Quantity or quality: what matters more in ranking higher education institutions?

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The issue of ranking higher education institutions has drawn much attention as of late. Many ranking models are being introduced; however, only a few of them incorporate quality dimensions rather than just absolute number of published papers, awards gained, etc. As a possible remedy to the issue, we applied statistical I-distance method on a dataset presented by SCImago Institutions Rankings methodology. Results pointed out that quality indicators such as 'Excellence Rate' and 'Normalized Impact' are far more important than gross number of published papers. In addition, a comparison of scientific output between China and India is elaborated upon.

Keywords: Higher education institutions, quality indicators, ranking, statistical methods.

THE issue of ranking higher education institutions (HEI) has drawn much attention as of late. Many different stakeholders, especially students, use rankings as an indicator of a university's reputation and performance[1–6]. The most cited ranking list is the Academic Ranking of World Universities (ARWU)[7], which has been the focus of researchers since its first release in 2003. 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[8]. The variables 'Alumni' and 'Award' measure the number of Nobel prizes and Fields 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 the out-put of researchers in a university/institution. 'HiCi' is the number of highly cited researchers of the institution; 'N&S' is the number of articles published in *Nature* and *Science* 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, whereas 'Alumni' and 'PCP' are each given a slightly lower weight of 10% (refs 5, 9–11).

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Yet, almost immediately after the release of its first ranking, the ARWU attracted a great deal of criticism[12–16]. One of the potential weaknesses frequently elaborated[17,18] is 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) World Reports[19], which quantifies the research performance of 3042 leading institutions in the world has attracted much attention[20]. The SIR approach integrates a quantity and various quality variables. Output (O) indicator is a measure of the quantity or size of the publication output of an institution. Five other variables represent quality dimension of scientific output: International Collaboration (IC), Normalized Impact (NI), High-Quality Publications (Q1), Specialization Index (SI) and Excellence Rate (ER). For instance, NI compares the average scientific impact of the institution with the world average (taken as 1). Thus a score of 0.8 implies a 20% below average performance, whereas a score of 1.3 means the institution is cited 30% above average[20]. Also, Q1 is the ratio of publications of an institution in what the SCImago team takes as the most influential scholarly journals of the world; those ranked in the first quartile (25%) in their categories as ordered by SCImago Journal Rank. Since this is reported as a percentage, the ratio (Q1/25) is a crude normalized proxy for the quality of publication, with a value of 1 taken as the world average[19,20]. On the other hand, ER indicates the percentage of scientific output of an institution that is included into the set formed by 10% of the most cited papers in their respective scientific fields. This indicator serves as a measure of the high-quality output of the research institutions. Again, the ratio ER/10 allows one to normalize this indicator so that the world average becomes 1 (refs 19, 20).

Having said this, it is essential to provide a framework for ranking the world's best HEI incorporating both the quantitative and qualitative dimensions. Further, it is vital to conclude which one of these dimensions provides better insight into scientific excellence of a HEI. As a possible remedy to the issue, statistical I-distance method has been elaborated and applied here.

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 examinations, entering competitions, UN participation, medicine selection and many other areas[5,21–24]. I-distance is a metric distance in an n-dimensional space. It was originally proposed and defined by Ivanovic[25] and has appeared in various publications since 1963. 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 $X^T = (X_1, X_2,\ldots, X_k)$ chosen to characterize the entities, the I-distance between the two entities $e_r = (x_{1r}, x_{2r},\ldots, x_{kr})$ and $e_s = (x_{1s}, x_{2s},\ldots, x_{ks})$ is defined as[21,26,27]

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

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: $d_i(r, s) = x_{ir} - x_{is}$, $i \in \{1,\ldots, k\}$, σ_i is the standard deviation of X_i and $r_{ji.12\ldots j-1}$ is a partial coefficient of the correlation between X_i and X_j ($j < i$).

The construction of the I-distance is iterative; it is calculated using 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[28–30].

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[5,30,31]. This makes the use of the square I-distance even more desirable. The square I-distance is given as:

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

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[32–34]. The entity with the minimal value for each indicator or a fictive minimal 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[35].

Results of the I-distance method

For this study, the latest release of the SIR World Reports[19] was analysed. Out of the 3042 leading research institutions ranked in the SIR 2011 reports, a little more than 2000 (2010 organizations, to be precise) are HEI and we applied the I-distance method on that sub-dataset. The results achieved and the first 20 HEI are shown in Table 1.

As can be seen from Table 1, Harvard University tops the I-distance method. It has an impressive Output, with 69,995 published papers. Also, its Q1 is 79%, which is also impressive. One should note that The Rockefeller University is highly placed (second spot), although it has a rather small number of published papers – just 3709 (compared to Harvard's 69,995). Precisely this information is crucial since it is essential to elaborate other variables in which The Rockefeller University impresses. For instance, in quality indicator such as Q1 (88.6%) and ER (48.8), The Rockefeller University is the absolute leader. Consequently, it is essential to determine which of the six input indicators is the most important for the process of ranking. Thus, this dataset 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 ER. This correlates highly with the I-distance value ($r = 0.787$). Also, NI and Q1 are far more important than quantitative dimension ~ gross number of published papers (Output). This finding clearly shows that qualitative dimension of scientific output is far more important than quantitative dimension. In addition, University of Belgrade is placed 338th when gross number of published papers (Output) is the only ranking criterion. On the other hand, when applying the I-distance method on six variables, the University of Belgrade slips to the 1407th place. Huge difference in rank is mostly based on poor qualitative indicators: ER is only 6.2 and Q1 is 35.5%. Thus it is vital for the University of Belgrade to dramatically improve its quality component of scientific output.

Further, our aim was to compare two countries which are often cited as new giants in scientific output – China

Table 1. Results of the square I-distance method for higher education institutions (HEI) provided in the SIR 2011 Report (first 20 HEI)

Rank	HEI	Country	I-distance
1	Harvard University	USA	134.302
2	The Rockefeller University	USA	70.711
3	University of Toronto	CAN	63.454
4	Johns Hopkins University	USA	63.257
5	University of Tokyo	JPN	58.027
6	University of Washington	USA	56.374
7	Stanford University	USA	56.297
8	University of California, Los Angeles	USA	55.059
9	University of Michigan, Ann Arbor	USA	54.846
10	University of California, San Francisco	USA	53.129
11	University of Oxford	GBR	51.469
12	University College London	GBR	51.464
13	University of Cambridge	GBR	50.002
14	University of Pennsylvania	USA	49.347
15	Harvard-MIT Division of Health Sciences and Technology	USA	49.268
16	Columbia University	USA	48.647
17	University of California, San Diego	USA	47.586
18	Imperial College London	GBR	46.324
19	University of California, Berkeley	USA	46.194
20	Massachusetts Institute of Technology	USA	45.104

Table 2. Correlation between input variables and I-distance values

	I-distance
Excellence Rate (ER)	0.787*
Normalized Impact (NI)	0.756*
High Quality Publications (Q1)	0.682*
Output (O)	0.623*
International Collaboration (IC)	0.558*
Specialization Index (SI)	0.305

*$P < 0.01$.

Table 3. Top 20 Chinese and Indian HEI appearing in SIR 2011 according to the square I-distance method

	Chinese HEI		Indian HEI	
Rank	Name	I-distance	Name	I-distance
1	Tsinghua Univ	38.123	Indian Inst of Sci	29.451
2	Zhejiang Univ	34.737	Tata Inst of Fund Res	23.189
3	Shanghai Jiao Tong Univ	27.745	Jaw Nehru Cen Adv Sci	23.067
4	Peking Univ	22.241	Mangalore Univ	22.848
5	Harbin Inst of Techn	20.204	Univ of Hyderabad	14.969
6	Huazhong Univ of Sci	16.652	Shivaji Univ	14.007
7	Tianjin Norm Univ	13.651	Natio Inst of Ment Heal	13.501
8	Fudan Univ	13.639	Harisingh Gour Univ	12.761
9	Anhui Med Univ	13.212	Panjab Univ	12.499
10	Bohai Univ	12.656	Jamia Hamdard	11.889
11	Nanjing Univ	12.608	Bharathiar Univ	11.787
12	BeiHang Univ	12.108	Gandhigram Rural Inst	11.743
13	Shanghai Norm Univ	12.038	Guru JambUniv of Sci	11.468
14	Shanghai Univ of Trad	11.734	Sanjay Gandhi Postgra	11.254
15	Univ of Jinan	11.680	Guru Nanak Dev Univ	11.081
16	Luoyang Norm Univ	11.452	Univ of Mumbai	10.814
17	Shenyang Pharm Univ	11.426	Devi Ahilya Univ	10.754
18	Northeast Norm Univ	11.414	Birla Inst of Techn	10.483
19	Chang’an Univ	11.284	Karnatak Univ	10.481
20	Dalian Univ of Techn	11.257	Bharathidasan Univ	10.413

and India. Altogether, 111 institutions from India appear in the SRI 2011 list, of which 85 belong to the higher education (HE) sector (nearly 77%). For China, 285 institutions are represented, of which 240 are from the HE sector (nearly 84%). These statistics indicate that the Chinese HE system is nearly three times bigger than the Indian system[20]. As can be seen from Table 3, the top 20 Indian and Chinese HEI according to I-distance method have similar values. As a matter of fact, 85 Indian HEI have higher average I-distance value than their Chinese counterparts, i.e. 245 Chinese HEI (9.182 ± 3.358 versus 8.371 ± 3.682, $P = 0.075$). In total, Indian scientific output is smaller than the Chinese output. This could be attributed to the smaller number of HEI (80 versus 245). Also, we would like to point out that the Indian Institute of Science tops the India rank list both the SRI and I-distance method. Particularly interesting is huge leap of the Tata Institute of Fundamental Research (TIFR) which is placed 14th in SRI, but I-distance method defines it as second ranked. This is mainly because TIFR has Q1 of 62.5 and ER of 13.2. Admirable results may be noted as the Jawaharlal Nehru Centre for Advanced Scientific Research is placed at the 34th rank, when gross number of published papers (Output) is the only ranking criterion. On the other hand, multidimensional I-distance approach ranks it at number three. All these findings provide us with better insight into the process of ranking HEI and also possible ideas how to enhance it and maintain an impartial ranking process.

Concluding remarks

With a growing worldwide interest in university rankings, the academic world is becoming ever more concerned with the assessment of higher education. These rankings are often used as a marketing tool for universities to showcase their educational or research excellence[5]. This is precisely the reason why it is important to provide rankings as accurately as possible. The analysis presented here has stressed upon the potential weaknesses in the ranking methods if based only on gross number of published papers. With all of the evidence presented in this article, it is essential to encourage the debate on how to determine the criteria to best conduct and analyse university rankings[36]. Furthermore, this could contribute to the emerging efforts to map regions of academic excellence and scientific output[37–40].

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