International Rankings: A Tool for Comparing Universities Through the Construction of Weighted Indicators

Paola Perchinunno[1(✉)] and Vito Ricci[2]

[1] DEMDI, University of Bari, Via C. Rosalba 53, 70100 Bari, Italy
paola.perchinunno@uniba.it
[2] University Statistics Staff of the General Management, University of Bari, Piazza Umberto I, 70121 Bari, Italy
vito.ricci@uniba.it

Abstract. International rankings are an important communication tool that allows the comparison of Universities according to combinations of different parameters, appropriately weighted. The causes of the widespread diffusion of this information tool are to be found in the process of internationalization of the university system and in the massive increase in the demand and supply of diversified university education. The purpose of the rankings is to allow external subjects to have synthetic and comparable information, for immediate reading, on a university institution. However, often the information rate of the ranking is not combined with a careful examination of the performance indicators that distinguish it and its weighting. The aim of this study is to deepen the methodological aspects of the main global rankings, highlighting the strengths and weaknesses of these tools, while comparing statistical positions to those of the universities that occupy the top place in the rankings.

Keywords: International ranking · Evaluation · Performance · Weighting · Indicators

1 Introduction

In the process of globalization of universities, international rankings have an increasing impact on higher education institutions [1]. International rankings proof to be an important communication tool allowing the comparison of the universities according to combinations of suitably weighted parameters.

The causes of the widespread diffusion of this information tool are to be found in the conspicuous increase in demand and offer of university training in a highly competitive international scenario. The purpose of the rankings is to allow external subjects to have synthetic and comparable information, for immediate reading, on a university institution.

The contribution is the result of joint reflections by the authors, with the following contributions attributed to V. Ricci (chapters 1 and 2), to P. Perchinunno (chapters 3 and 4).

© Springer Nature Switzerland AG 2019
S. Misra et al. (Eds.): ICCSA 2019, LNCS 11622, pp. 145–155, 2019.
https://doi.org/10.1007/978-3-030-24305-0_12

In recent years, the activities related to the international rankings of universities have assumed a growing strategic value due to their undoubted impact both towards foreign students, government agencies, evaluation and communication. In addition, they are used by universities to select partners with whom to conclude cooperation agreements and by some national agencies to give funding or grants to students and/or teachers [2–9].

The criteria and parameters used for the construction of the ranking mainly concern the institutional dimension (number of teachers, staff and students, both national and international), scientific research (number of publications, citations), the reputational survey (Academic reputation and Employer reputation), the economic-financial aspects (income, funds) and the performance of the universities.

The aim of this study is to deepen the methodological aspects of the rankings, highlighting the strengths and weaknesses of these tools. In addition, we will focus on some of the international rankings, synthetically analyzing the indicators considered and the relationship between the positions of some universities using similarity indexes.

2 Main International Ranking

2.1 Introduction

The rankings, according to the type of information analyzed, can be classified into:

1. Global rankings: Times Higher Education World University Rankings (THE), QS World University Rankings, Center for World Rankings (CWUR), Round University Ranking (RUR), Academic Ranking of World Universities (ARWU) and U-Multirank;
2. Search rankings: CWTS Leiden Ranking, Scimago Institution Rankings, Performance Ranking of Scientific Papers for World Universities (Taiwan ranking), University ranking by academic performance (URAP) and Best Global Universities Rankings.

We will focus only on the main global rankings, which consider indicators related to aspects of teaching and research, trying to compare their strengths and their criticalities with respect to the methodologies used and the combinations of appropriately weighted parameters.

2.2 Times Higher Education World University Rankings (THE)

Times Higher Education's mission is to help create the conditions and culture that universities need to succeed, by providing data and insights from the world's top universities. The data for the World University Ranking are: Performance data Universities, Reputation data Academics and Bibliometric data Elsevier. The Times Higher Education World University Rankings 2018 list the top 1,000 universities in the world, making it our biggest international league table to date.

Times Higher Education Ranking uses 13 carefully calibrated performance indicators, provide the most comprehensive and balanced comparisons, and are grouped

into 5 areas (Table 1): teaching (the learning environment); research (volume, income and reputation); citations (research influence); international outlook (staff, students and research); and industry income (knowledge transfer). For all indicators except for the Academic Reputation Survey, it is the cumulative probability function using a version of Z-scoring.

Also important is the ranking based on the eleven subjects that diversify the placements on the basis of the different thematic areas of interest in which the universities operate: Arts and Humanities, Social Sciences, Business and Economics, Life Sciences, Physical Sciences, Engineering and Technology, Computer Science, Social Sciences, Law, Education, Psychology, Clinical, Pre-clinical and Health.

Table 1. Performance indicators and weight of times higher education World University Rankings

Areas	Weight	Indicators	Weight
Teaching	30%	Reputation survey	15%
		Staff-to-student ratio	4.5%
		Doctorate-to-bachelor's ration	2.25%
		Doctorates-awarded-to-academic-staff ratio	6%
		Institutional income	2.25%
Research	30%	Reputation survey	18%
		Research income	6%
		Research productivity	6%
Citations	30%	Field Weighted Citations	30%
Industry income	2.5%	Industry research income to academic staff	2.5%
International outlook	7.5%	Proportion of international students	2.5%
		Proportion of international staff	2.5%
		International collaboration	2.5%

Source: elaborations by the authors.

This ranking appears to be balanced both in the choice of indicators and in the weighting system, guaranteeing an overall assessment based on a fairly complete profile of the single universities. However, there is a greater focus on research aspects that, overall (Research and Citations), account for 60% of the total assessment.

2.3 Qs World University Ranking

QS World University Ranking is based mainly on 6 main metrics: Academic Reputation, Employer Reputation, Faculty/Student Ratio, Citations per Faculty, International Faculty Ratio and International Student Ratio. All the indicators are normalized (z-score) so as to vary between 1 and 100; then they are aggregated with weighted average using the ones shown in the following table to obtain the overall score on the basis of which the ranking is achieved (Table 2).

This ranking is strongly influenced by the presence of indicators with very high weights compared to the others. In particular, Academic Reputation and Employer

Table 2. Performance indicators and weight of Qs World University Ranking

Indicators	Weight	Description
Academic reputation	40%	Opinions of over 80,000 experts regarding teaching and research quality at the world's universities based on Academic Survey
Employer reputation	10%	Opinions of over 40,000 employers that indicate those institutions from which they source the most competent, innovative, effective graduates based on QS Employer Survey
Faculty/student ratio	20%	Teacher/student ratios
Citations per faculty	20'%	Total number of citations received in all papers produced by an institution across a five-year period for the number of faculty members at that institution (Elsevier's Scopus database).
International faculty ratio	5%	Percentage of foreign teachers in the total number of teachers
International student ratio	5%	Percentage of foreigners enrolled in the total number of students

Source: elaborations by the authors.

reputation have a significant influence (50%) on the final result, as they assume a significantly higher weight compared to other metrics and are strongly characterized by subjective evaluations of the interviewees rather than by indicators of objective quality.

2.4 Center for World University Rankings (CWUR)

The rankings of CWUR measure the quality of education and training of students as well as the prestige of the faculty and the quality of their research, based on verifiable data and robust indicators. CWUR uses seven indicators to rank the world's top 1000 universities: Quality of Education, Alumni Employment, Quality of Faculty, Research Output, Quality of Publications, Influence and Citations (Table 3).

Table 3. Performance indicators and weight of Center for World University Rankings

Indicators	Weight	Description
Quality of education	15%	Number of a university's alumni who have won major international awards, prizes, and medals relative to the university's size
Alumni employment	15%	Number of a university's alumni who have held CEO positions at the world's top companies relative to the university's size
Quality of faculty	15%	Number of academics who have won major international awards, prizes, and medals
Research output	15%	Total number of research papers
Quality publications	15%	Number of research papers appearing in top-tier journals
Influence	15%	Number of research papers appearing in highly-influential journals
Citations	10%	Number of highly-cited research papers

Source: elaborations by the authors.

This ranking also appears to be well-balanced in the choice of indicators and in the weighting system, ensuring a comprehensive assessment of the different aspects that characterize the quality of a university institution.

2.5 Round University Ranking (RUR)

Round University Ranking (RUR) is published by Rankings Agency and based in Moscow, Russia. The RUR provides comparison of 930 universities according to 20 indicators distributed into 4 areas with equal weights in the measured groups: Teaching, Research, International diversity and Financial sustainability (Table 4). The main types of information to create a ranking are: Bibliometric data obtained from Web of Science Core Collection, Scopus, Google Scholar, etc.; Statistics which include the indicators provided by the universities; Reputational data which collected from specially conducted surveys. In addition to the overall ranking, RUR includes 30 rankings on 6 subject areas: Humanities, Life Sciences, Medical Sciences, Natural Sciences, Social Sciences, Engineering.

This ranking considers in a perfectly balanced way all the aspects useful for a good evaluation of the universities distributing the weighting system between Teaching and Research (40% for each).

Table 4. Performance indicators and weight of Round University Ranking

Areas	Weight	Indicators	Sub weight
Teaching	40%	Academic staff per students	8%
		Academic staff per bachelor degrees awarded	8%
		Doctoral degrees awarded per academic staff	8%
		Doctoral degrees awarded per bachelor degrees awarded	8%
		World teaching reputation	8%
Research	40%	Citations per academic and research staff	8%
		Doctoral degrees per admitted PhD	8%
		Normalized citation impact	8%
		Papers per academic and research staff	8%
		World research reputation	8%
International diversity	10%	Share of international academic staff	2%
		Share of international students	2%
		Share of international co-authored papers	2%
		Reputation outwith the region	2%
		International level	2%
Financial sustainability	10%	Institutional income per academic staff	2%
		Institutional income per students	2%
		Papers per research income	2%
		Research income per academic and research staff	2%
		Research income per institutional income	2%

Source: elaborations by the authors.

3 Comparison Ranking: Limits and Opportunities

3.1 Comparison Between Indicators and Weight Systems

After describing the characteristics and methodologies of the four systems we report a summary of the indicators considered in each of them and their weight systems. In particular, each indicator has a different number of indicators: 13 indicators for THE, 6 indicators for QS, 7 indicators for CWUR and 20 indicators for RUR (Table 5).

Some rankings are mainly based on research or teaching indicators, while others place great emphasis on public opinion surveys. It is evident that the THE and CWUR rankings are characterized by a strong relevance of the indicators linked to aspects of Research, while the RUR ranking is better balanced in the Research/Teaching report. The QS ranking, as already highlighted in the previous paragraph, however, is strongly unbalanced on the aspects related to the reputation of the single universities surveyed.

Table 5. Number of indicators and weight of the different ranking

	Number of indicators				Weight			
	THE	QS	CWUR	RUR	THE	QS	CWUR	RUR
Teaching	5	1	2	5	30%	20%	30%	40%
Research	3		3	5	30%		45%	40%
Citations	1	1	1		30%	20%	10%	
Industry income	1				2,5%			
International outlook	3	2		5	7,5%	10%		10%
Academic reputation		1				40%		
Employer reputation		1				10%		
Financial sustainability				5				10%
Alumni employment			1				15%	
Total	13	6	7	20	100%	100%	100%	100%

Source: elaborations by the authors.

3.2 Comparison of Rankings and Placements

The relationship between global rankings is then analyzed. Of the 17,500 Universities present in the world only 1,000 universities are included in the evaluation of the ranking. In 2018, the TOP 20 universities grouped by nationality see the prevalence of American universities, followed by those of the British. Only eight are European Universities and the rest of the continents are rarely represented [see the discussion by other international authors: 10, 11]. This presence is probably also influenced by the choice of indicators that are best suited to a type of "US" academic reality rather than a "European" one (Fig. 1).

To illustrate the difference between the various rankings, we report the ranking of the top 20 universities in alphabetical order (Table 6).

The various rankings are compared using two measures: Spearman's rank correlation coefficient and Spearman's footrule. The first is a nonparametric measure of rank

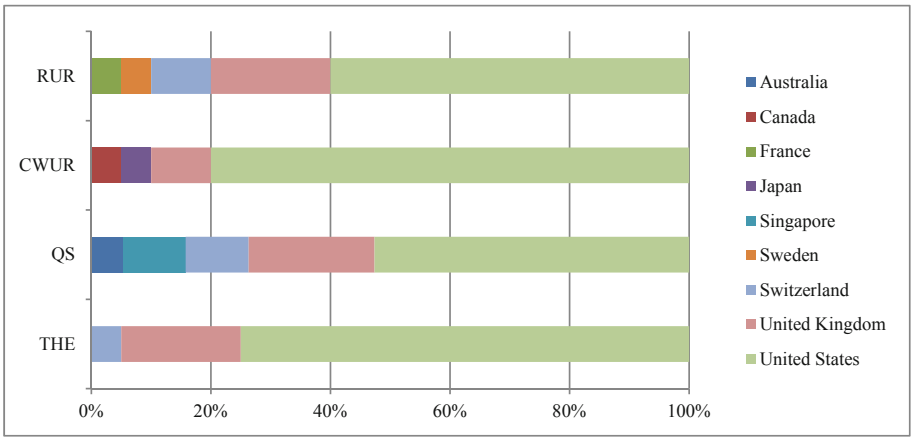

Fig. 1. Classifications of the top 20 university in 2018 by nationality

Table 6. Classifications of the Top 20 universities in 2018 by ranking

	THE	QS	CWUR	RUR
California Institute of Technology	3	4	9	2
Columbia University	14	18	8	8
Cornell University	19	14	14	20
ETH Zurich	10	10	28	15
Harvard University	6	3	1	1
Johns Hopkins University, Baltimore	13	17	16	21
Massachusetts Institute of Technology	5	1	3	6
Northwestern University	20	28	23	19
Princeton University	7	13	7	10
Stanford University	4	2	2	5
University College London	16	7	21	17
University of California, Berkeley	18	27	6	48
University of California, Los Angeles	15	27	15	23
University of Cambridge	2	5	4	9
University of Chicago	9	9	10	3
University of Edinburgh	27	23	34	37
University of Michigan	21	21	18	22
University of Oxford	1	6	5	7
University of Pennsylvania	11	19	13	12
Yale University	12	16	11	14

Source: elaborations by the authors.

correlation that assesses how well the relationship between two variables can be described using a monotonic function [12]. Intuitively, the Spearman's index between two ranks will be high when observations have a similar rank (i.e. relative position

label of the observations: 1st, 2nd, 3rd, etc.) and low when observations have a dissimilar rank between them. The following formula is used to calculate the Spearman rank correlation:

$$\rho = 1 - \frac{6\sum d_i^2}{N(N^2 - 1)} \tag{1}$$

with di = difference between the ranks of corresponding variables and N = number of observations. The value ρ = 1 means a perfect positive correlation of ranks and the value ρ = –1 means a perfect negative correlation of ranks.

A weighted metric based on the classical Spearman's footrule measures the distance between two permutations of n objects. 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. 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 [13]. 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. Spearman's footrule on these transformations [14, 15] is computed as:

$$Fr^{|Z|}(\sigma_1, \sigma_2) = \sum_{i=1}^{|Z|} |\sigma_1(i), \sigma_2(i)| \tag{2}$$

When the two rankings are identical on the set Z, $Fr^{|Z|}$ is zero, and its maximum value is $\frac{1}{2}|Z|^2$ if |Z| is even, and $\frac{1}{2}(|Z|+1)(|Z|-1)$ if |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. Thus, we compute the Normalized Spearman's footrule, NFr, for |Z| > 1:

$$NFr = \frac{Fr(|Z|)}{maxFr(|Z|)} \tag{3}$$

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:

$$F = 1 - NFr \tag{4}$$

Applying the similarity matrix between the four rankings, we obtain lower values for Spearman's rank correlation coefficient compared to Spearman's footrule (Table 7).

In particular, in the case of Spearman's rank correlation coefficient, which can take values between –1 and +1, positive values are always found. The two most similar rankings are THE ranking and RUR ranking, with a value of ρ = 0.668. On the other hand, similar rankings are QS and CWUR rankings with a value of ρ = 0.259.

As for the Normalized Spearman's footrule which assumes values between zero and one, the relationship between the rankings appears very evident with peaks

between THE and QS (F = 0.710) and lower values between QS and CWUR (F = 0.669).

Table 7. Spearman's rank correlation coefficient and Normalized Spearman's Footrule

	THE	QS	CWUR	RUR
	Spearman's rank correlation coefficient ρ			
THE	1,000			
QS	0,607	1,000		
CWUR	0,566	0,259	1,000	
RUR	0,668	0,623	0,605	1,000
	Normalized Spearman's Footrule F			
THE	1,000			
QS	0,710	1,000		
CWUR	0,689	0,639	1,000	
RUR	0,719	0,709	0,669	1,000

From the data analyzed we can, therefore, state that despite the various international rankings being based on different indicators, there is a positive relationship between the different positions of the universities with lower values in the relationship between Qs and CWUR. This factor is justified because the QS ranking is strongly unbalanced on the reputational aspect rather than on objective indicators related to research and teaching, while CWUR is the only ranking that assesses the quality of teaching and research output, without relying on surveys.

4 Conclusions

The rankings on the universities are built on the basis of sets of indicators chosen by the promoters of the rankings. These parameters are typically drawn from public data collections (the number of publications, the number of citations, etc.) or on the basis of data provided directly by the universities being assessed.

The construction of a rating is hardly ever based on a single parameter, but more often results from a combination of parameters, appropriately weighted. The methods of construction and attribution of scores are rarely the object of final user attention. In fact, the information rate that distinguishes the ranking of universities is not combined with the careful examination of the methodological notes that illustrate the criteria for constructing the ranking.

World university rankings are subject to some controversy: subjectivity in the choice of indicators, arbitrary attribution of weights, excessive consideration of the reputational factor, variability in the definition of the classification of results between ordinal/numerical representation and the effective quality of university education [16–21].

Another interesting factor in the international literature is the lack of attention paid to the effects, direct and indirect, that these tools have on students and their university

choices. In addition to the need for validity in the rankings they need to be considered as valid and stable [22, 23].

The results reported in this study are undoubtedly encouraging and show how the universities are increasingly willing to become involved to achieve good levels of ranking. The calculated indicators show a strong relationship between the rankings, highlighting how the Top 20 universities occupy high positions in all the classifications analyzed.

As emerges from the international literature [24], however, an awareness campaign would be opportune, aimed at a better communication of the results deriving from the rankings and a review of the indicators and weight systems, which are often not univocally applicable to the specificity of the European universities but strictly linked to the profiles of US universities.

References

1. Altbach, P.G.: The globalization of college and university rankings. Change Mag. High. Learn. **44**(1), 26–31 (2012)
2. Altbach, P.G.: The dilemmas of ranking. Int. High. Educ. **42**, 2–3 (2006)
3. Bastedo, M.N., Bowman, N.A.: College rankings as an interorganizational dependency: establishing the foundation for strategic and institutional accounts. Res. High. Educ. **52**(1), 3–23 (2011)
4. Hazelkorn, E.: Rankings and the battle for world-class excellence: institutional strategies and policy choices. High. Educ. Manage. Policy **21**(1), 55–76 (2009)
5. Hazelkorn, E.: Reflections on a decade of global rankings: what we've learned and outstanding issues. Eur. J. Educ. **49**(1), 12–28 (2014)
6. Huisman, J., Currie, J.: Accountability in higher education: bridge over troubled water? High. Educ. **48**(4), 529–551 (2004)
7. Marginson, S., van der Wende, M.: To rank or to be ranked: the impact of global rankings in higher education. J. Stud. Int. Educ. **11**(3/4), 306–329 (2007)
8. Salmi, J., Saroyan, A.: League tables as policy instruments: uses and misuses. High. Educ. Manage. Policy **19**(2), 31–68 (2007)
9. Williams, R.: Methodology, meaning and usefulness of rankings. Aust. Univ. Rev. **50**(2), 51–58 (2008)
10. Marginson, S.: University rankings and social science. Eur. J. Educ. **49**(1), 45–59 (2014)
11. Billaut, J., Bouyssou, D., Vinke, P.: Should we believe the Shanghai ranking? an MCDM view. Scientometrics **84**(1), 237–263 (2010)
12. Schmid, F., Schmidt, R.: Multivariate extensions of spearman's rho and related statistics. Stat. Prob. Lett. **77**(4), 407–416 (2007)
13. Aguillo, I.F., Bar-Ilan, J., Levene, M., Ortega, J.L.: Comparing university rankings. Scientometrics **85**, 243–256 (2010)
14. Diaconis, P., Graham, R.L.: Spearman's footrule as a measure of disarray. J. Roy. Stat. Soc. Ser. B (Methodol.) **39**, 262–268 (1977)
15. Dwork, C., Kumar, R., Naor, M., Sivakumar, D.: Rank aggregation methods for the Web. In: Proceedings of the 10th World Wide Web Conference, May 2001, Hong-Kong, pp. 613–622 (2001)
16. Dill, D.D., Soo, M.: Academic quality, league tables and public policy: a cross national analysis of university ranking systems. High. Educ. **49**, 499–533 (2005)

17. Frey, B.S., Rost, K.: Do rankings reflect research quality? J. Appl. Econ. **13**(1), 1–38 (2010)
18. Proulx, R.: Higher education ranking and leagues tables: lessons learned from benchmarking. High. Educ. Europe **32**(1), 71–82 (2007)
19. Saisana, M., d'Hombres, B., Saltelli, A.: Rickety numbers: volatility of university rankings and policy implications. Res. Policy **40**(1), 165–177 (2011)
20. Taylor, P., Braddock, R.: International university ranking systems and the idea of university excellence. J. High. Educ. Policy Manage. **29**(3), 245–260 (2007)
21. Tofallis, C.: A different approach to university rankings. High. Educ. **63**(1), 1–18 (2012)
22. Federkeil, G.: Some aspects of ranking methodology. The CHE ranking of German universities. High. Educ. Europe **27**(4), 389–397 (2002)
23. Fidler, B., Parsons, C.: World university ranking methodologies: stability and variability. High. Educ. Rev. **40**(3), 15–34 (2008)
24. Meredith, M.: Why do universities compete in the ratings game? an empirical analysis of the effects of the U.S. news & world report college rankings. Res. High. Educ. **45**(5), 443–461 (2004)