Subject ranking of universities

Research output plays a key role in the current evaluation of universities and is often measured by the number of research papers or their impacts (citations)[1,2]. Many popular university rankings include core indicators of papers and citations, e.g., Times Higher Education Supplement, United States News and World Report, QS World University ranks, CWTS Leiden Ranking and Academic Ranking of World Universities of Shanghai Jiaotong University.

However, there is a potential problem in this kind of evaluation system: The literature data in different subjects of a university are calculated as a whole, without considering the effects due to differences in the subjects. Bibliometrics reveals that both the number of papers and citations in some basic subjects, such as physics, chemistry and life sciences, are notably higher than those in applied subjects and social science[3,4]. If the overall data of various subjects are mixed in the evaluation procedure, universities with advantages in some basic subjects will rank higher while those that concentrate particularly on applied subjects and social sciences may rank lower. University rankings are in some way like a 'baton'. Using data which do not distinguish the subject differences in overall ranking will probably lead to two issues: (i) university leaders will excessively put their resources into some basic subjects to enhance the overall rank; and (ii) they will neglect the history, original structure and superiority of subjects in their own university.

Here we provide a method for measuring the academic impacts of universities by taking the different subjects into consideration. First, we rank universities in various subjects, and then convert the rankings into scores of universities in the related subjects. Then, we summarize the scores in each subject to the overall score of the universities. In the following empirical analysis, we use the data of Essential Science Indicators (ESI) to show how this method works. ESI is an evaluation system for high-impact countries/territories, institutions, journeys and authors based on the Web of Science (WoS) database. It divides the literature data indexed by WoS into 22 subjects, and compute data on the publications and citations in various subjects. The system gives an overall ranking of top 1% institutions based on total citations and rankings in 22 subjects. Since the present study focuses on university ranking, we only consider samples of universities in the following discussion.

Based on the ESI data, we develop a method of ranking universities using subject ranking, as follows.

(1) Calculate the weight of universities in 22 different subjects by the formula: $w = a^{1/2}(1/r)^{1/2}$, where a represents the number of top 1% universities in the subject, and r denotes the ranking of the university in that subject. This calculation is extended from the Zipf's Law[5] and its application on ranking[6]. We use the square root of the result as the weight to abstract the Matthew effect of the university located in the forefront.

(2) Compute the total weight of each university by the formula $tw_i = \sum_i^{22} w_i$. Then each university can be ranked according to tw. Using this method, we take the cases where total citations rank in the top 1000 in ESI as samples, and compare subject rank based on this method (subject ranking) with traditional citation ranking in ESI (total ranking).

Figure 1 shows that, although the subject ranking maintains similar trends with total ranking, the two rankings of most samples have significant differences. In addition, the differences are more obvious for universities ranked after 100. In general, the difference becomes more while the ranking becomes lower. It reveals that when a large number of universities with different subjects are ranked, the subject difference among them should be carefully considered. For most universities which are not in the top, whether the subject difference is considered or not will influence their rankings significantly.

Even for top universities, the subject ranking demonstrates new information. As shown in Table 1, the rankings of some universities, such as Univ Calif Berkeley and MIT, show remarkable improvement in the present method. Univ Calif Berkeley obtains high tw score by some applied subjects as well as basic subjects with low citation density such as commercial economics, computer science and mathematics. Similarly, MIT not only has advantages in basic subjects such as chemistry and physics, but also has outstanding achievement in computer science, engineering, materials science, molecular biology and genetics, etc. On the other hand, universities with relatively few preponderant subjects might be defeated in the subject ranking. For example, although Johns Hopkins Univ has outstanding advantages in a few highly cited fields such as clinical medicine and immunology, which leads to its overall high ranking, it does not reach such a ranking level in other subjects. As a result, it drops from third to tenth place. One important feature of the method is to avoid the situation where a few highly cited subjects excessively

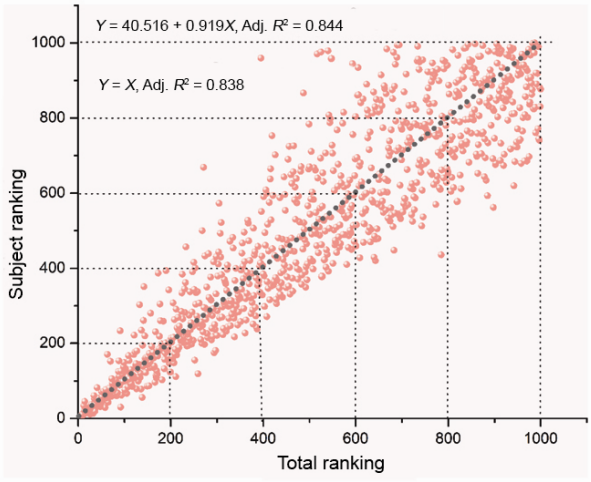

Figure 1. Ranking comparison. (Total ranking represents the rankings of universities calculated by total citation. Subject ranking represents the rankings of universities calculated by weighted subject rankings as proposed method in this study.)

Table 1. Top 20 universities according to subject ranking

Institution	Subject ranking	Total weights	Total ranking	Total citations
Harvard Univ	1	269.23	1	5,364,104
Univ Calif Berkeley	2	112.54	10	1,672,582
Stanford Univ	3	112.056	4	1,874,270
MIT	4	109.37	7	1,752,247
Univ Toronto	5	101.85	2	1,993,590
Univ Calif Los Angeles	6	100.88	5	1,766,320
Univ Michigan	7	99.88	9	1,735,735
Univ Washington Seattle	8	96.55	6	1,754,029
Univ Oxford	9	95.66	8	1,750,690
Johns Hopkins Univ	10	94.57	3	1,966,039
Univ Cambridge	11	87.78	13	1,610,659
Univ Coll London	12	86.63	11	1,650,145
Columbia Univ	13	85.70	14	1,512,468
Univ Penn	14	85.48	12	1,634,171
Imperial Coll London	15	82.77	18	1,374,174
Univ Calif San Diego	16	81.77	17	1,438,844
Cornell Univ	17	80.95	24	1,222,616
Univ Minnesota	18	80.51	25	1,178,409
Univ Calif Davis	19	79.12	39	983,855
Univ Wisconsin Madison	20	77.01	28	1,141,832

The table does not include integrated data of some state university systems in the US, such as Univ Calif System, Univ Texas System and Florida State Univ System.

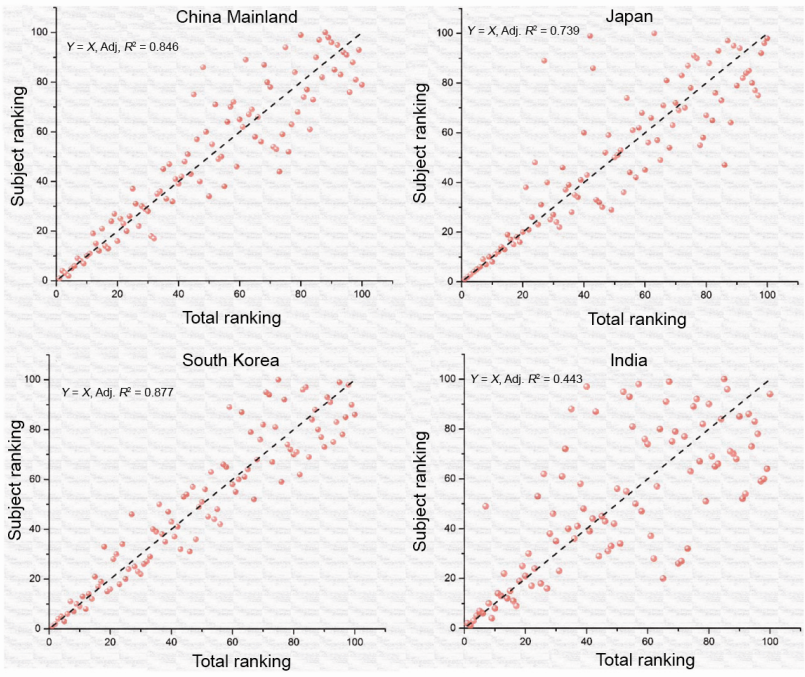

Figure 2. Ranking comparison among four Asian countries. (Top 100 cases of each country are included according to their total ranking.)

pull up the overall ranking of a university. This method can also contribute to examining the comprehensiveness of universities through the weight of subject ranking. It benefits the universities that have advantages in various subjects, i.e. truly comprehensive universities. Thus, it can be considered as a comprehensive ranking method based on subjects.

Furthermore, we found that there could be differences in the two ranking methods at the country level (Figure 2). China and South Korea show relatively strong consistency in both rankings, while only a small part of important universities in Japan presents a large difference in these two rankings. However, a considerable part of Indian universities shows a large gap in the different methods, which indicates that there are relatively strong imbalances between the structure of subjects in Indian universities. By combining these two methods, the pattern of subject for a country or territory can be abstracted and compared. Subject ranking could be used as a complementary perspective of observations for the traditional methods.

Ranking significantly influences the development strategies of universities around the world[7]. Subject development is one of the core tasks of university development. Therefore, we suggest that the academic community should pay more attention to subject differences in university ranking, and focus on the significant influence of difference between subjects in classical bibliometric indices such as citations. Meanwhile, university leaders should understand that subject ranking is more important than the overall university rankings. A world-class university should be built on a group of world-class subjects.

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