Comparing University Rankings

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Abstract

Recently there is increasing interest in university rankings. Annual rankings of world universities are published by QS for the Times Higher Education Supplement, the Shanghai Jiao Tong University, the Higher Education and Accreditation Council of Taiwan and rankings based on Web visibility by the Cybermetrics Lab at CSIC. In this paper we compare the rankings using a set of similarity measures. For the rankings that are being published for a number of years we also examine longitudinal patterns. The rankings limited to European universities are compared to the ranking of the Centre for Science and Technology Studies at Leiden University. The findings show that there are reasonable similarities between the rankings, even though each applies a different methodology. The biggest differences are between the rankings provided by the QS-Times Higher Education Supplement and the Ranking Web of the CSIC Cybermetrics Lab. The highest similarities were observed between the Taiwanese and the Leiden rankings from European universities. Overall the similarities are increased when the comparison is limited to the European universities.

Introduction

There is increasing interest worldwide in university rankings, as can be witnessed by the growing number of annual rankings being published and by the number of conferences/workshops being held on the topic (http://www.ireg-observatory.org/). The success of these rankings is due to globalization of the higher education in which a university may internationally compete for economic and human resources. Higher education institutions are using these rankings as a promotion tool that shows their educational, research or business excellence. These advertising activities are addressed to achieve educational funding and qualitative scholars which allow improving the university's position in the educational market (Dill & Soo, 2005; Eccles, 2002). From a scientific point of view, universities need these rankings in order to increase their research performance by taking part in international research projects and attracting doctoral students and researches.

The different rankings take into account different parameters including publication and citation counts, student/faculty ratio, and percentage of international students, Nobel and other prizes, number of highly cited researchers and papers, articles published in Science and Nature, the h-index and web visibility. van Raan (2005) discussed the conceptual and methodological problems when ranking universities by bibliometric methods. Problems and methodologies were also discussed by Liu and Cheng (2005). There is an ongoing debate related to these issues. As an example, Webster (2001) analyzed an earlier ranking published by the US News and World Report, and showed that the actual weights assigned to the different criteria are not as published, because of the interdependence of the ranking parameters.

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As a result of ongoing methodological discussions and taking into account that important ranking editors are private companies, in 2006, the Berlin Principles on Ranking of Higher Education Institutions were published (CEPES, 2006). Liu and Cheng (2008) examine the application of these principles for some of the rankings.
In this study we consider the following rankings

- ARWU – the rankings of the Shanghai Jiao Tong University for the years 2005-2008 (http://www.arwu.org/)
- QS-THES – the rankings of the Times Higher Education Supplement for the years 2005-2008 (http://www.topuniversities.com/home/)
- WR – Web Ranking of World Universities by the Cybermetrics Lab at CSIC for the years 2006-2008 (http://www.webometrics.info/)
- HEEACT – the rankings of the Higher Education and Accreditation Council of Taiwan for the years 2007-2008 (http://ranking.heeact.edu.tw)

For ranking European universities, we also consider

- CWTS – the ranking of the Centre for Science and Technology Studies at Leiden University. We use their orange ("brute force") ranking (http://www.cwts.nl/ranking/LeidenRankingWebSite.html)

The university rankings methods

The Academic Ranking of World Universities (ARWU) is published annually by the Institute of Higher Education, Shanghai Jiao Tong University, since 2003 (www.arwu.org). It is the first ranking with an intended worldwide coverage that focuses in the academic or research performance of universities. The indicators include the alumni and staff winning Nobel or similar prestigious prizes, highly cited researchers in major research fields, articles published in selected top journals, articles indexed by the citation indexes produced by Thomson-ISI and performance per capita.
The QS-THES World University Rankings (THES) is the only ranking produced by a private company, Quacquarelli Symonds Limited that started to publish the rankings in 2005. The ranking (www.topuniversities.com) is compiled based in six distinct indicators: academic prestige according to a large survey, results from an employer survey, the student faculty ratio, citations per capita according to the Elsevier Scopus database, and the proportions of international professors and international students. Before 2007, they derived the citation counts from the ISI Citation indexes.
The Ranking Web of World Universities or Webometrics Ranking (WR) is done since 2004 (Aguillo et al., 2006; 2008) by the Cybermetrics Lab, a research group of the Spanish National Research Council (CSIC). They use web data extracted from commercial search engines, including the number of webpages, documents in rich formats (pdf, doc, ppt & ps), papers indexed by Google Scholar (since 2006) and the number of external inlinks as a measure of link visibility or impact (www.webometrics.info).
The Performance Ranking of Scientific Papers for World Universities is edited by the Higher Education Evaluation & Accreditation Council of Taiwan (HEEACT) since 2007. It is based on the number of publications and citations according to the Thomson ISI citation databases, giving special attention to the recent publications (ranking.heeact.edu.tw).
The Leiden Ranking is the result of the bibliometric research done at Centre for Science and Technology Studies (CWTS), Leiden University. First published in 2007 currently only covers European University (www.cwts.nl/ranking/LeidenRankingWebsite.html), classified according the number of publications and a normalized citation ratio (a size-independent, field-normalized average impact). In the 2007 version only 100 European universities were ranked, but the lists published in 2008 are of length 250. They provide several rankings, here

we consider their orange ("brute force") ranking based on publication counts multiplied by their field normalized impact (van Raan, 1996).
The specifics of the different rankings displayed in Table 1 and Table 2 summarizes the emphases of the different rankings, it also includes the (national) rankings published by the magazines US News and World Report (USA) and McLean's (Canada). ARWU, HEEACT and CWTS are strongly based on research data, while QS-THES depends of the goodness and representativeness of a survey. The main weakness of Webometric ranking is that many universities do have not a strict web naming policy, frequently change web domains, use duplicate URLs and faculties or hospitals affiliated with the university are hosted by a different domain.

Table 1: Methods for ranking universities

CRITERIA	ARWU		THES		WR		HEEACT		CWTS	
Univ's Analyzed	3000		2000		16000		3500		600+	
Univ's Ranked	500		500+		5000+		500		250 (Europe)	
Quality of education	Alumni Nobel&Field	10%	Students/staff ratio	20%						
Internazionalization			Int'l students	5%						
			Int'l staff	5%						
Size	Size of Institution	10%			Web Size	20%				
Research Output	Nature&Science	20%			Rich Files	15%	Research Productivity	20%	Research Productivity	
	SCI&SSCI	20%			Google Scholar	15%				
Impact	Higly Cited Res'ers	20%	Citations (Scopus)	20%	(Link) Visibility	50%	Research Impact	30%	Normalized Citations	
Prestige	Staff Nobel&Field	20%	Academic Reputation	40%			Prestige	50%		
			Reputation Employers	10%						

Table 2: Different emphases of the rankings

<---------- Students oriented----------Research oriented ---------->					
US News & WR McLeans	**THES**	**Webometrics WR**	**Shanghai ARWU**	**Taiwan HEEACT**	**Leiden CWTS**
Costs	Scientific output				
Opinions		Web Visibility	Impact Prizes	Impact	
Services	Prestige	Web presence	Excellence		

Comparing rankings

The above-mentioned rankings are compared using three measures, where the measures complement each other. The measures were developed by Bar-Ilan, Levene and Lin (2007). The measures are the size of the overlap, the Spearman's footrule, and the M-measure.
The simplest of the three measures is the size of the overlap (OC). It ignores the rankings and counts the number of items that appear in both lists. One of the problems when comparing two ranked lists that the items ranked in the two lists are not identical, i.e., items that appear in list *A* do not necessarily appear in list *B* as well. When, for example, we compare the top-

ten items in two ranked lists, an item ranked at position 2 in list *A* might not be in list *B* at all or it may appear after position 10. In both cases it is not considered to be an overlapping element when comparing the rankings of the top-ten positions only.
The footrule (*F*) is a well-known measure for comparing two ranked lists where the set of items in both lists are identical. Thus this measure can be applied to the set of overlapping items only. The relative rank is assigned to each item in both lists. Thus, for example if originally both lists contained 10 elements, but only three of them, *a*, *b* and *c* appeared in both lists, and in list *A* these elements were ranked 7, 2 and 8, in the list used for computing the footrule, *a* will be ranked second, *b* first and *c* third.
The result of the re-rankings is two permutations σ_1 and σ_2 on 1…*Z* where |*Z*| is the number of overlapping publications. After these transformations Spearman's footrule (Diaconis & Graham, 1977; Dwork et al., 2001) is computed as

$$Fr^{|Z|}(\sigma_1,\sigma_2) = \sum_{i=1}^{|Z|} |\,(\sigma_1(i) - \sigma_2(i))\,|$$

When the two rankings are identical on the set *Z*, $Fr^{|Z|}$ is zero, and its maximum value is ½$|Z|^2$ when |*Z*| is even, and ½(|*Z*|+1)(|*Z*|-1) when |*Z*| is odd. When the result is divided by its maximum value, $Fr^{|Z|}$ will be between 0 and 1, independent of the size of the overlap. This measure is undefined for |*Z*|=0,1. Thus we compute the *normalized Spearman's footrule, NFr*, for |*Z*|>1

$$NFr = \frac{Fr^{(|Z|)}}{\max Fr^{(|Z|)}}$$

NFr ranges between 0 and 1; it attains the value 0 when the relative ranking of the publications in the set *Z* is identical. Since we are interested in similarity measures, we define *F* as

$$F = 1 - NFr$$

The weakness of this measure is that it totally ignores the non-overlapping elements and only takes into account the relative rankings, thus for example if |*Z*|=2, and these two items are ranked at ranks 1 and 2 in list *A*, while in list *B* they are ranked at 9 and 10 (and the first eight items are not ranked in list A), the value of *F* will be 1, just like the case where both *A* and *B* rank these two publications at ranks 1 and 2 respectively.

To overcome the problem that non-overlapping elements are totally ignored, Fagin, Kumar and Sivakumar (2003) introduced a new measure. The idea is to extend the footrule, by assigning a rank to the non-overlapping elements as well. If we are comparing two rankings of size ℓ then each element that appears in list *A* but does not appear in list be (either totally missing from *B* or ranked at position > ℓ), then the element is assigned rank ℓ +1. The Fagin-measure was shown to give excessive weight to non-overlapping element. In order to correct his problem, Bar-Ilan et al. (2007) introduced their *M* measure:

Let

$$N^{(k)}(\sigma_1\sigma_2) = \sum_{i\in Z} |\,\frac{1}{\sigma_1(i)} - \frac{1}{\sigma_2(i)}\,| + \sum_{i\in S} |\,\frac{1}{\sigma_1(i)} - \frac{1}{(k+1)}\,| + \sum_{i\in T} |\,\frac{1}{\sigma_2(i)} - \frac{1}{(k+1)}\,|$$

where *k* is the length of the ranked lists, *Z* is the set of overlapping elements, *S* is the set of non-overlapping elements in list *A* and *T* is the set of non-overlapping elements in list *B*.

This measure has to be normalized as well, thus

$$M^{(k)} = 1 - \frac{N^{(k)}}{\max N^{(k)}}$$

where

$$\max N^{(k)} = 2\sum_{i=1}^{k_1}(\frac{1}{i} - \frac{1}{k+1})$$

There are several cases where there are ties in the university rankings. In this study each tied item was assigned the mid-position, i.e., if there were two items ranked 78, each was assigned rank 78.5 and if there were three items at rank 2, each of them was assigned rank 3 for the computations.

The *M* measure is a normalized similarity measure; the strength of the similarity can be interpreted similarly to the strength of the correlation measures (Black, 1974). Thus we consider values below 0.2 to be negligible, values between 0.2 and 0.4 low, values between 0.4 and 0.7 medium, between 0.7 and 0.9 as high and above 0.9 as very high.

Results

Comparing the 2008 rankings for world universities

As can be seen from Table 3, for most pairs the similarity measure *M* is of medium strength. The values become higher as we consider longer lists. Most similar are Shanghai and Taiwan rankings, for lists of length 200 or more, the similarities between these two lists are considered to be high. When considering the top-500 universities these two rankings overlap on 444 items and the agreement on the ranking of the overlapping elements is also high – the F value is 0.75.

The two least similar rankings are the QS-THES ranking and the Webometrics ranking. Note the very small overlap between QS-THES and WR and QS-THES and HEEACT. Only two universities are common to the QS-THES and WR top-ten lists (Harvard, ranked 1st and second respectively, and MIT ranked 9th and 1st respectively) and to the QS-THES and HEEACT top-ten lists (Harvard and MIT – Harvard ranked no.1 on both lists, MIT ranked 9th and 8th respectively).

Longitudinal patterns

For the two rankings, ARWU and QS-THES there are four published rankings from four consecutive years. For these rankings, we also computed the similarity measures between the rankings published in the different years. The similarity values indicate the internal consistency of the different rankings. In Tables 4 and 5 we provide the similarity values when considering the top-100 lists.

Table 3: Similarity measure for 2008 world university rankings

		ARWU2008			THES2008			WR2008			HEEACT2008		
Top-ten		**OC**	**F**	**M**	**OC**	**F**	**M**	**OC**	**F**	**M**	**OC**	**F**	**M**
	ARWU2008				7	0.58	0.60	4	0.25	0.46	4	1	0.62
	THES2008	7	0.58	0.60				2	0	0.21	2	1	0.46
	WR2008	4	0.25	0.46	2	0	0.21				5	0.33	0.40
	HEEACT2008	4	1	0.62	2	1	0.46	5	0.33	0.40			
Top-100													
	ARWU2008				67	0.60	0.62	63	0.52	0.52	77	0.69	0.68
	THES2008	67	0.60	0.62				53	0.39	0.31	62	0.53	0.51
	WR2008	63	0.52	0.52	53	0.39	0.31				59	0.53	0.48
	HEEACT2008	77	0.69	0.68	62	0.53	0.51	59	0.53	0.48			
Top-200													
	ARWU2008				140	0.55	0.63	129	0.57	0.53	172	0.68	0.70
	THES2008	140	0.55	0.63				123	0.40	0.35	138	0.53	0.53
	WR2008	129	0.57	0.53	123	0.40	0.35				130	0.56	0.50
	HEEACT2008	172	0.68	0.70	138	0.53	0.53	130	0.56	0.50			
Top-400													
	ARWU2008				304	0.56	0.65	296	0.58	0.56	351	0.73	0.72
	THES2008	304	0.56	0.65				266	0.42	0.38	299	0.51	0.55
	WR2008	296	0.58	0.56	266	0.42	0.38				286	0.54	0.53
	HEEACT2008	351	0.73	0.72	299	0.51	0.55	286	0.54	0.53			
Top-500													
	ARWU2008				372	0.23	0.65	361	0.59	0.57	444	0.75	0.73
	THES2008	372	0.23	0.65				335	0.19	0.40	367	0.24	0.56
	WR2008	361	0.59	0.57	335	0.19	0.40				362	0.55	0.54
	HEEACT2008	444	0.75	0.73	367	0.24	0.56	362	0.55	0.54			

Table 4: Similarity values for the different years in which the ARWU ranking was published

top-100	**ARWU2005**			**ARWU2006**			**ARWU2007**			**ARWU2008**		
	OC	**F**	**M**	**OC**	**F**	**M**	**OC**	**F**	**M**	**OC**	**F**	**M**
ARWU2005				97	0.94	0.99	96	0.93	0.93	95	0.91	0.92
ARWU2006	97	0.94	0.99				99	0.95	0.93	96	0.92	0.92
ARWU2007	96	0.93	0.93	99	0.95	0.93				97	0.95	0.99
ARWU2008	95	0.91	0.92	96	0.92	0.92	97	0.95	0.99			

The similarities between the ARWU rankings for the different years are very high. On the other hand the similarities between the different QS-THES rankings are much lower. The low similarities may have been caused to some extent by the switch from ISI to Scopus data for citations. We see that for the last two years, when Scopus data were used, all three similarity measures are higher than in previous years. Still compared to the values in Table 4, we see less internal consistency in the QS-THES rankings versus the ARWU rankings. An additional explanation could be the representativeness of the survey population that changes from year to year. Probably there is strong correlation between the number of a certain country universities and the number of this country scholars that contribute to the survey.

Table 5 Similarity values for the different years in which the QS-THES ranking was published

top-100	THES2005			THES2006			THES2007			THES2008		
	OC	F	M	OC	F	M	OC	F	M	OC	F	M
THES2005				82	0.75	0.83	74	0.64	0.73	73	0.64	0.71
THES2006	82	0.75	0.83				80	0.70	0.81	79	0.69	0.78
THES2007	74	0.64	0.73	80	0.70	0.81				90	0.79	0.89
THES2008	73	0.64	0.71	79	0.69	0.78	90	0.79	0.89			

Top-ten universities

To illustrate the difference between the different rankings and years, all universities that were ranked among the top-ten universities for any of the rankings and any of the years are presented in alphabetical order in Table 6. There are 27 universities in Table 7, showing the diversity of the rankings.

Rankings limited to the European universities

Next we limit the discussion to European universities only. This allows us to include the CWTS rankings as well in our comparisons. Here we provide the similarity values for the rankings published in 2008. The similarity measures were computed for top-ten, top-100 and top-200 and they appear in Table 7. When limiting the datasets to European universities, the non-European universities were excluded and the remaining lists were re-ranked to provide a continuous ranking of the European universities. Turkish universities were excluded form the Leiden ranking.

Comparing the results presented in Table 3 with the results in Table 7, it is easy to see that the similarity measures when the datasets are limited to European universities are much higher than for world universities. The two most similar rankings in this case are the CWTS ranking and the Taiwanese ranking. This could be expected, because these are the two rankings that put the most emphasis on citation and publication counts. The CWTS is based only on these two, while the HEEACT in addition to publication and citation counts takes into account the h-index, the number of highly-cited papers and the number of articles published in high-impact journals. The additional parameters used by HEEACT are also indirectly based on publication and citation counts. The other rankings consider additional aspects related to university reputation as well.

Table 6: Top-ten world universities

INSTITUTION	ARWU2005	ARWU2006	ARWU2007	ARWU2008	THES2005	THES2006	THES2007	THES2008	WR2006	WR2007	WR2008	HEEACT2007	HEEACT2008
California Institute of Technology	6	6	6	6	8	7	7-8	5	35	42	40	32	31
Carnegie Mellon University	54	56	60	63	44	35	20-21	21	10	13	14	177	170
Columbia University New York	7	7	7	7	20	12	11	10	16	15	15	9	13
Cornell University	12	12	12	12	14	15	20-21	15	7	7	7	18	18
Ecole Polytechnique France	252	249	252	283-284	10	37	28	34-35	469	384	313	311	265
Harvard University	1	1	1	1	1	1	1	1	2	4	2	1	1
Imperial College	23	23	23	27	13	9	5	6	137	649	215	28	27
Johns Hopkins University	19	20	19	20	27	23	15	13-14	61	72-73	39	2	2
Massachusetts Institute of Technology	5	5	5	5	2	4-5	10	9	3	2	1	10	8
Pennsylvania State University	39	42	43	42	64	99-100	90-91	105	13	5	5	31	29
Princeton University	8	8-9	8	8	9	10	6	12	39	38	25	48	42
Stanford University	3	3	2	2	5	6	19	17	4	1	3	4	3
University College London	26	26	25	22	28	25	9	7	67	55	64	24	20
University of California Berkeley	4	4	3	3	6	8	22	36	1	3	4	7	6
University of California Los Angeles	14	14	13	13	37	31	41	30-31	17	20	17	5	5
University of California San Diego	13	13	14	14	42	44	58	58	26	39	34	8	10
University of California San Francisco	18	18	18	18	18				136	144-145	142	15	9
University of Cambridge	2	2	4	4	3	2	2-5	3	19	21	26	17	16
University of Chicago	9	8-9	9	9	17	11	7-8	8	12	14	19	26	24
University of Illinois Urbana Champaign	25	25	26	26	59	77	73	71	5	11	11	41	44
University of Michigan	21	21	21	21	36	29-30	38-39	18	6	6	6	6	7
University of Minnesota	32	32	33	28	150-154	188	142-143	87	15	12	8	22	23
University of Oxford	10	10	10	10	4	3	2-5	4	22	40	47	19	19
University of Texas Austin	36	39	38	39	26	32	51-52	70	9	9	10	66	71-72
University of Washington	17	17	16	16	88-92	84	55-56	59	11	10	13	3	4
University of Wisconsin Madison	16	16	17	17	73-75	79-80	55-56	55	8	8	9	20	21
Yale University	11	11	11	11	7	4-5	2-5	2	37-38	37-38	44	14	15

Table 7: Similarity measures for rankings of European universities

	CWTS			ARWU			THES			WR			HEEACT		
Top-ten	**OC**	**F**	**M**	**OC**	**F**	**M**	**OC**	**F**	**M**	**OC**	**F**	**M**	**OC**	**F**	**M**
CWTS				7	0.75	0.86	5	0.83	0.83	6	0.33	0.63	8	0.81	0.91
ARWU	7	0.75	0.86				6	0.78	0.82	5	0.67	0.66	7	0.67	0.85
THES	5	0.83	0.83	6	0.78	0.82				5	0.50	0.61	6	0.78	0.83
WR	6	0.33	0.63	5	0.67	0.66	5	0.50	0.61				6	0.44	0.62
HEEACT	8	0.81	0.91	7	0.67	0.85	6	0.78	0.83	6	0.44	0.62			
Top-100															
CWTS				83	0.67	0.81	69	0.61	0.74	66	0.48	0.56	90	0.80	0.90
ARWU	83	0.67	0.81				74	0.51	0.73	63	0.42	0.55	83	0.64	0.80
THES	69	0.61	0.74	74	0.51	0.73				60	0.44	0.54	68	0.58	0.72
WR	66	0.48	0.56	63	0.42	0.55	60	0.44	0.54				62	0.49	0.54
HEEACT	90	0.80	0.90	83	0.64	0.80	68	0.58	0.72	62	0.49	0.54			
Top-200															
CWTS				174	0.73	0.82	164	0.34	0.74	150	0.52	0.58	186	0.82	0.90
ARWU	174	0.73	0.82				171	0.36	0.74	149	0.51	0.57	174	0.73	0.81
THES	164	0.34	0.74	171	0.36	0.74				152	0.25	0.55	164	0.36	0.72
WR	150	0.52	0.58	149	0.51	0.57	152	0.25	0.55				145	0.47	0.56
HEEACT	186	0.82	0.90	174	0.73	0.81	164	0.36	0.72	145	0.47	0.56			

Top-ten European universities

In spite of the higher similarity measures for the European universities, the list of top-ten universities (i.e. universities that ranked among the first ten positions in any of the rankings) still contains 21 entries as can be seen in Table 8. When the lists are limited to the European universities only, there is total agreement between all the rankings for the top position: the best European university is Cambridge.

Table 8: Top-ten European universities

NAME	CWTS	ARWU	THES	WR	HEEACT
Catholic University of Leuven	6	54	24	59	11
Ecole Normale Superieure Paris		22	8	79	114
Imperial College	4	5	3	68	4
Karolinska Institute	9	11	10.5	189	5
King's College London	20	25	5	162	21
Ludwig Maximilians Universität München	13	14	36	56	6
Royal Institute of Technology Sweden	96	106	71	9	131
Swiss Federal Institute of Technology Zurich	8	4	7	2	9.5
Universität Wien	34	72	41	10	63
Université Paris 6 Pierre and Marie Curie	11	7	58		12
Université Paris XI Sud	25	10	113		27
University College London	3	3	4	6	3
University of Bristol	23	16	10.5	67	30
University of Cambridge	1	1	1	1	1
University of Copenhagen	10	8	13	32	22
University of Edinburgh	17	13	6	8	17
University of Helsinki	7	19	35	3	7
University of Manchester	12	6	9	124	9.5
University of Oslo	41	17	72.5	5	52
University of Oxford	2	2	2	4	2
Utrecht University	5	9	21	7	8

Conclusions

In this paper, we compared different world university rankings using a set of similarity measures. Taking into account that some of them are strongly based on bibliometric data (ARWU, HEEACT) and so measuring mainly research performance while others (QS-THES, Webometrics) consider also other aspects it is not surprising that the high similarities are between the citation based measures. The QS-THES is based on a not large and not representative enough survey that means the results are biased towards certain countries (over-representation of UK or Australian universities). The Webometrics ranking is the least similar, probably because of bad practices in the web naming of universities (two or more domains, URL changes, mergers) and other activities than research are measured by their set of parameters.

Overall, the size is an important factor in all the rankings, so from a policy point of view the emphasis by some governments to be ranked in top positions means the efforts should be addressed to enlarge institutions by merging, incorporating new disciplines (specially biomedicine and university hospitals), creating research institutes and reinforcing distance learning.

In the future we plan to study similarities between the rankings limited to additional subsets, e.g. Northern America, Asia and to specific countries with large number of universities.

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