Comparison of University Webometrics Ranking Using Multicriteria Decision Analysis: TOPSIS and VIKOR Method

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***Abstract*—**This study explores the Webometrics ranking for world universities. The webometrics for world universities were calculated by using size, visibility, rich content size, and scholar. In this paper by using two of multicriteria decision analysis which are TOPSIS and VIKOR technique, we propose a new method for webometrics ranking. The basic principle of the TOPSIS and VIKOR method is that the chosen alternative should have the ''shortest distance'' from the ideal solution and the ''farthest distance'' from the ''negative-ideal'' solution. It concludes by acknowledging that webometrics ranking systems are viewed differently by different stakeholders and hence can be approached in different ways. These models efficiently help evaluators to determine with a strategic view for future developments and more aspect by using multicriteria decision analysis. While no one ranking can be accepted as definitive, these webometrics ranking systems by using TOPSIS and VIKOR technique will remain a part of the higher education system for some time to come. A comparative analysis shows that these two methods use different normalizations and that they introduce different results for ranking.

***Keywords*—** ranking, TOPSIS, university, VIKOR, webometrics

I. Introduction

The arrival of university webometrics ranking has changed the setting of higher education and is likely to continue to luence further development nationally and internationally. This moment is a new era for university, characterized by global competition, in which university ranking systems have assumed an importance factor for surviving. Their emergence *has* also *been* a matter of *controversy*, often controversial and subject to considerable debate, has been met with a lot of scepticism, some enthusiasm and an institutional unease. Academic rankings are here to stay and it is results that count for most of higher education's stakeholders.

Recently, league tables that allow one to see who is the 'best in the world' according to their presence on the web, such as *G-factor* International University Ranking; *Webometrics* Ranking of World Universities and *4 International Colleges & Universities (4icu)*. Webometrics ranking of the world lists are prepared and published by the Cybermetrics Lab of Spain's National Research Council. Four indicators were calculated from the quantitative results of major search engines (Google and Bing). They are based on the idea that how good a university is by analyzing its institutional web domain, the production of its faculty and the frequency their respective products are consulted. Although Webometrics ranking correlates well with quality of education provided and academic prestige, but the analysis of the criteria used to rank universities internationally and the coincidences with similar analysis, leads to the conclusion that the serious methodological flaws they have make. They have a highly inappropriate tool for reliably assessing the overall quality of the institutions they claim to evaluate. Good quality evaluations of webometrics of university website are not impossible, but include approaches that would not fall into the simplifications of the common rankings. Only with selection of complementary formulations could a reasonably comprehensive approach be attained to rank something as complex as the website quality of a university

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II. Literature Review

A. Webometrics

The *G-factor* is based solely on the number of links from other university websites and claim that it is an objective form of 'peer review' because 'the millions of academics, administrators and students who create the massive volume of content on university websites collectively vote with their feet when deciding to add a link to some content on another university website' [1]. *Webometrics* use a four number of indicators (size, visibility and rich files) to rank universities according to their web publication [2], while *4icu* ranks universities in each country by web popularity as measured by a number of independent web metrics, including Google™ Page Rank, total number of inbound links and Alexa® Traffic Rank [3]. Although the ranking systems described above measure quality of higher education institutions on their web presence, each has positioned itself quite differently. *G-factor* and *4icu* seem to target themselves toward providing information to prospective staff and students while *Webometrics* pits institutions against each other on the basis of their web publication and open access initiatives [3].

B. Multi Criteria Decision Analysis

Multi Criteria Decision Analysis (MCDA) or Multi Criteria Decision Making (MCDM) is a branch of a general class of Operations Research models which is used in diverse fields such as engineering, economics, management science, transportation planning. This method deals with the process of making decisions in the presence of candidate priority alternatives with respect to various attributes. This class is further separated into Multi Objective Decision Making

(MODM) and Multi Attribute Decision Making (MADM) [4]. These methodologies share the common characteristics of conflict among criteria, incommensurable units, and difficulties in design/selection of alternatives [5].

TOPSIS

TOPSIS (technique for order preference by similarity to an ideal solution) method is a popular approach to MADM and has been widely used in the literature. TOPSIS was first developed by Hwang and Yoon [5] for solving a MADM problem. TOPSIS simultaneously considers the distances to the ideal solution and negative ideal solution regarding each alternative and selects the most relative closeness to the ideal solution as the best alternative [6]. The best alternative is the nearest one to the ideal solution and the farthest one from the negative ideal solution and the relative advantage of TOPSIS is the ability to identify the best alternative quickly

C. VIKOR

VIKOR method was developed as a multicriteria decision making method to solve a discrete decision problem with noncommensurable and conflicting criteria [7]. This method focuses on ranking and selecting from a set of alternatives, and determines compromise solutions for a problem with conflicting criteria. The VIKOR method is an effective tool in multicriteria decision analysis, particularly in situations where the decision maker does not know to express his/her preference at the beginning of system design to reach a final decision. Here, the compromise solution is a feasible solution which is the closest to the ideal, and a compromise means an agreement established by mutual concessions.

III. Research Method

This study uses an approach for data collection: by using Google and Bing search engine because it offers special function that search for matches only in web elements such as pages, domains, inlinks, and rich content and scholar. Collection was conducted within the same month (February 2012) in order to limit errors associated with frequent website updates. For ranking purpose, only those universities or research centers are considered which have independent web domain(s). Visibility is based on link analysis that uses the number of external inlinks. Three more indicators to the website component are also added before ranking. These are; number of documents measured from the number of rich files in a web domain, number of publications being collected by Google Scholar database, number of web pages in each university domain by Google.

A. Data

The recently 20 universities webometric highest ranks in January 2012 edition were selected for this study. The list of the studied universities is provided in Table 1. Sources of data includes: Catalogue of world universities (http://www.webometrics.info/university_by_country_select.asp.htm). Four indicators obtained from qualitative results provided by the main search engines are as follows:

- Size (S). Number of pages recovered from four engines: Google.
- Visibilty (V). The total number of unique external links received(inlinks) by a site can be only confidently obtained from Bing.
- Rich Files (R). After evaluation of their relevance to academic and publication activities and considering the volume of the different file formats, the following were selected: Adobe Acrobat (pdf) Adobe PostScript (ps) Microsoft Word (doc) and Microsoft PowerPoint (.pdf), (.ps), (.ppt).
- Scholar (Sc). Google Scholar provides the number of papers and citations for each academic domain. These results from the Scholar database represent papers, reports and other academic items. For each engine, results are log-normalized to 1 for the highest value and then combined to generate the rank. Rank / position of a university being ranked is obtained with the help of following formula: Webometrics Rank (Position): 4*RankV +2*RankS +1*RankR +1*RankSc

B. Ranking Method

Step 1

- Decide the criteria $B_j(j=1,2,.....,m$ where m is the number of criteria/attributes) for selecting the alternative(university websites). The criteria or attributes will be size, visibility, rich file, and scholar.
- Choose a set of university website alternatives $A_i(I=1,2,....,n$ where n is the number of alternative websites considered in the study).
- Measures the performance of each alternative with respect to attributes denoted as X_{ij} (for $i = 1, 2, \ldots, n$; $j = 1, 2, \ldots, m$).
- Decide the weight or relative importance of each attributes, $W_j(j=1,2,.....,m)$.

The values associated with the attributes (x_{ij}) may be in different units. So the elements of the decision table are normalized for different alternatives using the following equation.

$$X_{ij}^{*}=X_{ij}/\sum_{i=1}^{n} X_{ij} \quad (1)$$

where X_{ij}^{*} is the normalized value of X_{ij} and $\sum_{i=1}^{n} X_{ij}$ is the total of the values of j^{th} attribute for 'n' number of alternatives.

Step 2

Determine weights of importance of the attributes using webometrics standard, Size (0.2), visibility (0.5), rich files(0.15) and scholar (0.15). For the ranking process, two similiar Multi Criteria Decision Analysis, VIKOR and TOPSIS are considered. The above two steps are common for two methods. The TOPSIS and VIKOR methods are explained below.

TOPSIS METHOD

Step 3
Find the weighted normalized decision matrix. The weighted normalized value v_{ij} is calculated as
$v_{ij} = W_j r_{ij}, \quad j = 1, \ldots, m; \quad i = 1, \ldots, n;$
where w_j is the weight of the j^{th} attribute or criterion, and $\sum_{j=1}^{m} w_j = 1$.

Step 4
Determine the ideal and negative-ideal solution.
$A^* = \{v_1^*, \ldots\ldots, v_m^*\} = \{(\max v_{ij} | j \in I'), (\min v_{ij} | j \in I'')\}$ (2)
and $A^- = \{v_1^-, \ldots\ldots, v_m^-\} = \{(\min v_{ij} | j \in I'), (\max v_{ij} | j \in I'')\}$ (3)
where I' is associated with benefit criteria, and I'' is associated with cost criteria.

Step 5
Calculate the separation measures using n dimensional Euclidean distance. The separation of each alternative from the ideal solution and negative ideal solution is given as
$D_i^* = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j)^2}$ and $D_i^- = \sqrt{\sum_{j=1}^{m} (v_{ij} - v_j^-)^2}$, $i = 1, \ldots\ldots, n.$ (4)

Step 6
Find the relative closeness to the ideal solution. The relative closeness of the alternative a_i with respect to A^* is defined as:
$C_i^* = D_i^- / (D_i^* + D_i^-), \; i = 1, \ldots\ldots, n$ (5)

Step 7
Rank the preference order.

VIKOR METHOD

Step 3
Determine the maximum f_j^* and the minimum f_j^- values of all criterion functions, $j = 1. \ldots\ldots m.$
$f_j^* = \max_i f_{ij} = \max [(f_{ij}) | \; i = 1, 2, \ldots\ldots, n]$ (6)
$f_j^- = \min_i f_{ij} = \min [(fij) | \; i = 1, 2, \ldots\ldots, n]$ (7)
f_{ij} is the value of j^{th} criterion function for the alternative A_i.

Step 4
Compute the values S_i and R_i, $i = 1. \ldots\ldots n.$
$S_i = \sum_{j=1}^{m} W_j (f_j^* - f_{ij}) / (f_j^* - f_j^-)$ (8)
$R_i = \max_j [W_j (f_j^* - f_{ij}) / (f_j^* - f_j^-) | \; j = 1, 2, \ldots\ldots, m]$ (9)
(13)
where S_i and R_i represent the utility measure and the regret measure respectively for the alternative i. W_j is the weight of j^{th} criterion which represents the relative importance of criterion.

Step 5
Compute the values Q_i, $i = 1, \ldots\ldots, n.$
$Q_i = v(S_i - S^*)/(S^- - S^*) + (1 - v)(R_i - R^*)/(R^- - R^*)$ (10)
$S^* = \min_i S_i = \min [(S_i) | \; i = 1, 2, \ldots\ldots, n]$ (11)
$S^- = \max_i S_i = \max [(S_i) | \; i = 1, 2, \ldots\ldots, n]$ (12)
$R^* = \min_i R_i = \min [(R_i) | \; i = 1, 2, \ldots\ldots, n]$ (13)
$R^- = \max_i R_i = \max [(R_i) | \; i = 1, 2, \ldots\ldots, n]$ (14)
where v is the weight for the strategy of maximum group utility and $1 - v$ is the weight of the individual regret. v is usually set to 0.5.

Step 6
Rank the alternatives by Q_i. The less the value of Q_i is, the better decision of the alternatives is.

IV. Results and Analysis

Table 1 gives number of webpages (size), number of inlinks (visibility) for university websites, rich files, and scholar based on the world university highest webometrics rank in January 2012 edition. It shows that among all universities, Stanford University had the highest universities number of webpages while Pittsburg University had the lowest number of webpages. The calculation of visibility requires number of inlinks to a website (given in Table 1). Stanford University had the highest universities visibility while University of Minnesota had the lowest inlinks.

TABLE I
LIST OF WORLD UNIVERSITIES WITH THE CORRESPONDING NUMBER OF SIZE, VISIBILITY, RICH FILES, SCHOLAR

	University	Size(k)	Visibility	Rich Files					Scholar (k)
				*.pdf	*.ps	*.ppt	*.doc	Total	
1	www.harvard.edu	9950	177,321	259000	84200	9110	22900	375210	9950
2	www.mit.edu	8970	307,113	390000	26400	10800	13400	440600	8970
3	www.stanford.edu	33200	4,616,437	317000	22300	18100	19900	377300	33200
4	www.umich.edu	30100	362,854	268000	10100	8650	22800	309550	30100
5	www.berkeley.edu	26700	113,286	269000	12900	20000	20500	322400	26700
6	www.cornell.edu	31800	144,949	242000	13000	10300	12500	277800	31800
7	www.msu.edu	5550	415,198	253000	5550	8900	25300	292750	5550
8	www.wisc.edu	13900	138,804	447000	9790	11700	23300	491790	13900
9	www.pitt.edu	776	266,026	135000	2980	8210	10700	156890	776
10	www.cmu.edu	1530	118,231	245000	16700	11100	55500	328300	1530
11	www.washington.edu	19900	339,721	285000	15500	21400	30300	352200	19900
12	www.umn.edu	8910	57,035	346000	6090	11600	28100	391790	8910
13	www.psu.edu	8160	121,089	934000	32000	11000	28600	1005600	8160
14	www.purdue.edu	1930	243,812	202000	10300	9240	20300	241840	1930
15	www.upenn.edu	17000	206,485	140000	7200	6030	9400	162630	17000
16	www.ucla.edu	5000	73,305	184000	7040	8300	13200	212540	5000
17	www.utoronto.ca	6570	151,812	220000	4630	6200	14000	244830	6570
18	www.columbia.edu	8690	709,434	152000	18200	8080	10200	188480	8690
19	www.utexas.edu	14900	660,038	197000	8610	12100	16100	233810	14900
20	www.usp.br	3980	90,970	286000	17500	6630	21400	331530	3980

The comprehensive file-type-wise data regarding the number of rich files has been displayed in Table 1. Ranked first in rich files, especially from .pdf and .doc file type is Pennsylvania State University, followed by University of Wisconsin Madison in the second place. Also, there is a tendency that the total number of .pdf files exceeded the number of .doc and .ppt files. For the scholar result, it shows that Stanford University is the leading university exceeded Cornell University in the second rank.

TABLE II
LIST OF WORLD UNIVERSITIES WITH THE CORRESPONDING NUMBER OF SIZE, VISIBILITY, RICH FILES, SCHOLAR, UTILITY MEASURE AND REGRET MEASURE

	University	Size(k)	Visibility	Rich File	Scholar	S_i	R_i
1	www.harvard.edu	0,1434	0,4868	0,1114	0,1076	0,8492	0,4868
2	www.mit.edu	0,1495	0,4726	0,0999	0,1121	0,8340	0,4726
3	www.stanford.edu	0,0000	0,0000	0,1110	0,0000	0,1110	0,1110
4	www.umich.edu	0,0191	0,4665	0,1230	0,0143	0,6229	0,4665
5	www.berkeley.edu	0,0401	0,4938	0,1207	0,0301	0,6847	0,4938
6	www.cornell.edu	0,0086	0,4904	0,1286	0,0065	0,6341	0,4904
7	www.msu.edu	0,1706	0,4607	0,1260	0,1279	0,8852	0,4607
8	www.wisc.edu	0,1190	0,4910	0,0908	0,0893	0,7902	0,4910
9	www.pitt.edu	0,2000	0,4771	0,1500	0,1500	0,9771	0,4771
10	www.cmu.edu	0,1953	0,4933	0,1197	0,1465	0,9549	0,4933
11	www.washington.edu	0,0820	0,4690	0,1155	0,0615	0,7280	0,4690
12	www.umn.edu	0,1498	0,5000	0,1085	0,1124	0,8707	0,5000
13	www.psu.edu	0,1545	0,4930	0,0000	0,1158	0,7633	0,4930
14	www.purdue.edu	0,1929	0,4795	0,1350	0,1447	0,9520	0,4795
15	www.upenn.edu	0,0999	0,4836	0,1490	0,0749	0,8075	0,4836
16	www.ucla.edu	0,1739	0,4982	0,1402	0,1305	0,9428	0,4982
17	www.utoronto.ca	0,1643	0,4896	0,1345	0,1232	0,9115	0,4896
18	www.columbia.edu	0,1512	0,4285	0,1444	0,1134	0,8374	0,4285
19	www.utexas.edu	0,1129	0,4339	0,1364	0,0847	0,7678	0,4339
20	www.usp.br	0,1802	0,4963	0,1191	0,1352	0,9308	0,4963

The rich files need corresponding software for viewing. And can be downloaded from the link given alongside the links to the file itself. Also, many of the files were delivered in different formats, so that the user can access the file in desired format. Then, there was a university with a total of 1005600 rich files, and contrastingly there was one with only 156890 files. Thus, the websites of the selected universities proved to be a mixed variety, ranging from highest to the lowest, can be foundthe index values is computed but before that S^*, S^-, R^*,and R^- be supposed to calculate by (11), (12), (13), and (14). S^- is the minimum value and S^* is the maximum value in table S also R^- and $R^*$are minimum and maximum value in table R. $S^- = 0{,}1110$, $S^* = 0{,}9771$ and $R^- = 0{,}1110$, $R^* = 0{,}5000$ are minimum and maximum value in table S and R displayed in Table 2. At this time based on the above matter the Q can be accessible. Q is the index value for ranking the alternatives; it can be calculated based on (10).

TABLE III
LIST OF WORLD UNIVERSITIES WITH THE CORRESPONDING NUMBER OF SIZE, VISIBILITY, RICH FILES, SCHOLAR

		S	R	Qj
1	www.harvard.edu	0,4262	0,4830	0,9092
2	www.mit.edu	0,4174	0,4647	0,8821
3	www.stanford.edu	0,0000	0,0000	0,0000
4	www.umich.edu	0,2955	0,4569	0,7524
5	www.berkeley.edu	0,3312	0,4921	0,8233
6	www.cornell.edu	0,3020	0,4876	0,7896
7	www.msu.edu	0,4469	0,4495	0,8964
8	www.wisc.edu	0,3921	0,4885	0,8806
9	www.pitt.edu	0,5000	0,4705	0,9705
10	www.cmu.edu	0,4872	0,4914	0,9785
11	www.washington.edu	0,3562	0,4601	0,8164
12	www.umn.edu	0,4386	0,5000	0,9386
13	www.psu.edu	0,3766	0,4910	0,8675
14	www.purdue.edu	0,4855	0,4737	0,9592
15	www.upenn.edu	0,4021	0,4789	0,8810
16	www.ucla.edu	0,4802	0,4977	0,9779
17	www.utoronto.ca	0,4621	0,4866	0,9488
18	www.columbia.edu	0,4194	0,4080	0,8274
19	www.utexas.edu	0,3792	0,4150	0,7942
20	www.usp.br	0,4733	0,4952	0,9685

In this part we check whether the *C1* and *C2* are satisfied or not. For this point, first we calculate by using this following two conditions :

C1. *Acceptable advantage*: $R(A^{(2)}) - R(A^{(1)}) \geq 1/(m-1)$, where $A^{(2)}$ is the alternative with second position in the ranking list by R; m is the number of alternatives (university websites).

C2. *Acceptable stability in decision making*: Alternative $A^{(1)}$ must also be the best ranked by $\{S_i$ or/and $Q_i \mid i = 1, 2, ..., m\}$.

The result shows that $0{,}7524 \geq 0.0526$.

The *C1* is satisfied and Carnegie Mellon has best situation in and so condition *C2* also is satisfied. At this time we can confirm that service alternative number 10 (www.cmu.edu) is the best option with respect to webometrics criteriaThe final ranking list is shown below in Table 3.

The positive ideal (best) and the negative ideal (worst) solutions are now calculated using (2) and (3) respectively. Table 2 shows the relative closeness value of each alternative university website, which is calculated using (5)..

TABLE IV
COMPARISON OF WEBOMETRICS RANKING BASED ON WEBOMETRICS JANUARY 2012 EDITION. TOPSIS AND VIKOR METHOD

No	University Website	C_j	Q_j	Webometrics Ranking	TOPSIS Ranking	VIKOR Ranking
1	www.harvard.edu	0,251	0.9092	1	4	8
2	www.mit.edu	0,102	0.8821	2	12	10
3	www.stanford.edu	0,772	0.0000	3	1	20
4	www.umich.edu	0,274	0.7524	4	2	19
5	www.berkeley.edu	0,238	0.8233	5	5	15
6	www.cornell.edu	0,274	0.7896	6	3	18
7	www.msu.edu	0,087	0.8964	7	13	9
8	www.wisc.edu	0,136	0.8806	8	10	12
9	www.pitt.edu	0,041	0.9705	9	17	3
10	www.cmu.edu	0,019	0.9785	10	20	1
11	www.washington.edu	0,198	0.8164	11	6	16
12	www.umn.edu	0,086	0.9386	12	14	7
13	www.psu.edu	0,106	0.8675	13	11	13
14	www.purdue.edu	0,039	0.9592	14	19	5
15	www.upenn.edu	0,165	0.8810	15	8	11
16	www.ucla.edu	0,046	0.9779	16	16	2
17	www.utoronto.ca	0,065	0.9488	17	15	6
18	www.columbia.edu	0,153	0.8274	18	9	14
19	www.utexas.edu	0,188	0.7942	19	7	17
20	www.usp.br	0,039	0.9685	20	18	4

Now, the alternative university website are arranged in descending order according to their relative closeness values. It is observed that the Stanford University website is the best choice and followed by Univesity of Michigan based on TOPSIS method and Carnegie Mellon University and University of California Los Angeles as second rank based on VIKOR approach, which are not matching with the results as obtained from webometrics ranking. By using spearman rank correlation calculation, it shows that ρ is 0.499 and there is a significant difference between traditional webometrics ranking and webometrics ranking using TOPSIS or VIKOR approach.

V. CONCLUSION

In this paper, we have used a novel approach to measure webometrics ranking from quantitative point of view so that website evaluators are able to apply parameters like size, visibility, rich files, and scholar for future development and webometrics to ranking problem. We used TOPSIS and VIKOR to deal with website quality variables and presented to determine the best university website. The MCDM methods TOPSIS and VIKOR is based on an aggregating function representing ‘‘closeness to the ideal’’. The basic principle of the TOPSIS method is that the chosen alternative should have the ‘‘shortest distance’’ from the ideal solution and the ‘‘farthest distance’’ from the ‘‘negative-ideal’’ solution. The TOPSIS method introduces two ‘‘reference’’ points, but it does not consider the relative importance of the distances from these points. The TOPSIS method uses vector normalization to eliminate the units of criterion functions. The normalized value in the TOPSIS method depends on the evaluation unit of a criterion function. The VIKOR method uses linear normalisation, A comparative analysis shows that these two methods use different normalizations and that they introduce different aggregating functions for ranking. A comparative analysis shows that these two methods use different normalizations and that they introduce different results for ranking.

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