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Proportion of Collaborative Publications as an Ultimate Indicator of Leiden 2013 World Best Universities Rankings

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In recent years different models for ranking universities were introduced, each of them contributing immensely to the topic of university rankings. This paper will provide an overview of currently most popular ranking methods and in particular provide a thorough analysis of Leiden ranking methodology. Although providing valuable data, Leiden rankings fail to present an integrated indicator which can rank universities accordingly (characteristics of ARWU and THE ranking methodologies). As a remedy to the issue, by using statistical I-distance method we will integrate all the Leiden 2013 ranking indicators into one value, which will therefore represent a rank. Moreover, our results will provide us with the information on which of the input indicators is the most important one for the process of ranking. Our results clearly show that the Proportion of collaborative publications occupies the most significant spot. Moreover, performances of Universities of Ljubljana, Zagreb and Belgrade are presented and elaborated upon.

Keywords: Ranking of Universities, The I-distance Method, Leiden 2013 Rankings, Statistical Methods.

1. Introduction

An increasing number of methodologies for ranking higher education institutions (HEI) has attracted many different stakeholders, especially students. Consequently, those rankings are quite often used as an indicator of a university's reputation and performance (Bowman and Bastedo 2011, Garcia et al. 2012). Almost certainly, the most cited ranking list is the Academic Ranking of World Universities (ARWU) which has been the focus of researchers since its first creation in 2003 (Aguillo et al. 2010, Docampo et al. 2012).

The Shanghai (ARWU) ranking is based on six different criteria and aims to measure academic performance. Within each category, the best performing university is given a score of 100 and becomes the benchmark against which the scores of all other universities are to be measured. Universities are then ranked according to the overall score they obtain, which is simply a weighted average of their individual category scores (Dehon et al. 2010). The variables ''Alumni'' and ''Award'' measure the number of Nobel prizes and Field medals won by a university's alumni (''Alumni'') or faculty members who worked at an institution at the time of winning the prizes (''Award''). The next three variables, ''HiCi'', ''N&S'' and ''PUB'' reflect their researchers' outputs. ''HiCi'' is the number of highly cited researchers of the institution, ''N&S'' is the number of articles published in the "Nature" and "Science" journals, and ''PUB'' is the number of articles indexed in the Science Citation Index Expanded and the Social Science Citation Index. The sixth and final variable, ''PCP'', is a weighted average of all the scores obtained from the previous five categories, divided by the number of current full-time equivalent academic staff members. The variables ''Award'', ''HiCi'', ''N&S'' and ''PUB'' each make up 20% of the final score, while ''Alumni'' and ''PCP'' are each given a slightly lower weight of 10% (Dehon et al. 2010, Jeremic et al. 2011, Jovanovic et al. 2012).

Yet, almost immediately after the release of its first ranking, the ARWU attracted a great deal of criticism concerning arbitrary chosen weighting factors, favouring Nature & Science journals or generally comments that ARWU ranking mainly reflects the size of a university (Zitt and Filliatreau 2007, Docampo 2013, Billaut et al.

2010). One of the potential weaknesses frequently elaborated on (Prathap 2012, 2013, Radojicic and Jeremic 2012) is the absence of scientific quality indicators such as high quality papers (as those ranked in the first quartile ~ 25% ~ in their categories) etc. Thus, the latest release of the SCImago Institutions Rankings (SIR) IBER Reports (SIR 2013), which quantifies the research performance of 1600 leading research institutions of Ibero-American countries, brings even more to the table.

The SIR approach integrates one quantitative and various qualitative variables. The Output (O) indicator is a measure of the quantity or size of the publication output of an institution. It represents the Total number of documents published in scholarly journals indexed in Scopus (Romo-Fernández et al. 2011). Seven other variables represent the quality dimension of the scientific output: International Collaboration (IC), Normalized Impact (NI), High Quality Publications (Q1), Specialization Index (SI), Excellence Rate (ER), Scientific Lead (Lead) and Excellence with Leadership (EwL). The IC represents an institution's output ratio produced in collaboration with foreign institutions (Lancho-Barrantes et al. 2013). The NI compares the average scientific impact of the institution with the world average (SIR 2013). Also, the Q1 is the ratio of publications that the institution publishes in what the SCImago team takes as the most influential scholarly journals of the world (Miguel et al. 2011). The SI indicates the extent of thematic concentration/dispersion of an institution's scientific output (López-Illescas et al. 2011). On the other hand, the ER indicates the percentage of an institution's scientific output that is included into the set formed by 10% of the most cited papers in their respective scientific fields (a measure of the high-quality output of research institutions), as explained by Bornmann (Bornmann et al. 2012). Additionally, Lead indicates an institution's "output as main contributor", that is the number of papers in which the corresponding author belongs to the institution (Moya-Anegón 2012). Finally, the EwL indicates the amount of documents in the Excellence rate in which the institution is the main contributor (SIR 2013).

However, despite all the similarities between SCImago and CWTS Leiden methodologies (both of them are based on bibliometric data, both rankings focus on the research performance of institutions), there are also a number of substantial differences between the SIR and the Leiden Ranking (Waltman et al. 2012). The SIR ranking is based on the Scopus database, while the Leiden Ranking uses Thomson Reuters WoS. In addition, in the Leiden ranking the journals which are not published in English or authors are concentrated in one or a few countries (the journal does not have a strong international scope) and the journals with a small number of references to other journals in the Web of Science database are excluded from the analysis (Waltman et al. 2012). The Leiden Ranking also excludes arts and humanities publications. Further, the Leiden Ranking provides perspective on the advanced distance based collaboration indicators. Moreover, the Leiden Ranking by default reports size-independent indicators (average statistics per publication, such as a university's average number of citations per publication). The advantage of size-independent indicators is that they enable comparisons between smaller and larger universities (Leiden 2013). As an alternative to size-independent indicators, the Leiden Ranking can also report size-dependent indicators, which provide overall statistics of the publications of a university (the total number of citations of the publications of a university). Size-dependent indicators are strongly influenced by the size of a university and therefore tend to be less useful for comparison purposes (Waltman et al. 2012).

The Leiden 2013 Ranking offers the indicators of the scientific impact (citations are counted until the end of 2012; with author self citations being excluded) and scientific collaboration of a university:

- *MCS (mean citation score)*. The average number of citations of the publications of a university.
- *MNCS (mean normalized citation score)*. The average number of citations of the publications of a university, normalized for field differences and publication year. An MNCS value of two, for instance, means that the publications of a university have been cited twice above world average.
- *PP(top 10%) (proportion of top 10% publications)*. The proportion of the publications of a university that, compared with other publications in the same field and in the same year, belong to the top 10% most frequently cited (Leiden 2013).
- *PP(collab) (proportion of interinstitutional collaborative publications)*. The proportion of the publications of a university that have been co-authored with one or more other organizations.
- *PP(int collab) (proportion of international collaborative publications*. The proportion of the publications of a university that have been co-authored by two or more countries.

- *PP(UI collab) (proportion of collaborative publications with industry)*. The proportion of the publications of a university that have been co-authored with one or more industrial partners.
- *MGCD (mean geographical collaboration distance)*. The average geographical collaboration distance (in km) of the publications of a university, where the geographical collaboration distance of a publication equals the largest geographical distance between two addresses mentioned in the publication's address list (Leiden 2013).

Although the Leiden rankings provide plenty of data concerning world class universities, it fails to deliver an integrated indicator which will therefore represent a rank of university (as already done by ARWU and Times Higher Education). Having said this, it is essential to provide a potential upgrade of the current framework and create a synthesised indicator which will incorporate both the scientific impact and collaboration dimensions of the Leiden 2013 Rankings. Further, it is vital to conclude which one of these dimensions provides a better insight into the scientific excellence of a HEI. As a possible remedy to the issue, statistical I-distance method is elaborated and applied.

2. I-distance Method

Quite frequently, the ranking of specific marks is done in such a way that it can seriously affect the process of taking exams, entering competitions, UN participation, medicine selection and many other areas (Jeremic and Radojicic 2010). The I-distance is a metric distance in an n-dimensional space. It was originally proposed and defined by B. Ivanovic, and has appeared in various publications since 1963 (Ivanovic 1977). Ivanovic devised this method to rank countries according to their level of development on the basis of several indicators; many socio-economic development indicators had been considered and the problem was how to use all of them in order to calculate a single synthetic indicator which would thereafter represent the rank.

For a selected set of variables $X^T = (X_1, X_2, ..., X_k)$ chosen to characterize the entities, the I-distance between the two entities $e_r = (x_{1r}, x_{2r}, ..., x_{kr})$ and $e_s = (x_{1s}, x_{2s}, ..., x_{ks})$ is defined as

$$D(r,s) = \sum_{i=1}^{k} \frac{|d_i(r,s)|}{\sigma_i} \prod_{j=1}^{i-1} \left(1 - r_{ji.12...j-1}\right) \quad \textbf{(1)}$$

where $d_i(r,s)$ is the distance between the values of variable X_i for e_r and e_s, e.g. the discriminate effect,

$$d_i(r,s) = x_{ir} - x_{is},\ i \in \{1,...,k\} \quad \textbf{(2)}$$

σ_i the standard deviation of X_i, and $r_{ji.12...j-1}$ is a partial coefficient of the correlation between X_i and X_i $(j < i)$ (Bulajic et al. 2012, Dobrota et al. 2012).
The construction of the I-distance is iterative; it is calculated through the following steps:

- Calculate the value of the discriminate effect of the variable X_1 (the most significant variable, that which provides the largest amount of information on the phenomena that are to be ranked)
- Add the value of the discriminate effect of X_2 which is not covered by X_1
- Add the value of the discriminate effect of X_3 which is not covered by X_1 and X_2
- Repeat the procedure for all variables (Jeremic et al. 2012, Radojicic et al. 2012).

Sometimes, it is not possible to achieve the same sign mark for all variables in all sets, and, as a result, a negative correlation coefficient and a negative coefficient of partial correlation may occur (Jeremic et al. 2011, Maletic et al. 2012). This makes the use of the square I-distance even more desirable. The square I-distance is given as:

$$D^2(r,s)=\sum_{i=1}^{k}\frac{d_i^2(r,s)}{\sigma_i^2}\prod_{j=1}^{i-1}\left(1-r_{ji.12\ldots j-1}^2\right) \quad (3)$$

In order to rank the entities (in this case, universities), it is necessary to have one entity fixed as a referent in the observing set using the I-distance methodology (Jeremic et al. 2012, Jovanovic et al. 2012). The entity with the minimum value for each indicator or a fictive minimum entity should be utilized as the referent entity, as the ranking of the entities in the set is based on the calculated distance from the referent entity (Seke et al. 2013).

3. Results of the I-distance Method

For this study, the latest release of the CWTS Leiden Rankings 2013 (Leiden 2013) was analyzed. Based on Web of Science indexed publications from the period 2008-2011, 500 major universities worldwide are evaluated. Official data were obtained and examined using the I-distance method. The results achieved by means of the square I-distance method and the first twenty HEI are shown in Table 1 below.

As can be seen from Table 1, Harvard University tops the I-distance method list. This University has impressive numbers for each of the observed indicators. One should note that the London School of Hygiene & Tropical Medicine is highly placed (2nd place), although it has a rather small number of published papers. Precisely this information is crucial since it is essential to elaborate other variables in which the London School of Hygiene & Tropical Medicine impresses.

Table 1. Results of the square I-distance Method for HEI provided in CWTS Leiden Rankings 2013 (first 20 placed HEI)

HEI	Country	I-distance	Rank I-distance
Harvard Univ	United States	142.247	1
London Sch Hyg & Trop Med	United Kingdom	91.868	2
Caltech	United States	84.655	3
MIT	United States	83.088	4
Humboldt-Univ Berlin	Germany	78.466	5
Stanford Univ	United States	78.246	6
Freie Univ Berlin	Germany	77.469	7
Univ Calif - Santa Cruz	United States	72.091	8
Univ Calif - Berkeley	United States	70.975	9
Paris Diderot Univ	France	70.056	10
Univ Göttingen	Germany	70.03	11
Univ Lübeck	Germany	69.838	12
Univ Trieste	Italy	69.329	13
Univ Calif - San Francisco	United States	69.03	14
Univ Calif - Los Angeles	United States	69.004	15
Univ Cape Town	South Africa	68.411	16
Univ Melbourne	Australia	66.363	17
Univ Calif - San Diego	United States	66.342	18
Univ Pierre & Marie Curie	France	66.131	19
Univ Oxford	United Kingdom	65.921	20
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Univ Ljubljana	Slovenia	22.266	411
Univ Zagreb	Croatia	20.482	426
Univ Belgrade	Serbia	15.910	451

For instance, in scientific collaboration indicators such as *Proportion of collaborative publications PP(collab)* (91.2) and *Proportion of international collaborative publications PP(int collab)* (70.9), the London School of Hygiene & Tropical Medicine is one of the Top 5 universities. Consequently, it is essential to determine which of the nine input indicators is the most important for the process of ranking. Thus, this data set has been further examined and the correlation coefficients of each variable with the I-distance values have been determined. The results shown in Table 2 demonstrate that the most significant variable for the calculated I-distance value is the *Proportion of collaborative publications PP(collab)*. This correlates highly with the I-distance value ($r=0.746$, $p<0.01$). Also, *Mean citation score (MCS)* and *Mean normalized citation score (MNCS)* are very important indicators with each correlation stronger than 0.6 ($p<0.01$).

Table 2. The Correlation between Input Variables and I-distance Values

	I-distance
Proportion of collaborative publications PP(collab)	0.746^{**}
Mean citation score (MCS)	0.692^{**}
Mean normalized citation score (MNCS)	0.607^{**}
Proportion of top 10% publications PP(top10%)	0.592^{**}
Proportion of international collaborative publications PP(int collab)	0.579^{**}
Proportion of collaborative publications with industry PP(UI collab)	0.507^{**}
Mean geographical collaboration distance (MGCD)	0.476^{**}
Number of publications P(collab)	0.467^{**}
Number of publications P(impact)	0.357^{*}

** $p<0.01$, * $p<0.05$

Concluding Remarks

An emerging number of world best universities ranking methodologies is pushing the academic world into becoming even more concerned with the assessment of higher education. With these rankings often used as a marketing tool for universities to show their educational or research excellence, the necessity to provide rankings as accurate as possible becomes exceptionally important (Radojicic and Jeremic 2012). As a potential remedy to this issue, the analysis presented here has stressed out potential improvements in the CWTS Leiden Rankings methodology. In addition, our analysis focuses on the performance of former Yugoslavia universities where the University of Ljubljana leads the way. Although the University of Belgrade has a larger number of published papers (which is also noted in the ARWU 2012 ranking list), in other indicators it is far worse than Ljubljana. For instance, with *Mean citation score (MCS)* of 2.5 (compared with Ljubljana's 3.1) and *Proportion of collaborative publications with industry PP(UI collab)* of 3.4 (compared with Zagreb's 6.9 and Ljubljana's 6.5), the University of Belgrade is far from achieving a position of scientific excellence. It is essential to mention that many of the journals indexed in WoS (included into ARWU 2012, but not in the Leiden 2013 ranking list) in which a significant number of Serbian academicians published their papers have been excluded by CWTS Leiden 2013, since those journals are concentrated on the authors from one or a few countries (the journal does not have a strong international scope) or the journal with a small number of references (Jeremic et al., 2013) to other journals in the WoS database (indicating that in terms of citation traffic the journal is only weakly connected to these other journals). Consequently, it is vital for the University of Belgrade to focus on more prestigious journals and publish works in those types of scientific publications.

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