



UNIVERSIDAD CARLOS III DE MADRID

working
papers

Working Paper
Economic Series 16-03
January 2016
ISSN 2340-5031

Departamento de Economía
Universidad Carlos III de Madrid
C/ Madrid, 126, 28903 Getafe (Spain)
Fax (34) 916249875

“THE IMPACT OF CLASSIFICATION SYSTEMS IN THE EVALUATION OF THE RESEARCH PERFORMANCE OF THE LEIDEN RANKING UNIVERSITIES”

Antonio Perianes-Rodríguez^a and Javier Ruiz-Castillo^b

^aDepartamento de Biblioteconomía y Documentación, Universidad Carlos III,
SCImago Research Group

^bDepartamento de Economía, Universidad Carlos III

Abstract

Barring source (citing-side) normalization procedures, any other normalization procedure will depend on the classification system used, namely, on the way publications (or journals) are assigned to scientific fields. In this paper, we study the consequences for the ranking of the 500 universities in the 2013 edition of the Leiden Ranking of using one of two classification systems: a Web of Science journal-level system, consisting of 236 subject categories, or a publication-level algorithmically constructed system, consisting of 5,119 clusters. Universities are ranked according to the *Top 1%* citation impact indicator. The reference sets for this indicator under the two classification systems are very different. Our main result is the following: the choice of classification system changes quite considerably the ranking of the 500 universities in the 2013 edition of the Leiden Ranking.

Acknowledgements. This research project builds on earlier work started by Antonio Perianes-Rodríguez during a research visit to the Centre for Science and Technology Studies (CWTS) of Leiden University as awardee of José Castillejo grant, CAS15/00178, funded by the Spanish MEC. Ruiz-Castillo is a visiting researcher at CWTS and gratefully acknowledges CWTS for the use of its data. Ruiz-Castillo acknowledges financial support from the Spanish MEC through grant ECO2014-55953-P, as well as grant MDM 2014-0431 to his Departamento de Economía.

I. INTRODUCTION

Assume we want to compare the performance of a set of research units taking into account the citation distributions of the articles in the periodical literature they have published during a certain period of time in a number of scientific fields. The ranking of these units is a complex task that depends on a large number of factors. In this paper, we study the consequences of choosing between two *classification systems* of science, that is, between two ways of assigning individual publications (or journals) to scientific fields. This is an important problem, since differences in production and citation practices between scientific fields must be normalized before any meaningful assessment of these units' research output is possible. Barring source (citing-side) normalization procedures (see *inter alia* Waltman *et al.*, 2013, and the references cited there), any other normalization procedure will depend on the classification system used.

The two classification systems compared in this paper are the following: the Web of Science (WoS hereafter) journal-level classification system, consisting of 236 journal subject categories (or simply categories hereafter), and an alternative publication-level system arising from the algorithmic methodology introduced in Waltman & Van Eck (2012) that classifies individual publications into clusters solely based on direct citations between them.

In practice, the choice of the WoS classification system is often made because, together with the Scopus system, it is readily available. However, a number of studies question the appropriateness of this system for normalization purposes.¹ Among the publication-level alternatives, Klavans and Boyack (2015) conclude that classification systems based on direct citation using the Waltman & Van Eck (2012) methodology are more accurate than classification systems based on bibliographic coupling or co-citation. Ruiz-Castillo & Waltman (2015) apply the Waltman & Van Eck (2012) methodology to a WoS

¹ See *inter alia* Neuhaus & Daniel (2009) for Chemistry and related fields, Van Leeuwen & Calero Medina (2012) for Economics & Business, Van Eck *et al.* (2013) for Clinical and Basic Medical Research, and Leydesdorff & Bornman (2015) for Library and Information Science, and Science & Technology Studies.

dataset consisting of 9.4 million publications from the 2003-2012 period. A sequence of twelve independent classification systems is obtained, in each of which the same set of publications is assigned to an increasing number of clusters. In this paper, we use the version corresponding to granularity level 8 (the G8 classification systems hereafter) consisting of 5,119 clusters. This is the version recommended in Ruiz-Castillo & Waltman (2015) and Perianes-Rodriguez & Ruiz-Castillo (2016).

Naturally, ranking outcomes may also depend on many other factors, including the choice of citation impact indicators. In this paper, we focus on a percentile rank indicator for two reasons. Firstly, although percentile rank indicators directly incorporate a suitable normalization procedure for citation counts of publications from different clusters or categories (see *inter alia* Bornmann & Marx, 2013), it is important to understand that they are conditional on the classification system used. For example, given any classification system with J clusters, the *Top X%* indicator is defined as the percentage of an institution's scientific output included in the set formed by the top $X\%$ of the most cited publications in each of the J clusters.

Secondly, percentile rank indicators occupy a prominent role both in the Leiden Ranking of universities and the SCImago Institutions Ranking.² Together with the Mean Normalized Citation Score, the 2015 version of the Leiden Ranking includes the *Top 50%*, the *Top 10%*, and the *Top 1%* indicators, whereas the SCImago Institutions Ranking includes the *Top 10%* indicator. Since Ruiz-Castillo & Waltman (2015) studied the consequences of using the *Top 10%* indicator under the WoS and the G8 systems, in this paper we study the consequences of using the *Top 1%* indicator. This is an interesting contrast, since it is well known that differences between classification systems tend to increase as the threshold of excellence goes up (Zitt *et al.*, 2005, and Perianes-Rodriguez & Ruiz-Castillo, 2016).

² SCImago is a research group from the *Consejo Superior de Investigaciones Científicas*, University of Granada, Extremadura, Carlos III (Madrid) and Alcalá de Henares in Spain. The *SCImago Institutions Rankings* (SIR; www.scimagoir.com) is a bibliometric ranking of research institutions based on Elsevier's Scopus database that includes the Top 10% indicator.

Naturally, to facilitate the comparison of the consequences of using the *Top 10%* or the *Top 1%* indicators, we follow closely the following four methodological decisions adopted in Ruiz-Castillo & Waltman (2015). (i) We focus on the 3.6 million articles published in the 2005-2008 period, and the citations they receive during a five-year citation window for each year in that period. (ii) In the WoS system, approximately 45% of the articles in the dataset are assigned to two or more categories up to a maximum of six. To deal with this problem, we adopt a fractional strategy. (iii) The set of research units investigated consists of the 500 universities included in the 2013 edition of the CWTS Leiden Ranking (Waltman *et al.*, 2012a) –the LR universities hereafter. (iv) There are 2.4 million distinct articles in which at least one author belongs to one of the LR universities. Only 30% of this total has a single address line. We use the address-line fractional counting approach to solve the problem of the remaining publications assigned to several co-authors working in different institutions. As a result, the total number of articles in the LR universities becomes 1.9 million. (v) To solve the problems generated in the computation of the indicators by the discrete nature of citation distributions combined with the presence of many publications with the same number of citations, we follow the approach recommended in Waltman & Schreiber (2013).

The rest of the paper is organized into three Sections and two Appendices. Section II serves two purposes: it presents the data, as well as the results concerning the differences between the WoS and the G8 classification systems as the threshold of excellence increases. Section III contains the empirical results concerning the consequences of applying the *Top 1%* indicator to the 500 LR universities under the two classification systems. Finally, Section IV offers some conclusions. Appendix I discusses the method for establishing the differences between the WoS and the G8 systems when the WoS system is constructed according to a fractional scheme, whereas Appendix II includes the ranking of the LR universities according to the *Top 1%* indicator under the two classification systems.

II. DATA, AND DIFFERENCES BETWEEN CLASSIFICATION SYSTEMS

III.1. The data

Our dataset results from the application of the publication-level algorithmic methodology in Waltman & Van Eck (2012) to 9,446,622 distinct articles published in 2003-2012. Publications in local journals, as well as popular magazines and trade journals, have been excluded (for the details, see Ruiz-Castillo & Waltman, 2015). We work with journals in the sciences, the social sciences, and the arts and humanities, although many arts and humanities journals are excluded because they are of a local nature.

In this paper, we focus on the set of 3,614,447 distinct articles published in the period 2005-2008. To save space, descriptive statistics of this dataset are available in Ruiz-Castillo & Waltman (2015). To deal with the problem of multiple assignment of articles to WoS categories, we adopt a fractional strategy according to which each article is fractioned into as many equal pieces as necessary, with each piece assigned to a corresponding category.

III.2. Differences between classification systems

Following Zitt *et al.* (2005), we consider the possibility of computing the set of the top $X\%$ most cited publications in every cluster in a pair of classification systems A and B. An article that belongs to the top $X\%$ in cluster j in system A (or B) may not belong to the top $X\%$ in cluster l in system B (or A). The more often this is the case, the more different the two systems will be according to the $X\%$ criterion. For comparison purposes, we begin by studying the differences between the G8 system and the member of the sequence of twelve independent classification systems in Ruiz-Castillo & Waltman (2015) corresponding to granularity level 6 –the G6 classification system hereafter– consisting of 1,363 clusters.

Let \mathbf{c}_j be the ordered citation distribution of cluster j in system G8, where $j = 1, \dots, 5119$. The union $\mathbf{C} = \cup_j \{\mathbf{c}_j\}$ is the overall citation distribution. Similarly, let \mathbf{d}_g be the ordered citation distribution of cluster g in system G6, where $g = 1, \dots, 1363$, and let $\mathbf{D} = \cup_g \{\mathbf{d}_g\}$ be the overall citation distribution in this case. The total number of articles in \mathbf{C} , and \mathbf{D} is 3.6 million. For the comparison between the G6

and G8 systems, let \mathbf{x}_j and \mathbf{x}_g be the sets of the top $X\%$ most cited articles in cluster citation distributions \mathbf{c}_j and \mathbf{c}_g , and denote the union of these sets by $\mathbf{X}^{G8} = \cup_j \{\mathbf{x}_j\}$, and $\mathbf{X}^{G6} = \cup_g \{\mathbf{x}_g\}$. Since both systems have the same number of articles, the number of articles in \mathbf{X}^{G8} and \mathbf{X}^{G6} is also the same, say N^X . Let \mathbf{X}^{68} be the set of distinct articles common to both systems, namely, let $\mathbf{X}^{68} = \mathbf{X}^{G6} \cap \mathbf{X}^{G8}$. Let N^{X68} be the number of articles in \mathbf{X}^{68} . The difference between the top $X\%$ most cited articles in both systems is measured through the percentage that the articles in $\mathbf{X}^{G8} - \mathbf{X}^{68}$ represent in \mathbf{X}^{G8} (or the percentage that the articles in $\mathbf{X}^{G6} - \mathbf{X}^{68}$ represent in \mathbf{X}^{G6}), that is, through the expression $100(N^X - N^{X68})/N^X$. The results for the top 50%, 10%, and 1% most cited articles in the dataset with 3.6 million articles are in Table 1.

Table 1 around here

Let \mathbf{e}_k be the ordered citation distribution of category k in the WoS system, where $k = 1, \dots, 236$. The union $\mathbf{E} = \cup_k \{\mathbf{e}_k\}$ is the overall citation distribution in this case. Although the number of articles in each citation distribution \mathbf{e}_k will typically be a fractional number, the total number of articles in \mathbf{E} is 3.6 million. However, to compare the systems G8 and G6 with the WoS system we must take into account that the later has been constructed according to a fractional scheme. To facilitate the reading of the text, the extension of the original method can be found in Appendix I. The results for the comparison between the WoS and the two granularity levels are also in Table 1.

Table 1 warrants the following two comments. Firstly, independently of the pair of classification systems being compared, we confirm that—as in Zitt *et al.* (2005) and Perianes-Rodriguez & Ruiz-Castillo (2016)—the difference between them increases as the threshold of excellence goes up. Secondly, in the key comparison between the WoS and the G8 systems we observe that, at least in the upper tail of the cluster and categories citation distributions the difference is very large. In particular, for the top 1% of

most cited articles this difference is 51.7%, or twenty percentage points above the difference for the top 10% of most cited articles.³ Therefore, the choice between classification systems could have dramatic consequences for the ranking of research units when the citation impact indicators are defined over the very upper tail of citation distributions, such as the *Top 1%* indicator studied in Section III.

There are 2,420,054 distinct articles –or 67% of the 3.6 million articles published in 2005-2008– with at least one address line belonging to an LR university. Differences between the WoS and G8 systems for this dataset according to the top $X\%$ criterion when $X = 50\%$, 10% , and 1% , are essentially the same as the differences presented in Table 1 (results are available on request).

III.3. Counting method

The distribution of the 2.4 million distinct articles with at least one address line belonging to an LR university by the number of address lines, as well as other descriptive statistics can be found in Perianes-Rodriguez & Ruiz-Castillo (2015b). It turns out that the percentage of articles with a single address line is 30.0% of the total. The assignment of the remaining 70% of the 2.4 million distinct articles that are co-authored by two or more institutions is made according to the address-level fractional counting method. The total number of articles in the LR universities according to the address-level fractional counting method is 1,886,106.1, or 77.9% of the 2.4 million articles with at least one address line belonging to a LR university, and 52.2% of the 3.6 million articles published in 2005-2008 (see Perianes-Rodriguez & Ruiz-Castillo, 2015a, for the distribution of the 1.9 million articles among the 500 LR universities).

III. EMPIRICAL RESULTS

Columns 1 and 2 in Table A in Appendix II present the results of applying the *Top 1%* indicator in the two classification systems, ordered by the *Top 1%* values in the G8 system. Table A reports the

³ Using the same dataset, Perianes-Rodriguez & Ruiz-Castillo (2016) make the same comparisons when the problem of the assignment of articles to multiple categories in the WoS system is solved according to a multiplicative strategy. Differences between the WoS and the G8 systems are of the same order of magnitude for every $X = 50\%$, 10% , and 1% .

ratio of each university's *Top 1%* value and the world reference, namely, 1.00%. Thus, if a university has a *Top 1%* value of 1.12%, Table A reports a value of $(1.12\%/1.00\%) = 1.12$, so that the value one can serve as a benchmark for evaluating the research units in the usual way. The university ranks according to the *Top 1%* values in the WoS system, the ranking differences, and the differences between the indicator values are presented in column 3, 4, and 5, respectively.

Consider the possibility of measuring the discriminatory power of an indicator by the coefficient of variation and the range of their values. We know that differences in citation impact between the LR universities tend to increase when we reach the last few percentiles of citation distributions including the most highly cited articles (Figure 3 in Perianes-Rodriguez & Ruiz-Castillo, 2015b). Therefore, the greater the threshold of excellence is, that is, the further we go towards the very upper tail of citation distributions, the greater the discriminatory power of indicators of citation excellence is expected to be. In our case, the first observation is that, independently of the classification system we use, the *Top 1%* indicator has a greater discriminatory power than the *Top 10%* indicator. For example, when we use the G8 system, the coefficient of variation and the range of the *Top 1%* values are 0.56 and 3.78, whereas these quantities for the *Top 10%* values are 0.35 and 2.08.

Since cardinal differences in university values when we use the *Top 1%* indicator are greater than when we use the *Top 10%* indicator under both classification systems, this fact has no implications concerning how important the consequences of using the two systems are. Turning towards this issue, we begin by observing that the Pearson and the Spearman correlation coefficients between university values and ranks according to the *Top 1%* indicator –0.92 and 0.90– are significantly lower than according to the *Top 10%* indicator in Ruiz-Castillo & Waltman (2015) –0.97 and 0.96.

As far as differences for individual universities of going from the WoS to the G8 system when the *Top 1%* is used, we take two aspects into account: the re-rankings that take place in such a move (column 4 in Table A), and the differences between the university values themselves (columns 5). The results,

which are presented in Table 2, can be compared with the differences found in going from the WoS and the G8 systems when using the *Top 10%* indicator. To facilitate the comparison, these differences are presented in Table 3, taken from Table 6 in Ruiz-Castillo & Waltman (2015).

Tables 2 and 3 around here

Relatively large re-rankings of more than 25 positions according to the *Top 1%* indicator occur much more frequently than according to the *Top 10%* indicator: 296 *versus* 195 universities (Panel A in Tables 2 and 3). This is mostly due to the situation among the last 400 universities, where these numbers are 264 and 188, respectively. Nevertheless, as many as 32 large re-rankings take place among the first 100 universities. On the other hand, only 61 universities, or 12.2% of the total exhibit small re-rankings equal to or smaller than five positions.

Something similar occurs when we consider differences in indicator values (Panel B in Tables 2 and 3). Large changes greater than 0.10 in indicator values occur more or less equally frequently among the first 100 and the last 400 universities according to the *Top 1%* indicator: in both cases, approximately 60% of universities exhibit large changes in indicator values. Instead, these percentages are 13% and 20.5% according to the *Top 10%* indicator.

By way of example, Panel C in Table 2 includes the largest gainers and losers among the first 100 universities when going from the WoS to the G8 system. The three columns include the ranking according to the G8 system, the number of positions in the re-ranking, and the difference in *Top 1%* values. With the criterion of a re-ranking greater than 50 positions, we have only 11 gainers. In nine cases the gains take place between positions 49 and 99. We have also added the loser with the greatest difference in *Top 1%* values, namely, Rice University.

Finally, to illustrate the sensitivity of university *Top 1%* values to the choice of a classification system, we use the 32 Chinese universities (excluding Hong Kong) as an interesting example. Each of these universities is indicated using a red cross in Figure 1. The main lesson is that, as we go from the

WoS system to G8, the performance of almost all Chinese universities worsens. This deterioration is especially significant for the best performing Chinese universities. Not surprisingly, these results coincide with what we saw in Ruiz-Castillo & Waltman (2015) when we use the *Top 10%* indicator. An explanation of the Chinese case is beyond the scope of this paper, but it may relate to the specific characteristics of the research areas in which Chinese universities focus their activity or to the citation behavior of Chinese researchers (since researchers' citation behavior determines how publications are clustered in the algorithmic methodology).

Figure 1 around here

IV. DISCUSSION AND CONCLUSIONS

There are a number of recent results favoring publication-level over journal-level classification systems. Using a set of new gold standards –consisting of articles with at least 100 references–, Klavans & Boyack (2015) compare publication-level algorithmically constructed classification systems based in direct citations à la Waltman & Van Eck (2012) with six journal-level systems that do not include the WoS. They conclude that the former are more accurate than the latter in the sense that they are better at concentrating references. Among the alternatives to the WoS system, Ruiz-Castillo & Waltman (2015) study a sequence of twelve independent classification systems based on the Waltman & Van Eck (2012) algorithmic methodology at different granularity levels. Although it is difficult to isolate an optimal granularity level, Ruiz-Castillo & Waltman (2015) conclude that classification systems with a few thousands clusters with a minimum size provide a credible alternative to the WoS system, and focus their empirical analysis on the G8 system. Finally, in Perianes-Rodriguez & Ruiz-Castillo (2016) we study the standard target (cited-side) normalization procedures in which raw citation counts are normalized using the clusters' mean citations as normalization factors for different classification systems. We reach the following two conclusions. Firstly, the granularity level 8 clearly dominates the granularity level 6 within the Ruiz-Castillo & Waltman (2015) sequence. Secondly, although the G8- and WoS-based

standard normalization procedures turned out to be non-comparable, the G8-normalization procedure performs better using the WoS system for evaluation purposes than the WoS-normalization procedure using the G8 system for evaluation purposes.

In practice, the Centre for Science and Technology Studies (CWTS) adopts a publication-level algorithmically constructed classification system à la Waltman & Van Eck (2012) consisting of 3,822 clusters in the 2015 edition of the Leiden Ranking. Taking into account the above results, we sympathize with this choice. However, we believe that it is important to keep studying the consequences of moving from joint-level classification systems to publication-level alternatives. This paper has contributed to this topic by comparing the consequences for the ranking of the 500 LR universities of using a WoS journal-level classification system with 236 categories, or the G8 publication-level system with 5119 clusters. Naturally, the ranking of research units depend also on which citation impact indicator we use. Since Ruiz-Castillo & Waltman (2015) studied the *Top 10%* indicator, in this paper we have focused on the *Top 1%* indicator.

The consequences of moving from the WoS to the G8 system using one *Top X%* indicator depend on two factors. Firstly, the difference between the set of the top $X\%$ of most cited articles in every category in the WoS system, and the set of the top $X\%$ of most cited articles in every cluster in the G8 system. The greater the difference between these sets is, the greater should be the consequences for the ranking of research units of using one or the other system independently of the value of X . Secondly, the differences between the universities' research performance at the top $X\%$ of their citation distributions. The greater is the superiority of one university over another, the lower the consequences of using one or the other classification system, i. e. the more robust will be the ranking of these universities to the system we use.

Our main result is best explained in two parts.

1. The difference between the sets of top 10% most cited publications in every cluster and every category in the G8 and WoS systems is considerable, namely, 31.7%. However, differences in the universities' *Top 10%* values are not that large. Firstly, 95 universities, or 19% of the total exhibit differences larger than 0.10. Secondly, truly large re-rankings of more than 50 positions are present in 81 universities, or 16.2% of the total.

2. The difference between the sets of top 1% most cited publications in every cluster and every category in the G8 and WoS systems is twenty percentage points greater, namely, 51.7%. Differences in the universities' *Top 1%* values are also very much larger. Firstly, 303 universities, or 60.6% of the total exhibit differences larger than 0.10. Secondly, large re-rankings of more than 50 positions are present in 164 universities, or 32.8% of the total.

The conclusion is clear. Recent results indicate that there are good reasons to move from journal-level to publication-level algorithmically constructed classification systems. At the same time, due to the high skewness of citation distributions, we are witnessing a shift towards citation impact indicators defined over the very upper tail of citation distributions. Personally, we believe that both moves are advisable. However, the results of this paper indicate that this double trend has important consequences in an interesting case: the move from the WoS to the G8 system using the *Top 1%* indicator changes quite considerably the ranking of the 500 universities in the 2013 edition of the Leiden Ranking.

APPENDIX I

DIFFERENCES BETWEEN THE G8 AND THE (FRACTIONAL) WoS SYSTEM

The G8 system

As indicated in the text, let \mathbf{x}_j be the set of top $X\%$ most cited articles in cluster j in the G8 system, and let $\mathbf{X}^{G8} = \cup_j \{\mathbf{x}_j\}$ be the union of all such sets, so that the number of articles in \mathbf{X}^{G8} , N^X , is the $X\%$ of N .⁴ Let \mathbf{X}_ν^{G8} be the set of articles in \mathbf{X}^{G8} assigned to ν categories in the WoS system, where $\nu = 1, \dots, 6$, and let N_ν be the number of articles in \mathbf{X}_ν^{G8} , so that $\mathbf{X}^{G8} = \cup_\nu \{\mathbf{X}_\nu^{G8}\}$ and $N^X = \sum_\nu N_\nu$. For $\nu \geq 2$, we need to expand the set \mathbf{X}_ν^{G8} as follows. For any $\nu \geq 2$, denote by $\mathbf{X}_\nu^{G8}(\mathbf{E})$ the ν -replica of \mathbf{X}_ν^{G8} , so that $|\mathbf{X}_\nu^{G8}(\mathbf{E})| = \nu N_\nu$. For example, if $\nu = 2$ and $\mathbf{X}_\nu^{G8} = (c_{i1}, \dots, c_{i5}, \dots, c_{iN_\nu})$, we have

$$\mathbf{X}_2^{G8}(\mathbf{E}) = (c_{i1}, c_{i1}, \dots, c_{i5}, c_{i5}, \dots, c_{iN_\nu}, c_{iN_\nu})$$

with $|\mathbf{X}_2^{G8}(\mathbf{E})| = 2 N_2$.

The WoS system

As indicated in the text, let \mathbf{e}_k be the citation distribution of category k in the WoS system, $k = 1, \dots, 236$, and let $\mathbf{E} = \cup_k \{\mathbf{e}_k\}$ be the overall citation distribution. Every distinct article in C can be assigned to ν categories in the WoS system with $\nu \in \{1, \dots, 6\}$. Therefore, every element of citation distribution \mathbf{e}_k consists of a number of citations, say e_{kb} , and a weight $w_{kb} = 1/\nu$ for some $\nu \in \{1, \dots, 6\}$. Let $n_k = \sum_b w_{kb}$ be the number of articles in so that $N = \sum_k n_k = \sum_k \sum_b w_{kb}$.

Let \mathbf{y}_k be the set of top $X\%$ most cited articles in category k in the WoS system, and let $\mathbf{X}^{WoS} = \cup_k \{\mathbf{y}_k\}$ be the union of all such sets, so that the number of articles in \mathbf{X}^{WoS} is N^X , namely, the $X\%$ of N . For any $\nu \in \{1, \dots, 6\}$, let \mathbf{X}_ν^{WoS} be the set of elements in \mathbf{X}^{WoS} with weight equal to $1/\nu$, so that $\mathbf{X}^{WoS} = \cup_\nu \{\mathbf{X}_\nu^{WoS}\}$. Let M_ν be the number of elements in \mathbf{X}_ν^{WoS} , so that we can represent this set by $\mathbf{X}_\nu^{WoS} = \{(1/\nu) e_{\nu b}, l = 1, \dots, M_\nu\}$, and $N^X = \sum_\nu (M_\nu/\nu)$. Finally, for any ν we need the citation distribution consisting of the citations received by the elements in \mathbf{X}_ν^{WoS} , that is, for any ν , we need

$$\mathbf{X}_\nu^{WoS}(\mathbf{D}) = \{e_{\nu b}, l = 1, \dots, M_\nu\}.$$

The intersections

Let $\cap_I = \mathbf{X}_I^{G8} \cap \mathbf{X}_I^{WoS}(\mathbf{D})$,

and for any $\nu \geq 2$, define the intersections

$$\cap_\nu = \mathbf{X}_\nu^{G8}(\mathbf{E}) \cap \mathbf{X}_\nu^{WoS}(\mathbf{D}).$$

⁴ To simplify matters, we shall assume that all \mathbf{x}_j consists of a whole number of distinct articles. This assumption will be dropped in the example.

Let I_ν be the number of articles in \cap_ν , $\nu = 1, \dots, 6$. The number of articles common to the sets \mathbf{X}^{G8} and \mathbf{X}^{WoS} is

$$I = \sum_\nu (I_\nu / \nu).$$

Therefore, the difference between the G8 and the WoS systems according to the X criterion can be expressed as $100(N^X - I)/N^X$.

AN EXAMPLE

Assume there are 12 distinct articles and four clusters in system G8:

$$\mathbf{c}_1 = (0, 1, 3, 12), N_1 = 4; \quad \mathbf{c}_2 = (1, 6), N_2 = 2; \quad \mathbf{c}_3 = (4, 8), N_3 = 2; \quad \mathbf{c}_4 = (0, 5, 7, 9), N_4 = 4.$$

Assume that there are three categories, and that the distinct articles with citations 3, 5, and 7 are assigned to the three of them. Let n_k be the number of articles in category k , $k = 1, 2, 3$. The three categories are:

$$\begin{aligned} \mathbf{e}_1 &= (1, 1/3 \text{ of } 3, 1/3 \text{ of } 5, 1/3 \text{ of } 7), n_1 = 2, \\ \mathbf{e}_2 &= (0, 0, 1/3 \text{ of } 3, 4, 1/3 \text{ of } 5, 6, 1/3 \text{ of } 7, 8), n_2 = 6, \\ \mathbf{e}_3 &= (1, 1/3, 1/3 \text{ of } 5, 1/3 \text{ of } 7, 9, 12), n_3 = 4. \end{aligned}$$

If $X = 50\%$, then

$$\mathbf{x}_1 = (3, 12), \quad \mathbf{x}_2 = (6), \quad \mathbf{x}_3 = (8), \quad \mathbf{x}_4 = (7, 9),$$

so that $\mathbf{X}^{G8} = (3, 6, 7, 8, 9, 12)$, $N^X = 6$.

Note that $\mathbf{X}^{G8} = \mathbf{X}_1^{G8} \cup \mathbf{X}_3^{G8}$, where $\mathbf{X}_1^{G8} = (6, 8, 9, 12)$, and $\mathbf{X}_3^{G8} = (3, 7)$. Therefore, $\mathbf{X}_3^{G8}(\mathbf{E}) = (3, 3, 3, 7, 7, 7)$.

Similarly,

$$\mathbf{y}_1 = (1/3 \text{ of } 3, 1/3 \text{ of } 5, 1/3 \text{ of } 7), \quad \mathbf{y}_2 = (1/3 \text{ of } 4, 1/3 \text{ of } 5, 6, 1/3 \text{ of } 7, 8), \quad \mathbf{y}_3 = (9, 12),$$

so that $\mathbf{X}^{WoS} = (1/3 \text{ of } 3, 1/3 \text{ of } 4, 1/3 \text{ of } 5, 1/3 \text{ of } 5, 6, 1/3 \text{ of } 7, 1/3 \text{ of } 7, 8, 9, 12)$.

Note that $\mathbf{X}_1^{WoS}(\mathbf{D}) = (1/3 \text{ of } 4, 6, 8, 9, 12)$, and $\mathbf{X}_3^{WoS}(\mathbf{D}) = (3, 5, 5, 7, 7)$.

Observe that:

$$\cap_1 = \mathbf{X}_1^{G8} \cap \mathbf{X}_1^{WoS}(\mathbf{D}) = (6, 8, 9, 12),$$

and $\cap_3 = \mathbf{X}_3^{G8}(\mathbf{E}) \cap \mathbf{X}_3^{WoS}(\mathbf{D}) = (3, 7, 7)$,

so that $I = I_1 + I_3/3 = 4 + 1 = 5$.

Therefore, the difference between the G8 and the WoS systems when $X = 50\%$ is $100(12 - 5)/12 = 58.3\%$.

REFERENCES

- Klavans, R., & Boyack, K. W. (2015). Which type of citation analysis generates the most accurate taxonomy of scientific and technical knowledge? arXiv:1511.05078v1 [[cs.DL](#)].
- Perianes-Rodriguez, A., and Ruiz-Castillo, J. (2015a). A comparison of two ways of evaluating research units working in different scientific fields. Forthcoming in *Scientometrics* (DOI: 10.1007/s11192-015-1801-5).
- Perianes-Rodriguez, A., and Ruiz-Castillo, J. (2015b). University citation distributions. Forthcoming in *Journal of the American Society for Information Science and Technology* (DOI: 10.1002/asi.23619).
- Perianes-Rodriguez, A., & Ruiz-Castillo, J. (2016). A comparison of the web of science with publication-level classification systems of science. Working Paper 16-02, Universidad Carlos III (<http://hdl.handle.net/10016/22137>).
- Ruiz-Castillo, J., and Waltman, L. (2015). Field-normalized citation impact indicators using algorithmically constructed classification systems of science. *Journal of Informetrics*, 9, 102-117.
- Waltman L., & Van Eck, N. J. (2013). Source normalized indicators of citation impact: An overview of different approaches and an empirical comparison. *Scientometrics*, 96, 699-716.
- Waltman, L., Calero-Medina, C., Kosten, J., Noyons, E. C. M., Tijssen, R. J. W., Van Eck, N. J., Van Leeuwen, T. N., Van Raan, A. F. J., Visser, M. S., & Wouters, P. (2012a). The Leiden Ranking 2011/2012: Data collection, indicators, and interpretation. *Journal of the American Society for Information Science and Technology*, 63, 2419–2432.
- Waltman, L., & Schreiber, M. (2013). On the calculation of percentile-based bibliometric indicators. *Journal of the American Society for Information Science and Technology*, 64, 372-379.
- Zitt M., Ramana-Rahari, S., and Bassecouard, E. (2005). Relativity of Citation Performance and Excellence Measures: From Cross-field to Cross-scale Effects of Field-Normalization. *Scientometrics*, 63, 373-401.

APPENDIX II

Table A. University rankings according to the *Top 1%* indicator in the WoS and G8 classification systems, ordered by the G8 indicator values

Rank G8	University	Value G8 (1)	Value WoS (2)	Rank WoS (3)	Re-rankings = Rank WoS-Rank G8 (4)	(2) - (1) (5)
1	Massachusetts Institute of Technology	3.86	3.77	1	0	-0.10
2	Princeton University	3.36	3.71	2	0	0.35
3	Harvard University	3.20	2.88	5	2	-0.32
4	Stanford University	2.97	3.14	4	0	0.17
5	University of California, Berkeley	2.90	2.53	7	2	-0.37
6	California Institute of Technology	2.87	2.81	6	0	-0.06
7	London School of Hygiene & Tropical Medicine	2.75	1.58	59	52	-1.18
8	University of California, Santa Barbara	2.54	2.52	8	0	-0.01
9	University of St Andrews	2.43	1.70	44	35	-0.73
10	University of Chicago	2.28	1.89	32	22	-0.39
11	Yale University	2.28	2.15	15	4	-0.13
12	University of California, San Francisco	2.25	1.83	37	25	-0.42
13	University of Oxford	2.17	1.75	40	27	-0.42
14	Northwestern University	2.16	2.19	12	-2	0.03
15	University of Washington - Seattle	2.15	2.27	11	-4	0.12
16	Columbia University	2.13	1.99	24	8	-0.14
17	University of California, San Diego	2.12	1.93	27	10	-0.19
18	New York University	2.09	2.00	23	5	-0.09
19	University of Cambridge	2.09	1.93	28	9	-0.16
20	University of California, Santa Cruz	2.08	2.03	22	2	-0.05
21	Duke University	2.08	1.96	26	5	-0.12
22	University of California, Los Angeles	2.06	2.09	19	-3	0.04
23	École Polytechnique Fédérale de Lausanne	2.05	2.11	18	-5	0.05
24	ETH Zurich	2.03	1.74	42	18	-0.29
25	University College London	2.01	1.62	52	27	-0.38
26	Carnegie Mellon University	2.01	2.44	9	-17	0.44
27	Oregon Health & Science University	1.99	1.56	63	36	-0.43
28	University of Dundee	1.98	2.17	14	-14	0.19
29	Rice University	1.98	3.47	3	-26	1.49
30	University of Pennsylvania	1.97	2.05	20	-10	0.08
31	University of Colorado Boulder	1.97	1.89	33	2	-0.07
32	Georgia Institute of Technology	1.93	2.39	10	-22	0.46
33	Cornell University	1.92	1.92	30	-3	0.00
34	Johns Hopkins University	1.90	1.86	35	1	-0.04
35	Imperial College London	1.89	1.75	41	6	-0.14
36	Delft University of Technology	1.88	1.34	88	52	-0.54
37	Tufts University	1.87	1.92	29	-8	0.05
38	University of North Carolina at Chapel Hill	1.84	1.96	25	-13	0.12
39	ParisTech - École Polytechnique	1.84	1.44	73	34	-0.41
40	Emory University	1.84	1.66	48	8	-0.17
41	University of Michigan	1.82	2.04	21	-20	0.22
42	University of Bristol	1.77	1.59	56	14	-0.18
43	University of California, Irvine	1.77	1.91	31	-12	0.14

Rank G8	University	Value G8 (1)	Value WoS (2)	Rank WoS (3)	Re-rankings = Rank WoS-Rank G8 (4)	(2) - (1) (5)
44	Icahn School of Medicine at Mount Sinai	1.77	1.68	47	3	-0.09
45	Washington University in St. Louis	1.75	1.66	49	4	-0.09
46	King's College London	1.75	1.58	58	12	-0.17
47	University of Texas at Austin	1.73	1.72	43	-4	-0.01
48	University Texas Southwestern Med Center Dallas	1.73	1.86	36	-12	0.13
49	University of Nice Sophia Antipolis	1.72	1.03	175	126	-0.69
50	University of Illinois at Urbana-Champaign	1.70	1.39	79	29	-0.31
51	University of Minnesota, Twin Cities	1.69	1.68	46	-5	-0.01
52	University of Wisconsin - Madison	1.68	1.35	84	32	-0.34
53	Weizmann Institute of Science	1.67	1.81	38	-15	0.13
54	Trinity College, Dublin	1.66	2.12	17	-37	0.46
55	University of Rochester	1.66	1.52	66	11	-0.14
56	University of Utah	1.66	1.61	54	-2	-0.06
57	Boston University	1.65	1.89	34	-23	0.24
58	University of East Anglia	1.64	1.70	45	-13	0.05
59	University of Twente	1.63	1.57	62	3	-0.06
60	University of Notre Dame	1.61	2.17	13	-47	0.56
61	Arizona State University	1.60	1.55	65	4	-0.05
62	University of California, Riverside	1.57	2.15	16	-46	0.57
63	University of Pittsburgh	1.57	1.50	68	5	-0.07
64	Oregon State University	1.55	1.21	118	54	-0.34
65	Brown University	1.55	1.30	99	34	-0.25
66	Drexel University	1.54	1.33	92	26	-0.21
67	University of Edinburgh	1.53	1.13	141	74	-0.39
68	University of Geneva	1.52	1.19	125	57	-0.32
69	Lancaster University	1.52	1.40	78	9	-0.12
70	University of Maryland, College Park	1.51	1.52	67	-3	0.01
71	Pennsylvania State University	1.50	1.61	53	-18	0.11
72	University of Toronto	1.48	1.22	116	44	-0.26
73	University of Southampton	1.48	1.16	130	57	-0.32
74	Eindhoven University of Technology	1.48	1.31	95	21	-0.17
75	McMaster University	1.47	1.17	128	53	-0.30
76	University of Melbourne	1.47	1.34	89	13	-0.13
77	Durham University	1.47	1.46	71	-6	0.00
78	University of Stuttgart	1.45	1.37	80	2	-0.09
79	University of Southern California	1.45	1.36	82	3	-0.08
80	University of Colorado Denver	1.45	1.10	149	69	-0.34
81	Baylor College of Medicine	1.45	1.29	101	20	-0.16
82	University of Virginia	1.44	1.21	121	39	-0.23
83	University of Lausanne	1.44	1.48	70	-13	0.04
84	Stony Brook University, State University of NY	1.43	1.65	50	-34	0.22
85	Erasmus University Rotterdam	1.41	1.35	85	0	-0.06
86	Ohio State University	1.41	1.28	102	16	-0.13
87	University of Miami	1.40	1.25	107	20	-0.15
88	Dartmouth College	1.40	1.56	64	-24	0.15
89	University of Zurich	1.40	1.33	90	1	-0.07
90	Case Western Reserve University	1.38	1.16	134	44	-0.22
91	RWTH Aachen University	1.38	1.30	98	7	-0.08

Rank G8	University	Value G8 (1)	Value WoS (2)	Rank WoS (3)	Re-rankings = Rank WoS-Rank G8 (4)	(2) - (1) (5)
92	Technical University of Denmark	1.38	1.40	76	-16	0.02
93	University of Arizona	1.37	1.34	87	-6	-0.03
94	University of Exeter	1.37	1.16	135	41	-0.21
95	Katholieke Universiteit Leuven	1.36	1.06	167	72	-0.31
96	Newcastle University	1.36	1.14	139	43	-0.23
97	University of British Columbia	1.35	1.21	119	22	-0.14
98	Vrije Universiteit Brussel	1.35	0.80	273	175	-0.54
99	Tulane University	1.34	1.63	51	-48	0.29
100	Indiana University Bloomington	1.34	1.17	126	26	-0.17
101	University of California, Davis	1.34	1.30	97	-4	-0.03
102	Florida State University	1.33	1.10	150	48	-0.23
103	University of Auckland	1.32	0.93	216	113	-0.39
104	University of Massachusetts Amherst	1.32	1.57	60	-44	0.25
105	Vanderbilt University	1.32	1.35	83	-22	0.04
106	Australian National University	1.30	1.11	145	39	-0.19
107	University of Massachusetts Medical School	1.30	1.80	39	-68	0.50
108	George Washington University	1.30	1.23	115	7	-0.07
109	University of Glasgow	1.30	1.08	158	49	-0.22
110	Technische Universität München	1.29	1.08	157	47	-0.21
111	Utrecht University	1.29	1.25	108	-3	-0.04
112	University of Amsterdam	1.29	1.25	105	-7	-0.03
113	Wageningen University and Research Centre	1.27	1.16	132	19	-0.11
114	Northeastern University	1.27	1.33	91	-23	0.06
115	University of Sheffield	1.26	1.20	124	9	-0.07
116	McGill University	1.26	1.14	137	21	-0.12
117	Georgetown University	1.26	1.01	186	69	-0.25
118	VU University Amsterdam	1.25	1.27	103	-15	0.02
119	University of Bath	1.25	1.23	113	-6	-0.02
120	University of Aberdeen	1.25	1.43	75	-45	0.18
121	Purdue University - Lafayette	1.24	1.29	100	-21	0.05
122	Philipps-Universität Marburg	1.24	1.01	184	62	-0.23
123	Université Libre de Bruxelles	1.24	1.05	169	46	-0.19
124	University of Copenhagen	1.24	1.23	112	-12	0.00
125	University of Ferrara	1.23	1.00	188	63	-0.23
126	University of Hawaii, Manoa	1.23	1.03	177	51	-0.20
127	Rutgers State University at New Brunswick	1.23	1.57	61	-66	0.34
128	University of York	1.22	1.26	104	-24	0.04
129	Queen Mary, University of London	1.22	1.06	165	36	-0.16
130	Yeshiva University	1.22	1.48	69	-61	0.26
131	University of Paris-Sud 11	1.21	1.33	93	-38	0.12
132	Goethe University Frankfurt	1.21	1.34	86	-46	0.13
133	University of Göttingen	1.21	0.89	232	99	-0.32
134	University Texas Health Science Center San Antonio	1.21	1.60	55	-79	0.39
135	University of Hong Kong	1.20	1.31	96	-39	0.11
136	University of Basel	1.20	1.21	117	-19	0.02
137	University of Vienna	1.19	1.07	164	27	-0.13
138	University of Southern Denmark	1.18	0.99	193	55	-0.20
139	University of Bern	1.18	1.09	154	15	-0.09

Rank G8	University	Value G8 (1)	Value WoS (2)	Rank WoS (3)	Re-rankings = Rank WoS-Rank G8 (4)	(2) - (1) (5)
140	University of Warwick	1.18	0.88	235	95	-0.30
141	Universitat Politècnica de Catalunya	1.18	0.69	325	184	-0.48
142	Colorado State University	1.17	1.06	166	24	-0.12
143	Technische Universität Berlin	1.17	0.94	213	70	-0.23
144	Virginia Commonwealth University	1.17	1.09	152	8	-0.07
145	University of Otago	1.16	0.68	330	185	-0.49
146	University of Connecticut	1.16	0.94	209	63	-0.21
147	University of Queensland	1.16	1.14	138	-9	-0.02
148	Michigan State University	1.16	1.44	72	-76	0.28
149	University of Central Florida	1.15	0.97	198	49	-0.18
150	Ludwig-Maximilians-Universität München	1.15	1.11	144	-6	-0.04
151	University of Vermont	1.15	0.70	320	169	-0.45
152	University of Cincinnati	1.15	1.24	111	-41	0.09
153	Ghent University	1.15	1.04	171	18	-0.11
154	Washington State University	1.15	0.75	299	145	-0.39
155	University College Dublin	1.14	0.86	248	93	-0.29
156	Universität Regensburg	1.14	1.07	162	6	-0.07
157	Stockholm University	1.14	1.09	153	-4	-0.05
158	University of Strathclyde	1.14	0.88	241	83	-0.26
159	Paris Diderot University	1.14	0.88	238	79	-0.26
160	University of Helsinki	1.14	0.94	210	50	-0.20
161	Université Montpellier 2	1.13	1.16	133	-28	0.03
162	University of Groningen	1.13	1.02	180	18	-0.11
163	University of Sussex	1.13	0.81	269	106	-0.31
164	Wake Forest University	1.12	1.08	156	-8	-0.04
165	University of Leeds	1.12	0.95	208	43	-0.18
166	Politecnico di Torino	1.12	0.70	324	158	-0.43
167	University of Reading	1.12	0.99	192	25	-0.13
168	Texas A&M University - College Station	1.12	0.96	201	33	-0.15
169	Swedish University of Agricultural Sciences	1.12	0.79	281	112	-0.33
170	University of Parma	1.12	0.99	194	24	-0.13
171	University of Illinois at Chicago	1.12	1.03	173	2	-0.08
172	University of Bergen	1.11	0.87	242	70	-0.24
173	Medical University of Vienna	1.11	0.80	276	103	-0.31
174	University of New South Wales	1.10	0.85	253	79	-0.25
175	University of Trieste	1.10	0.80	274	99	-0.30
176	University of Sydney	1.10	0.86	247	71	-0.24
177	Joseph Fourier University	1.10	0.88	237	60	-0.22
178	University of Manchester	1.10	1.07	161	-17	-0.03
179	North Carolina State University	1.10	1.10	148	-31	0.00
180	University of Montreal	1.10	0.93	214	34	-0.17
181	University of Iowa	1.10	0.89	233	52	-0.21
182	University of New Mexico	1.10	1.33	94	-88	0.23
183	University of Bremen	1.09	0.83	265	82	-0.26
184	University of Barcelona	1.09	0.84	261	77	-0.25
185	Aix-Marseille University	1.09	0.98	195	10	-0.11
186	University of Delaware	1.09	1.05	168	-18	-0.03
187	Karolinska Institute	1.09	1.02	179	-8	-0.07

Rank G8	University	Value G8 (1)	Value WoS (2)	Rank WoS (3)	Re-rankings = Rank WoS-Rank G8 (4)	(2) - (1) (5)
188	University of Ottawa	1.09	1.11	146	-42	0.02
189	Leiden University	1.09	1.24	110	-79	0.15
190	Maastricht University	1.08	0.95	207	17	-0.14
191	National University of Singapore	1.08	1.40	77	-114	0.32
192	Universitat Politècnica de València	1.08	1.25	106	-86	0.17
193	Karlsruhe Institute of Technology	1.08	1.23	114	-79	0.15
194	University of Georgia	1.07	1.03	178	-16	-0.05
195	University of Liverpool	1.07	0.81	271	76	-0.26
196	University of Strasbourg	1.07	0.91	223	27	-0.16
197	Wayne State University	1.06	0.67	336	139	-0.39
198	University Claude Bernard Lyon 1	1.06	0.83	264	66	-0.23
199	Monash University	1.06	0.94	211	12	-0.12
200	Iowa State University	1.06	1.21	120	-80	0.15
201	Technische Universität Darmstadt	1.06	0.82	266	65	-0.23
202	Virginia Polytechnic Institute and State University	1.05	1.00	187	-15	-0.05
203	University of Bordeaux 1 Science and Technology	1.05	1.07	160	-43	0.02
204	University of Duisburg-Essen	1.05	0.70	322	118	-0.35
205	Johannes Gutenberg Univ Mainz	1.05	0.97	199	-6	-0.08
206	University of Maryland, Baltimore	1.05	1.04	170	-36	0.00
207	Queen's University	1.04	1.11	147	-60	0.06
208	University of Liège	1.04	0.80	277	69	-0.25
209	University of Birmingham	1.04	0.66	338	129	-0.38
210	Queen's University Belfast	1.04	0.89	231	21	-0.15
211	George Mason University	1.04	0.97	200	-11	-0.07
212	University of South Carolina	1.04	1.43	74	-138	0.40
213	Cardiff University	1.04	0.78	290	77	-0.26
214	Gottfried Wilhelm Leibniz Universität Hannover	1.03	0.67	337	123	-0.36
215	Indiana University - Purdue University Indianapolis	1.03	1.15	136	-79	0.12
216	University of Gothenburg	1.02	0.83	263	47	-0.19
217	Giessen University	1.02	0.51	392	175	-0.50
218	University of Western Ontario	1.02	0.73	307	89	-0.28
219	Aarhus University	1.01	0.95	205	-14	-0.06
220	Simon Fraser University	1.01	0.75	300	80	-0.26
221	University of Milan Bicocca	1.01	0.70	321	100	-0.31
222	University of Hamburg	1.01	0.85	254	32	-0.16
223	Massey University	1.01	0.91	222	-1	-0.10
224	Heidelberg University	1.01	0.84	259	35	-0.16
225	Friedrich-Alexander-Universität Erlangen-Nürnberg	1.01	1.25	109	-116	0.24
226	University of Western Australia	1.01	0.95	206	-20	-0.06
227	Paris Descartes University	1.00	0.60	361	134	-0.40
228	University of Bonn	1.00	0.96	202	-26	-0.04
229	University of Nottingham	1.00	1.01	185	-44	0.01
230	University of Ulm	0.99	0.68	329	99	-0.32
231	University of Pavia	0.99	0.85	250	19	-0.14
232	Norwegian University of Science and Technology	0.99	0.91	220	-12	-0.08
233	Indian Institute of Technology Kharagpur	0.99	0.73	309	76	-0.26
234	University Pierre and Marie Curie	0.99	0.84	260	26	-0.15
235	University of Medicine and Dentistry of New Jersey	0.99	1.00	189	-46	0.01

Rank G8	University	Value G8 (1)	Value WoS (2)	Rank WoS (3)	Re-rankings = Rank WoS-Rank G8 (4)	(2) - (1) (5)
236	Université Bordeaux Segalen	0.98	0.92	218	-18	-0.07
237	University of Tübingen	0.98	0.95	204	-33	-0.03
238	University of Perugia	0.98	0.68	332	94	-0.30
239	University of Houston	0.98	0.87	244	5	-0.11
240	Aalto University	0.98	0.45	405	165	-0.52
241	Auburn University	0.97	0.70	323	82	-0.28
242	University of South Florida at Tampa	0.97	1.16	131	-111	0.19
243	University of Newcastle	0.97	0.81	270	27	-0.15
244	University of Adelaide	0.96	0.73	311	67	-0.24
245	Vienna University of Technology	0.96	0.98	196	-49	0.01
246	Politecnico di Milano	0.96	0.54	385	139	-0.42
247	Université Catholique de Louvain	0.96	0.84	262	15	-0.12
248	Humboldt-Universität zu Berlin	0.95	0.86	249	1	-0.09
249	City University of Hong Kong	0.95	1.02	181	-68	0.07
250	Radboud University Nijmegen	0.94	1.17	127	-123	0.23
251	Kansas State University	0.94	1.12	143	-108	0.17
252	Universidad Autónoma de Madrid	0.94	0.65	346	94	-0.29
253	University at Buffalo, State University NY	0.94	0.68	328	75	-0.25
254	University of Kansas	0.93	1.03	176	-78	0.10
255	Medical University of South Carolina	0.93	0.87	243	-12	-0.05
256	Temple University	0.92	0.90	229	-27	-0.03
257	University of Padova	0.92	0.74	304	47	-0.18
258	University of Leicester	0.92	0.96	203	-55	0.04
259	Ruhr-Universität Bochum	0.92	0.66	340	81	-0.26
260	University of Cologne	0.91	0.85	258	-2	-0.07
261	Laval University	0.91	1.01	183	-78	0.10
262	University of Tennessee	0.91	1.14	140	-122	0.23
263	Paul Sabatier University	0.91	0.73	306	43	-0.17
264	Lund University	0.91	0.91	224	-40	0.01
265	Hebrew University of Jerusalem	0.90	0.94	212	-53	0.03
266	Thomas Jefferson University	0.90	0.93	217	-49	0.02
267	Freie Universität Berlin	0.90	0.91	227	-40	0.01
268	University of Calgary	0.89	0.68	331	63	-0.22
269	University of Antwerp	0.89	0.89	230	-39	0.00
270	University of Alberta	0.89	0.74	303	33	-0.15
271	University of Waterloo	0.89	0.79	286	15	-0.10
272	Chalmers University of Technology	0.88	0.77	293	21	-0.11
273	University of the Witwatersrand	0.88	0.52	388	115	-0.36
274	University of Victoria	0.88	0.82	267	-7	-0.07
275	Saarland University	0.88	0.75	301	26	-0.13
276	University of Münster	0.88	0.88	236	-40	0.01
277	University of Nebraska - Lincoln	0.87	0.80	275	-2	-0.07
278	University of Missouri	0.87	1.02	182	-96	0.15
279	Martin Luther University of Halle-Wittenberg	0.87	0.60	364	85	-0.27
280	University of Florida	0.86	0.97	197	-83	0.11
281	University of Freiburg	0.86	1.13	142	-139	0.27
282	Medical College of Wisconsin	0.86	0.65	345	63	-0.21
283	University of Guelph	0.86	0.85	252	-31	0.00

Rank G8	University	Value G8 (1)	Value WoS (2)	Rank WoS (3)	Re-rankings = Rank WoS-Rank G8 (4)	(2) - (1) (5)
284	Chinese University of Hong Kong	0.85	0.77	294	10	-0.08
285	Technical University of Lisbon	0.85	0.59	367	82	-0.26
286	Nanyang Technological University	0.85	1.08	159	-127	0.23
287	University of Würzburg	0.85	0.79	283	-4	-0.06
288	University of Alabama at Birmingham	0.85	0.88	239	-49	0.03
289	Universidade Nova de Lisboa	0.84	0.91	225	-64	0.07
290	Henri Poincaré University	0.84	0.59	370	80	-0.26
291	Hong Kong University of Science and Technology	0.84	1.09	155	-136	0.24
292	Umeå University	0.84	0.70	319	27	-0.13
293	Technische Universität Dresden	0.83	0.91	226	-67	0.08
294	Ewha Womans University	0.83	0.89	234	-60	0.05
295	University of Rennes 1	0.83	0.64	347	52	-0.19
296	Pohang University of Science and Technology	0.83	1.20	123	-173	0.38
297	University of Bologna	0.82	0.76	296	-1	-0.06
298	Heinrich Heine Univ Düsseldorf	0.81	1.04	172	-126	0.23
299	Uppsala University	0.80	0.73	308	9	-0.07
300	University of Wollongong	0.80	1.07	163	-137	0.26
301	Dalhousie University	0.80	0.60	362	61	-0.21
302	University of Oslo	0.80	0.77	292	-10	-0.03
303	Oklahoma State University - Stillwater	0.80	0.61	353	50	-0.19
304	University of Kentucky	0.80	0.87	246	-58	0.07
305	University of Cape Town	0.80	0.81	268	-37	0.02
306	Hannover Medical School	0.80	0.90	228	-78	0.10
307	University of Santiago de Compostela	0.79	1.03	174	-133	0.24
308	University of Texas Medical Branch at Galveston	0.79	0.60	356	48	-0.19
309	University of Surrey	0.79	0.60	360	51	-0.19
310	Southeast University	0.78	1.59	57	-253	0.81
311	University of Aveiro	0.78	0.71	316	5	-0.07
312	Louisiana State University	0.78	0.77	295	-17	-0.01
313	Technion - Israel Institute of Technology	0.78	0.65	343	30	-0.12
314	University of Tokyo	0.77	0.72	312	-2	-0.05
315	Montpellier 1 University	0.77	1.00	190	-125	0.23
316	Macquarie University	0.77	0.79	278	-38	0.02
317	University of Jena	0.77	0.66	339	22	-0.11
318	University of Porto	0.77	0.79	280	-38	0.03
319	Universidad Autónoma de Barcelona	0.76	0.78	289	-30	0.02
320	Harbin Institute of Technology	0.76	0.55	377	57	-0.21
321	Loughborough University	0.75	0.46	402	81	-0.29
322	Peking University	0.75	0.91	221	-101	0.16
323	University of Valencia	0.75	0.60	357	34	-0.14
324	Otto-von-Guericke University Magdeburg	0.74	0.48	401	77	-0.27
325	Clemson University	0.74	0.81	272	-53	0.07
326	University of Louisville	0.74	0.75	298	-28	0.01
327	Dalian University of Technology	0.74	0.92	219	-108	0.18
328	Kiel University	0.74	0.77	291	-37	0.03
329	KTH Royal Institute of Technology	0.73	0.70	318	-11	-0.03
330	University of Genoa	0.73	0.66	341	11	-0.07
331	University of Torino	0.72	0.59	368	37	-0.13

Rank G8	University	Value G8 (1)	Value WoS (2)	Rank WoS (3)	Re-rankings = Rank WoS-Rank G8 (4)	(2) - (1) (5)
332	University of Florence	0.72	0.79	282	-50	0.07
333	Lanzhou University	0.72	0.79	285	-48	0.07
334	University Paris-Est Créteil Val de Marne	0.72	1.09	151	-183	0.38
335	University of Rostock	0.72	0.72	313	-22	0.00
336	Hong Kong Polytechnic University	0.71	0.68	327	-9	-0.03
337	University of Lisbon	0.71	0.30	452	115	-0.41
338	University of Milan	0.71	0.71	314	-24	0.01
339	Amirkabir University of Technology	0.71	0.88	240	-99	0.17
340	West Virginia University	0.71	0.53	387	47	-0.18
341	Tel Aviv University	0.70	0.73	310	-31	0.03
342	University of Turku	0.69	0.63	350	8	-0.07
343	Central South University	0.69	0.61	355	12	-0.09
344	University of Tasmania	0.69	0.44	413	69	-0.26
345	Universität Leipzig	0.69	0.79	284	-61	0.10
346	University of Manitoba	0.69	0.56	374	28	-0.13
347	University of Modena and Reggio Emilia	0.68	0.58	372	25	-0.10
348	Complutense University	0.68	0.60	363	15	-0.08
349	University of Warsaw	0.67	0.52	389	40	-0.16
350	Innsbruck Medical University	0.67	0.87	245	-105	0.20
351	Aristotle University of Thessaloniki	0.67	0.35	435	84	-0.31
352	University of Eastern Finland	0.66	0.62	352	0	-0.04
353	Tsinghua University	0.65	0.93	215	-138	0.28
354	University College Cork	0.65	0.85	255	-99	0.20
355	Stellenbosch University	0.65	0.33	441	86	-0.31
356	University of Oklahoma	0.64	0.55	376	20	-0.09
357	Tokyo Institute of Technology	0.64	0.78	288	-69	0.14
358	Queensland University of Technology	0.64	0.33	442	84	-0.31
359	National Technical University of Athens	0.64	0.31	451	92	-0.33
360	Tokyo Medical and Dental University	0.64	0.65	344	-16	0.01
361	Osaka University	0.63	0.67	335	-26	0.04
362	Kyoto University	0.63	0.74	305	-57	0.10
363	University of Mississippi	0.63	0.45	408	45	-0.18
364	Sharif University of Technology	0.62	0.44	412	48	-0.19
365	University of Naples Federico II	0.61	0.48	398	33	-0.13
366	Ben-Gurion University of the Negev	0.61	0.36	434	68	-0.25
367	Banaras Hindu University	0.61	0.44	410	43	-0.17
368	Xiamen University	0.60	0.85	256	-112	0.25
369	University of Zaragoza	0.60	0.59	365	-4	-0.01
370	Federal University of Rio de Janeiro	0.60	0.30	453	83	-0.30
371	University of Burgundy	0.60	0.65	342	-29	0.06
372	Pontifical Catholic University of Chile	0.60	0.68	333	-39	0.08
373	Indian Institute of Science	0.60	0.54	386	13	-0.06
374	National Sun Yat-sen University	0.60	0.50	395	21	-0.10
375	Bar-Ilan University	0.59	0.21	476	101	-0.38
376	University of Science Malaysia	0.59	1.37	81	-295	0.77
377	Texas Tech University	0.59	0.71	315	-62	0.13
378	East China University of Science and Technology	0.58	0.74	302	-76	0.16
379	University of KwaZulu-Natal	0.58	0.85	251	-128	0.28

Rank G8	University	Value G8 (1)	Value WoS (2)	Rank WoS (3)	Re-rankings = Rank WoS-Rank G8 (4)	(2) - (1) (5)
380	Università Cattolica del Sacro Cuore	0.58	0.41	417	37	-0.17
381	University of Pisa	0.57	0.59	366	-15	0.02
382	University of Seville	0.57	0.54	383	1	-0.03
383	Nanjing University	0.56	0.68	334	-49	0.11
384	Shandong University	0.56	0.48	400	16	-0.08
385	Lomonosov Moscow State University	0.55	0.36	432	47	-0.20
386	Korea Advanced Institute of Science and Technology	0.55	0.62	351	-35	0.07
387	York University	0.55	0.61	354	-33	0.06
388	University of Oviedo	0.54	0.41	416	28	-0.13
389	Sun Yat-sen University	0.53	1.21	122	-267	0.67
390	Tohoku University	0.53	0.55	378	-12	0.02
391	Nagoya University	0.53	0.46	403	12	-0.07
392	University of Bari Aldo Moro	0.52	0.40	421	29	-0.12
393	University of Oulu	0.51	0.57	373	-20	0.05
394	Universidad de Granada	0.51	0.51	390	-4	0.01
395	Linköping University	0.51	0.64	348	-47	0.14
396	University of Patras	0.50	0.33	443	47	-0.17
397	University of the Basque Country	0.50	0.60	358	-39	0.10
398	University of Coimbra	0.50	0.36	433	35	-0.14
399	Kyushu University	0.50	0.40	420	21	-0.10
400	Kcio University	0.50	0.49	397	-3	-0.01
401	Sapienza University of Rome	0.50	0.40	419	18	-0.09
402	University of Tehran	0.49	0.17	489	87	-0.32
403	East China Normal University	0.48	0.45	406	3	-0.03
404	National and Kapodistrian University of Athens	0.48	0.32	446	42	-0.16
405	National Taiwan University	0.48	0.54	384	-21	0.06
406	Chonbuk National University	0.47	0.63	349	-57	0.16
407	University of Nantes	0.47	0.50	396	-11	0.02
408	University of Rome Tor Vergata	0.47	0.50	394	-14	0.03
409	Shanghai Jiao Tong University	0.47	0.60	359	-50	0.13
410	University of Saskatchewan	0.47	0.55	380	-30	0.08
411	Griffith University	0.46	0.59	371	-40	0.12
412	National Tsing Hua University	0.46	0.54	381	-31	0.08
413	University of Palermo	0.46	0.46	404	-9	0.00
414	University of Ljubljana	0.46	0.31	450	36	-0.15
415	Pusan National University	0.45	0.28	458	43	-0.17
416	Nankai University	0.45	1.17	129	-287	0.72
417	Yonsei University	0.45	0.51	393	-24	0.06
418	Seoul National University	0.45	0.71	317	-101	0.26
419	Chonnam National University	0.44	0.41	418	-1	-0.03
420	Istanbul University	0.43	0.25	467	47	-0.18
421	Kanazawa University	0.43	0.34	438	17	-0.09
422	Flinders University	0.43	0.51	391	-31	0.08
423	Fudan University	0.43	0.76	297	-126	0.33
424	University of Lübeck	0.42	0.48	399	-25	0.06
425	Kobe University	0.42	0.39	423	-2	-0.03
426	Federal University of Santa Catarina	0.42	0.10	496	70	-0.31
427	Universidade Federal de Minas Gerais	0.41	0.34	436	9	-0.07

Rank G8	University	Value G8 (1)	Value WoS (2)	Rank WoS (3)	Re-rankings = Rank WoS-Rank G8 (4)	(2) - (1) (5)
428	University of Tsukuba	0.41	0.42	415	-13	0.01
429	State University of Campinas	0.41	0.28	460	31	-0.12
430	Waseda University	0.40	0.30	454	24	-0.10
431	University of Murcia	0.40	0.33	440	9	-0.06
432	Indian Institute of Technology Madras	0.39	0.28	459	27	-0.11
433	Hanyang University	0.38	0.28	462	29	-0.10
434	University of Belgrade	0.38	0.18	484	50	-0.20
435	University of Siena	0.37	0.38	424	-11	0.01
436	University of Zagreb	0.37	0.28	461	25	-0.09
437	University of Science and Technology of China	0.37	0.99	191	-246	0.62
438	Hokkaido University	0.37	0.27	464	26	-0.10
439	Technical University of Madrid	0.36	0.19	479	40	-0.17
440	National Cheng Kung University	0.36	0.56	375	-65	0.20
441	Hacettepe University	0.35	0.19	483	42	-0.17
442	Cairo University	0.35	0.13	493	51	-0.22
443	Federal University of Rio Grande do Sul	0.35	0.32	445	2	-0.02
444	University of Pretoria	0.35	0.23	471	27	-0.11
445	National Chung Hsing University	0.34	0.85	257	-188	0.50
446	Hiroshima University	0.34	0.30	455	9	-0.05
447	Saint Petersburg State University	0.34	0.18	486	39	-0.17
448	Jagiellonian University in Krakow	0.34	0.38	429	-19	0.04
449	Zhejiang University	0.34	0.39	422	-27	0.05
450	Korea University	0.34	0.59	369	-81	0.25
451	University of Buenos Aires	0.34	0.22	472	21	-0.11
452	Kyungpook National University	0.34	0.38	425	-27	0.05
453	University of Catania	0.33	0.22	475	22	-0.11
454	National Chiao Tung University	0.33	0.55	379	-75	0.22
455	Kyung Hee University	0.33	0.25	468	13	-0.08
456	Wuhan University	0.33	0.42	414	-42	0.09
457	Mahidol University	0.33	0.32	448	-9	-0.01
458	Tongji University	0.32	0.22	474	16	-0.10
459	Chulalongkorn University	0.32	0.54	382	-77	0.22
460	Okayama University	0.32	0.19	481	21	-0.13
461	Ankara University	0.30	0.19	480	19	-0.10
462	Universidade de São Paulo	0.30	0.29	457	-5	-0.01
463	Sungkyunkwan University	0.29	0.32	447	-16	0.03
464	National Central University	0.29	0.29	456	-8	0.00
465	University of Science and Technology Beijing	0.29	0.44	411	-54	0.15
466	National Autonomous University of Mexico	0.29	0.25	469	3	-0.04
467	Chiba University	0.28	0.38	430	-37	0.09
468	Charles University in Prague	0.28	0.18	485	17	-0.10
469	Xi'an Jiaotong University	0.28	0.34	439	-30	0.06
470	South China University of Technology	0.27	0.79	279	-191	0.52
471	Huazhong University of Science and Technology	0.26	0.20	478	7	-0.07
472	Tianjin University	0.25	0.45	407	-65	0.20
473	Inha University	0.25	0.12	495	22	-0.13
474	Jilin University	0.24	0.69	326	-148	0.44
475	Federal University of Paraná	0.24	0.20	477	2	-0.04

Rank G8	University	Value G8 (1)	Value WoS (2)	Rank WoS (3)	Re-rankings = Rank WoS-Rank G8 (4)	(2) - (1) (5)
476	University of Ulsan	0.24	0.38	426	-50	0.14
477	Universidade Estadual Paulista	0.24	0.17	487	10	-0.07
478	China Agricultural University	0.23	0.34	437	-41	0.11
479	Tehran University of Medical Sciences	0.23	0.07	499	20	-0.16
480	Middle East Technical University	0.23	0.38	428	-52	0.15
481	Chang Gung University	0.22	0.17	488	7	-0.05
482	University of Chile	0.22	0.17	490	8	-0.05
483	Chungnam National University	0.22	0.26	466	-17	0.05
484	Federal University of São Paulo	0.22	0.14	492	8	-0.08
485	National University of La Plata	0.22	0.24	470	-15	0.02
486	Ege University	0.21	0.31	449	-37	0.10
487	Beijing Normal University	0.20	0.33	444	-43	0.13
488	Sichuan University	0.20	0.38	431	-57	0.18
489	National Yang-Ming University	0.19	0.28	463	-26	0.08
490	Konkuk University	0.19	0.38	427	-63	0.20
491	Federal University of Viçosa	0.18	0.14	491	0	-0.04
492	University of Malaya	0.17	0.22	473	-19	0.05
493	King Saud University	0.16	0.09	498	5	-0.08
494	Nihon University	0.16	0.10	497	3	-0.06
495	Gazi University	0.16	0.13	494	-1	-0.03
496	Shanghai University	0.16	0.44	409	-87	0.28
497	Northwestern Polytechnical University	0.15	0.01	500	3	-0.14
498	Hunan University	0.13	0.78	287	-211	0.66
499	Tarbiat Modares University	0.11	0.19	482	-17	0.08
500	Catholic University of Korea	0.08	0.27	465	-35	0.20
	Average	0.98	0.93			
	SD	0.55	0.55			
	CV	0.56	0.59			

Table 1. Differences in % between the top most cited articles in the G8, G6 and WoS classification systems in the dataset consisting of 3.6 million of distinct articles

	Most cited articles:		
	Top 50%	Top 10%	Top 1%
G8 vs G6	9.0%	20.4%	31.1%
G8 vs WoS	12.7%	31.7%	51.7%
G6 vs WoS	11.2%	27.0%	44.7%

Table 2.A. University ranking differences according to the *Top 1%* indicator in going from the WoS to the G8 systems

	First 100 universities (1)	Remaining 400 universities (2)	Total (1+2)
>50 positions	11	153	164
26-50	21	111	132
16-25	15	52	67
6-15	22	54	76
1-5	25	28	53
Unchanged	6	2	8
Total	100	400	100

Table 2.B. University differences in *Top 1%* values in going from the WoS to the G8 systems

	First 100 universities	400 remaining universities	WoS values - G8 values
>0.20	31	125	156
>0.10 and ≤0.20	31	116	147
>0.05 and ≤0.10	18	86	104
≤0.05	20	73	93
Total	100	400	100

Table 2.C. Main gainers and losers in the change from the WoS to the G8 system (only universities in the top 100 according to the G8 system are considered) according to the *Top 1%* indicator

University	Rank G8	Re-ranking positions	WoS _{Top 1%} - G8 _{Top 1%}
Gainers			
1 London School of Hygiene & Tropical Medicine	7	52	-1.18
2 Delft University of Technology	36	52	-0.54
3 University of Nice Sophia Antipolis	49	126	-0.69
4 Oregon State University	64	54	-0.34
5 University of Edinburgh	67	74	-0.39
6 University of Geneva	68	57	-0.32
7 University of Southampton	73	57	-0.32
8 McMaster University	75	53	-0.30
9 University of Colorado Denver	80	69	-0.34
10 Katholieke Universiteit Leuven	95	72	-0.31
11 Vrije Universiteit Brussel	98	175	-0.54
Losers			
1 Rice University	29	-26	1.49

Table 3.A. University ranking differences according to the *Top 10%* indicator in going from the WoS to the G8 systems

	First 100 universities (1)	Remaining 400 universities (2)	Total (1+2)
>50 positions	0	81	81
26-50	7	107	114
16-25	13	74	87
6-15	36	81	117
≤ 5 positions	44	57	101
Total	100	400	100

Table 3.B. University differences in *Top 10%* values in going from the WoS to the G8 systems

	First 100 universities	400 remaining universities	WoS values - G8 values
>0.20	1	16	17
>0.10 and ≤0.20	12	66	78
>0.05 and ≤0.10	27	124	151
≤0.05	60	94	254
Total	100	400	100

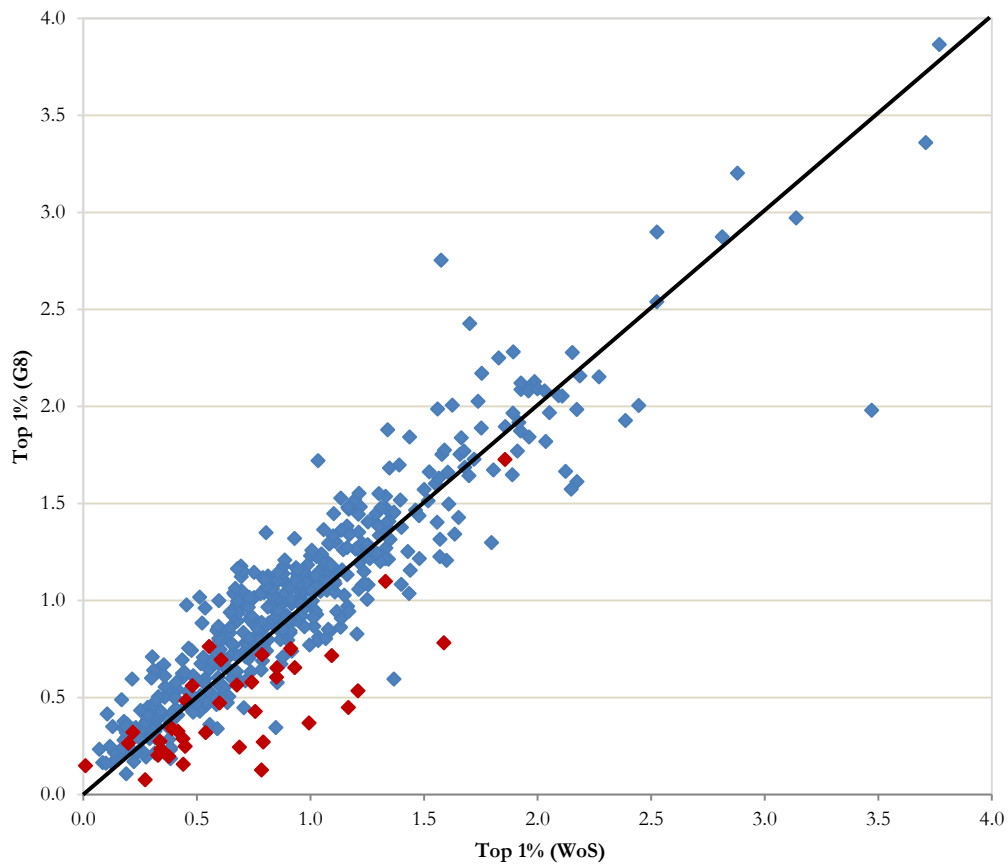


Figure 1. Scatter plot of the 500 LR universities' *Top 1%* values when we use the WoS or the G8 classification systems. Chinese universities (excluding Hong Kong) are indicated in red.