Far East Journal of Mathematical Education
© 2024 Pushpa Publishing House, Prayagraj, India
https://pphmjopenaccess.com
http://dx.doi.org/10.17654/0973563124006
Volume 26, Number 1, 2024, Pages 39-54
P-ISSN: 0973-5631
E-ISSN: 2583-343X

A CRITICAL REVIEW OF THE DETERMINATION OF WEIGHTS USED IN UNIVERSITY RANKINGS

Özlem Deniz Başar and Seda Bağdatlı Kalkan

Department of Statistics
Istanbul Commerce University
İstanbul, Turkey

Abstract

University rankings have been shared with the public for years as a very important criterion for both students who will make university preferences and academics. However, it is known that as the criteria in these rankings and the weights of these criteria change, the rankings will change very differently. This situation has been criticized for years and has been the subject of many publications. In this study, Times Higher Education (THE) ranking is taken into consideration and based on the view that the weights of the criteria used in the creation of this ranking are subjective, new criteria weights are created with the help of FUCOM, one of the multi-criteria decision making methods, and the results are interpreted.

Received: January 27, 2024; Accepted: March 30, 2024
Keywords and phrases: university rankings, the world university rankings, FUCOM.

How to cite this article: Özlem Deniz Başar and Seda Bağdatlı Kalkan, A critical review of the determination of weights used in university rankings, Far East Journal of Mathematical Education 26(1) (2024), 39-54. http://dx.doi.org/10.17654/0973563124006

This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

Published Online: April 18, 2024

Introduction

Today, developments in the education sector all over the world are followed with great curiosity and interest. The ability of educational institutions to catch up with developments also increases their preferability. For this reason, various measurements are made and shared with the public in order to compare these institutions in various periods.

There are many rankings applied worldwide to compare universities such as THE World University Rankings (THE), QS World University Rankings (QS), Webometrics University Rankings, The Center for University Rankings (CWUR).

These rankings, which are shared with the public under different names and by different organizations, are based on an examination of various criteria. Since each ranking method uses very different criteria, the results are not only dissimilar but also heavily criticized. For each ranking method, institutions share the algorithms and weights they use and are criticized for being subjective. Szluka et al. compared four different ranking methods, including THE and QS, using Spearman's correlation coefficient and stated that each ranking method shows different results due to the different structures of universities. This study shows that the ranking of universities according to the discipline in which the university is dominant is different in each method due to the differences in the criteria chosen (Szluka et al. [15]). In their study, Dearden et al. found that in addition to the fact that university rankings are a factor that can directly affect students' preferences, ranking methods with different designs will benefit students if they prefer the one that is oriented towards their fields of interest (Dearden et al. [6]). In their study, Arkali Olcay and Bulu, with the criticism that each university ranking gives weight to different criteria and that even the rankings determined as the best rankings in the world cannot fully measure young universities, determined the relationship between 5 different university rankings, including THE, with Pearson correlation coefficient. The study found a strong and statistically significant correlation between only two rankings. These two rankings were determined to be rankings that weighted the same

criteria. They also argued that the fact that some universities that are very good in one ranking are ranked lower in other rankings is due to the subjective measurement of the criteria (Arkali Olcay and Bulu [3]). In their study, Jöns and Hoyler criticize university rankings for not taking geographical location and inequalities into account and graphically illustrate these situations [11]. In their study, Saraç and Erdoğan argued that the evaluation criteria especially benefit historical and well-known universities, and therefore the ranking results are biased. They stated that many universities see these rankings as a measure of competition and that they do more harm than good, especially for academics (Saraç and Erdoğan [14]). Ioannidis et al. argue in their study that rankings do not provide construct validity in terms of education and research and that measurement error is inevitable. For this purpose, the Shanghai Jiao Tong University 'Academic Ranking of World Universities' and THE were examined and the results of the study emphasized that universities should develop more standardized and transparently measurable methods to improve their reputation and should not focus only on numbers (Ioannidis et al. [1]). In his study, Ishikawa tried to explain with a critical approach through a Japanese example that university rankings bring a standard in the world as well as preventing the diversification required in academic life (Ishikawa [2]).

In his study, Harvey examined many university rankings and concluded that these rankings are a threat to quality processes. He concludes that while the simple measurement involved in the creation of these rankings may seem very appealing to many authorities, they do not reward education at all, and that the efforts to rank high in the rankings only hinder the development of students' thinking (Harvey [10]). In his study, Moed examined 5 different university rankings, including THE, and tried to determine the relationship between some indicators with the Spearman correlation coefficient. He concluded that these systems are still one-dimensional, although they are constantly being improved, and that orientations have a great influence on the ranking of certain institutions (Moed [9]).

In the study, only THE rankings were taken into consideration and new

criteria weights were created with the help of FUCOM, one of the multi-criteria decision-making methods, based on the view that the weights of the criteria used in the creation of this ranking are subjective. In this direction, firstly, THE ranking method and methodology are explained, and then FUCOM method, which is one of the alternative multi-criteria decision making methods for the creation of weights to be used in the rankings, is explained. Following the theoretical information about the FUCOM method, an application was made to calculate the importance weights of the criteria used by THE to determine the weights of the criteria affecting the university rankings by obtaining the opinions of a group of academicians working as administrators.

Table 1. Main criteria, sub-criteria and weights used in THE ranking (Education [8])

Main Criteria	Sub-criteria/Weight	Weight
Teaching	Teaching reputation / 15% Staff to student ratio / 4.5% Doctorate to bachelor's ratio / 2% Doctorates awarded to academic staff ratio / 5.5% Institutional income / 2.5%	29.5%
Research environment	Research reputation / 18% Research income / 5.5% Research productivity / 5.5%	29%
Research quality	Citation impact / 15% Research strength / 5% Research excellence / 5% Research influence / 5%	30%
International outlook	Proportion of international students / 7.5% Proportion of international staff / 2.5% International collaboration / 2.5%	7.5%
Industry	Industry income / 2% Patents / 2%	4%

Since 2004, THE, which has been preparing university rankings on a world basis, aims to guide students to make the right choices for their future with the help of the criteria it determines. While preparing this ranking, 5 main criteria and sub-criteria under these main criteria are taken into consideration methodologically. The table shows the headings, subheadings and the weights indicating the level of importance given to these criteria in the study.

Methodology

FUCOM (Full Consistency Method), which is one of the multi-criteria decision making techniques and subjective weighting methods, was developed by Pamučar et al. [13]. This linear programming based method allows the solution to be reached by making fewer pairwise comparisons compared to other weighting methods (Ayçin [4]). The steps of the method are given below (Pamucar et al. [12]):

Step 1. The criteria are ranked by the decision maker from the most important to the least important as

$$C_{j(1)} > C_{j(2)} > \cdots > C_{j(k)}.$$

Step 2. The comparative priorities of the ranked criteria obtained in the first step are determined. Thus, a comparative priority vector is obtained as

$$\phi = (\varphi_{1/2}, \varphi_{2/3}, ..., \varphi_{k/(k+1)}).$$

Step 3. $(w_1, w_2, ..., w_n)^T$ weights are calculated. However, the following conditions must be met in order to calculate the weights.

Condition 1. The ratio of the calculated weights must be equal to the comparative priority values calculated in the second step:

$$\frac{w_k}{w_{k+1}} = \varphi_{k/(k+1)}.$$

Condition 2. The final value of the weight coefficients must satisfy the mathematical transitivity condition:

$$\varphi_{k/(k+1)} \otimes \varphi_{(k+1)/(k+2)} = \varphi_{(k)/(k+2)},$$

$$\varphi_{k/(k+1)} = w_k / w_{(k+1)} \text{ and } \varphi_{(k+1)/(k+2)} = w_{(k+1)} / w_{(k+2)},$$

$$w_k / w_{(k+1)} \otimes w_{(k+1)} / w_{(k+2)} = w_{(k)} / w_{(k+2)}.$$

Under these conditions, maximum consistency is achieved and the deviation from full consistency calculated for the criteria weights is $\chi = 0$ (Ayçin [4]).

The latest model is expressed as follows:

$$\min \chi$$

$$\left| \frac{w_{j(k)}}{w_{j(k+1)}} - \varphi_{k/(k+1)} \right| \leq \chi, \quad \forall_j$$

$$\left| \frac{w_{j(k)}}{w_{j(k+2)}} - \varphi_{k/(k+1)} \otimes \varphi_{(k+1)/(k+2)} \right| \leq \chi, \quad \forall_j$$

$$\sum w_j = 1, \quad j = 1, 2, ..., n$$

$$w_j \geq 0, \quad \forall_j.$$

By solving this model, the weight values for each criterion $(w_1, w_2, ..., w_n)^T$ are calculated (Çevik Aka [5]).

Application

The criteria determined by THE and used in university rankings formed the basis of this study. In the study, 3 academicians with different titles who actively work in universities and have studies on university rankings were interviewed and the results were shared with tables.

The main and sub-criteria in the application are shown in the table with the abbreviations to be used throughout the study.

Table 2. Main and sub-criteria used in THE ranking

Main criteria	Sub-criteria
C1- Teaching (the learning environment)	C11- Teaching reputation C12- Staff to student ratio C13- Doctorates awarded to academic staff ratio C14- Doctorate to bachelor's ratio C15- Institutional income
C2- Research environment	C21- Research reputation C22- Research income C23- Research productivity
C3- Research quality	C31- Citation impact C32- Research strength C33- Research excellence C34- Research influence
C4- International outlook	C41- Proportion of international students C42- Proportion of international staff C43- International collaboration
C5- Industry	C51- Industry income C52- Patents

FUCOM method will be used in the study. When determining weights with this method, three different academicians are named as decision maker-1, decision maker-2 and decision maker-3 in the process of ranking the importance of the criteria. In the first step of the process, these three decision makers were asked to rank the main criteria according to the level of importance and to determine the comparative priorities of these criteria from 1 (equal) to 9 (highest). Accordingly, the values are given in the table.

Table 3. Decision makers' ranking and evaluation of the importance of their main criteria

	C1	C2	C3	C4	C5
Decision maker - 1	1	2	4	5	7
Decision maker - 2	1	3	5	7	5
Decision maker - 3	3	1	2	5	5

When the statements in the table are analyzed, for example, it can be said that the most important criterion for decision maker-3 is C2 and this criterion is 2 times more important than C3, 3 times more important than C1, 5 times more important than C4 and C5. Similar comments can be made for other decision makers.

Table 4. Decision makers' ranking and evaluation of the importance of sub-criteria

	Decision maker - 1	Decision maker - 2	Decision maker - 3
C11	7	6	1
C12	1	1	2
C13	3	3	4
C14	2	2	6
C15	5	4	5
C21	5	5	1
C22	1	1	2
C23	3	3	2
C31	1	1	1
C32	4	2	4
C33	6	6	3
C34	2	5	3
C41	3	2	2
C42	4	3	3
C43	1	1	1
C51	0,6	0,5	0,6
C52	0,4	0,5	0,4

In the next stage of the study, decision makers were asked to identify and evaluate the sub-criteria in order of importance. The findings for this are given in the table. The findings will have similar interpretations to those previously mentioned and made for the main criteria.

Here, it was determined that the FUCOM algorithm could not be run for the sub-criteria of the fifth main criterion. Since FUCOM is based on a pairwise comparison system, it could not be used if the number of sub-criteria was 2 or less. In this case, unlike the calculation of the weights of the other sub-criteria, the decision makers were asked to give a weight for the sub-criteria used for K5 in line with their personal opinion, being aware that it may be more subjective, and recorded.

In the next stage of the study, comparative priorities are calculated for all criteria with the help of the evaluations obtained. The comparative priorities calculated for decision maker-1 with the help of the values given in Table 3 are given below:

$$\varphi_{c1/c2} = 2/1 = 2, \quad \varphi_{c2/c5} = 4/2 = 2,$$

$$\varphi_{c5/c3} = 5/4 = 1{,}25, \quad \varphi_{c3/c4} = 7/5 = 1{,}4.$$

According to the algorithm of the FUCOM method, the ratio of the weight coefficients of the criteria will be shown as follows:

$$w_{c1/c2} = 2, \quad w_{c2/c5} = 2, \quad w_{c5/c3} = 1{,}25, \quad w_{c3/c4} = 1{,}4.$$

Since the final values of the weight coefficients must satisfy the mathematical transitivity condition, the values calculated for the main criteria as a result of decision maker-1's evaluations are shown below:

$$\frac{w_1}{w_5} = w_{c1/c2} * w_{c2/c5} = 4,$$

$$\frac{w_2}{w_3} = w_{c2/c5} * w_{c5/c3} = 2{,}5,$$

$$\frac{w_5}{w_4} = w_{c5/c3} * w_{c3/c4} = 1{,}75.$$

As a result of these evaluations, the final weights for the main criteria for decision maker-1 are calculated with the help of the following linear programming model:

$$\text{Min } \chi$$

$$\left|\frac{w_1}{w_2} - 2\right|, \left|\frac{w_2}{w_5} - 2\right|, \left|\frac{w_5}{w_3} - 1{,}25\right|, \left|\frac{w_3}{w_4} - 1{,}4\right| \leq \chi$$

$$\left|\frac{w_1}{w_5} - 4\right|, \left|\frac{w_2}{w_3} - 2{,}5\right|, \left|\frac{w_5}{w_4} - 1{,}75\right| \leq \chi$$

$$\sum_{j=1}^{5} w_j = 1$$

$$w_j \geq 0, \quad \forall_j.$$

The related problem was solved with Excel Solver and the main criteria importance weights for decision maker-1 $w_1 = 0{,}478$, $w_2 = 0{,}239$, $w_3 = 0{,}119$, $w_4 = 0{,}096$, $w_5 = 0{,}068$. For all other decision makers, the main criteria were analyzed separately and the weight values calculated for these criteria are given in the table below.

Table 5. Local importance weights for the main criteria

Criteria	Decision maker - 1	Decision maker - 2	Decision maker - 3	Average weight
C1	0,478	0,533	0,149	0,387
C2	0,239	0,178	0,448	0,288
C3	0,119	0,107	0,224	0,150
C4	0,096	0,107	0,090	0,098
C5	0,068	0,076	0,090	0,078

In order to determine a final weight, the average of the weight values calculated with the help of the feedback from the three decision makers was calculated as the main criteria weight values to be proposed for this study and presented in the last column in Table 5.

Similarly, the sub-criteria were analyzed separately for all decision makers and the calculated weights and average weight are presented in Table 6.

Table 6. Local importance weights for sub-criteria

Criteria	Decision maker - 1	Decision maker - 2	Decision maker - 3	Average weight
C11	0,066	0,074	0,472	0,204
C12	0,460	0,444	0,236	0,380
C13	0,153	0,148	0,118	0,140
C14	0,230	0,222	0,079	0,177
C15	0,092	0,111	0,094	0,099
C21	0,130	0,130	0,500	0,253
C22	0,652	0,652	0,250	0,518
C23	0,217	0,217	0,250	0,228
C31	0,522	0,536	0,522	0,527
C32	0,261	0,268	0,130	0,220
C33	0,130	0,089	0,174	0,131
C34	0,087	0,107	0,174	0,123
C41	0,211	0,273	0,273	0,252
C42	0,158	0,182	0,182	0,174
C43	0,632	0,545	0,545	0,574
C51	0,600	0,500	0,600	0,567
C52	0,400	0,500	0,400	0,433

At this stage of the study, global weights for all sub-criteria were calculated by multiplying the main criteria weights shown in Table 5 and Table 6 by the average weights of the sub-criteria and are shown in Table 7.

Table 7. Global weights and ranking of criteria

Main criteria	Sub-criteria	Global weights	Rank
C1 (0,387)	C11 (0,204)	0,079	4
	C12 (0,380)	0,147	2
	C13 (0,140)	0,054	9
	C14 (0,177)	0,068	6
	C15 (0,099)	0,038	11
C2 (0,288)	C21 (0,253)	0,073	5
	C22 (0,518)	0,149	1
	C23 (0,228)	0,066	7
C3 (0,150)	C31 (0,527)	0,079	3
	C32 (0,220)	0,033	13
	C33 (0,131)	0,020	15
	C34 (0,123)	0,018	16
C4 (0,098)	C41 (0,252)	0,025	14
	C42 (0,174)	0,017	17
	C43 (0,574)	0,056	8
C5 (0,078)	C51 (0,567)	0,044	10
	C52 (0,433)	0,034	12

From table, it can be said that the most important criterion is “teaching” (C1) with a weight of 38.7%. However, most important sub-criterion is “research income” (C22). Other main and sub-criteria can be interpreted similarly.

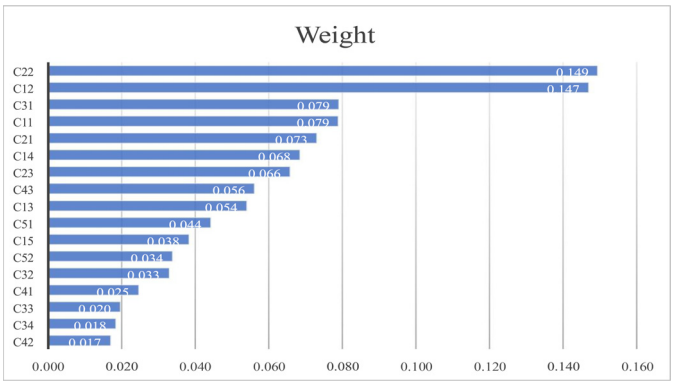


Figure 1. The ranking of the weights calculated for all sub-criteria according to their magnitudes.

Figure 1 shows all sub-criteria according to their weights and importance ranking. Since the aim of the study was to revise the weights for the criteria used in the THE analyses, the original weights and the calculated weights for the sub-criteria were compared with each other and presented in Table 8.

Table 8. Comparison of THE weights and FUCOM weights (%)

	C11	C12	C13	C14	C15	C21	C22	C23	C31	C32	C33	C34	C41	C42	C43	C51	C52
THE weight	15	5	6	2	3	18	6	6	15	5	5	5	3	3	3	2	2
FUCOM weight	7,9	14,7	5,4	6,8	3,8	7,3	14,9	6,6	7,9	3,3	2,0	1,8	2,5	1,7	5,6	4,4	3,4

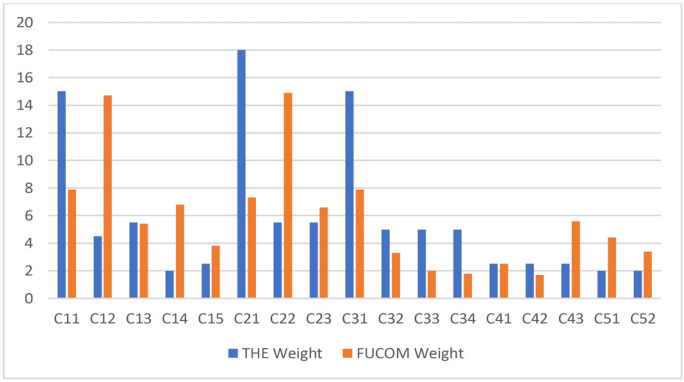


Figure 2. Comparison of THE weights and FUCOM weights.

When THE weights are analyzed, it is seen that the most important sub-criterion is “research reputation” (C21), while when FUCOM weights are analyzed, it is determined that the most important sub-criterion is “research income” (C22). Other criteria can be interpreted similarly.

Conclusion

It is known that university rankings, which are made worldwide and shared with the public, are followed with great attention every year for universities to be globally respected and preferred. In this study, THE, which is considered one of the most prestigious among many announced rankings, is analyzed. In this ranking, sub-criteria examined under five main criteria are evaluated with certain weights. It is known that these weights have a great impact on rankings. However, it is obvious that changing the weights will also change the university rankings. For this reason, it was considered that the determination of these weights may be subjective and new weights were calculated for all criteria with FUCOM, one of the multi-criteria decision-making methods.

As a result of the study, the criterion “research quality” (C3 - 30%), which is considered to be the most important main criterion (with the highest weight) in the THE ranking, ranked third in the FUCOM method, while the criterion “teaching” (C1 - 38.7%) was identified as the most important main criterion in the FUCOM method. The least important sub-criterion in both comparisons was “industry” (C5), with a weight of 4% for THE and 7.8% for FUCOM.

A similar interpretation can be made for the sub-criteria. For THE, the top three sub-criteria that can be said to be the most important according to their weights are “research reputation” (C21), “teaching reputation” (C11) and “citation impact” (C31), while for FUCOM these criteria are “research income” (C22), “staff to student ratio” (C12) and “citation impact” (C31).

In the FUCOM method, 3 academicians who are experts in their fields were interviewed and weights were created. It is obvious that different results would be obtained if different experts were interviewed. However, it is seen

that the weights determined in university rankings are very subjective, and if these weights change, the rankings will also change. For this reason, differentiating the criteria and using different weights will lead to different results in determining the best university.

References

[1] J. Ioannidis, N. Patsopoulos, F. Kavvoura, A. Tatsioni, E. Evangelou, I. Kouri and G. Liberopoulos, International ranking systems for universities and institutions: a critical appraisal, BMC Medicine 5 (2007), 1-9.

[2] M. Ishikawa, University rankings, global models, and emerging hegemony: critical analysis from Japan, Journal of Studies in International Education 13(2) (2009), 159-173.

[3] G. Arkali Olcay and M. Bulu, Is measuring the knowledge creation of universities possible?: A review of university rankings, Technological Forecasting and Social Change 123 (2017), 153-160.

[4] E. Ayçin, İş zekası uygulamaları seçimindeki kriterlerin önem ağırlıklarının FUCOM yöntemi ile belirlenmesi, KOCATEPEIIBFD 23(2) (2021, 8 23), 195-208.

[5] D. Çevik Aka, Evaluation of the effects of industry 4.0 on organizational agility with FUCOM: implementation in the textile industry, International Journal of Economic and Administrative Studies 40 (2023), 33-48.

[6] J. Dearden, R. Grewal and G. Lilien, Strategic manipulation of university rankings, the prestige effect, and student university choice, Journal of Marketing Research 56(4) (2019), 691-707.

[7] F. Ecer, Çok Kriterli Karar Verme: Geçmişten Günümüze Kapsamlı bir Yaklaşım, Ankara: Seçkin Yayınevi, 2020.

[8] T. H. Education, World University Rankings 2024: methodology, Times Higher Education, (2023, 10 10). https://www.timeshighereducation.com/world-university-rankings/world-university-rankings-2024-methodologyadresindenalındı

[9] H. F. Moed, A critical comparative analysis of five world university rankings, Scientometrics 110 (2017), 967-990.

[10] L. Harvey, Rankings of higher education institutions: a critical review, Quality in Higher Education 14(3) (2008), 187-207.

[11] H. Jöns and M. Hoyler, Global geographies of higher education: the perspective of world university rankings, Geoforum 46 (2013), 45-59.

[12] D. Pamucar, F. Ecer and M. Deveci, Assessment of alternative fuel vehicles for sustainable road transportation of United States using integrated fuzzy FUCOM and neutrosophic fuzzy MARCOS methodology, Science of the Total Environment 788 (2021), 1-21.

[13] D. Pamučar, Ž. Stević and S. Sremac, A new model for determining weight coefficients of criteria in MCDM models: full consistency methods (FUCOM), Symmetry 10(9) (2018), 393.

[14] B. Saraç and B. Z. Erdoğan, What do(‘nt) university rankings tell us? The visible and invisible side of the iceberg, TÜBA Higher Education Research Review 13(2) (2023), 257-271.

[15] P. Szluka, E. Csajbók and B. Győrffy, Relationship between bibliometric indicators and university ranking positions, Scientific Reports 13(1) (2023), 1-11.