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Exploring the h-index at the institutional level: A practical application in world university rankings

Mu-Hsuan Huang,

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A practical application in world university rankings

Mu-Hsuan Huang
Department and Graduate Institute of Library and Information Science, National Taiwan University, Taiwan, ROC

Abstract

Purpose – The purpose of this study is to evaluate the scientific performance of universities by extending the application of the h-index from the individual to the institutional level. A ranking of the world's top universities based on their h-index scores was produced. The geographic distribution of the highly ranked universities by continent and by country was also analysed.

Design/approach/methodology – This study uses bibliometric analysis to rank the universities. In order to calculate their h-index the numbers of papers and citations in each university were gathered from Web of Science, including the Science Citation Index and Social Science Citation Index. Authority control dealing with variations in university names ensured the accuracy of each university's number of published journal papers and the subsequent statistics of their citations.

Findings – It was found that a high correlation exists between the h-index ranking generated in this study and that produced by Shanghai Jiao Tong University. The results confirm the validity of the h-index in the assessment of research performance at the university level.

Originality/value – The h-index has been used to evaluate research performance at the institutional level in several recent studies; however these studies evaluated institutions' performance only in certain disciplines or in a single country. This paper measures the research performance of universities all over the world, and the applicability of the h-index at the institutional level was validated by calculating the correlation between the ranking result of the h-index and the ranking by the Shanghai Jiao Tong University.

Keywords H-index, Research evaluation, Bibliometrics, University rankings, Research, Organizational performance

Paper type Research paper

Introduction

The evaluation of university research attempts to achieve the difficult task of examining the research performance of a given university. If executed appropriately research evaluations not only provide knowledge about the level of research performance of a university, but also offer valuable insights for policy makers to set long-term goals and to make decisions in allocating limited resources. Indeed research performance evaluations have been shown to provide useful information for decision-makers in higher education (Huang *et al.*, 2006). Aside from budgeting purposes academic performance measures also help the administration to set strategic goals in faculty recruitment and grant allocation.

Generally speaking peer reviews and bibliometric indicators are the two main approaches for the assessment of research performance. The peer review, an expert

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assessment method, has been criticised for its subjectivity and high costs, and because as research fields become narrower, the pool of fully qualified reviewers is limited. At the same time it remains the primary method in research evaluation practice if properly designed and administrated. Yet with the specialisation of knowledge and the growing trend of multidisciplinary research it is becoming more difficult for a relatively few domain experts to trace and assess research performance at the university level. Bibliometrics aims to explicitly track the development and dissemination of intellectual outputs by looking at the patterns that emerge from the published literature (Pritchard, 1969; Ikpaahindi, 1985). Although bibliometric methods have been criticised from conceptual, technical and methodological perspectives, they are still widely used in research evaluation for objectivity and operability. As a result bibliometrics has become a powerful tool to complement peer reviews, which inevitably suffer from partial and subjective information (Aguillo *et al.*, 2010; Bookstein *et al.*, 2010; Huang, 2008; van Raan, 2005).

In general bibliometric indicators have been widely employed. The indicators include the total number of papers, total number of citations, citations per paper, and the number of "significant papers", defined as the number of papers with $>$ y citations and the number of citations to each of the q most-cited papers, etc. (Hirsch, 2005). Researchers have attempted to strike a balance between the quantitative and qualitative aspects of those performance indicators. By relying on performance indicators of either aspect alone, one risks missing out on the other aspect of assessing research performance.

Hirsch claimed that the h-index could avoid the shortcomings of the other indicators, which inevitably only consider either the number of papers or the number of citations alone, but not both at the same time. He proposed the h-index, a new metric designed to assess a scholar's productivity, and defined it thus: "a scientist has index h if h of his or her Np papers have at least h citations each and the other (Np−h) papers have $\leq$ h citations each" (Hirsch, 2005, p. 16569).

Hirsch applied the h-index to estimate the total number of citations ($N_{c,tot} = ah^2$) and empirically derived that a ranges between three and five. He pointed out that the academic with a higher h value is likely to be more accomplished, because the h-index can assess both their productivity and impact at the same time. He also mentioned that self-citations could increase the h-index value, but the relative impact is lower than that on the number of total citation counts. The h-index has been adopted as an indicator to measure the academic performances of universities (Huang and Chi, 2010; Ye, 2010). In addition several global ranking systems use the h-index in evaluating the academic performance of institutions. For instance both the SCImago Journal & Country Rank from Spain and the Higher Education Evaluation and Accreditation Council of Taiwan (HEEACT) Rankings provide h-indexes. SCImago provides journal-level and country-level h-indexes from the Scopus database, while the HEEACT Ranking has published world university rankings based on calculating the h-index (accounting for 10 percent of the weight) based on the Science Citation Index and Social Science Citation Index since 2007 (Huang, 2011). The Shanghai Ranking – Academic Ranking of World Universities (ARWU; see www.arwu.org/ARWU2007.jsp) published by Shanghai Jiao Tong University emphasises the highest level of academic performance of world universities with indicators such as the number of Nobel Prize and Fields Medal-winning alumni and staff. The Shanghai Ranking also calculates the data based on the Science Citation Index and Social Science Citation Index databases. The ranking system employs five criteria to evaluate university performance: quality of education, quality of faculty, research (papers published in *Nature* and *Science*), output (SCI index) and size of institution (Academic Ranking of World Universities, 2011; Huang, 2011). Of these three major ranking systems HEEACT regards the h-index as one of its multiple indicators, SCImago does not provide h-index figures at institutional levels, and Shanghai Ranking does not use the h-index.

The purpose of this study is to evaluate the scientific performance of universities by extending the application of the h-index from the individual to the institutional level. We calculated and ranked the h-index of more than 700 universities around the world and produced a list of the top 500 universities. As it does not use the h-index Shanghai Ranking was selected as the control in this study. The ranking by h-index was correlated with the 2007 Shanghai Ranking results to assess the capacity of the h-index to evaluate universities' research performance.

Literature review

After Hirsch introduced the h-index Ball (2005) posted positive comments in *Nature* and generated many discussions. This index has several advantages, such as the criteria of productivity and impact, easy access to the necessary data in Thomson's ISI Web of Science database, insensitivity to extreme values, resistance to inflation, automatic sampling of the most relevant papers concerning citations, etc. Yet it contains shortcomings as well, including the lack of consensus on disciplinary and sub-disciplinary standards and on the proper weighting of co-authorship, and different h-index distributions in different fields of science. Moreover the h-index is an integer number and many researchers may have the same h-index. Since it is not sensitive to extreme value, researchers with the same h-index may not be distinguished from each other (Batista *et al.*, 2006).

Many researchers have further tested the h-index, and some have explored its bibliometric properties and/or its applicability across a wide range of settings. For example Batista *et al.* (2006) proposed a complementary index $h_I = \frac{h^2}{N_a^{(T)}}$, with $N_a^{(T)}$ being the total number of authors in the considered h papers. If a researcher has published papers without any kind of collaboration, the index h_I will be equal to their index h. Nevertheless, as for co-authorship, calculating method varies. There are huge differences in the numbers of authors in each field. For example papers in physics have large numbers of authors, while in mathematics the numbers of co-authors are relatively small. In a research field with numerous authors, the greater the number of authors, the higher the chance of self-citations that the h-index fails to compare across disciplines. As a result the h_I index takes co-authorship effects into consideration in order to solve the problem. Batista *et al.* also adopted the h_I index in an empirical study to decrease the co-authorship effect. This method has proven to be effective, for it enables the h_I to compare different research areas.

Some other researchers work on the basis of the variation in h-indexes by changing the period for which the calculation is done. For instance Liang (2006) proposed constructing the sequence and matrix of h-indexes. The method involves calculating the h-sequence by continually changing the time-span of the data, and constructing the h-matrix based on a group of correlative h-sequences. From the analysis of each h-sequence and the comparison of the h-sequences in the h-matrix, Liang obtained some useful information. First not all researchers have a linear pattern of accumulated published papers; therefore the h-sequence can reveal the different publication patterns of each researcher. Second the h-matrix makes it possible to compare scientists at different stages. The h-indexes can be comparable in the h-matrix by taking a certain year as the beginning year of the h-sequences of all the scientists who published their first paper no later than that year. The beginning year could be the year they published their first paper, or the year they received a PhD. An alternative would be to select the most productive n years or the most active n years of a scientist as the time-span to calculate the h-sequence, and to compare the h-sequences of the scientists at different academic stages.

Bornmann and Daniel (2005) investigated the peer review committee for awarding long-term fellowships to post-doctoral researchers, as practiced by the Boehringer Ingelheim Fonds (an international foundation for the promotion of basic research in biomedicine) where applicants who demonstrate excellence in scientific work are selected for the fellowships. The study involved 414 applicants from the years 1990 to 1995 (64 approved and 350 rejected). They found that the h-indexes of the 64 accepted applicants are all higher than the values of the 350 rejected applicants. This result suggests that the h-index is a promising rough measurement of the quality of a young scientist's work.

Saad (2006) used the Web of Science database covering the period 1989-2005 to evaluate all 55 scholars who published five or more papers in the *Journal of Consumer Research*. As expected the h-index of these productive scholars strongly correlated with their total citation counts. Moreover a significant correlation was found between journal h-indexes and their ISI impact factors.

Braun *et al.* (2006) suggested that the h-index could supplement the journal impact factor. They found that the distributions of the h-index and impact factors are different in the journals published in 2001. The journals with an h-index higher than 50 mainly belong to the biomedical field, except two physics journals and one from chemistry. Although these three journals are the most prestigious ones in their fields, they are not included in the top 100 rankings by impact factor.

The h-index can be applied to many levels of aggregation, from one single scholar to multiple universities, even to different countries (Norris and Oppenheim, 2010). For instance SCImago developed country and journal rankings to evaluate academic performance, based on data from Scopus since 1996. The scores of indicators including the h-index are all open to the public for further research. SCImago provides h-indexes and rankings for 18,732 journals and 235 countries. Spiroski (2010) has used the h-index information from SCImago's Journal & Country Rank to calculate the journal rankings in the field of medicine in the Republic of Macedonia and other countries of the former Yugoslavia. Moreover SCImago proposed a new indicator, SCImago Journal Rank, which refers the algorithm to Google PageRank (Gonzalez-Pereira *et al.*, 2009; Jacsó, 2010; SCImago, 2007; Spiroski, 2010).

Prathap (2006) proposed that the h-index could be used for evaluating an institution's scientific research output. He also defined a new h-type index: h_2, i.e. h individuals in an institution have at least h h-index. After Prathap's suggestion much research was focused on measuring institutions' research performance with the h-index. Pires da Luz *et al.* (2008) calculated Brazilian psychiatric postgraduate programmes' institutional h-index and found it was correlated with the number of citations and number of papers within the top 10 percent most cited papers. Rousseau *et al.* (2010) adopted both h_1 and h_2 indexes to evaluate institutions in the field of HIV infection and therapy. Ponce and Lozano (2010) evaluated the publication performance of American and Canadian neurosurgical departments based on the ISI database. The balanced nature of h-indexes brings new issues when applied to multiple levels.

Methodology

Following the idea that the number of papers reflects the performance of an institution, we ranked more than 3,000 institutions from the ISI Essential Science Indicators (ESI) by their paper counts. We removed the research institutes and selected the best 678 universities from the top 700 institutes. The list was gathered from the ESI database covering 11 years from 1996 to 2006. The top 500 universities were selected to be our research sample according to the h-index ranking of the 678 universities. The way we selected the universities avoids the risk of abnormal results from a few papers with high h-indexes. For example the University of Alexandria ($h = 30$) and Hong Kong Baptist University ($h = 45$) are not on the list, although both have high h-indexes, because the total number of papers did not reach the threshold required to make the school list.

Targeting the universities mentioned previously, the number of papers and the number of citations in 2005 and 2006 in each university were collected from the ISI Web of Science database in May 2008. The data includes the Science Citation Index and Social Sciences Citation Index. The total citation number is the number of times each paper is cited from its publication date to the retrieval date. Additionally each university's h-index was calculated according to Hirsch's definition, thus the top 500 universities were obtained.

To prevent the ambiguity and misinterpretations caused by variations and changes of institutional names, the data were attributed to each institution according to vigorous authority control. Variations due to different versions of the name of a university i.e. the official name, abbreviations and other possible forms of the names were carefully taken into consideration. This study also considered the merging and splitting universities (or different campuses in a university system) and included publications by a university's affiliated institutions such as research centres and university hospitals. The effort ensured the accuracy of each university's number of published journal papers and the subsequent statistics of their citations. However it should be noted that some records lack institutional affiliations. In physics for example about 2.86 percent of the records from 1989-2008 are without institutional affiliations, which cannot be accessed (Huang and Lin, 2010). In this study this problem is acknowledged as a research limitation, but we do not think that it has much impact on the ranking order of institutions.

It should be noted that one characteristic of the h-index – being an integer number – may lead to some universities having the same h-index, making it hard to compare those universities. In the study we regard the universities with the same h-index as having the same rank, but distinguish them by their two-year citation counts in the ranking table.

Results and discussion

We calculated the top 500 world universities (actually 504 universities ranking from 1st to 469th) by h-index values. The highest h-index is 86 and the lowest h-index is 16. In the top 500 universities, the h-index mean is 27.25, the median is 25, and standard deviation is 10.21. In addition the top 15 universities are all in the USA. The two best universities in Europe among the top 500 are Cambridge (h-index = 52) and Oxford (h-index = 52), both ranked 15th. The two best universities in Asia among the top 500 are the University of Tokyo (h-index = 48) ranked 27th, and the National University of Singapore (h-index = 35) ranked in the top 87. The highest ranked in Oceania is the University of Melbourne (h-index = 37), in the top 67.

Top 20 world universities by h-index

Table I shows the top 20 world universities by h-index: 21 of them are in the USA, two in the UK and one in Canada. The best university in the world is Harvard University with an h-index value of 86, the second is Johns Hopkins University which has an h-index value of 68, followed by Massachusetts Institute of Technology with an h-index value of 65. The only one located in Canada is the University of Toronto. The h-indexes of the top 20 universities all exceed 50, with a mean value of 56.54, a median value of 55, and standard deviation of 7.84.

Comparison among continents

Table II provides an overview of the number of universities and the h-index means of the top 20, 50, 100, 300 and 500. Within the range of the top 50 universities, 39 (78

Rank	Continent	Country	Universities	H-index
1	Americas	The USA	Harvard University	86
2	Americas	The USA	Johns Hopkins University	68
3	Americas	The USA	Massachusetts Institute of Technology	65
4	Americas	The USA	University of Washington - Seattle	61
5	Americas	The USA	Stanford University	60
6	Americas	The USA	University of California – San Diego	59
7	Americas	The USA	University of California – Los Angeles	58
7	Americas	The USA	University of California – Berkeley	58
7	Americas	The USA	University of Michigan – Ann Arbor	58
7	Americas	The USA	University of California – San Francisco	58
11	Americas	The USA	Columbia University	56
12	Americas	The USA	University of Pennsylvania	55
13	Americas	The USA	Yale University	54
14	Americas	The USA	Duke University	53
15	Americas	The USA	Cornell University	52
15	Europe	The UK	University of Cambridge	52
15	Europe	The UK	University of Oxford	52
18	Americas	Canada	University of Toronto	51
18	Americas	The USA	Mayo Clinic College of Medicine	51
20	Americas	The USA	University of Pittsburgh – Pittsburgh	50
20	Americas	The USA	University of Chicago	50
20	Americas	The USA	University of North Carolina – Chapel Hill	50
20	Americas	The USA	California Institute of Technology	50
20	Americas	The USA	Washington University in St Louis	50

Table I. Top 20 world universities by h-index

Table II.
The h-index means and number of universities in each continent

	Region	All	Africa	Americas Total	Americas North	Americas Central and South	Asia/Pacific	Europe
TOP20	No.	24	0	22	22	0	0	2
	Average	56.46	0	56.95	56.95	0	0	52
	Threshold	50	0	50	50	0	0	52
TOP50	No.	50	0	39	39	0	3	8
	Average	50.36	0	51.33	51.33	0	46.33	47.13
	Threshold	40	0	40	40	0	44	43
TOP100	No.	103	0	68	68	0	7	28
	Average	43.27	0	45	45	0	40.57	39.75
	Threshold	34	0	34	34	0	35	34
TOP300	No.	305	0	140	139	1	35	130
	Average	32.90	0	36.16	36.20	30	29.71	30.26
	Threshold	23	0	23	23	30	23	23
TOP500	No.	504	3	197	187	10	89	215
	Average	27.25	18.33	30.98	31.69	19	22.97	25.67
	Threshold	16	16	16	16	16	16	16

percent) universities are in North America, eight (16 percent) are in Europe and three (6 percent) in the Asia/Pacific region. The top 100 universities include 68 universities (66 percent) in North America, with the mean h-index of 45, whereas the other 28 universities are in Europe, with the mean value of 39.75, which is lower than the mean of the seven universities in Asia and the Pacific (40.57).

The total number of universities in Europe ranked in the top 100 is significantly lower than that of their American counterparts. However, within the top 300 list, the number of Europe's universities (130) is closer to that of North America (139). One thing worth noticing is that the number of universities in Europe exceeds that of the Americas in the top 500 list.

In the top 500 list the highest proportion is in Europe, a total of 215 universities, and the Americas come next with a total of 197, 187 of which are in North America. There are 89 universities in the Asia/Pacific region and three in Africa. The means of the h-index for the four continents are different; 30.98 for the Americas, 25.67 for Europe, 22.97 for Asia/Pacific and 18.33 for Africa. The Americas are the only continents whose mean value exceeds the mean value of all the other continents.

Comparison among countries

Table III shows again that the top 20 universities are only found in the USA, UK, and Canada. Most (88 percent) of the universities are in the USA with a mean h-index of 57.24, which is the highest and exceeds the mean of the top 20 universities (56.54).

Table III.
The h-index means and number of universities in each country (top 20 universities)

Countries	No.	Average	Threshold
The USA	21	57.24	50
The UK	2	52	52
Canada	1	51	51
All	24	56.54	50

Four other countries – Japan, Belgium, Sweden and Germany – emerge in the top 50 list (shown in Table IV). Again most (72 percent) of the top 50 universities are in the USA and their mean h-index (51.86) is still the highest, exceeding the mean value (50.36). The rest of the top 50 universities are distributed as follows: five in the UK, three in Japan, three in Canada, and only one each in Belgium, Sweden and Germany.

More (16) countries appear in the top 100 list; however the USA, the UK, Canada, Germany and Japan account for most of the universities (as shown in Table V). Particularly in Germany and the UK, the increase of the number of universities in the top 100 compared to that in the top 50 is obvious. The number of universities in Germany increases from one to five when the ranking expands from 50 to 100, and for the UK the number increases from five to nine. Comparing the percentages of universities located in the USA among the top 20 list (88 percent), the top 50 (72 percent) and the top 100 (61 percent), the descending trend is obvious. The mean h-indexes in Belgium, the USA, and Japan are higher than the average mean of the top 100 universities. The UK, Sweden, and Canada also have excellent h-indexes.

Country	No.	Average	Threshold
The USA	36	51.86	40
The UK	5	48.60	43
Japan	3	46.33	44
Canada	3	45	41
Belgium	1	46	46
Sweden	1	45	45
Germany	1	43	43
All	50	50.36	40

Table IV. The h-index means and number of universities in each country (top 50 universities)

Country	No.	Average	Threshold
The USA	63	45.32	34
The UK	9	43.11	35
Canada	5	41	35
Germany	5	38	35
Japan	4	44	37
Switzerland	3	37	35
The Netherlands	3	36.33	34
Sweden	2	42	39
France	2	35	34
Belgium	1	46	46
Italy	1	39	39
Denmark	1	38	38
Finland	1	38	38
Australia	1	37	37
Israel	1	36	36
Singapore	1	35	35
All	103	43.27	34

Table V. The h-index means and number of universities in each country (top 100 universities)

Table VI reveals the results of analysing the top 300 list. There are 29 countries contributing to the total number of 305 universities, with the majority in the USA, Germany and the UK. The percentage of universities in the USA (41 percent) has decreased again, compared to the three smaller lists. In contrast, the other countries, such as Italy, France and the Netherlands, have increased numbers of universities. For example France, with no universities ranked in the top 100 list, has 13 universities ranked in the top 300 list. Italy increases from 1 to 15 as well.

The universities in Germany have increased from five in the top 100 list to 30 in the top 300 list. However the h-index mean (29.27) of Germany falls far behind that of the UK (32.70). The countries which have higher h-index means than the mean value (32.90) in the top 300 list are the USA (36.69), Sweden (33.50) and Switzerland (33.43).

Table VII shows the 40 countries that produce the top 500 universities. The USA leads with 164 universities (33 percent), followed by Germany with 44, the UK with 38 and Japan with 31 universities. Among Asian countries Japan has the most universities in the top 500 list. China is in second place with 14 universities, followed by South Korea with 10. South Korea has three universities ranked in the top 300 list, which increases to 10 in the top 500 list; and China increases from 4 to 14 as well.

Country	No.	Average	Threshold
The USA	125	36.69	23
Germany	30	29.27	23
The UK	27	32.70	23
Italy	15	29.20	24
Canada	14	31.79	24
France	13	27.54	23
Japan	12	32.17	23
The Netherlands	10	31.40	23
Switzerland	7	33.43	30
Australia	7	29.57	24
Sweden	6	33.50	25
Belgium	5	30.80	23
Israel	4	30.50	24
Spain	4	27.50	26
China	4	26.25	23
Denmark	3	31.67	24
South Korea	3	27.33	23
Austria	3	27	24
Norway	2	26	24
Hong Kong	2	26.50	23
Finland	1	38	38
Singapore	1	35	35
Brazil	1	30	30
Ireland	1	26	26
New Zealand	1	26	26
Russia	1	25	25
Czech	1	24	24
Taiwan	1	24	24
Greece	1	23	23
All	305	32.90	23

Table VI.
The h-index means and number of universities in each country (top 300 universities)

Country	No.	Average	Threshold
The USA	164	32.41	16
Germany	44	25.98	16
The UK	38	28.92	17
Japan	31	23.84	16
Italy	28	24.21	16
Canada	23	26.57	16
France	19	24.68	16
China	14	20.71	16
The Netherlands	12	29.42	18
Australia	12	24.50	16
Spain	12	21	16
Sweden	10	27.50	18
South Korea	10	22.20	18
Switzerland	8	31.38	17
Israel	6	26.33	16
Finland	6	22.33	16
Austria	6	22.33	16
Taiwan	6	18.50	16
Belgium	5	30.80	23
Denmark	5	26.40	16
Brazil	5	20.20	16
Greece	4	20.25	18
Hong Kong	3	24	19
Norway	3	23.67	19
Ireland	3	21.67	17
Poland	3	18.67	16
South Africa	3	18.33	16
Hungary	3	17.67	16
Portugal	3	17	17
Singapore	2	26.50	18
New Zealand	2	24	22
India	2	19	16
Chile	2	17	17
Russia	1	25	25
Czech	1	24	24
Mexico	1	22	22
Thailand	1	19	19
Croatia	1	18	18
Argentina	1	17	17
Puerto Rico	1	16	16
All	503	27.25	16

Table VII. The h-index means and number of universities in each country (top 500 universities)

In the top 500 ranking table the countries exceeding the mean value (27.25) are the USA (32.41), Switzerland (31.38), Belgium (30.80), the Netherlands (29.42), the UK (28.92), and Sweden (27.50). The mean h-index of the two universities in Singapore (26.50) is the best in Asia. Although Japan has more universities in the list than other Asian countries, its mean h-index, 23.84, is lower than that of Singapore (26.50) and Hong Kong (24).

The top 10 countries ranked by the mean h-index are different from those ranked by university numbers. Those ranked in the top 10 of the top 500 list by university numbers, including Japan, Italy, France, China, Australia and Spain, are not in the top 10 when countries are ranked by the mean value of their h-index. In contrast Switzerland, Belgium, Sweden, Denmark and Israel have fewer universities in the top 500 list but have greater mean h-indexes, indicating higher quality research in these universities. Furthermore the countries which are ranked in the top 10 by mean h-index are mostly located in Europe and North America, except Israel, the only country elsewhere that achieves as high as the ninth position, with a value of 26.33 (see Table VIII).

Correlation with academic ranking of world universities (Shanghai Ranking)

The Pearson correlation was applied to test the agreement between the top 500 world universities ranked by h-index and the Shanghai Ranking published by Shanghai Jiao Tong University (2007). We examined the 432 universities common to both ranking tables. First we identified the rank position of these 432 universities in the ranking table published by Shanghai Jiao Tong University according to their total scores. Then the two rank positions of each university, the Shanghai Ranking and the ranking based on the h-index from this study, were compared. Then the two ranking systems were compared. A significant correlation coefficient of 0.804 ($p = 0.000$) was obtained. The high correlation suggests the validity of the h-index in the assessment of research performance at the university level.

Comparing the ranking of schools by h-index to the Shanghai Ranking of 2007 there are 17 universities listed among both of these lists' top 20 universities. While the results show consistency between these two ranking systems, there are still some discrepancies in the ranking results. For example the University of Cambridge ranked fourth in the Shanghai Ranking, but 15th by h-index. Among the top 500 universities the numbers of universities in each continent are approximately consistent in the two ranking systems, except for Asia/Pacific and Europe. In the Asia/Pacific region, there are 99 universities in the Shanghai Ranking, but 89 universities using the h-index. Europe has 207 universities in the Shanghai Ranking, but 215 universities using the h-index. Looking at the ranking results at country level, among the top 10 countries,

Rank	Country	No.	Average
1	USA	164	32.41
2	Switzerland	8	31.38
3	Belgium	5	30.80
4	The Netherlands	12	29.42
5	UK	38	28.92
6	Sweden	10	27.50
7	Canada	23	26.57
8	Denmark	5	26.40
9	Israel	6	26.33
10	Germany	44	25.98

Table VIII.
The top 10 countries by h-index means

compared to the Shanghai Ranking, the ranking by h-index alone benefits Switzerland, Belgium, and the Netherlands, rather than the UK and Germany.

Although the ranking results using the h-index are highly correlated with the Shanghai Ranking which indicates that evaluating academic performance of institutions by the single indicator of the h-index is feasible, it is still worth noting the possible effects of self-citations, university size, staff size, and so on (Molinari and Molinari, 2008; Vieira and Gomes, 2010).

Conclusion

The study analysed the top 500 world universities using the h-index value. The top school is Harvard University with an h-index value of 86, while the bottom 36 universities each have an h-index value of 16. The mean h-index of the 504 universities is 27.25 and the median value is 25. The top 15 universities in the top 500 list are all in the USA. The USA is also the country with the most universities (164) in the top 500, followed by Germany (44) and the UK (38). In the Asia/Pacific region, Japan has the highest number of universities in the top 500 list (31). The USA had the highest h-index mean (32.41), followed by Switzerland (31.38) and Belgium (30.80).

Comparing the number of universities from each continent in the top 500 list generated using the h-index gives 215 in Europe, 197 in the Americas, 89 in Asia/Pacific but only three in Africa. The mean h-index of the Americas (30.98) is greater than the average mean of the top 500 universities (27.25). It is also higher than the mean h-index of other continents, such as Europe (25.67), Asia/Pacific (22.97) and Africa (18.33).

The correlation coefficient was generated between the h-index ranking of world universities generated in this study and the academic ranking of world universities published by Shanghai Jiao Tong University. A high correlation of 0.804 was found between the two rankings. The applicability of the h-index to assessing research performance at the institutional level proved to be valid. The results suggest that the h-index can be used to accurately measure the academic performance at the university level.

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About the author

Mu-Hsuan Huang is a Professor in the Department and Graduate Institute of Library and Information Science, and the Deputy Dean of the College of Liberal Arts, at National Taiwan University, Taipei, Taiwan. Her early research focused on information retrieval and information behaviour, and turned to bibliometrics, science and technology policy, intellectual property, and patent information in later years. She did many studies on bibliometrics, patentometrics, and research assessment in Chinese and in English. She is also the project investigator for several large national research projects, including Performance Ranking of Scientific Papers for World Universities (Higher Education Evaluation and Accreditation Council of Taiwan Ranking) and National Science and Technology Programme – Energy. Mu-Hsuan Huang can be contacted at: mhhuang@ntu.edu.tw

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