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Webometric Ranking of World Universities: Introduction, Methodology, and Future Developments

ISIDRO F. AGUILLO, JOSÉ LUÍS ORTEGA and MARIO FERNÁNDEZ

Today the worldwide web (web) is one of the main sources of information and the main showcase for everyone (institutions, business enterprises, individuals, etc.) who wants to be recognized on in the 'real world'. At the academic level, universities have a very important role as a means to communicate scientific and cultural achievements. Web publication by scholars is not only a tool for scholarly communication but it is also a means to reach larger audiences and in general a reflection of the performance of the institutions. There have been several efforts to develop web indicators that can ultimately lead to build a university's rankings. This paper presents the Webometric Ranking of World Universities which is built using a combined indicator called WR that takes into account the number of published web pages (S) (twenty-five percent), the number of rich files, those in pdf, ps, doc and ppt format (R) (12.5 percent), the number of articles gathered from the Google Scholar Database (Sc) (12.5 percent,) and the total number of external inlinks (V) (fifty percent). The results show that there is a larger than expected academic digital divide between higher education institutions in the United States and those in the European Union. This kind of rankings using web indicators should be used to measure universities' performance in conjunction with more traditional academic indicators.

Introduction

More and more scholars are turning to the Internet to find scientific information and academic institutions are devoting more and more resources to improving their presence on the web. The web is probably already the main showcase for universities, but in the near future the virtual institution might be as important and representative as a real one. In a world where every day we become more interconnected, the global visibility of academia is clearly linked to their commitment to the worldwide web.

It is therefore of paramount importance to take into consideration web publication not only as a primary tool for scholarly communication but as a true reflection of the overall organisation and performance of universities. It is very surprising to discover that for many scholars web presence is not related to their academy duties and they are ignoring requests to contribute to the common effort. Given the huge and diverse audiences that web contents could reach even in developing countries at very modest cost, enhancing also the social role of the scientists.

The academic web is a global source of expertise and also a means to communicate scientific and cultural achievements (Aguillo, Granadino, Ortega, and Prieto, 2005). The impact of electronic publications is far larger than that obtained by traditional journals and books on paper. Websites are the most efficient and cheapest way for boosting all three academic missions: teaching, research and transfer.

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Thus, why not consider web data in the evaluation of the universities and research centres? What is the reason for ignoring them at all? In fact, the problem is so acute that even key institutions or whole systems of higher education are failing to be in the elite group of web world-class universities. Lack of visibility on the web is leading to a worrying level of academic digital divide.

Rankings and Web Ranking

Several research teams have been working on the development of web indicators from the mid-1990s, especially after the European Commission funded two projects, EICSTES (<www.eicstes.org>) and WISER (<www.wiserWeb.org> and <www.Webindicators.org>).

After realising the importance of the search engines as the main intermediaries in the information access processes in the web (Wouters, Reddy, and Aguillo, 2006), new indicators (Scharnhorst and Wouters, 2006; Aguillo, Granadino, Ortega, and Prieto, 2006) were introduced to solve the problems derived from the instability of search engine results (Bar-Ilan, 2005) and the artefacts produced by the Web Impact Factor (Ingwersen, 1998).

Using a worldwide catalogue of universities collected during the EICSTES project and automatic procedures developed for WISER, a preliminary version of a web indicators-based ranking was published in 2004. This application of the cybermetric or webometric techniques does not differ from similar scientometric proposals, where bibliometric data is the core information used for the analysis (Thelwall, 2004). In fact, the application of quantitative methods to the analysis of scientific activities and scholarly communication has been a powerful tool for science policy and research evaluation.

Most of the bibliometric indicators, such as the number and distribution of publications and citations, are easy to obtain. But the problem with this approach is that only a restricted number of the activities of the researchers or institutions are considered, since only formal publications are usually taken into account. In fact, *scientometric tasks should be a multifaceted enterprise and more variables should be added to the analysis* (Moed, 2006).

However, including additional aspects, especially when they are difficult to obtain and the data is very heterogeneous, could make the analysis complex and sometimes unfeasible when global scenarios are intended. Web publication is frequently questioned for the quality of the contents, not taking into account that besides research results published in prestigious journals, the same authors develop a wide range of activities reflected on the web pages. Teaching materials, raw data, drafts, slides, software, bibliographic or link lists are also relevant and inform about the commitment of professors to their students. The structure, composition, and all kinds of administrative information provided by the institution itself are very valuable. When this information is made publicly available through the web, it speaks of the high academic level of the university. The web is providing a comprehensive way to describe this wider range of activities where scientific publications are only one of components to be found on a website (see Table 1).

A few years ago, many websites of even very important institutions were small, with little relevant information and without any added value. This is no longer the case and the top-level universities are publishing millions of pages produced by dozens of

TABLE 1. SOME PERSONAL ACTIVITIES REFLECTED IN PERSONAL WEBPAGES

RESEARCH	TEACHING
Raw data	Multimedia and graphics
Personal info (CV)	
Research team description	
Press notes and interviews	
New software	Workshops slides
Conference slides	Bibliographies
Project Reports	Webliographies
Book chapters	Bureacratic reports
Thesis, dissertations	
Books, Monographies	Seminar slides
Popular Science	
Organising events	
Patents	Textbooks
Drafts, pre-prints	Book reviews
Peer-review	Websites for e-learning
Papers in prestigious journals	
Papers in local journals	

Source: The authors.

departments and services, hundreds of research teams and thousands of scholars. Strong web presence informs of a wide variety of factors that are clearly correlated with the global quality of the institution: widespread availability of computer resources, global internet literacy, policies promoting democracy and freedom of speech, competition for international visibility or support of open access initiatives, etc.

Although an unknown fraction of the contents of a university domain are not academic, the patterns obtained are meaningful enough given the large numbers involved in the webometric analysis. In addition, granting access to and promoting web publication among faculty members means that other colleagues will be aware of the scientific results produced, more candidate students can learn about the university, companies can find suitable partners for industrial projects, and organizations can easily access contact data for experts. These and other reasons should be taken into consideration when supporting Open Access initiatives (<http://en.wikipedia.org/wiki/Open_access>) intended to obtain institutional mandates for information web archiving.

Collecting Data

Counting a large number of web domains with huge numbers of pages can only be done automatically. One possibility is to use one of the available commercial or free crawlers, but tuning up these robots can be very difficult and they require important human and computer resources (Cothey, 2004). On the other hand, search engines already have well designed and tested robots; they frequently update their databases and they have automatic tools that can be customized with powerful operators for data extraction. Moreover, as search engines are the main intermediaries in web navigation, the presence of a domain in their databases is a indicator of visibility. Commercial search engines also have limitations, including inconsistent and rounded results, biases in geographical and linguistic coverage or frequent and opaque changes in their working procedures.

TABLE 2. OPERATORS OF THE MAIN SEARCH ENGINES

Indicator	Operator/search engines GOOGLE	YAHOO	LIVE	EXALEAD	SCHOLAR	ALEXA
SIZE			**site**			(site)[1]
ENGLISH			language filter in advanced search			
RICH FILES	**filetype**	originurlextension	filetype[2]	filetype[2]		(filetype)[1]
VISIBILITY	PageRank	**linkdomain**	linkdomain[3]	**link**		
LUMINOSITY			linkfromdomain			
SUBDOMAINS		feature index				
POPULARITY						Traffic Rank

Source: The authors.
Those used in the WR calculation are shown in bold. [1]not fully implemented; [2]incomplete coverage; [3] temporarily disabled.

To avoid some of these problems, several search engines are used together. The number of independent search engines with large databases is small and not all of them are usable for cybermetric purposes. They are Google (and Google Scholar), Yahoo Search, Live (but not Academic Live), Exalead and Alexa (Aguillo et al., 2006).

Extracting values from search engines can be done with the help of operators, such as site, link or file-type (see Table 2). However not all the engines support the same options nor is the syntax ever the same. Unfortunately, both Google and Live are now not usable for hypertext analysis. On the other hand, Google PageRank and Alexa Traffic Rank can be recovered as relative positions values. An interesting option provided only by Yahoo search is the possibility to identify sub-domains for a certain domain although the results are usually very noisy.

Constructing the Ranking

The web has an important advantage over other systems as it is easier to identify the institutional units even if their names or locations are very similar. Usually each organization has a different web domain that can be used for recovering data from search engines. Unfortunately this is not universally the case, as a few universities have more than one main domain, use aliases or provide independent domains for some of their sub-units or services. In some cases there is no central domain or the central or unique domain refers only to a faculty or department. Some universities have different domains according to the language of the contents and there are examples where a domain is shared by third parties, like some French universities with CNRS (Center National de la Recherche Scientifigue) research centres or the University of Helsinki with the City Hall.

Most domains do not change over long periods, but sometimes institutions merge or split or merely adopt a new domain. These changes have a deep impact on the rankings as the number of external inlinks decreases abruptly.

However the impact of these 'bad practices' in the naming of the web domains is limited to a few institutions that can reverse the situation very easily once they realise the importance of this problem.

There are three key aspects to be measured in the academic web:

TABLE 3. CRITERIA AND WEIGHTS USED (OR NOT) IN THE CALCULATION OF THE WR INDICATOR

Criteria	Indicator	Sources	Weight	
Size	S	Number of pages	Google, Yahoo, Live & Exalead	25%
	R	Number of rich files (PDF, PPT, DOC and PS)	Google	12.5%
	Sc	Number of papers Number of pages in English	Google Scholar	12.5%
Visibility	V	Number of external links	Yahoo, Exalead, (Live)	50%
Luminosity		Number of external outlinks		
Subdomains		Number of subdomains		
Popularity		Number of visits		

Source: The authors.

- *Size*, that is, volume of information published;
- *Visibility*, the number of 'situations' (site citations=external inlinks) the domain receives; and
- *Popularity* as the number of visits or visitors of the web pages.

Bibliometrics have traditionally ignored journal circulation and focused on impact, the ratio between number of citations and number of papers. A similar approach is proposed not only to make comparisons possible but also due to the methodological problems for obtaining trustworthy data of visits and visitors.

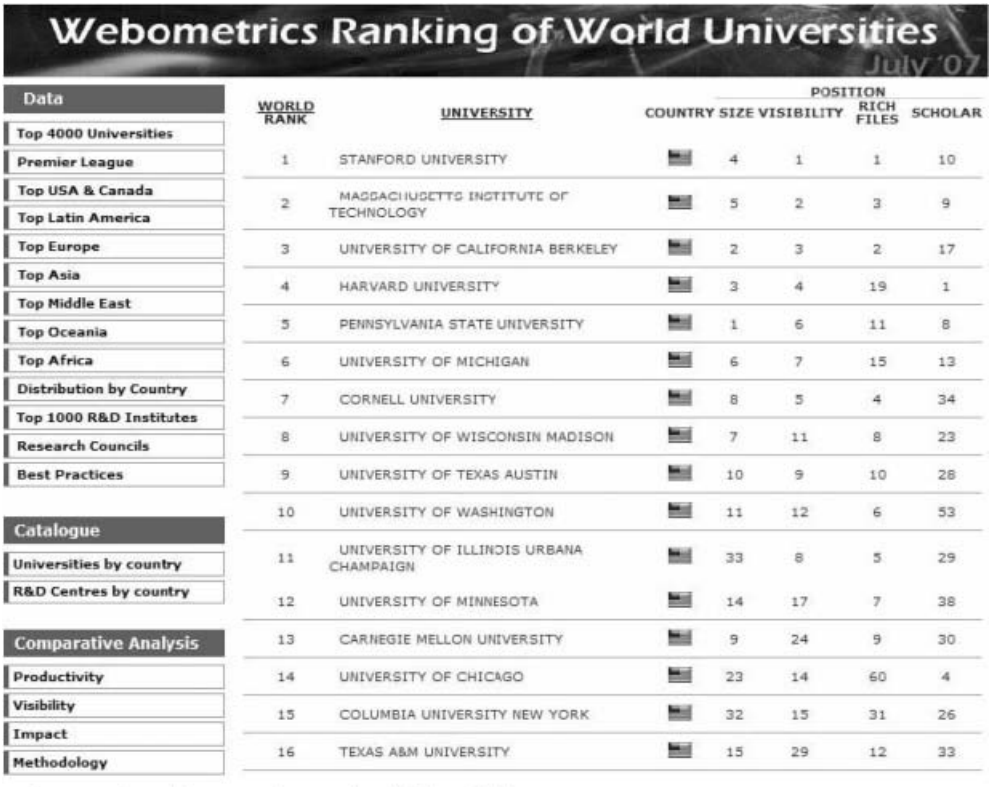
A series of criteria (see Table 3) are monitored, but only size and visibility are included in the final ranking. The model states that the ratio between both is 1:1, but in order to reflect the diversity of the academic contents, the size component is split into

TABLE 4. NUMBER OF UNIVERSITIES DISTRIBUTED BY REGION (WITH LEADING COUNTRIES WITHIN THE REGION) ACCORDING TO THEIR PRESENCE IN THE TOP 100, 200, 500, AND 1,000 INSTITUTIONS OF THE WEBOMETRIC RANKING

	Countries	100	200	500	1000	Total
Africa	47			1	5	514
Asia	45	2	8	33	101	3,474
- Japan		1	3	12	37	579
- China			1	5	20	897
- Taiwan		1	1	7	16	88
Oceania	8	1	6	17	34	98
Australia		1	6	15	28	53
Europe	52	20	65	222	407	3,966
- Germany		4	20	52	70	371
- United Kingdom		4	11	39	67	226
- France				12	41	576
Latin America	33	1	2	9	25	2,796
- Brazil			1	5	13	1,591
North America	6	76	119	218	428	2,195
- USA		68	104	191	389	1,996
- Canada		8	15	27	39	195
	191				13,043	

Source: The authors.

FIGURE 1. SCREENSHOT OF THE WEBPAGE SHOWING THE FIRST INSTITUTIONS IN THE TOP 4,000 UNIVERSITIES RANKING



Webometrics Ranking of World Universities — July '07

Data
- Top 4000 Universities
- Premier League
- Top USA & Canada
- Top Latin America
- Top Europe
- Top Asia
- Top Middle East
- Top Oceania
- Top Africa
- Distribution by Country
- Top 1000 R&D Institutes
- Research Councils
- Best Practices

Catalogue
- Universities by country
- R&D Centres by country

Comparative Analysis
- Productivity
- Visibility
- Impact
- Methodology

WORLD RANK	UNIVERSITY	COUNTRY	POSITION SIZE	VISIBILITY	RICH FILES	SCHOLAR
1	STANFORD UNIVERSITY		4	1	1	10
2	MASSACHUSETTS INSTITUTE OF TECHNOLOGY		5	2	3	9
3	UNIVERSITY OF CALIFORNIA BERKELEY		2	3	2	17
4	HARVARD UNIVERSITY		3	4	19	1
5	PENNSYLVANIA STATE UNIVERSITY		1	6	11	8
6	UNIVERSITY OF MICHIGAN		6	7	15	13
7	CORNELL UNIVERSITY		8	5	4	34
8	UNIVERSITY OF WISCONSIN MADISON		7	11	8	23
9	UNIVERSITY OF TEXAS AUSTIN		10	9	10	28
10	UNIVERSITY OF WASHINGTON		11	12	6	53
11	UNIVERSITY OF ILLINOIS URBANA CHAMPAIGN		33	8	5	29
12	UNIVERSITY OF MINNESOTA		14	17	7	38
13	CARNEGIE MELLON UNIVERSITY		9	24	9	30
14	UNIVERSITY OF CHICAGO		23	14	60	4
15	COLUMBIA UNIVERSITY NEW YORK		32	15	31	26
16	TEXAS A&M UNIVERSITY		15	29	12	33

Source: <http://www.webometrics.info/top4000.asp>

three to measure raw volume of pages, number of rich files, and number of papers collected by Google Scholar. The last two indicators are relevant as we intend to measure commitment to open access publication. According to the proposed model the ranking (WR) is obtained with the following formula:

$$\mathrm{WR} = 2\mathrm{xRank}(\mathrm{S}) + 1\mathrm{xRank}(\mathrm{R}) + 1\mathrm{xRank}(\mathrm{Sc}) + 4\mathrm{xRank}(\mathrm{V})$$

The ratio combining the weights assigned to each element is (2+1+1):4 or 1:1 as intended. Other variants are also acceptable, but empirical tests show they provide results less comparable to other sources.

In order to avoid size-related problems, search engines bias, and other factors, the absolute numbers collected were log-normalised, transformed in ordinals and then combined with the aforementioned formula for (WR) (Zitt and Filliatreau, 2007).

Results

During the July 2007 edition, data from search engines were obtained for 17,958 web domains, including 13,043 higher education institutions (Table 4) and 4,554 R&D-related organizations. The total number of items counted was over 3,430 million,

TABLE 5. NUMBER OF FILES OF THE UNIVERSITIES RANKED IN THE POSITION INDICATED FOR EACH INDICATOR

	No. of files in rank position			
Types	100	200	500	1,000
PDF	38,400	25,500	10,200	3,980
DOC	6,600	4,530	2,480	1,330
PPT	2,460	1,600	699	338
PS	2,520	1,120	214	33
SCHOLAR	6,560	3,890	1,370	438

Source: The authors.

TABLE 6. COMPARISON OF THE NUMBER OF UNIVERSITIES BY COUNTRY ACCORDING TO DIFFERENT RANKINGS

	Institutions in Top 200				
Country/Region	ARWU'07	WR'07	THES'06	ESI Papers	ESI Citations
USA	87	104	56	76	89
Canada	7	15	7	10	9
Other Americas	3	2	1	4	1
Australia	7	6	13	7	6
Japan	9	3	11	11	9
China	1	1	6	6	
Other Asia/Pacific	7	5	21	13	8
United Kingdom	23	11	28	16	19
Germany	14	20	10	19	19
Netherlands	9	8	11	8	9
Switzerland	6	4	7	4	6
Sweden	4	5	4	3	4
France	7		7	4	3
Belgium	4	1	5	3	3
Italy	4	2	1	8	7
Other countries in Europe	8	13	12	8	8

Source: The authors.
ARWU: Academic Ranking of world University, Shanghai Jiao Tong University: THES: Times Higher Education Supplement; ESI: Essential Science Indicators Thomson Reuters.

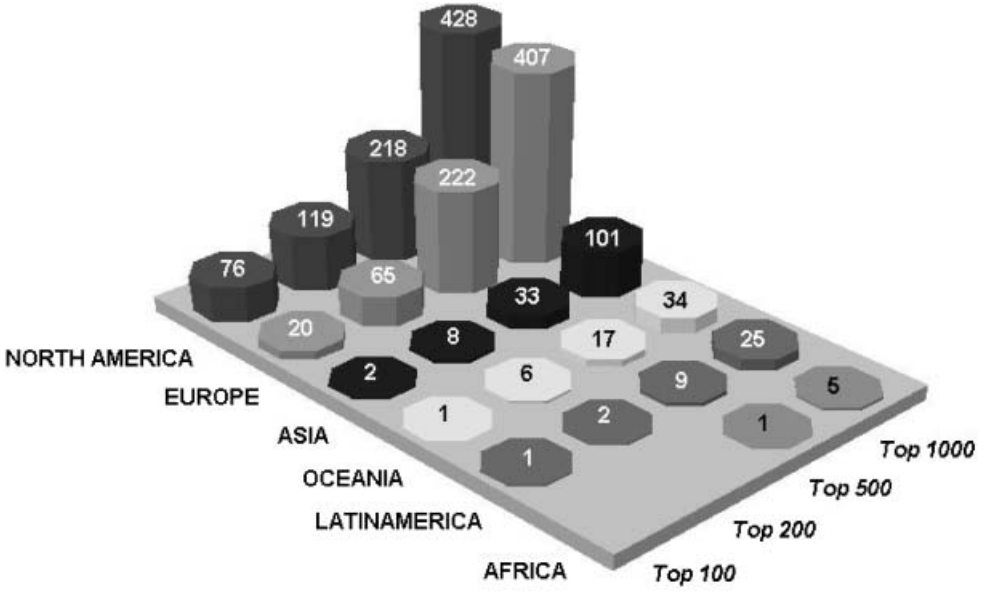
including 10.2 million Google Scholar records and 39 million Google rich files. Institutions with more than one domain were checked, deleting the one with a lower rank if the difference between them was significant.

For the regional lists, no WR recalculation was done so they preserve the position according to their world rank, although minor changes could be expected if national or regional ranks are built in the future, merging both universities and R&D centres databases.

Table 5 shows the absolute values for certain variables obtained by the institutions ranked in the position noted. The numbers provided indicate that open access mandates are needed for achieving good positions as the volume of files provided by the top rankers is already very large.

Excluding the cited institutions with bad practices in web naming or those with large databases, the ranking shows an overall similarity with the competitors. Table 6 compares the country distribution in the Top 200 institutions according to five

FIGURE 2. DISTRIBUTION BY CONTINENTS OF THE TOP UNIVERSITIES ACCORDING TO THE WEBOMETRICS RANKING (JULY 2007)

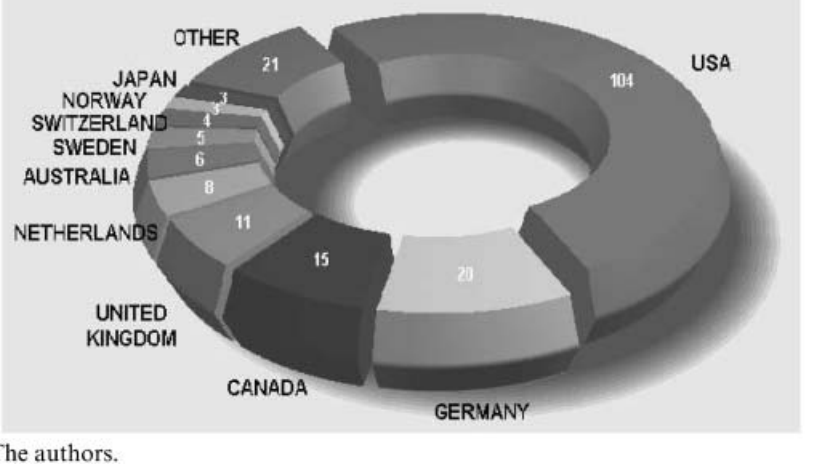


Source: The authors.

different rankings. The bold numbers indicate the most striking differences, some of them with a possible explanation. Preliminary review shows the following patterns:

i. THES ranking builds on the peer review exercise with a large number of contributors showing some biases favouring the UK, Australia, Hong Kong, and Singapore.
ii. Bibliometric rankings provide a slightly different view than ARWU, which undervalues Germany and Italy.

FIGURE 3. DIGITAL DIVIDE AS SHOWN BY THE WEBOMETRICS RANKING OF THE TOP 200 UNIVERSITIES (SITUATION IN 2007)



Source: The authors.

TABLE 7. ORGANIZATION AND COVERAGE OF THE DIFFERENT LISTS AS PRESENTED IN THE WEBOMETRICS RANKING WEBSITE

Name	Range	Size	Rank
Top universities	World	4000	1–4000
Premier league	World	200	1–200
Top USA & Canada	USA & Canada	100	1–155
Top Latin America	Latin America	200	68–3466
Top Europe	Europe	500	21–1279
Top Asia	Asia (excl. ME, tr, il)	100	59–991
Top Middle East	ae, bh, iq, ir, jo, kw, lb, om, ps, qa, sa, sy, ye	100	1128–6596
Top Oceania	Oceania	100	60–12063
Top Africa	Africa	100	380–7756
Top Asia Pacific	Asia, Middle East, Oceania, tr, il	100	59–744
Top Iberoamerica	Iberoamerica (incl. pt, es)	100	68–1492
Top Middle East & North Africa	Middle East & North Africa	100	1128–6226
Top Francophone	Francophone	100	79–1496
Top South East Asia	sg, th, id, my, mm, ph, vn, bn, la, kh, tl	100	158–4504
Top Indian subcontinent	in, pk, lk, bd, np, bt, mv	100	674–7282
Top Central & Eastern Europe	Central & Eastern Europe	100	111–1921
Top Nordic countries	dk, fi, fo, gl, is, no, se	100	44–2561
Top BRIC countries	br, ru, in, cn, hk	100	120–1657
Top by country		..5000	
CSIRO	Australia	30	
CONICET	Argentina	70	
NIH	USA	30	
FRAUNHOFFER	Germany	77	
CNRS	France	734	
CSIC	Spain	119	
CNR	Italy	91	
MAX PLANCK	Germany	91	
Top R&D Centers	World	1000	1–1000
Top European R&D Centers	Europe	100	6–207

Source: The authors. Country codes (ISO 3166).

iii. There is an academic digital divide affecting the WR exceptional performance of North American universities and the below than expected contribution of France, Italy or Japan.

A Wide Digital Divide is Opening Among Developed Countries

One of the most important results obtained from the Webometrics Ranking is the evidence of a larger than expected digital divide between US and EU universities. Compared to other rankings results, the number and positions of the US universities are far bigger and better than their European counterparts, even considering British institutions. This is very interesting, as Cambridge and Oxford Universities, usually leaders of the world tables, are prominent in the European listings but in delayed positions when compared with Harvard, MIT, Stanford or Berkeley.

There are several possibilities to explain this situation, which should be empirically tested. At the moment, only preliminary information is available, but all data suggest a

TABLE 8. INDICATORS USED IN THE THREE PUBLISHED WEB-BASED RANKINGS

	Webometrics Rank	Mike Tung	G-factor
Number of universities	13,000	1,720	300
Size	Google, Yahoo, Live, Exalead	Google	NO
	full domain	only main server	
	Yahoo, Live, Exalead	Google	Google
Visibility	all external inlinks	external from pages with high PR & internal inlinks	inlinks from 300 universities
Scholar	YES +rich files	YES	NO

Source: The authors.

better and deeper use of the web by North American universities, probably linked to advantages due to the use of English as communication tool not only for academic papers but for the whole web. This is supported by the lower positions of Japanese, French or Italian universities, with a lot of pages in local languages or the top positions of many Nordic institutions, which usually publish their websites in English.

Structure and Contents

Our website[1] offers three different main Rankings, sub-divided in some cases into regional or sub-regional Rankings:

The complete list of universities and research centres are available from two catalogues, organized geographically. Our mailbox periodically receives comments and suggestions for adding new centers, or information about merging of centres and requests for deleting old entries.

The regionalization was introduced to grant flexibility when comparisons were to be made. At least in Africa, South East Asia, and Middle East, this has been successful in promoting discussion about the positions of local institutions.

The ranking is updated every six months with fresh data collected during a period of fifteen days in January and July. Previous data is not taken into account for each new version, although three-in-a-row comparative data are provided for the Top 200 (Premier League).

Other Web Ranking Proposals

There at least two other ranking proposals based on web data:

The G-factor (University Metrics) has been proposed by Peter Hirst.[2] The data is obtained from links between universities from requests to Google, although only a group of 300 among the best-known universities are used.

The other proposal is the Ranking Colleges using Google and OSS by Mike Tung[3] that provides a different list of web variables obtained from the Google search engine that are

[1] Available at <http://www.Webometrics.info>
[2] Available at <http://www.universitymetrics.com>
[3] Available at <http://vcmike.blogspot.com/2006/01/ranking-colleges-using-google-and-oss.html>

used to build the rankings. Most of the proposed indicators can be obtained with webometric methods, but without a model, the weight assignation is very tentative.

Agenda and Future Developments

There are specific challenges in the ranking of universities by means of web indicators. Methodological problems related to the naming of the pages, the frequent changes of domains or the use of robot-barrier designs is not only a problem for the ranking researcher but also affects the visibility (findability) of the institution's web presence. If there is a strong correlation between an adequate web presence and quality of the institution, the contrary is not true and there are prestigious universities underperforming in the webometrics arena due to erroneous decisions, incomplete mandates or insufficient motivations regarding their web policy. The Webometrics Ranking is already showing these flaws and many institutions are facing the problem, although there are still a surprisingly high number of organizations not even considering the web at all.

To pinpoint the best universities in the world using only web data is currently a secondary aim. Even when all the institutions worldwide adopt a strong web policy, these indicators should be considering jointly with others in order to adequately describe a complex organization like a university. Currently, the main objective of Webometrics Ranking is to promote electronic publication *sensu lato* and the proposed procedure is to motivate the academic community in a similar way as impact factor and related bibliometric measures affected the evaluation processes of scientists and institutions and the publication behaviour of researchers.

There are economic advantages in the current generation of open access initiatives, but a more ambitious proposal is already possible. Web publication not only allows for a more detailed (lengthy) description of the research methods and results, but is open to other information related to the teaching activities, the transfer of results or contacts with industry or the community, among others. When it is said that the web reaches larger audiences, this includes not only colleagues both in developed and developing countries but a lot of other actors, potentially all the internet users worldwide. Another important extra outcome could be the extension of the peer-review processes in a wider and more open environment.

More methodological issues are also on the agenda. Ranking complex institutions as universities is a difficult task, but the webometrics method could be easily applied to lower-level units like departments or research groups that are more comparable. This is a different issue and does not mean that university ranking will be superseded but supplemented with new data.

We are considering offering some national or regional reports combining both universities and research institutions re-ranking the whole set together.

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