15245	0,062982	9,822311	13,40297

Poland	0,94162	1,779847	10,98923	0,138966	0,052846	8,774938	12,31173
Portugal	0,925241	2,304838	12,16665	0,137379	0,057094	9,043168	13,05039
Romania	0,996092	2,368862	8,830631	0,130241	0,052026	8,570573	11,9458
Russia	0,839473	2,548127	5,690851	0,130399	0,052771	7,165561	11,17839
Serbia	0,950109	2,356057	7,456978	0,127227	0,058063	8,327889	11,94702
Slovakia	0,98282	2,074355	10,20429	0,134524	0,053442	8,902667	12,06261
Slovenia	1,019637	2,176792	11,18547	0,145628	0,055454	9,004849	12,9934
Spain	0,995984	3,610913	11,97041	0,143566	0,058734	8,711074	13,36692
Sweden	1,135625	1,626192	16,68008	0,150229	0,061268	9,950039	13,36262
Switzerland	1,155202	1,101201	16,48385	0,152608	0,059256	10,75473	13,52427
Turkey	0,729606	5,275519	7,456978	0,132937	0,047628	7,267744	12,24333
Ukraine	0,781879	4,28956	6,27956	0,122626	0,052696	6,910104	11,53346
UK	1,067681	2,881048	15,30643	0,147373	0,058138	9,285852	13,00174