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"MULTIPLICATIVE VERSUS FRACTIONAL COUNTING METHODS FOR CO-AUTHORED PUBLICATIONS. THE CASE OF THE 500 UNIVERSITIES IN THE LEIDEN RANKING"

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Abstract

This paper studies the assignment of responsibility to the participants in the case of co-authored scientific publications. In the conceptual part, we establish that the key shortcoming of the full counting method is its incompatibility with the use of additively decomposable citation impact indicators. In the empirical part of the paper, we study the consequences of adopting the address-line fractional or multiplicative counting method. For this purpose, we use a Web of Science dataset consisting of 3.6 million articles published in the 2005-2008 period, and classified into 5,119 clusters. Our research units are the 500 universities in the 2013 edition of the CWTS Leiden Ranking. Citation impact is measured using the Mean Normalized Citation Score, and the Top 10% indicators. The main findings are the following. Firstly, although a change of counting methods alters co-authorship and citation impact patterns, cardinal differences between co-authorship rates and between citation impact values are generally small. Nevertheless, such small differences generate considerable re-rankings between universities. Secondly, the universities that are more favored by the adoption of a fractional rather than a multiplicative approach are those with a large co-authorship rate for the citation distribution as a whole, a small co-authorship rate in the upper tail of this distribution, a large citation impact performance, and a large number of solo publications.

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I. INTRODUCTION

The assignment of responsibility to the participants in the case of co-authorship has been a vexing question since the beginning of Scientometrics (see Anderson *et al.*, 1988, for an early discussion, as well as Albarrán *et al.*, 2010, Shen & Barabási, 2014, Waltman & Van Eck, 2014, and the references quoted therein). The continuous increase in co-authorship in all scientific disciplines exacerbates the problem with the passage of time.

In an important contribution, Waltman & Van Eck (2014) –hereafter WVE– focus on the comparison between the *fractional counting* and the *full counting* methods. The former assigns co-authored publications fractionally to each co-author, while the latter fully assigns co-authored publications to each co-author. WVE argue that there is a close connection between counting methods and field-normalization, that is, the correction for differences in citation practices between scientific fields. They establish that properly field-normalized results cannot be obtained with full counting. Among fractional counting variants –all of which provide proper field-normalized results– WVE advocate the address-line fractional counting.

However, WVE recall that in the *multiplicative counting* method co-authored publications are fully assigned to each co-author, like in full counting, but results are properly field-normalized, like in fractional counting (p. 41-42). Both full and multiplicative counting extends as much as necessary the citation distributions of the units of analysis in question –authors, organizations, or countries. However, under full counting the overall citation distribution is maintained equal to the citation distribution of the original set of distinct articles, while in the multiplicative approach the overall citation distribution is made equal to the union of the units' extended citation distributions.

This paper has two parts, one conceptual, and one empirical. In the conceptual part, we establish that, in our view, the key problem with full counting is its incompatibility with the use of additively decomposable citation impact indicators. In the empirical part, following WVE's recommendation (p.

42), we compare the fractional with the multiplicative approach. For this purpose, we use a Web of Science (WoS) dataset consisting of 3.6 million publications in the 2005-2008 period, the citations they receive over a five-year citation window for each year in that period, and a classification system consisting of 5,119 clusters (Ruiz-Castillo & Waltman, 2015). Our research units are the 500 universities in the 2013 edition of the CWTS Leiden Ranking (Waltman *et al.*, 2012), referred to as the LR universities. There are 2.4 million distinct articles in which at least one author belongs to one of these universities. For reasons explained in the data Section, we assign these articles to the 500 LR universities following exclusively the address-line variant of the fractional and multiplicative approaches.

In the comparison between the two approaches, we investigate three issues.

• Firstly, assume that we order universities according to the percentage of co-authored publications with respect to the total –or the co-authorship rate– in the fractional case. Of course, for any university, a move from the fractional to the multiplicative approach will tend to increase the co-authorship rate. The first question we investigate is whether this increase affects universities in a widely different manner. In other words, we investigate the importance of re-rankings when we order universities by the co-authorship rate in the multiplicative approach.

• Secondly, although changes in co-authorship patterns constitute a natural first step, we cannot stop here. We want to investigate whether the change in counting methods causes a great change in the ranking of universities by citation impact. For this purpose, we evaluate citation impact according to two commonly used indicators: the Mean Normalized Citation Score (*MNCS* hereafter), and the *Top 10%* indicator, defined as the percentage of an institution's scientific output included in the set formed by the 10% of the most highly cited publications in the world.[1]

[1] The *Top 10%* indicator is used in the influential Leiden Ranking (www.leidenranking.com), and the *SCImago Institutions Rankings* (www.scimagoir.com).

• Thirdly, given the change in co-authorship and citation impact patterns, we investigate a new issue in this debate. We want to analyze which type of university is more likely to benefit from a move from the fractional to the multiplicative counting method (or vice versa). Naturally, there are several university characteristics worth investigating. For example, we can ask whether universities with a greater co-authorship rate, a greater citation impact, or a greater number of solo articles are the gainers or losers with the change from the fractional to the multiplicative approach. To study this issue involving several variables we must use multiple regression techniques.

The rest of the paper is organized into three Sections. Section II serves two purposes: it introduces the citation impact indicators and the counting methods studied in this paper, and it clarifies the nature of the logical shortcomings precluding the use of full counting in practical applications. Section III presents the data, and the empirical results comparing the fractional and the multiplicative approaches, while Section IV discusses the results and offers some conclusions.

II. CITATION IMPACT INDICATORS AND COUNTING METHODS

II.1. Notation and citation impact indicators

Suppose we have an initial citation distribution $\boldsymbol{C} = \{c_l\}$ consisting of N distinct publications, indexed by $l = 1,\ldots, N$, where c_l is the number of citations received by publication l. A *classification system* is an assignment of publications in $\boldsymbol{C}$ to J fields, indexed by $j = 1,\ldots, J$. Let I be the number of research units, indexed by $i = 1,\ldots, I$. In this Section, the assignment of publications in $\boldsymbol{C}$ to the I research units is taken as given. Let c_{ijk} be the number of citations received by the k-th article of unit i in field j. Then $\boldsymbol{c_{ij}} = \{c_{ijk}\}$ denotes the *citation distribution of unit i in field j*, while $\boldsymbol{c_j}$ denotes the *citation distribution of field j*, that is, the union of all research units' citation distributions in that field: $\boldsymbol{c_j} = \cup_i \{\boldsymbol{c_{ij}}\}$. We assume that the assignment of publications in $\boldsymbol{C}$ to the I research units is such that the set of distributions $\boldsymbol{c_{ij}}$, $i = 1,\ldots, I$, form a partition of $\boldsymbol{c_j}$. Of course, $\boldsymbol{C} = \cup_i \cup_j \{\boldsymbol{c_{ij}}\} = \cup_j \{\boldsymbol{c_j}\}$, and the total number of articles in

the overall citation distribution is $N = \Sigma_i \Sigma_j N_{ij} = \Sigma_j N_j$, where N_{ij} is the number of articles in distribution c_{ij}, and $N_j = \Sigma_i N_{ij}$ is the total number of articles in field *j*.

In our context, where in every field *j* we have $c_j = \cup_i \{c_{ij}\}$, the evaluation of any citation distribution is done by taking into account a key characteristic of distribution c_j, say θ_j. Thus, a *citation impact indicator* is a function F defined in the product space of all citation distributions and the characteristic space, so that –given the characteristic θ_j– the expression $F_{ij} = F(c_{ij}; \theta_j)$ denotes the citation impact of unit *i* in field *j*, while $F_j = F(c_j; \theta_j)$ denotes the citation impact of field *j* as a whole. To clarify this notion, consider the following two indicators that will be used in this paper. In order to be able to compare research units of different size working in the same field, as well as research units working in different fields, both indicators are size- and scale-independent.

1. Let μ_{ij} and μ_j be the mean citation of distributions c_{ij} and c_j, respectively. The *Relative citation rate RCR,* is defined as

$$RCR_{ij} = RCR(c_{ij}; \mu_j) = \mu_{ij}/\mu_j \qquad (1)$$

In this case, $\theta_j = \mu_j$. For field *j* as a whole, $RCR_j = RCR(c_j; \mu_j) = \mu_j/\mu_j = 1$.

2. Let X_j be the set of the 10% most cited articles in citation distribution c_j, and let x_{ij} be the subset of articles in X_j corresponding to unit *i*, so that $X_j = \cup_i \{x_{ij}\}$ with x_{ij} non-empty for some *i*. If n_{ij} is the number of articles in X_{ij}, then the *Top 10% indicator T,* is defined as

$$T_{ij} = T(c_{ij}; X_j) = n_{ij}/N_{ij} \qquad (2)$$

In this case, $\theta_j = X_j$. If $n_j = \Sigma_i n_{ij}$ is the number of articles in X_j, then for field *j* as a whole, $T_j = T(c_j; X_j) = n_j/N_j = 0.10$.

II.2. The additive decomposability property[2]

The following property plays a key role in this paper. Given θ, an indicator F is said to be *additively decomposable* if for any partition of a citation distribution c into G disjoint sub-groups, indexed by $g = 1,..., G$, the citation impact of distribution c can be expressed as follows:

$$F(c; \theta) = \Sigma_g (n_g/n)F(c_g; \theta),$$

where n_g is the number of publications in sub-group g, and $n = \Sigma_g n_g$ is the number of publications in distribution c. To illustrate the usefulness of this property, consider the following two situations in which the indicator F is assumed to be size- and scale-independent.

A. Under our assumptions, in every field j the distributions c_{ij}, $i = 1,\ldots, I$, constitute a partition of c_j. If F is additively decomposable, then we can write

$$F(c_j; \theta_j), = \Sigma_i (N_{ij}/N_j)F(c_{ij}; \theta_j). \quad (3)$$

This is a very natural condition, indicating that the citation impact of field j as a whole can be expressed as the weighted average of the research units' citation impact under a common θ_j.

B. Assume that country v consists of R regions, indexed by $r = 1,\ldots, R$, and assume that the R citation distributions in field j, c_{vrj}, form a partition of the citation distribution of country v in that field, c_{vj}. If F is additively decomposable, then we can write

$$F(c_{vj}; \theta_j) = \Sigma_r (N_{vrj}/N_j)F(c_{vrj}; \theta_j), \quad (4)$$

where N_{vrj} is the number of publications in region r, so that $N_{vj} = \Sigma_r N_{vrj}$. Equation 4 indicates that the citation impact of country v in field j can be expressed as the weighted average of the regions' citation impact in field j under a common θ_j.

Finally, note the following two points. Firstly, equation 3 can be written as follows:

[2] This presentation borrows heavily from Perianes-Rodriguez & Ruiz-Castillo (2014a).

$$\Sigma_i (N_{ij}/N_j) [F(c_{ij}; \theta_j)/F(c_j; \theta_j)] = 1,$$

so that the value one can serve as a benchmark for evaluating the research units in the usual way. The same can be said of equation 4. Secondly, the two indicators introduced in expressions 1 and 2 are additively decomposable.

II.3. Counting methods

The assignment of responsibility becomes problematic when some of the N distinct articles in C are co-authored by two or more research units. Let us begin by distinguishing between the following two counting methods.

(i) In the fractional counting approach, each co-authored publication in c_j is fractionally assigned to each co-author. The weight with which a publication is assigned to a co-author indicates the share of the publication allocated to that co-author. The sum of the weights of all co-authors of a publication equals one. Let c^f_{ij} be unit i's citation distribution in field j in the fractional case, and let w_{ij} be the fractional number of publications in c^f_{ij}. Of course, for all fields j, $c_j = \cup_i \{c^f_{ij}\}$, and $N_j = \Sigma_i w_{ij}$. Consequently, $C = \cup_j \cup_i \{c^f_{ij}\}$, and $N = \Sigma_j \Sigma_i w_{ij}$.

(ii) In the full counting approach, each co-authored publication in c_j is fully assigned to each co-author. Let c^m_{ij} be unit i's citation distribution in field j in the full counting case, and let N^m_{ij} be the number of publications in c^m_{ij}. The citation distribution in each field in the full counting case, $\cup_i \{c^m_{ij}\}$, does not coincide with c_j, and the sum of publications, $N^m_j = \Sigma_i N^m_{ij}$, is typically larger than N_j. Consequently, C is not equal to the union $\cup_j \cup_i \{c^m_{ij}\}$, and $N^m = \Sigma_j \Sigma_i N^m_{ij}$, is typically larger than N.

To illustrate the problem with full counting, WVE find it convenient to distinguish between two field normalization concepts. "*Weak field normalization requires the average of the normalized citation scores of all publications in a field to be equal to one. Strong field normalization is more demanding. It requires the weighted average of*

the MNCS of all countries active in a field to be equal to one, where the weight of a country is given by its number of publications in the field." (p. 15). As shown by WVE's examples, full counting is in agreement with the idea of weak normalization, but it violates the idea of strong field normalization.

In our view, this proposal warrants the following two comments. Firstly, the weak field-normalization condition is only satisfied in the case studied by WVE, namely, the standard field-normalization procedure in which field mean citations are used as normalization factors. However, this condition need not be satisfied in any other normalization context. For example, it is not satisfied in four of the field-normalization procedures studied in Li *et al.* (2013). Secondly, quite independently of the previous point, we will presently establish that, for exhibiting the full counting shortcomings, it suffices to examine the situation in a single field prior to any normalization of raw citations scores in this or any other field. Consequently, to illustrate the problem we do not need a field-normalized citation impact indicator, as in WVE –who use the *MNCS*. It suffices to consider any additively decomposable indicator F. The reason is that, except in the trivial case in which all publications have the same number of citations, as long as $c_j \neq \cup_i \{c'''_{ij}\}$, so that the citation distributions c_{ij}, $i = 1,\ldots, I$, do not constitute a partition of c_j, we have:

$$\Sigma_i \, (N'''_{ij}/N'''_j) \, F(c'''_{ij};\, \theta_j) \neq \mathrm{F}(c_j;\, \theta_j),$$

or

$$\Sigma_i \, (N'''_{ji}/N'''_j) \, [F(c'''_{ij};\, \theta_j)/\mathrm{F}(c_j;\, \theta_j)] \neq 1.$$

In WVE's terminology, the difference $\Sigma_i \, (N'''_{ij}/N'''_j) \, [F(c'''_{ij};\, \theta_j)/\mathrm{F}(c_j;\, \theta_j)] - 1$ is the full counting bonus.[3] Naturally, in the general case with several scientific fields, the appearance of a set of full counting bonus of different size in each field only worsens the situation.

[3] In practice, as pointed out in WVE, the full counting bonus is typically positive independently of the citation impact indicator we use.

We will illustrate the logical flaw of the full counting method using the example in Table 1 (taken from Table 6 in WVE, p. 11). Rather than the *MNCS* indicator, we will choose another additively decomposable indicator, for example the *Top 50%* indicator. Under full counting, c^m_A = (3, 6, 10), and c^m_B = (1, 10), but C = (1, 3, 6, 10). The top 50% publications in C are (6, 10). Therefore, the *Top 50%* indicators in the full counting case are T^{fc}_A = 2/3, and T^{fc}_B = 1/2, so that

$$(3/5)\ (2/3) + (2/5)\ (1/2) = 3/5 = 0.6 \neq 0.5.$$

Table 1 around here

Under fractional counting the problem disappears. In this case, c^f_A = (3, 6, ½ of 10), and c^m_B = (1, ½ of 10), so that $C = c^f_A \cup c^f_B$. The top 50% publications in C are (6, 10). Therefore, T^f_A = 1.5/2.5, and T^f_B = 0.5/1.5, so that (2.5/4)(1.5/2.5) + (1.5/4)(0.5/1.5) = 2/4 = 0.5.

In the multiplicative approach, like in the full counting case, each co-authored publication in c_j is fully assigned to each co-author. Therefore, like in the full counting case, c^m_i is unit i's citation distribution in field j in the multiplicative case, and N^m_{ij} is the number of publications in c^m_{ij}. The difference is that the citation distribution in each field, c^m_j, is made equal to the union of citation distributions in all units in that field, that is, $c^m_j = \cup_i \{c^m_{ij}\}$. Likewise, the overall citation distribution, C^m, becomes $C^m = \cup_j \{c^m_j\} = \cup_j \cup_i \{c^m_{ij}\}$.

Under multiplicative counting, the compatibility with additively decomposable indicators is also restored. In the above example, c^m_A = (3, 6, 10), and c^m_B = (1, 10), but $C^m = c^m_A \cup c^m_B$ = (1, 3, 6, 10, 10). The top 50% publications in C^m are (1/2 of 6, 10, 10). Therefore, T^m_A = 1.5/3 = 1/2, and T^m_B = 1/2, so that (3/5)(1/2) + (2/5)(1/2) = 1/2 = 0.5.

In brief, full counting is incompatible with evaluating research units using additively decomposable citation impact indicators. Consequently, full counting should not be used in practice.

On the other hand, other counting methods different from the fractional and the multiplicative ones require additional information.[4] Quite apart from the fact that we do not have this information, this paper focuses solely on a comparison between the readily applicable fractional and multiplicative approaches.

III. DATA, AND CHARACERISTICS OF UNIVERSITY DISTRIBUTIONS UNDER THE FRACTIONAL AND MULTIPLICATIVE COUNTING METHODS

III.1. The data and descriptive statistics

Our dataset results from the application of the publication-level methodology introduced 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. 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 use the classification system recommended in Ruiz-Castillo & Waltman (2015), consisting of 5,119 clusters. We focus on the set of 3,614,447 distinct articles published in 2005-2008. In terms of the notation introduced in Section II.1, we have $\boldsymbol{C} = \cup_j \{c_j\} = (c_1,\ldots, c_N)$ with J = 5,119, and N = 3,614,447. Citation distributions refer to the citations received by these articles over a five-year citation window for each year in that period.

Let us focus on the 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. The distribution of this total by the number of address lines, as well as the evolution of mean normalized citations as we increase the number of address lines is in columns 1 to 3 in Table 2. For later reference, the same information for the top 10% of highly cited articles is in columns 4 to 6 in Table 2. Two points need to be emphasized. Firstly, the percentage of articles with a single address line, *solo articles* hereafter, is 30% of the total.

[4] Consider, for example, the following three alternatives in which the scientific credit is allocated (a) according to the order in which the authors appear in the publication's byline (Hagen, 2008, Zhang, 2009, and Stallings *et al.*, 2013), (b) solely to the corresponding author (Moya-Anegón *et al.*, 2013), and (c) according to the author's contribution as perceived by the scientific community (Shen & Barabási, 2014).

Interestingly, this percentage is only slightly lower in the top 10% of the distribution. Secondly, as expected, mean normalized citations steadily increase with the number of address lines in both distributions, but at a very small rate.

Table 2 around here

III.2. Counting methods

Of course, each solo article is fully assigned to the corresponding LR university in both counting methods. The number of solo articles in each university is in column 1 in Table A in the Appendix. What we need to make precise is how to assign the remaining 70% of the 2.4 million distinct articles that are co-authored by two or more institutions.

We know the total number of address lines of every publication, but we have information about the number of address lines of specific institutions only for the 500 LR that have at least 500 publications in the 2005-2008 period. Therefore, we cannot identify small-sized universities and, more importantly, key non-teaching research institutes in many countries of the world. In other words, we are restricted to working with 500 institutions, which is a number well below I –the total number of research units in the notation introduced in Section II.1. As explained in WVE, the reason is that performing a comprehensive unification of organization names is extremely time consuming and, therefore, not feasible. Consequently, it is not possible to use the organization-level fractional (or multiplicative) counting method.

The address-level fractional counting method works as follows. If a publication is co-authored by two or more LR universities, then it is assigned fractionally to all of them in proportion to the number of address lines in each case. For example, if the address list of an article contains five addresses and two of them belong to a particular university, then 0.4 of the article is assigned to this university, and only 0.2 of the article is assigned to each of the other three universities. Finally, consider a publication co-authored by an LR university and an unknown number of other institutions outside the Leiden

Ranking. Assume, for example, that the publication has four address lines, two of which correspond to the LR university. In this case, only 0.5 of the article will be assigned to the LR university. 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. Consequently, the percentage of co-authored articles decreases to 61.5%. The distribution of the 1.9 million articles among the 500 universities, as well as the percentage of co-authored articles, or the co-authorship rate, is in columns 2, and 3 in Table A in the Appendix, where universities are ordered by the co-authorship rate in column 2.

Next, we turn to the address-level multiplicative counting method. In the presence of co-authorship, each LR university with v_u address lines is assigned v_u articles. If the article has a total of address lines, v, greater than or equal to the sum $\Sigma_u v_u$ over the LR universities, then the article is multiplied v times. The total number of articles in the LR universities according to the address-level multiplicative counting method is 4,351,584, or 179.8% of the 2.4 million articles with at least one address line belonging to a LR university, and 120.4% of the 3.6 million articles published in 2005-2008. Consequently, the percentage of co-authored articles increases to 83.3%. The distribution of the 4.3 million articles among the 500 universities, as well as the co-authorship rate is in columns 4, and 5 in Table A in the Appendix.

III.3. Changes in co-authorship patterns

For any university i, let S_i, CF_i, and CM_i be the number of solo articles, and the number of co-authored articles in the fractional and the multiplicative case, so that $TF_i = S_i + CF_i$, and $TM_i = S_i + CM_i$ are the total number of articles under the two approaches in columns 2 and 4 in Table A in the Appendix. In spite of the fact that the total number of articles in the LR universities in the multiplicative case is 2.3 times greater than this number in the fractional case, the Pearson correlation

coefficient between the two measures of university size is 0.98.

In the above notation, $CRF_i = CF_i/TF_i$ and $CRM_i = CM_i/TM_i$ are the co-authorship rates under the two approaches in columns 3 and 5 in Table A. The Pearson correlation coefficient between the two variables is 0.97. However, this does not preclude that the move from the fractional to the multiplicative approach generates important differences in university co-authorship rates. We will consider two aspects of the changes induced by this move. Firstly, we study the re-rankings when universities are ordered according to the two co-authorship rates, CRF_i and CRM_i. The results are in Panel A in Table 3. Secondly, we study the cardinal differences between these rates, namely, the variable $\Delta CR_i = CRM_i - CRF_i$. The results are in Panel B in Table 3.

Table 3 around here

As observed in Panel A in Table 3, only 42 universities, or 8.4% of the total, experience small re-rankings of less than or equal to five positions in the move from the fractional to the multiplicative approach. Most universities experience intermediate re-rankings of between 6 and 25 positions (51.0%), or large re-rankings of greater than 26 positions (40.6%). The last two figures are even larger for the 100 universities with the largest co-authorship rates. On the other hand, differences in co-authorship rates are generally small: 314 universities, or 62.8% of the total, experience differences smaller than or equal to 0.05 percentage points. In brief, small differences in co-authorship rates generate relatively large re-rankings.

IV. THE CITATION IMPACT CONSEQUENCES OF ADOPTING THE TWO COUNTING METHODS

IV.1. Citation impact indicators in the all-sciences case

Changes in co-authorship rates are both expected and worth monitoring in the move from the fractional to the multiplicative counting method. However, a complete evaluation of this move requires

studying changes in citation impact. In this Section, we consider the citation performance of the LR universities in what we call the all-sciences case.

As explained in Perianes-Rodriguez & Ruiz-Castillo (2014a), given an appropriate citation indicator, there are two ways of solving the all-sciences aggregation problem. The first procedure consists of two steps. One first uses some sort of normalization procedure to make the citations of articles in different scientific fields at least approximately comparable. Then, one applies the citation indicator to each unit's normalized citation distribution. In the second procedure, the citation impact of a research unit is made equal to the average (weighted by the publication output) of the unit's citation impact in each field. When the citation procedure is the relative citation rate *RCR* introduced in Section II.1, and we use the standard field-normalization procedure where field mean citations are taken as normalization factors, then both solutions coincide and lead to the *MNCS* defined as

$$\Sigma_j (N_{ij}/N_i)\, RCR_{ij} = \Sigma_j (N_{ij}/N_i)\, (\mu_{ij}/\mu_j) = (1/N_i)\, \Sigma_j \Sigma_k\, c_{ijk}/\mu_j = M_i,$$

where $N_i = \Sigma_j N_{ij}$ is the total number of articles in university i, and c_{ijk} is the number of citations received by article k in field j in university i. The M_i values for the 500 universities according to the fractional and the multiplicative counting methods, denoted by M^F_i and M^M_i, respectively, are in columns 1 and 2 in Table B in the Appendix, where universities are ordered according to the M^F_i values.

For any other citation indicator, such as the *Top 10%* indicator *T* introduced in Section II.1, the two solutions to the all-sciences aggregation problem differ. However, using the dataset described above, Perianes-Rodriguez & Ruiz-Castillo (2014a) find that the differences between the rankings of the 500 LR universities obtained with both solutions is of a small order of magnitude.[5] In any case,

[5] In Perianes-Rodriguez & Ruiz-Castillo (2014a), articles are assigned to universities following the address-line fractional counting method described above.

since it is preferable to handle the all-sciences aggregation problem by avoiding any kind of prior normalization operation, in this paper we adopt the second solution:

$$T_i = \Sigma_j (N_{ij}/N_i)\ T_{ij} = \Sigma_j (N_{ij}/N_i)\ (n_{ij}/N_{ij}) = \Sigma_j\ n_{ij}/N_i$$ [6]

The T_i values for the 500 universities according to the fractional and the multiplicative counting methods, denoted by T^F_i and T^M_i, respectively, are in columns 4 and 6 in Table B in the Appendix.

IV.2. The comparison of university rankings

We begin with the case in which citation impact is measured in terms of the *MNCS*. Both the Pearson and the Spearman correlation coefficients between university values are 0.99. However, high correlations between university values and ranks do not preclude important differences for individual universities. In analyzing the consequences of going from the fractional to the multiplicative approach we take two aspects into account: the re-rankings that take place in such a move (from the left-hand column to column 3 in Table B in the Appendix), and the differences between the university values themselves (columns 1 and 2 in Table B). The results for both aspects are in Table 4.

Table 4 around here

Fortunately, we have a relevant instance with which to compare our results: the differences found in Table 5 in Ruiz-Castillo & Waltman (2015) in going from the university rankings according to the *MNCS* indicator using the Web of Science classification system with 236 journal subject categories, or sub-fields, and the classification system we are using in this paper with 5,119 clusters.

• Only 41 universities or 8.2% of the total –among which seven belong to the first 100– experience small re-rankings of less than or equal to five positions in the move from the fractional to the multiplicative approach. These figures are considerably smaller than in the move from the WoS classification system to our dataset. At the other extreme, 142 universities, or 28.4% of the total,

[6] This is the solution actually used in the Leiden Ranking itself (Waltman *et al.*, 2012), as well as in the SCImago ranking (Bornmann *et al.*, 2012), and in the InCites software in the Web of Science (see 'percentile in subject area' in http://incites.isiknowledge.com/common/help/h_glossary.html).

experience re-rankings of greater than 25 positions, while 168 universities, or 33.6% of the total, are in this situation in the change between classification systems.

• As far as cardinal changes are concerned, differences are more or less negligible: 86.6% of universities have differences in *MNCS* values smaller than or equal to 0.05 in the change of counting methods. This percentage is 73% among the first 100 universities. In the change between classification systems, these figures are smaller: 67.8% and 56%, respectively.

In brief, relative to the move from the WoS classification system to our dataset, differences in *MNCS* values when moving from the fractional to the multiplicative approach are small. However, these small differences give rise to rather important re-rankings of an intermediate size: almost two thirds of universities experience re-rankings of greater than five and smaller than 26 positions, a figure equal to 44.2% in the case of the change of classification systems. The situation is illustrated in Figure 1.

Figure 1 around here

Next, we consider the case in which citation impact is measured in terms of the *Top 10%* indicator. Again, both the Pearson and the Spearman correlation coefficients between university values are very high indeed: 0.99. However, in order to analyze the consequences of going from the fractional to the multiplicative approach for individual universities we take into account the re-rankings that take place in such a move (columns 5 and 7 in Table B in the Appendix), and the differences between the university values themselves (columns 4 and 6 in Table B). The results for both aspects are in Table 5 and Figure 2.

Table 5 and Figure 2 around here

The situation is very similar to what we have seen when citation impact is measured in terms of the *MNCS* indicator. On the one hand, 73.4% universities have differences in *Top 10%* values which are smaller than or equal to 0.05 (versus 86.6% in the previous case). On the other hand, these small

cardinal differences give rise to important re-rankings: 48.6% and 40.8% universities experience intermediate or large re-rankings between 6 and 25 positions or greater than 25 positions (versus 63.4% and 28.4% in the previous case).

IV.3. Regression analysis

Depending on the issue at hand, different analysts may legitimately disagree on whether the changes just analyzed are large or small. Perhaps, a majority may find these changes large enough to recommend applying both approaches in order to study the robustness of any ranking in practical applications. Be that as it may, we are all interested in learning what type of university is more likely to become a gainer or a loser in the move from the fractional to the multiplicative approach in our dataset. Our attempt to answer this question in this Sub-section relies on multiple regression methods.

The dependent variable is the difference in *MNCS* values, namely $\Delta M_i = M^M_i - M^F_i$, and the difference in *Top 10%* values, namely $\Delta T_i = T^M_i - T^F_i$, $i = 1,\ldots, 500$. We study the effect on the dependent variables of the following four explanatory variables.

1. The move from the fractional to the multiplicative approach typically entails increases in co-authorship rates. As we saw in Section III.3, small differences between these rates generate considerable re-rankings when universities are ordered by the two rates CRF_i and CRM_i. Given the high correlation between the two variables, in order to study the effect of co-authorship on citation impact differences, we include in the regressions the co-authorship rate in the multiplicative case, CRM_i. In so far as mean field-normalized citations steadily increase with the number of address lines (column 3 in Table 2), it is possible that the regression coefficient of CRM_i is positive.

2. On the other hand, like for other units of analysis, university citation distributions are typically highly skewed (Perianes-Rodriguez and Ruiz-Castillo, 2014b). Therefore, we expect universities' citation impact –however measured– to be heavily dependent on what takes place in the upper tail of their

citation distributions. As observed in column 6 in Table 2, co-authored articles have greater mean field-normalized citations than solo articles. Thus, the conjecture is that universities with a large share of highly cited co-authored articles are the ones that most benefit from a change from the fractional to the multiplicative approach. Given the high correlation between the co-authorship rate among the top 10% of highly cited articles (correlation coefficient equal to 0.96), we include in the analysis the rate in the multiplicative case, CRM^T_i.

3. Consider, for example, the case in which citation impact is measured in terms of the *MNCS*. An interesting question is whether the best (worse) universities according, for example, to M^F_i, are the most benefited by the move from the fractional to the multiplicative approach. To study this question, we will discretize M^F_i by defining two dummy variables identifying high and low ranked universities. After some experimentation, we find it useful to define the following two variables:

$DH_i = 1$ if $M^F_i \geq 1.11$

0 otherwise;

$DL_i = 1$ if $M^F_i < 0.90$

0 otherwise.

In this case, there are 150 and 157 universities with $DH_i = 1$ and $DL_i = 1$, respectively. The remaining 193 universities with $DH_i = 0$ and $DL_i = 0$ have intermediate M^F_i values. Similarly, when citation impact is measured in terms of the *Top 10%* indicator we define

$DH_i = 1$ if $M^F_i \geq 1.15$

0 otherwise;

$DL_i = 1$ if $M^F_i < 0.81$

0 otherwise.

In this case, there are 147 universities in the best and worse groups, whereas the remaining 206 universities have intermediate M^F_i values.

4. Finally, we would like to investigate whether large or small universities benefit the most from the move from the fractional to the multiplicative approach. Since the total number of articles depends very much on the counting method used, an alternative is to approximate university size by the number of solo articles S_i, which is a variable of interest in its own right, and whose correlation coefficient with TF_i and TM_i are 0.95 and 0.86, respectively.

In order to test for non-linearities, we include a pair of quadratic terms $(CRM_i)^2$ and $(CRM^T_i)^2$. The final regressions are:

$$\Delta M_i = \alpha + \beta_1 CRM_i + \beta_2 (CRM_i)^2 + \beta_3 CRM^T_i + \beta_4 (CRM^T_i)^2 + \beta_5 DH_i + \beta_6 DL_i + \beta_7 S_i,$$

$$\Delta T_i = \alpha' + \beta'_1 CRM_i + \beta'_2 (CRM_i)^2 + \beta'_3 CRM^T_i + \beta'_4 (CRM^T_i)^2 + \beta'_5 DH_i + \beta'_6 DL_i + \beta'_7 S_i,$$

Descriptive statistics, and regression results are presented in Table 6. They warrant the following four comments.

Table 6 around here

1. It is observed that 12 out of 14 regression coefficients for the seven explanatory variables are statistically significant. Furthermore, the adjusted R^2 coefficients for the two regressions, 0.39 and 0.49, indicate that the goodness of fit for the two models is acceptable.

2. The marginal effects of the variables CRM_i and CRM^T_i, evaluated at the corresponding sample means, are presented in Panel C in Table 6. The results are very interesting. On the one hand, the co-authorship rate CRM_i has a negative effect on both dependent variables. This means that the move from the fractional to the multiplicative approach penalizes universities with a high co-authorship rate

for the distribution as a whole. On the contrary, this move benefits universities with a high co-authorship rate CRM^T_i in the upper tail of the citation distribution.

3. Universities have been classified into three groups according to their *MNCS* and *Top 10%* values. Our results clearly indicate that the worse the citation performance of a university is, the greater is the benefit for this university of a move from the fractional to the multiplicative counting method. Of course, it could be argued that this partition of the set of universities into three groups is a useful but arbitrary procedure. This is particularly the case in a situation in which universities' citation impact values are very close to each other, so that it is difficult to assert, for example, that one university is among the best and the next one in the ranking is among the intermediate ones. Fortunately, it is possible to study the appropriateness of the above definitions in a sensitivity analysis that accentuates the differences between the three groups by eliminating a number of intermediate universities which are close to the best ones, as well as a number of intermediate universities which are close to the worst ones.[7] To save space, the regression results are presented in Table C in the Appendix. It suffices to say that, except for their smaller statistical significance in the *Top 10%* case, the regression coefficients for all variables and, specifically for the variables DH_i and DL_i, for the remaining 424 and 410 universities are very close to what we obtained for the 500 universities. This establishes the robustness of the effect of the university citation impact on both dependent variables.

4. The S_i variable has a negative regression coefficient in both regressions, but this coefficient is only significant in the *Top 10%* case. This indicates that the greater the number of solo articles is, the smaller is the probability that a university has a greater citation impact in the multiplicative case. It should be noted that, judging from the size of regression coefficients, this effect is small.

V. SUMMARY AND DISCUSSION

[7] In the *MNCS* case, we eliminate 38 universities with M^F_i in the interval [1.07, 1.11), and another 38 with M^F_i in the interval [0.90, 0.95), whereas in the *Top 10%* case, we eliminate 46 universities with M^F_i in the interval [1.08, 1.15), and 44 with M^F_i in the interval [0.81, 0.89).

The attribution of responsibility for co-authored publications poses a severe evaluation problem at all levels of analysis: authors; organizations, such as research groups, university departments, or the corresponding divisions in research institutes, and geographical areas, such as regions, countries, or wider aggregates such as the European Union.

At a conceptual level, this paper has clarified that the logical shortcomings of the full counting method are quite independent of the field-normalization issue. The problem appears, even in a single scientific field, as long as we use citation impact indicators that are additively decomposable. However, the problem disappears as soon as the overall citation distribution in each field is made equal to the union of the extended citation distributions of the research units working in the field in question, as it is done in the multiplicative counting method.

Once full counting is eliminated from contention, we can focus on the two alternatives which are readily applicable with a minimum of information: the fractional and the multiplicative counting methods. A preliminary question should be clarified at the outset. It is obvious that, relative to the solo publications, adopting the multiplicative approach inflates the scientific impact of publications with multiple authors. But adopting the fractional approach diminishes the scientific impact of such publications. In WVE's words "*the disadvantage of multiplicative counting is that publications do not have the same weight in the calculation of field-normalized indicators*" (p. 42). Others will claim that the disadvantage of fractional counting is that it penalizes co-authored publications in field-normalized calculations. *A priori*, we do not find reasons to prefer one bias to the other before or after field-normalization.

Using a large WoS dataset, the rest of the paper has investigated the empirical consequences of adopting the two approaches in the particular case of 500 LR universities. Among other possible alternatives, the available data only allows us to use the fractional and multiplicative counting methods of the address lines variety. Nevertheless, it is hoped that a better understanding of changes in co-authorship and citation impact patterns, as well as the type of universities most affected by a change in

counting methods might prove helpful for practitioners who must choose between the two alternative methodologies.

Of course, co-authorship and citation impact patterns are changed when we move from a fractional to a multiplicative approach (and vice versa). The question is whether these changes are large or small. Our first finding is that cardinal differences between co-authorship rates, *MNCS* values, and *Top 10%* values are rather small. However, these small differences generate considerable re-rankings between universities. In brief, from a cardinal point of view, a move from a fractional to a multiplicative approach does not cause dramatic differences in co-authorship and citation impact patterns.

Nevertheless, the choice between the two approaches may well depend on which universities end up being gainers or losers in this move. Our second finding is that, *ceteris paribus*, the gainers are characterized by (i) a low co-authorship rate for citation distributions as a whole, but a high co-authorship rate in the upper tail of these distributions; (ii) a low citation impact performance, and (iii) a small number of solo articles. Do we want to benefit or to penalize universities with these characteristics? In the former case, we should use the multiplicative approach, whereas in the latter case we should use the fractional approach. On our part, we do not have a clear preference in this respect.

Of course, it would be very convenient to extend the methods of analysis used in this paper to other datasets, other types of research units, as well as other variants of counting methods based at the organization or the country level rather than the address line. However, if forced to choose between the two approaches at this point, then we do prefer the multiplicative alternative on the following grounds. As pointed out eloquently by WVE, at a low level of aggregation multiplicative counting is in agreement with the intuitive idea that "*all publications of a researcher or a research group should be considered of equal importance*" (p. 41). At a high aggregate level, such as countries or organizations, WVE consider absolutely essential to use fractional counting because, as they exhibit in their examples, "*At this level,*

there is a serious risk of misinterpretation of full counting results" (p. 40). However, as we have established in this paper, no such risk affects in the least the multiplicative approach. Thus, in our opinion, all publications of a university or a country should be considered of equal importance regardless of the number of co-authors.

Naturally, others may think differently. Therefore, in practical applications at every aggregation level it seems sensible to study the robustness of the results achieved with both approaches. For example, this is exactly what we do when studying the entire university citation distributions using this same dataset (Perianes-Rodriguez & Ruiz-Castillo, 2014b). Interestingly enough, we find that the key result concerning the high skewness and the strong similarity between university citation distributions is independent of the counting method used.

Before finishing, we wish to make two remarks. The first comment is that having additional information concerning the "true" responsibility of each unit in co-authored publications would not necessarily solve the problem we have faced in this paper. Consider the possibility that all journals demand from the authors of each publication a statement indicating who did what in the manner actually done in PLoS ONE. Assume, for example, that we have information on who had the idea, who did the work, who did the analysis, and who wrote each paper. Assume that, on the basis of that information, it can be established that one of two authors is responsible for 2/3 of the article. Under a fractional approach the solution is to assign 2/3 to one author and 1/3 to the other. But this is only if we decide to treat each coauthored publication, independently of the number of authors, as equal to one solo publication. Given that the percentage of solo articles has been decreasing for a long period of time, one may not want to stop here. In this case, from a multiplicative point of view it would be possible to count fully two publications, assigning 4/3 to one author, and 2/3 to the other, or to assign one publication to the first author and only ½ to the second author. The conclusion is that we must address two issues: how to assign the responsibility of a co-author publication to its authors, and how

to establish the relationship between one solo article and a co-authored publication with a given number of authors. Beyond a pure evaluation perspective, the second issue is linked to policy considerations.

The second remark arises also from the distinction between the evaluation of scientific publications' citation impact and the research policy perspective as practiced, for example, in the European Union (EU hereafter) where there are programs clearly favoring co-authorship between nationals from different EU countries. This policy may be a response to the decline of the solo article, as pointed our above. On the other hand, given the relation between number of co-authors and mean citations exhibited in Table 2, this policy might be justified for the incentives it provides for achieving a greater citation impact. Finally, another possible justification is the desire to strengthen the EU cohesion by providing incentives for collaborating across EU countries. Be that as it may, in so far as this policy favors co-authorship, it is consistent with an evaluation strategy that uses the multiplicative counting method.

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APPENDIX

Table A. The distribution of the total number of articles, and the co-authorship rate in the 500 LR universities according to the fractional and the multiplicative counting methods (universities are ordered by the co-authorship rate in the fractional case)

			Fractional		Multiplicative		
Rank CF_i/TF_i	University	Solo papers	TF_i	CF_i/TF_i	TM_i	CM_i/TM_i	Rank CM_i/TM_i
		(1)	(2)	(3)	(4)	(5)	(6)
1	Natl Yang-Ming Univ	135	1,896	0.93	7,437	0.98	208
2	Univ Eastern Finland	216	1,523	0.86	5,229	0.96	314
3	Univ Lübeck	198	1,217	0.84	4,014	0.95	382
4	Paris Descartes Univ	558	2,832	0.80	9,825	0.94	146
5	Montpellier 1 Univ	223	1,093	0.80	3,393	0.93	428
6	Humboldt-Univ Berlin	986	4,797	0.79	14,721	0.93	67
7	Mahidol Univ	361	1,653	0.78	4,546	0.92	345
8	Paris Diderot Univ	588	2,662	0.78	8,785	0.93	175
9	Karolinska Inst	1,527	6,896	0.78	20,382	0.93	36
10	Freie Univ Berlin	1,024	4,559	0.78	13,739	0.93	84
11	Univ Bordeaux Segalen	330	1,434	0.77	4,207	0.92	366
12	Maastricht Univ	808	3,283	0.75	9,560	0.92	153
13	Harvard Univ	6,623	26,869	0.75	82,926	0.92	1
14	Baylor Coll Med	1,170	4,743	0.75	14,136	0.92	77
15	Chonbuk Natl Univ	327	1,325	0.75	3,394	0.90	427
16	Univ Turku	573	2,309	0.75	7,142	0.92	218
17	Univ Lisbon	386	1,553	0.75	4,014	0.90	382
18	Univ Colorado - Denver	990	3,967	0.75	11,706	0.92	111
19	Univ Calif - San Francisco	2,222	8,758	0.75	26,051	0.91	12
20	Univ Pavia	530	2,082	0.75	5,746	0.91	287
21	Natl Taiwan Univ	2,147	8,403	0.74	23,012	0.91	24
22	Univ Ferrara	364	1,421	0.74	4,315	0.92	360
23	Charles Univ Prague	949	3,688	0.74	10,320	0.91	132
24	Tehran Univ Med Sci	278	1,076	0.74	2,799	0.90	470
25	VU Univ Amsterdam	1,355	5,190	0.74	14,428	0.91	72
26	Kyung Hee Univ	380	1,453	0.74	3,764	0.90	404
27	Pusan Natl Univ	574	2,182	0.74	5,425	0.89	298
28	Chonnam Natl Univ	486	1,842	0.74	4,822	0.90	328
29	Erasmus Univ Rotterdam	1,353	5,117	0.74	14,287	0.91	74
30	Univ Helsinki	1,657	6,246	0.73	18,664	0.91	46
31	Innsbruck Med Univ	402	1,507	0.73	4,150	0.90	373
32	Univ Oslo	1,398	5,235	0.73	14,847	0.91	66
33	Univ Bergen	680	2,523	0.73	7,367	0.91	210
34	Tokyo Med & Dent Univ	444	1,636	0.73	4,452	0.90	353
35	Chang Gung Univ	519	1,909	0.73	5,396	0.90	301
36	Univ Trieste	333	1,216	0.73	3,761	0.91	405
37	London Sch Hyg & Trop Med	350	1,276	0.73	3,542	0.90	416
38	Ewha Womans Univ	320	1,161	0.72	2,984	0.89	458
39	Univ Oulu	507	1,837	0.72	5,270	0.90	310
40	Univ Pierre & Marie Curie	1,837	6,653	0.72	19,023	0.90	43
41	Univ Texas-Hlth Sci Ctr S Antonio	168	603	0.72	1,740	0.90	495
42	Univ Lausanne	765	2,681	0.71	7,273	0.89	215
43	Med Univ Wien	855	2,991	0.71	8,279	0.90	188
44	Univ Alabama - Birmingham	1,311	4,578	0.71	13,250	0.90	90
45	Yeshiva Univ	835	2,915	0.71	8,169	0.90	189

Rank CF_i/TF_i	University	Solo papers	Fractional		Multiplicative		
			TF_i	CF_i/TF_i	TM_i	CM_i/TM_i	Rank CM_i/TM_i
		(1)	(2)	(3)	(4)	(5)	(6)
46	Univ Roma Tor Vergata	678	2,366	0.71	6,300	0.89	259
47	Univ Porto	827	2,863	0.71	7,293	0.89	213
48	Chungnam Natl Univ	416	1,433	0.71	3,406	0.88	425
49	Univ Ulsan	477	1,635	0.71	4,268	0.89	361
50	Seoul Natl Univ	2,787	9,544	0.71	24,000	0.88	18
51	Univ Nova Lisboa	377	1,290	0.71	3,006	0.87	454
52	Radboud Univ Nijmegen	1,441	4,906	0.71	13,106	0.89	94
53	Hannover Med Sch	518	1,752	0.70	4,643	0.89	341
54	Univ Aveiro	504	1,704	0.70	3,849	0.87	397
55	Univ Milan	1,799	6,082	0.70	16,360	0.89	54
56	Univ Amsterdam	1,881	6,336	0.70	16,880	0.89	53
57	Indiana Univ-Purdue	1,080	3,636	0.70	9,961	0.89	143
58	Case Western Reserve Univ	1,548	5,210	0.70	14,090	0.89	79
59	Univ Florence	1,165	3,890	0.70	9,960	0.88	144
60	Univ Southern Denmark	553	1,839	0.70	4,662	0.88	338
61	Leiden Univ	1,478	4,893	0.70	12,934	0.89	97
62	Univ Maryland - Baltimore	1,093	3,615	0.70	9,459	0.88	157
63	Univ Milan Bicocca	248	817	0.70	2,170	0.89	487
64	Univ Claude Bernard Lyon 1	1,081	3,553	0.70	9,401	0.89	159
65	Univ Pittsburgh	3,058	9,971	0.69	27,602	0.89	11
66	Univ Chile	594	1,935	0.69	4,623	0.87	342
67	Univ Copenhagen	2,384	7,765	0.69	20,114	0.88	38
68	Johns Hopkins Univ	3,965	12,894	0.69	36,067	0.89	3
69	Univ Barcelona	1,713	5,558	0.69	14,146	0.88	76
70	Univ Autónoma Barcelona	1,278	4,139	0.69	10,601	0.88	124
71	Univ Padova	1,552	5,023	0.69	13,212	0.88	92
72	Aarhus Univ	1,670	5,391	0.69	13,793	0.88	83
73	Univ Napels Federico II	1,237	3,984	0.69	10,510	0.88	127
74	Med Coll Wisconsin	637	2,040	0.69	5,414	0.88	299
75	Univ Paris-Sud 11	1,430	4,559	0.69	11,918	0.88	109
76	Joseph Fourier Univ	880	2,804	0.69	7,349	0.88	211
77	Univ Antwerp	755	2,402	0.69	6,066	0.88	268
78	Univ Modena & Reggio Emilia	507	1,610	0.69	3,969	0.87	392
79	Univ Paris-Est Créteil	279	884	0.68	2,431	0.89	482
80	Univ Toronto	5,146	16,287	0.68	44,951	0.89	2
81	Aix-Marseille Univ	1,086	3,429	0.68	8,861	0.88	172
82	Univ Torino	1,078	3,403	0.68	9,312	0.88	163
83	Sapienza Univ Roma	2,044	6,444	0.68	16,916	0.88	52
84	Fed Univ São Paulo	573	1,806	0.68	4,252	0.87	362
85	Univ Cattolica Sacro Cuore	501	1,576	0.68	4,010	0.88	384
86	Oregon Hlth & Sci Univ	670	2,108	0.68	5,661	0.88	291
87	Vanderbilt Univ	1,959	6,161	0.68	16,963	0.88	51
88	Univ Texas - Medical Branch	757	2,376	0.68	5,822	0.87	283
89	Fed Univ Rio Grande Sul	815	2,556	0.68	6,027	0.86	273
90	Konkuk Univ	395	1,239	0.68	3,017	0.87	451
91	Univ Fed Minas Gerais	646	2,020	0.68	4,697	0.86	336
92	Univ Parma	558	1,741	0.68	4,178	0.87	369
93	Boston Univ	1,741	5,410	0.68	14,945	0.88	64
94	Fed Univ Viçosa	163	506	0.68	1,079	0.85	500
95	Emory Univ	1,848	5,732	0.68	14,899	0.88	65
96	Univ Groningen	1,746	5,405	0.68	13,468	0.87	87

Rank CF_i/TF_i	University	Solo papers	Fractional		Multiplicative		
			TF_i	CF_i/TF_i	TM_i	CM_i/TM_i	Rank CM_i/TM_i
		(1)	(2)	(3)	(4)	(5)	(6)
97	Fed Univ Paraná	298	921	0.68	2,109	0.86	489
98	Univ Siena	590	1,818	0.68	4,433	0.87	354
99	Univ Montréal	1,560	4,790	0.67	12,552	0.88	103
100	Univ Calif - Los Angeles	4,328	13,267	0.67	35,960	0.88	4
101	Utrecht Univ	2,436	7,464	0.67	18,379	0.87	47
102	Korea Univ	1,232	3,772	0.67	8,981	0.86	168
103	Wageningen Univ & Res Ctr	1,171	3,570	0.67	8,075	0.85	193
104	Paul Sabatier Univ	1,201	3,659	0.67	8,884	0.86	170
105	Columbia Univ	3,505	10,666	0.67	28,483	0.88	9
106	Univ N Carolina - Chapel Hill	2,655	8,073	0.67	21,237	0.87	32
107	Univ Texas - SW Med Ctr	398	1,206	0.67	3,176	0.87	439
108	Univ Belgrade	739	2,231	0.67	4,966	0.85	322
109	Yonsei Univ	1,749	5,279	0.67	12,657	0.86	101
110	Univ Gothenburg	1,392	4,201	0.67	10,348	0.87	131
111	Univ Coimbra	559	1,685	0.67	3,979	0.86	389
112	Virginia Commonwealth Univ	934	2,807	0.67	6,946	0.87	231
113	Nagoya Univ	1,928	5,776	0.67	14,133	0.86	78
114	Univ Cincinnati	1,634	4,894	0.67	13,114	0.88	93
115	Univ Libre Bruxelles	838	2,499	0.66	6,229	0.87	261
116	Fed Univ Rio de Janeiro	1,083	3,222	0.66	7,336	0.85	212
117	Univ Bari Aldo Moro	729	2,163	0.66	5,586	0.87	296
118	Univ Strasbourg	1,050	3,102	0.66	7,643	0.86	202
119	Tulane Univ	605	1,785	0.66	4,318	0.86	358
120	Univ Montpellier 2	718	2,116	0.66	4,838	0.85	327
121	Univ Washington - Seattle	4,253	12,523	0.66	32,726	0.87	7
122	Univ Estadual Paulista	879	2,586	0.66	5,778	0.85	285
123	Kobe Univ	864	2,540	0.66	5,872	0.85	280
124	Univ Genoa	877	2,574	0.66	6,922	0.87	232
125	Univ Liège	797	2,334	0.66	5,659	0.86	292
126	Tufts Univ	1,139	3,334	0.66	8,609	0.87	181
127	Univ Catholique Louvain	979	2,863	0.66	6,966	0.86	229
128	Kiel Univ	913	2,669	0.66	6,951	0.87	230
129	Umeå Univ	837	2,446	0.66	6,020	0.86	274
130	Univ Nacl La Plata	480	1,402	0.66	3,120	0.85	441
131	Catholic Univ Korea	419	1,224	0.66	3,002	0.86	455
132	Laval Univ	1,240	3,614	0.66	8,409	0.85	184
133	Pontificia Univ Católica Chile	402	1,169	0.66	2,757	0.85	471
134	Chulalongkorn Univ	587	1,707	0.66	3,790	0.85	401
135	Sungkyunkwan Univ	1,327	3,842	0.65	9,466	0.86	156
136	Icahn Sch Med Mt Sinai	1,016	2,941	0.65	7,631	0.87	203
137	Duke Univ	3,128	9,018	0.65	23,450	0.87	22
138	Univ Melbourne	2,531	7,279	0.65	17,828	0.86	48
139	Swed Univ Agr Sci	639	1,835	0.65	3,992	0.84	387
140	Univ Zurich	1,972	5,636	0.65	13,939	0.86	80
141	Kyushu Univ	2,240	6,392	0.65	14,462	0.85	71
142	Washington Univ - St Louis	2,691	7,676	0.65	19,539	0.86	40
143	Univ Calif - San Diego	3,505	9,989	0.65	25,093	0.86	14
144	Univ Valencia	1,260	3,588	0.65	8,524	0.85	183
145	Univ Nantes	492	1,398	0.65	3,533	0.86	417
146	Xiamen Univ	561	1,594	0.65	3,173	0.82	440
147	Wake Forest Univ	910	2,580	0.65	6,797	0.87	239

Rank CF_i/TF_i	University	Solo papers	Fractional		Multiplicative		
			TF_i	CF_i/TF_i	TM_i	CM_i/TM_i	Rank CM_i/TM_i
		(1)	(2)	(3)	(4)	(5)	(6)
148	Chiba Univ	947	2,678	0.65	6,334	0.85	258
149	Univ Tennessee - Knoxville	1,540	4,346	0.65	10,493	0.85	128
150	Univ Rennes 1	707	1,993	0.65	4,528	0.84	347
151	Yale Univ	3,084	8,673	0.64	22,010	0.86	28
152	Univ Coll London	3,606	10,138	0.64	24,870	0.86	15
153	Univ Hamburg	1,241	3,483	0.64	8,582	0.86	182
154	Tel Aviv Univ	2,345	6,571	0.64	15,582	0.85	59
155	Univ Med & Dent New Jersey	1,068	2,991	0.64	7,218	0.85	216
156	Univ Vienna	1,195	3,346	0.64	7,818	0.85	200
157	Istanbul Univ	983	2,739	0.64	6,187	0.84	263
158	McGill Univ	3,047	8,491	0.64	21,806	0.86	30
159	Univ Geneva	1,416	3,945	0.64	9,841	0.86	145
160	Univ Adelaide	1,068	2,975	0.64	6,978	0.85	227
161	Natl & Kapodistrian Univ Athens	1,959	5,454	0.64	12,851	0.85	98
162	Brown Univ	1,395	3,875	0.64	9,478	0.85	154
163	Univ So Calif	2,343	6,507	0.64	15,800	0.85	58
164	Univ Leipzig	1,050	2,915	0.64	6,853	0.85	236
165	Univ Duisburg-Essen	959	2,658	0.64	6,210	0.85	262
166	Univ Penn	4,132	11,439	0.64	28,707	0.86	8
167	St Petersburg State Univ	322	890	0.64	1,959	0.84	492
168	Univ Colorado - Boulder	1,571	4,336	0.64	10,216	0.85	135
169	Univ Tokyo	5,302	14,623	0.64	34,858	0.85	5
170	Univ Burgundy	476	1,311	0.64	3,043	0.84	448
171	Univ Perugia	656	1,804	0.64	4,585	0.86	343
172	Univ Catania	635	1,745	0.64	4,141	0.85	376
173	Univ Bern	1,325	3,641	0.64	8,715	0.85	179
174	Univ Louisville	883	2,420	0.64	5,884	0.85	279
175	Univ São Paulo	3,902	10,690	0.63	23,611	0.83	21
176	Hebrew Univ Jerusalem	2,044	5,597	0.63	12,729	0.84	100
177	Univ Tsukuba	1,248	3,415	0.63	8,165	0.85	190
178	Ben-Gurion Univ Negev	1,297	3,549	0.63	7,972	0.84	194
179	Univ Tübingen	1,561	4,266	0.63	10,246	0.85	134
180	Uppsala Univ	1,799	4,912	0.63	11,608	0.85	113
181	Lomonosov Moscow State Univ	1,041	2,841	0.63	6,371	0.84	257
182	Univ Iowa	2,110	5,751	0.63	14,264	0.85	75
183	Univ Chicago	2,254	6,134	0.63	15,334	0.85	61
184	Heidelberg Univ	2,177	5,913	0.63	14,654	0.85	69
185	Univ Basel	1,228	3,334	0.63	8,083	0.85	192
186	Wayne State Univ	1,399	3,789	0.63	9,580	0.85	152
187	Natl Autonomous Univ Mexico	1,915	5,182	0.63	11,075	0.83	118
188	Fudan Univ	1,878	5,077	0.63	10,535	0.82	126
189	Tech Univ Dresden	1,098	2,965	0.63	6,975	0.84	228
190	Univ Fed Santa Catarina	443	1,194	0.63	2,457	0.82	481
191	Univ Münster	1,398	3,760	0.63	8,834	0.84	173
192	Hacettepe Univ	1,022	2,746	0.63	5,935	0.83	276
193	Med Univ S Carolina	866	2,326	0.63	5,642	0.85	293
194	Vrije Univ Brussel	695	1,866	0.63	4,410	0.84	355
195	Univ Michigan	5,325	14,286	0.63	34,597	0.85	6
196	Univ Pisa	1,393	3,735	0.63	8,973	0.84	169
197	Giessen Univ	756	2,026	0.63	4,817	0.84	329
198	Chinese Univ Hong Kong	1,737	4,652	0.63	10,148	0.83	140

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			TF_i	CF_i/TF_i	TM_i	CM_i/TM_i	Rank CM_i/TM_i
		(1)	(2)	(3)	(4)	(5)	(6)
199	Univ Nice Sophia Antipolis	463	1,238	0.63	2,941	0.84	462
200	Univ Rochester	1,681	4,490	0.63	11,104	0.85	117
201	Univ Zagreb	764	2,039	0.63	4,528	0.83	347
202	Univ Calif - Davis	3,612	9,627	0.62	22,208	0.84	27
203	Peking Univ	2,403	6,392	0.62	13,642	0.82	86
204	Northwestern Univ	3,040	8,080	0.62	19,520	0.84	41
205	Gutenberg Univ Mainz	1,113	2,957	0.62	7,119	0.84	219
206	Kyungpook Natl Univ	800	2,123	0.62	5,265	0.85	311
207	Katholieke Univ Leuven	3,202	8,495	0.62	19,654	0.84	39
208	Univ Autónoma Madrid	1,379	3,653	0.62	8,355	0.83	186
209	Univ Florida	3,965	10,500	0.62	23,994	0.83	19
210	Univ Buenos Aires	1,166	3,087	0.62	6,762	0.83	240
211	Sun Yat-sen Univ	1,275	3,373	0.62	7,067	0.82	224
212	Dartmouth Coll	741	1,959	0.62	4,652	0.84	340
213	Thomas Jefferson Univ	803	2,122	0.62	5,145	0.84	318
214	King's Coll London	1,884	4,978	0.62	11,583	0.84	114
215	Univ Western Australia	1,402	3,704	0.62	8,343	0.83	187
216	Norwegian Univ Sci & Technol	1,087	2,870	0.62	6,408	0.83	256
217	Henri Poincaré Univ	684	1,804	0.62	4,169	0.84	370
218	NYU	2,413	6,364	0.62	14,959	0.84	63
219	Linköping Univ	909	2,393	0.62	5,324	0.83	307
220	Philipps-Univ Marburg	880	2,315	0.62	5,345	0.84	304
221	Michigan State Univ	2,254	5,923	0.62	13,445	0.83	88
222	Univ Massachusetts Med Sch	712	1,870	0.62	4,532	0.84	346
223	Univ Miami - Miami	1,533	4,026	0.62	9,724	0.84	149
224	Hanyang Univ	1,149	3,015	0.62	6,455	0.82	255
225	Ankara Univ	776	2,035	0.62	4,316	0.82	359
226	von-Guericke Univ Magdeburg	596	1,563	0.62	3,533	0.83	417
227	Nanjing Univ	1,771	4,638	0.62	9,188	0.81	165
228	Maximilians-Univ München	2,430	6,362	0.62	15,170	0.84	62
229	Univ Aberdeen	1,032	2,700	0.62	6,043	0.83	270
230	Lund Univ	2,609	6,826	0.62	15,927	0.84	57
231	Nihon Univ	809	2,115	0.62	4,801	0.83	331
232	Flinders Univ	454	1,183	0.62	2,698	0.83	474
233	Dalhousie Univ	1,166	3,037	0.62	6,909	0.83	233
234	Univ Ulm	894	2,325	0.62	5,404	0.83	300
235	Friedrich Schiller Univ Jena	1,034	2,689	0.62	5,915	0.83	277
236	Univ Tasmania	492	1,279	0.62	2,839	0.83	467
237	Univ Glasgow	1,626	4,220	0.61	9,773	0.83	148
238	Univ Bologna	2,172	5,637	0.61	13,045	0.83	96
239	Univ Queensland	2,588	6,715	0.61	14,687	0.82	68
240	Univ Hong Kong	2,090	5,421	0.61	11,952	0.83	108
241	Univ New Mexico	1,072	2,780	0.61	6,737	0.84	241
242	Stanford Univ	4,605	11,937	0.61	28,299	0.84	10
243	Univ Cologne	1,143	2,959	0.61	7,275	0.84	214
244	Rice Univ	805	2,082	0.61	4,709	0.83	335
245	Univ Bonn	1,503	3,884	0.61	9,367	0.84	160
246	Univ Freiburg	1,441	3,720	0.61	8,654	0.83	180
247	Univ Arizona	2,496	6,435	0.61	15,498	0.84	60
248	Univ Maryland - College Park	2,242	5,750	0.61	13,051	0.83	95
249	Univ Oklahoma	1,196	3,060	0.61	7,108	0.83	220

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			TF_i	CF_i/TF_i	TM_i	CM_i/TM_i	Rank CM_i/TM_i
		(1)	(2)	(3)	(4)	(5)	(6)
250	ParisTech - École Polytech	506	1,294	0.61	3,113	0.84	444
251	Gazi Univ	779	1,991	0.61	4,103	0.81	379
252	Univ Cape Town	771	1,970	0.61	4,572	0.83	344
253	Univ Liverpool	1,479	3,779	0.61	8,813	0.83	174
254	Univ Rostock	659	1,682	0.61	3,811	0.83	398
255	Univ Calif - Santa Barbara	1,644	4,192	0.61	9,328	0.82	162
256	Tohoku Univ	3,647	9,299	0.61	20,697	0.82	35
257	Complutense Univ	1,771	4,515	0.61	9,786	0.82	147
258	Tech Univ München	1,837	4,682	0.61	10,601	0.83	124
259	Hiroshima Univ	1,369	3,488	0.61	7,897	0.83	198
260	Ohio State Univ	3,668	9,339	0.61	22,002	0.83	29
261	Univ Coll Cork	673	1,713	0.61	3,614	0.81	415
262	Shanghai Univ	637	1,621	0.61	3,073	0.79	446
263	Univ Kansas	1,310	3,322	0.61	7,558	0.83	206
264	Univ Hawaii - Manoa	1,082	2,743	0.61	6,498	0.83	254
265	Iowa State Univ	1,804	4,560	0.60	10,150	0.82	139
266	Imperial Coll London	3,612	9,125	0.60	21,023	0.83	33
267	Univ Western Ontario	1,840	4,647	0.60	10,855	0.83	121
268	Univ Manitoba	1,195	3,016	0.60	6,882	0.83	234
269	Univ Mississippi	679	1,709	0.60	4,052	0.83	381
270	Univ Minnesota - Twin Cities	4,212	10,591	0.60	24,108	0.83	17
271	Univ British Columbia	3,895	9,777	0.60	22,818	0.83	25
272	Univ Göttingen	1,453	3,647	0.60	8,096	0.82	191
273	Tech Univ Lisbon	935	2,338	0.60	4,902	0.81	325
274	Monash Univ	1,961	4,902	0.60	10,762	0.82	123
275	Univ S Florida - Tampa	1,195	2,986	0.60	6,809	0.82	238
276	Univ Vermont	735	1,836	0.60	4,201	0.83	367
277	Univ Sydney	2,982	7,449	0.60	17,156	0.83	49
278	Oregon State Univ	1,248	3,113	0.60	6,523	0.81	252
279	Natl Sun Yat-sen Univ	637	1,588	0.60	3,426	0.81	423
280	Univ Granada	1,110	2,765	0.60	5,765	0.81	286
281	Drexel Univ	764	1,901	0.60	4,103	0.81	379
282	Natl Univ Singapore	3,682	9,155	0.60	19,103	0.81	42
283	Univ Halle-Wittenberg	729	1,812	0.60	3,909	0.81	395
284	Univ Calif - Berkeley	3,701	9,186	0.60	20,829	0.82	34
285	Univ Ottawa	1,515	3,757	0.60	8,773	0.83	176
286	Heinrich Heine Univ Düsseldorf	999	2,476	0.60	5,822	0.83	283
287	Goethe Univ Frankfurt	1,426	3,533	0.60	7,941	0.82	196
288	Univ Erlangen-Nürnberg	1,634	4,032	0.59	8,876	0.82	171
289	Stony Brook Univ - SUNY	1,335	3,289	0.59	7,426	0.82	209
290	Temple Univ	828	2,039	0.59	4,385	0.81	356
291	Univ Utah	2,201	5,414	0.59	12,391	0.82	105
292	Univ Calgary	2,086	5,128	0.59	11,748	0.82	110
293	Univ Georgia	1,834	4,499	0.59	9,346	0.80	161
294	George Washington Univ	838	2,055	0.59	4,798	0.83	332
295	Univ Nebraska - Lincoln	1,203	2,950	0.59	6,151	0.80	264
296	Univ Santiago de Compostela	1,068	2,619	0.59	5,352	0.80	303
297	Hokkaido Univ	2,639	6,463	0.59	13,830	0.81	82
298	Univ Sci & Technol Beijing	403	983	0.59	1,792	0.78	493
299	Univ Virginia	2,202	5,363	0.59	12,164	0.82	107
300	Univ Missouri - Columbia	1,655	4,029	0.59	8,743	0.81	177

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			TF_i	CF_i/TF_i	TM_i	CM_i/TM_i	Rank CM_i/TM_i
		(1)	(2)	(3)	(4)	(5)	(6)
301	Arizona State Univ	1,801	4,378	0.59	9,051	0.80	167
302	McMaster Univ	2,054	4,992	0.59	11,278	0.82	115
303	Kanazawa Univ	833	2,015	0.59	4,468	0.81	351
304	Univ Wisconsin - Madison	4,601	11,123	0.59	24,485	0.81	16
305	Univ Kentucky	1,943	4,690	0.59	10,254	0.81	133
306	Ghent Univ	2,765	6,672	0.59	14,289	0.81	73
307	Jagiellonian Univ Krakow	990	2,387	0.59	5,187	0.81	316
308	Univ Bordeaux 1 Sci Technol	810	1,953	0.59	3,995	0.80	386
309	Univ Illinois - Chicago	2,090	5,035	0.58	11,161	0.81	116
310	MIT	3,465	8,347	0.58	18,998	0.82	44
311	City Univ Hong Kong	1,254	3,020	0.58	5,736	0.78	288
312	Waseda Univ	783	1,884	0.58	4,163	0.81	371
313	Univ Palermo	906	2,179	0.58	4,657	0.81	339
314	Washington State Univ	1,236	2,964	0.58	6,013	0.79	275
315	Penn State Univ	3,986	9,559	0.58	20,326	0.80	37
316	Keio Univ	1,247	2,988	0.58	6,612	0.81	244
317	State Univ Campinas	1,749	4,191	0.58	8,396	0.79	185
318	Clemson Univ	782	1,873	0.58	3,674	0.79	412
319	Ege Univ	777	1,860	0.58	3,711	0.79	410
320	Univ Illinois-Urbana-Champaign	3,743	8,958	0.58	18,901	0.80	45
321	China Agr Univ	707	1,692	0.58	3,291	0.79	431
322	Eindhoven Univ Technol	1,148	2,738	0.58	5,319	0.78	308
323	Univ Houston - Houston	860	2,049	0.58	4,240	0.80	364
324	George Mason Univ	521	1,241	0.58	2,600	0.80	477
325	Osaka Univ	4,076	9,701	0.58	21,314	0.81	31
326	Univ Würzburg	1,345	3,201	0.58	7,108	0.81	220
327	Univ Calif - Santa Cruz	735	1,746	0.58	4,180	0.82	368
328	Univ Calif - Irvine	2,364	5,614	0.58	12,824	0.82	99
329	Natl Cheng Kung Univ	2,236	5,310	0.58	11,637	0.81	112
330	Univ Connecticut	1,910	4,514	0.58	9,478	0.80	154
331	Cornell Univ	4,396	10,369	0.58	22,446	0.80	26
332	Princeton Univ	1,935	4,548	0.57	10,199	0.81	136
333	Saarland Univ	829	1,947	0.57	4,146	0.80	374
334	Univ Edinburgh	2,425	5,681	0.57	12,614	0.81	102
335	Florida State Univ	1,310	3,069	0.57	6,551	0.80	248
336	Natl Chiao Tung Univ	1,464	3,425	0.57	6,984	0.79	226
337	Univ New S Wales	2,219	5,188	0.57	10,866	0.80	120
338	Rutgers State Univ	1,885	4,405	0.57	9,423	0.80	158
339	Australian Natl Univ	1,795	4,178	0.57	8,741	0.79	178
340	Okayama Univ	1,293	3,007	0.57	6,663	0.81	243
341	Univ Regensburg	1,074	2,477	0.57	5,261	0.80	312
342	Univ Otago	1,133	2,613	0.57	5,327	0.79	306
343	Queen's Univ Belfast	1,191	2,740	0.57	5,736	0.79	288
344	Univ Alberta	3,317	7,628	0.57	16,149	0.79	55
345	Natl Chung Hsing Univ	822	1,890	0.57	3,939	0.79	394
346	Karlsruhe Inst Technol	1,563	3,593	0.57	7,852	0.80	199
347	Queen Mary Univ London	797	1,825	0.56	4,110	0.81	378
348	Kansas State Univ	909	2,081	0.56	4,211	0.78	365
349	Stellenbosch Univ	609	1,393	0.56	2,889	0.79	463
350	Univ Patras	1,004	2,293	0.56	4,528	0.78	347
351	W Virginia Univ	805	1,837	0.56	3,777	0.79	403

Rank CF_i/TF_i	University	Solo papers	Fractional		Multiplicative		
			TF_i	CF_i/TF_i	TM_i	CM_i/TM_i	Rank CM_i/TM_i
		(1)	(2)	(3)	(4)	(5)	(6)
352	Univ Saskatchewan	1,224	2,792	0.56	5,693	0.78	290
353	Univ Basque Country	1,003	2,287	0.56	4,723	0.79	334
354	Univ Leicester	1,140	2,598	0.56	5,598	0.80	295
355	N Carolina State Univ	2,142	4,879	0.56	9,628	0.78	150
356	Natl Cent Univ	732	1,667	0.56	3,523	0.79	419
357	Oklahoma State Univ - Stillwater	670	1,523	0.56	3,117	0.79	442
358	Ruhr-Univ Bochum	1,376	3,126	0.56	6,871	0.80	235
359	Univ Oxford	4,808	10,911	0.56	23,874	0.80	20
360	Univ Dublin Trinity Coll	897	2,035	0.56	4,143	0.78	375
361	Univ Coll Dublin	1,219	2,763	0.56	5,871	0.79	281
362	Stockholm Univ	1,155	2,614	0.56	5,641	0.80	294
363	Univ Wollongong	682	1,540	0.56	2,969	0.77	459
364	Massey Univ	650	1,467	0.56	2,845	0.77	466
365	Queensland Univ Technol	633	1,428	0.56	2,757	0.77	471
366	Tarbiat Modares Univ	415	934	0.56	1,776	0.77	494
367	Univ Malaya	496	1,116	0.56	2,096	0.76	490
368	Leibniz Univ Hannover	387	870	0.56	1,731	0.78	497
369	Northeastern Univ	603	1,356	0.56	2,879	0.79	464
370	Caltech	2,342	5,265	0.56	12,387	0.81	106
371	Tech Univ Madrid	711	1,598	0.56	2,987	0.76	456
372	Univ St Andrews	798	1,793	0.55	3,616	0.78	414
373	Beijing Normal Univ	679	1,525	0.55	3,028	0.78	449
374	Texas A&M Univ - College Stn	3,206	7,195	0.55	14,641	0.78	70
375	Colorado State Univ	1,487	3,336	0.55	7,056	0.79	225
376	Univ Newcastle	684	1,532	0.55	3,189	0.79	438
377	Univ Bristol	2,331	5,215	0.55	10,930	0.79	119
378	Univ Seville	1,003	2,244	0.55	4,486	0.78	350
379	Carnegie Mellon Univ	1,302	2,912	0.55	6,065	0.79	269
380	Univ Cent Florida	963	2,153	0.55	4,244	0.77	363
381	Univ Auckland	1,449	3,238	0.55	6,536	0.78	250
382	Newcastle Univ	1,597	3,562	0.55	7,504	0.79	207
383	Univ Politècnica Catalunya	769	1,712	0.55	3,232	0.76	434
384	Kyoto Univ	5,359	11,923	0.55	25,233	0.79	13
385	Hong Kong Univ Sci & Technol	1,277	2,836	0.55	5,237	0.76	313
386	Univ East Anglia	727	1,614	0.55	3,261	0.78	432
387	Pohang Univ Sci & Technol	1,089	2,414	0.55	4,691	0.77	337
388	Univ Bremen	592	1,312	0.55	2,621	0.77	476
389	Univ Leeds	2,324	5,133	0.55	10,471	0.78	129
390	Texas Tech Univ	956	2,109	0.55	4,322	0.78	357
391	Tech Univ Berlin	835	1,842	0.55	3,466	0.76	421
392	Univ Tehran	902	1,987	0.55	3,792	0.76	399
393	Hong Kong Polytech Univ	1,608	3,540	0.55	6,505	0.75	253
394	Univ Warwick	1,188	2,614	0.55	5,387	0.78	302
395	Natl Tsing Hua Univ	1,420	3,115	0.54	6,036	0.76	272
396	E China Normal Univ	538	1,180	0.54	2,198	0.76	485
397	Weizmann Inst Sci	1,151	2,523	0.54	5,169	0.78	317
398	Macquarie Univ	607	1,330	0.54	2,640	0.77	475
399	Univ Twente	987	2,158	0.54	4,138	0.76	377
400	Israel Inst Technol	2,264	4,948	0.54	10,161	0.78	138
401	Virginia Tech	1,800	3,928	0.54	7,682	0.77	201
402	Univ Buffalo - SUNY	1,701	3,711	0.54	7,930	0.79	197

Rank CF_i/TF_i	University	Solo papers	Fractional		Multiplicative		
			TF_i	CF_i/TF_i	TM_i	CM_i/TM_i	Rank CM_i/TM_i
		(1)	(2)	(3)	(4)	(5)	(6)
403	Sichuan Univ	1,657	3,612	0.54	6,737	0.75	241
404	Univ Ljubljana	1,328	2,891	0.54	5,914	0.78	278
405	Queen's Univ	1,460	3,176	0.54	6,547	0.78	249
406	Univ Southampton	2,182	4,746	0.54	9,627	0.77	151
407	Shandong Univ	1,702	3,701	0.54	6,852	0.75	237
408	RWTH Aachen University	1,654	3,597	0.54	7,601	0.78	204
409	Wuhan Univ	1,530	3,323	0.54	6,127	0.75	265
410	Purdue Univ - Lafayette	3,049	6,619	0.54	13,353	0.77	89
411	Tech Univ Denmark	1,570	3,408	0.54	6,553	0.76	247
412	Univ Dundee	893	1,938	0.54	3,974	0.78	391
413	Georgetown Univ	1,050	2,277	0.54	4,962	0.79	323
414	E China Univ Sci & Technol	809	1,752	0.54	3,115	0.74	443
415	Louisiana State Univ	1,514	3,277	0.54	6,561	0.77	246
416	Chalmers Univ Technol	724	1,566	0.54	2,985	0.76	457
417	Cent S Univ	859	1,856	0.54	3,411	0.75	424
418	Univ Sci & Technol China	2,237	4,834	0.54	9,118	0.75	166
419	Univ Cambridge	5,167	11,145	0.54	23,149	0.78	23
420	Jilin Univ	1,577	3,400	0.54	6,070	0.74	267
421	Univ Sheffield	2,389	5,147	0.54	10,135	0.76	142
422	Univ Texas - Austin	3,210	6,915	0.54	13,870	0.77	81
423	Bar-Ilan Univ	808	1,736	0.53	3,367	0.76	429
424	Cardiff University	1,641	3,524	0.53	7,155	0.77	217
425	Georgia Inst Technol	2,499	5,365	0.53	10,148	0.75	140
426	Univ Victoria	837	1,797	0.53	3,789	0.78	402
427	Univ Witwatersrand	679	1,457	0.53	3,008	0.77	453
428	Univ Zaragoza	1,115	2,387	0.53	4,803	0.77	330
429	Vienna Univ Technol	756	1,616	0.53	3,099	0.76	445
430	Durham Univ	1,145	2,448	0.53	4,904	0.77	324
431	Univ Birmingham	2,408	5,137	0.53	10,765	0.78	122
432	Ecole Polytech Fédérale Lausanne	1,755	3,744	0.53	7,596	0.77	205
433	Griffith Univ	683	1,454	0.53	2,820	0.76	469
434	Univ Exeter	763	1,620	0.53	3,192	0.76	437
435	Univ Manchester	3,880	8,213	0.53	16,979	0.77	50
436	Tech Univ Darmstadt	947	2,002	0.53	3,761	0.75	405
437	ETH Zurich	3,178	6,706	0.53	13,231	0.76	91
438	Univ Sains Malaysia	566	1,191	0.52	2,198	0.74	485
439	Univ Calif - Riverside	1,405	2,956	0.52	6,079	0.77	266
440	Univ Nottingham	2,515	5,269	0.52	10,180	0.75	137
441	Nankai Univ	1,385	2,893	0.52	5,189	0.73	315
442	Univ Strathclyde Glasgow	875	1,825	0.52	3,401	0.74	426
443	Cairo Univ	671	1,398	0.52	2,552	0.74	479
444	Korea Adv Inst Sci & Technol	1,843	3,837	0.52	7,075	0.74	223
445	Univ York	1,245	2,578	0.52	5,035	0.75	321
446	Delft Univ Technol	1,657	3,426	0.52	6,240	0.73	260
447	Univ Guelph	1,382	2,846	0.51	5,483	0.75	297
448	Univ Warsaw	891	1,824	0.51	3,729	0.76	407
449	Univ Reading	952	1,948	0.51	3,624	0.74	413
450	Auburn Univ	1,034	2,111	0.51	3,901	0.73	396
451	Univ Delaware	1,389	2,834	0.51	5,290	0.74	309
452	Univ Massachusetts - Amherst	1,469	2,996	0.51	6,041	0.76	271
453	Univ Pretoria	657	1,335	0.51	2,564	0.74	478

Rank CF_i/TF_i	University	Solo papers	Fractional		Multiplicative		
			TF_i	CF_i/TF_i	TM_i	CM_i/TM_i	Rank CM_i/TM_i
		(1)	(2)	(3)	(4)	(5)	(6)
454	Univ Murcia	798	1,613	0.51	3,009	0.73	452
455	Indiana Univ - Bloomington	1,595	3,223	0.51	6,525	0.76	251
456	Aristotle Univ Thessaloniki	2,069	4,174	0.50	7,944	0.74	195
457	York Univ	798	1,608	0.50	3,233	0.75	433
458	Univ Oviedo	941	1,895	0.50	3,675	0.74	411
459	Univ Bath	917	1,846	0.50	3,344	0.73	430
460	Univ S Carolina	1,264	2,540	0.50	5,333	0.76	305
461	Univ KwaZulu-Natal	562	1,122	0.50	2,155	0.74	488
462	Lancaster Univ	745	1,475	0.49	2,956	0.75	460
463	Lanzhou Univ	1,175	2,325	0.49	3,979	0.70	389
464	Aalto Univ	1,067	2,102	0.49	4,008	0.73	385
465	Politecnico Milano	1,060	2,087	0.49	3,792	0.72	399
466	Univ Waterloo	1,993	3,919	0.49	7,096	0.72	222
467	Univ Notre Dame	1,085	2,131	0.49	4,465	0.76	352
468	Univ Stuttgart	1,133	2,209	0.49	3,943	0.71	393
469	S E Univ	922	1,796	0.49	3,049	0.70	447
470	Tokyo Inst Technol	2,812	5,474	0.49	10,427	0.73	130
471	Tongji Univ	763	1,475	0.48	2,526	0.70	480
472	Politecnico Torino	852	1,644	0.48	2,943	0.71	461
473	Univ Surrey	968	1,867	0.48	3,445	0.72	422
474	KTH Royal Inst Technol	1,628	3,135	0.48	5,840	0.72	282
475	Simon Fraser Univ	1,104	2,112	0.48	3,990	0.72	388
476	S China Univ Technol	854	1,629	0.48	2,719	0.69	473
477	Dalian Univ Technol	1,470	2,793	0.47	4,732	0.69	333
478	Huazhong Univ Sci & Technol	2,022	3,841	0.47	6,574	0.69	245
479	Xi'an Jiaotong Univ	1,577	2,968	0.47	5,069	0.69	320
480	Hunan Univ	738	1,386	0.47	2,347	0.69	483
481	Zhejiang Univ	5,078	9,488	0.46	16,013	0.68	56
482	Inha Univ	1,110	2,063	0.46	3,721	0.70	408
483	King Saud Univ	475	879	0.46	1,629	0.71	498
484	Univ Politècnica València	1,211	2,226	0.46	3,712	0.67	409
485	Nanyang Technol Univ	3,039	5,579	0.46	9,310	0.67	164
486	Middle East Tech Univ	991	1,816	0.45	3,024	0.67	450
487	Loughborough Univ	1,094	1,941	0.44	3,203	0.66	436
488	Univ Sussex	924	1,634	0.43	2,879	0.68	464
489	Amirkabir Univ Technol	537	936	0.43	1,474	0.64	499
490	Indian Inst Sci	1,813	3,155	0.43	5,087	0.64	319
491	Tsinghua Univ	4,811	8,362	0.42	13,724	0.65	85
492	Shanghai Jiao Tong Univ	4,321	7,445	0.42	12,412	0.65	104
493	Tianjin Univ	1,592	2,692	0.41	4,154	0.62	372
494	Banaras Hindu Univ	756	1,271	0.41	2,065	0.63	491
495	Sharif Univ Technol	877	1,454	0.40	2,247	0.61	484
496	Harbin Inst Technol	1,967	3,198	0.38	4,871	0.60	326
497	Indian Inst Technol Kharagpur	1,495	2,359	0.37	3,505	0.57	420
498	Indian Inst Technol Madras	1,231	1,926	0.36	2,822	0.56	468
499	Natl Tech Univ Athens	1,406	2,109	0.33	3,224	0.56	435
500	Northwestern Polytech Univ	815	1,208	0.33	1,735	0.53	496
	Total	725,608	1,882,370.33	303.63	4,351,584	408.69	
	Average	1451.22	3764.74	0.61	8703.17	0.82	
	SD	1022.86	2775.21	0.08	7214.18	0.06	

Rank CF_i/TF_i	University	Solo papers	Fractional		Multiplicative		Rank CM_i/TM_i
			TF_i	CF_i/TF_i	TM_i	CM_i/TM_i	
		(1)	(2)	(3)	(4)	(5)	(6)
	CV	0.70	0.74	0.13	0.83	0.08	

Table B. University rankings according to the *MNCS* and the Top 10% indicators in the fractional and the multiplicative case (universities are ordered by *MNCS* values in the fractional case)

Rank M^F	University	M^F (1)	M^M (2)	Rank M^M (3)	T^F (4)	Rank T^F (5)	T^M (6)	Rank T^M (7)
1	MIT	1.96	1.91	1	2.41	8	2.40	11
2	Princeton Univ	1.83	1.71	4	2.22	42	2.16	48
3	Harvard Univ	1.80	1.72	2	2.27	1	2.21	1
4	Caltech	1.78	1.64	6	2.12	34	1.91	42
5	Stanford Univ	1.78	1.71	3	2.19	2	2.15	2
6	Univ Calif - Berkeley	1.73	1.66	5	2.07	10	2.02	13
7	Univ Göttingen	1.72	1.54	8	0.99	191	1.02	192
8	Univ Calif - Santa Barbara	1.66	1.63	7	1.94	59	1.97	62
9	London Sch Hyg & Trop Med	1.58	1.46	13	1.79	294	1.73	258
10	Univ Calif - San Francisco	1.54	1.50	10	1.93	15	1.93	8
11	Yale Univ	1.54	1.48	11	1.88	18	1.83	14
12	Univ Chicago	1.52	1.47	12	1.80	35	1.79	33
13	Carnegie Mellon Univ	1.52	1.46	15	1.76	125	1.71	148
14	Northwestern Univ	1.50	1.42	22	1.77	23	1.66	26
15	Univ Calif - San Diego	1.50	1.45	16	1.77	14	1.74	12
16	Ecole Polytech Fédérale Lausanne	1.49	1.46	14	1.77	84	1.73	107
17	Univ Washington - Seattle	1.49	1.45	17	1.80	5	1.78	6
18	Univ Calif - Santa Cruz	1.47	1.53	9	1.71	245	1.76	226
19	ETH Zurich	1.47	1.42	21	1.73	33	1.68	46
20	Columbia Univ	1.46	1.44	18	1.73	11	1.75	9
21	Rice Univ	1.46	1.40	26	1.72	196	1.72	201
22	Univ Calif - Los Angeles	1.46	1.38	29	1.73	3	1.67	4
23	Univ Oxford	1.45	1.43	20	1.68	12	1.66	17
24	Univ Cambridge	1.44	1.44	19	1.62	13	1.62	19
25	Duke Univ	1.43	1.39	27	1.68	20	1.72	15
26	Univ Texas - SW Med Ctr	1.42	1.38	31	1.82	301	1.77	283
27	Univ Penn	1.42	1.38	33	1.71	9	1.67	10
28	Univ Colorado - Boulder	1.42	1.41	24	1.70	72	1.72	71
29	Weizmann Inst Sci	1.42	1.42	23	1.73	154	1.67	178
30	Johns Hopkins Univ	1.41	1.40	25	1.63	7	1.68	3
31	Washington Univ - St Louis	1.41	1.39	28	1.65	30	1.67	24
32	NYU	1.41	1.37	34	1.63	38	1.68	35
33	Georgia Inst Technol	1.40	1.38	30	1.62	51	1.64	77
34	Univ Michigan	1.39	1.36	36	1.60	4	1.62	7
35	Univ St Andrews	1.39	1.27	54	1.42	275	1.36	304
36	Cornell Univ	1.39	1.37	35	1.60	17	1.59	21
37	Imperial Coll London	1.36	1.31	43	1.58	22	1.55	25
38	Univ N Carolina - Chapel Hill	1.36	1.34	40	1.52	31	1.51	27
39	Univ Coll London	1.35	1.30	45	1.55	19	1.53	18
40	Univ Illinois-Urbana-Champaign	1.35	1.38	32	1.50	25	1.55	29
41	Dartmouth Coll	1.35	1.34	38	1.58	231	1.60	220
42	Emory Univ	1.35	1.35	37	1.62	45	1.62	38
43	Boston Univ	1.35	1.34	39	1.56	54	1.59	41
44	Univ Texas - Austin	1.34	1.31	44	1.50	39	1.49	53
45	Univ Calif - Irvine	1.34	1.32	42	1.54	52	1.56	54
46	Univ Calif - Riverside	1.33	1.23	69	1.58	140	1.48	172
47	Univ Dundee	1.32	1.32	41	1.36	268	1.46	273
48	Tufts Univ	1.32	1.27	55	1.56	122	1.51	108
49	Univ Bristol	1.32	1.28	52	1.48	68	1.44	86

Rank M^F	University	M^F (1)	M^M (2)	Rank M^M (3)	T^F (4)	Rank T^F (5)	T^M (6)	Rank T^M (7)
50	Univ Wisconsin - Madison	1.31	1.28	47	1.50	16	1.48	20
51	Univ Maryland - College Park	1.31	1.28	51	1.48	53	1.49	57
52	Oregon Hlth & Sci Univ	1.30	1.27	57	1.42	243	1.42	206
53	Univ Massachusetts Med Sch	1.30	1.26	58	1.47	261	1.49	239
54	Vanderbilt Univ	1.29	1.25	60	1.50	46	1.47	37
55	Baylor Coll Med	1.29	1.28	48	1.53	74	1.51	50
56	Univ Lausanne	1.29	1.27	53	1.48	173	1.50	139
57	Univ Rochester	1.29	1.25	62	1.41	92	1.41	88
58	Brown Univ	1.28	1.28	50	1.40	113	1.40	105
59	Icahn Sch Med Mt Sinai	1.28	1.28	49	1.53	149	1.52	128
60	Univ Minnesota - Twin Cities	1.28	1.27	56	1.43	21	1.43	22
61	Univ So Calif	1.28	1.25	63	1.42	47	1.40	47
62	Delft Univ Technol	1.28	1.22	71	1.35	144	1.32	193
63	Univ Twente	1.27	1.25	61	1.44	230	1.48	260
64	Arizona State Univ	1.27	1.29	46	1.27	109	1.34	120
65	Queen Mary Univ London	1.26	1.22	72	1.11	324	1.19	305
66	Univ Virginia	1.26	1.23	67	1.46	62	1.44	72
67	Univ Pittsburgh	1.26	1.24	66	1.42	24	1.45	16
68	Tech Univ Denmark	1.26	1.22	73	1.38	139	1.35	176
69	Univ Dublin Trinity Coll	1.26	1.19	86	1.36	259	1.26	294
70	Univ Edinburgh	1.25	1.24	64	1.44	58	1.41	67
71	ParisTech - École Polytech	1.25	1.18	93	1.28	366	1.28	342
72	Univ Massachusetts - Amherst	1.25	1.19	85	1.44	157	1.33	205
73	Stony Brook Univ - SUNY	1.24	1.22	74	1.34	152	1.38	152
74	Penn State Univ	1.24	1.25	59	1.34	28	1.40	31
75	Univ Utah	1.23	1.24	65	1.39	70	1.43	70
76	Rutgers State Univ	1.23	1.20	81	1.31	101	1.33	114
77	Univ Toronto	1.23	1.18	88	1.35	6	1.31	5
78	King's Coll London	1.23	1.19	84	1.35	81	1.31	92
79	Univ Geneva	1.23	1.20	76	1.28	127	1.34	106
80	Eindhoven Univ Technol	1.23	1.21	75	1.25	203	1.30	233
81	Erasmus Univ Rotterdam	1.23	1.14	112	1.37	75	1.26	65
82	Durham Univ	1.23	1.23	68	1.37	209	1.32	248
83	Univ Calif - Davis	1.23	1.20	79	1.34	27	1.37	28
84	Univ Zurich	1.23	1.18	89	1.39	66	1.31	63
85	Yeshiva Univ	1.22	1.19	83	1.33	178	1.38	134
86	Wageningen Univ & Res Ctr	1.22	1.20	82	1.41	129	1.40	133
87	VU Univ Amsterdam	1.22	1.13	121	1.30	80	1.15	76
88	Tech Univ München	1.21	1.16	98	1.34	93	1.34	102
89	Univ East Anglia	1.21	1.20	80	1.31	314	1.31	325
90	Univ Notre Dame	1.21	1.23	70	1.28	262	1.29	277
91	Utrecht Univ	1.21	1.14	111	1.29	43	1.22	45
92	Univ Amsterdam	1.21	1.12	125	1.32	55	1.24	52
93	Lancaster Univ	1.20	1.11	142	1.35	329	1.32	350
94	Univ Basel	1.20	1.20	78	1.39	141	1.33	141
95	Univ Stuttgart	1.20	1.16	99	1.22	264	1.21	311
96	Leiden Univ	1.20	1.14	108	1.35	85	1.27	79
97	Univ Colorado - Denver	1.20	1.18	87	1.35	116	1.37	81
98	Paris Diderot Univ	1.20	1.15	105	1.22	218	1.23	140
99	Univ British Columbia	1.20	1.17	96	1.30	29	1.27	30
100	McMaster Univ	1.19	1.20	77	1.21	97	1.29	97
101	Univ York	1.19	1.18	90	1.33	204	1.33	241

Rank M^F	University	M^F (1)	M^M (2)	Rank M^M (3)	T^F (4)	Rank T^F (5)	T^M (6)	Rank T^M (7)
102	Katholieke Univ Leuven	1.18	1.16	97	1.26	36	1.27	36
103	Australian Natl Univ	1.18	1.15	107	1.26	119	1.22	143
104	Univ Melbourne	1.18	1.16	101	1.23	50	1.19	51
105	Univ Exeter	1.18	1.17	94	1.30	312	1.32	332
106	RWTH Aachen University	1.17	1.10	146	1.12	168	1.08	196
107	Univ Cincinnati	1.17	1.13	116	1.33	88	1.35	68
108	Univ Bern	1.17	1.11	140	1.20	153	1.17	153
109	Ohio State Univ	1.17	1.15	103	1.24	32	1.27	32
110	Oregon State Univ	1.17	1.14	114	1.25	176	1.27	191
111	Univ Iowa	1.16	1.13	117	1.27	73	1.27	64
112	Indiana Univ - Bloomington	1.16	1.11	135	1.29	164	1.26	194
113	Univ New Mexico	1.16	1.18	92	1.20	213	1.24	186
114	Case Western Reserve Univ	1.16	1.13	123	1.26	87	1.26	69
115	Univ Southampton	1.15	1.14	113	1.19	104	1.17	136
116	Northeastern Univ	1.15	1.11	139	1.20	370	1.20	377
117	Univ Copenhagen	1.15	1.10	147	1.23	44	1.18	40
118	Univ Glasgow	1.15	1.15	104	1.23	123	1.27	117
119	Univ Sheffield	1.15	1.12	124	1.25	89	1.23	115
120	Stockholm Univ	1.15	1.15	106	1.17	237	1.20	240
121	Univ Freiburg	1.14	1.11	133	1.22	148	1.24	142
122	Univ Arizona	1.14	1.13	120	1.21	65	1.22	59
123	Michigan State Univ	1.14	1.13	119	1.24	71	1.27	74
124	Univ Aberdeen	1.14	1.11	132	1.24	210	1.23	222
125	Univ Miami - Miami	1.14	1.11	141	1.15	145	1.16	135
126	Univ Paris-Sud 11	1.14	1.10	145	1.19	112	1.23	95
127	Maximilians-Univ München	1.14	1.14	109	1.23	64	1.26	58
128	McGill Univ	1.13	1.12	126	1.19	41	1.20	34
129	Hong Kong Univ Sci & Technol	1.13	1.12	131	1.19	208	1.19	255
130	Aarhus Univ	1.13	1.08	157	1.23	83	1.17	80
131	Purdue Univ - Lafayette	1.13	1.10	151	1.17	67	1.19	83
132	Karlsruhe Inst Technol	1.13	1.11	137	1.21	155	1.25	161
133	Univ Bordeaux Segalen	1.13	1.08	158	1.12	372	1.13	312
134	Wake Forest Univ	1.13	1.12	128	1.19	233	1.20	200
135	Florida State Univ	1.13	1.15	102	1.17	194	1.21	208
136	Univ Delaware	1.13	1.17	95	1.18	211	1.26	242
137	Univ Bath	1.12	1.11	144	1.16	307	1.17	349
138	Univ Texas-Hlth Sci Ctr S Antonio	1.12	1.12	127	1.23	480	1.33	449
139	Georgetown Univ	1.12	1.10	149	1.27	252	1.24	259
140	Univ Maryland - Baltimore	1.12	1.11	134	1.18	160	1.24	126
141	Univ Nottingham	1.12	1.11	138	1.19	94	1.20	119
142	Radboud Univ Nijmegen	1.12	1.09	155	1.14	105	1.12	96
143	Univ Groningen	1.12	1.05	185	1.17	91	1.07	98
144	Univ Pierre & Marie Curie	1.12	1.10	150	1.18	63	1.21	43
145	Univ Würzburg	1.12	1.08	160	1.21	177	1.19	182
146	Karolinska Inst	1.11	1.07	169	1.14	61	1.11	44
147	Univ Queensland	1.11	1.09	154	1.18	60	1.13	75
148	Univ Leeds	1.11	1.10	153	1.14	99	1.14	122
149	Univ Montpellier 2	1.11	1.04	197	1.11	291	1.16	284
150	Univ Nice Sophia Antipolis	1.11	1.08	164	1.22	383	1.18	375
151	Univ Warwick	1.11	1.05	190	1.17	236	1.13	261
152	Univ Liverpool	1.11	1.04	203	1.15	156	1.14	155
153	Univ Erlangen-Nürnberg	1.10	1.06	176	1.15	143	1.12	157

Rank M^F	University	M^F (1)	M^M (2)	Rank M^M (3)	T^F (4)	Rank T^F (5)	T^M (6)	Rank T^M (7)
154	Joseph Fourier Univ	1.10	1.07	167	1.10	232	1.16	181
155	Paris Descartes Univ	1.10	1.13	122	1.19	206	1.28	113
156	Iowa State Univ	1.10	1.13	115	1.08	133	1.09	137
157	Univ Sussex	1.10	1.18	91	1.10	350	1.16	382
158	Tulane Univ	1.10	1.07	168	1.17	316	1.20	297
159	Univ S Carolina	1.10	1.02	221	1.16	248	1.08	276
160	Gutenberg Univ Mainz	1.10	1.11	143	1.09	221	1.14	203
161	Colorado State Univ	1.10	1.10	152	1.15	183	1.19	185
162	Newcastle Univ	1.09	1.14	110	1.13	170	1.20	174
163	Univ Vermont	1.09	1.12	129	1.10	327	1.21	300
164	Maastricht Univ	1.09	1.02	232	1.08	197	1.03	160
165	Univ Bordeaux 1 Sci Technol	1.09	1.08	159	1.04	323	1.09	322
166	Univ Strasbourg	1.09	1.06	173	1.09	205	1.07	199
167	Univ Connecticut	1.09	1.08	162	1.09	132	1.11	145
168	Univ Bonn	1.08	1.05	191	1.14	151	1.10	149
169	Univ Manchester	1.08	1.06	178	1.09	49	1.09	61
170	Univ Reading	1.08	1.11	136	1.13	298	1.18	326
171	Natl Univ Singapore	1.08	1.05	192	1.12	40	1.12	49
172	Univ Catholique Louvain	1.08	1.09	156	1.13	219	1.17	202
173	Med Univ S Carolina	1.08	1.05	187	1.07	284	1.05	266
174	Drexel Univ	1.08	1.16	100	1.06	325	1.22	301
175	Univ Hawaii - Manoa	1.08	1.10	148	1.14	228	1.29	183
176	Heidelberg Univ	1.08	1.06	180	1.05	95	1.05	91
177	Univ Auckland	1.07	1.07	171	1.08	199	1.07	231
178	Univ Libre Bruxelles	1.07	1.08	161	1.16	250	1.17	227
179	Philipps-Univ Marburg	1.07	1.01	238	1.09	276	1.02	289
180	Vrije Univ Brussel	1.07	1.04	202	1.04	339	1.09	310
181	Monash Univ	1.07	1.05	186	1.12	110	1.12	121
182	Univ Helsinki	1.07	1.03	204	1.07	82	1.06	56
183	Tech Univ Berlin	1.07	1.06	174	1.12	320	1.15	343
184	Texas A&M Univ - College Stn	1.07	1.05	188	1.07	69	1.07	87
185	Univ New S Wales	1.07	1.03	216	1.10	103	1.05	131
186	Univ Claude Bernard Lyon 1	1.07	1.01	241	1.04	187	1.05	159
187	Univ Sydney	1.07	1.03	213	1.10	56	1.10	60
188	Univ Hong Kong	1.07	1.03	211	1.08	100	1.08	109
189	Univ Georgia	1.07	1.05	183	1.11	130	1.10	151
190	Med Coll Wisconsin	1.07	1.07	165	1.08	299	1.15	256
191	Humboldt-Univ Berlin	1.06	1.03	205	1.12	115	1.09	82
192	Univ Politècnica Catalunya	1.06	1.00	254	0.95	371	0.89	411
193	Univ Hamburg	1.06	1.06	177	1.07	186	1.09	167
194	Univ Paris-Est Créteil	1.06	1.12	130	1.18	446	1.23	402
195	Univ Alabama - Birmingham	1.06	1.06	179	1.08	131	1.07	101
196	Univ Birmingham	1.06	1.07	170	1.05	114	1.09	124
197	Univ Tübingen	1.06	1.05	195	1.07	147	1.03	144
198	Swed Univ Agr Sci	1.06	1.05	196	1.02	344	1.08	324
199	George Washington Univ	1.06	1.13	118	1.08	297	1.15	286
200	Univ Vienna	1.06	1.03	210	1.09	188	1.10	180
201	Goethe Univ Frankfurt	1.06	1.05	182	1.13	171	1.15	170
202	Queen's Univ	1.05	1.07	166	1.09	200	1.13	221
203	Univ Illinois - Chicago	1.05	1.01	245	1.04	121	1.03	130
204	Univ Cent Florida	1.05	1.04	198	1.11	286	1.12	313
205	Univ Ottawa	1.05	1.03	218	1.12	162	1.09	164

Rank M^F	University	M^F (1)	M^M (2)	Rank M^M (3)	T^F (4)	Rank T^F (5)	T^M (6)	Rank T^M (7)
206	Virginia Commonwealth Univ	1.05	1.06	181	1.03	249	1.10	212
207	Norwegian Univ Sci & Technol	1.05	1.04	200	1.08	229	1.07	237
208	Univ Bergen	1.05	0.99	260	1.01	273	1.04	214
209	Simon Fraser Univ	1.05	1.02	222	1.04	300	1.05	336
210	Freie Univ Berlin	1.05	1.01	236	1.06	136	1.03	100
211	Univ S Florida - Tampa	1.04	1.03	214	1.08	220	1.11	216
212	Univ Montréal	1.04	1.02	228	1.02	134	1.02	112
213	Ghent Univ	1.04	1.06	175	1.03	78	1.04	94
214	Univ Gothenburg	1.04	1.03	208	0.95	172	1.02	146
215	Med Univ Wien	1.04	0.98	275	1.01	241	0.93	210
216	Washington State Univ	1.04	1.03	215	1.06	226	1.08	246
217	Indiana Univ-Purdue	1.04	1.02	223	1.07	179	1.04	150
218	Aix-Marseille Univ	1.04	1.02	229	1.00	201	1.06	166
219	Univ Duisburg-Essen	1.04	1.02	220	1.06	256	1.07	243
220	Univ Waterloo	1.04	1.02	224	1.04	167	1.05	219
221	N Carolina State Univ	1.04	1.01	240	1.03	128	1.04	156
222	Univ Antwerp	1.04	1.00	248	1.07	271	1.03	253
223	Univ Alberta	1.04	1.03	212	1.07	57	1.10	66
224	City Univ Hong Kong	1.04	1.03	207	1.05	225	1.10	251
225	Virginia Tech	1.04	1.02	225	1.04	166	1.06	198
226	Heinrich Heine Univ Düsseldorf	1.03	1.05	184	1.03	274	1.08	250
227	Ruhr-Univ Bochum	1.03	0.99	268	1.06	214	1.05	229
228	Univ Regensburg	1.03	0.98	272	1.06	269	1.01	293
229	Univ Houston - Houston	1.03	0.99	267	1.03	313	0.99	331
230	Univ Leicester	1.03	1.05	193	1.04	265	1.02	278
231	Univ Cologne	1.03	1.08	163	1.01	246	1.09	207
232	Cardiff University	1.03	1.05	189	1.02	190	1.10	209
233	Univ Otago	1.03	1.01	234	1.06	258	1.00	291
234	Paul Sabatier Univ	1.03	1.03	206	1.08	174	1.09	163
235	Chalmers Univ Technol	1.03	1.03	209	1.07	365	1.08	387
236	Univ Barcelona	1.03	1.02	230	1.00	107	1.02	99
237	Univ Florida	1.03	0.99	266	1.01	37	1.01	39
238	Univ Southern Denmark	1.03	1.00	256	0.97	351	1.00	314
239	Thomas Jefferson Univ	1.02	1.04	201	1.02	305	1.08	285
240	Univ Oslo	1.02	1.00	247	1.01	118	1.04	90
241	Lund Univ	1.02	1.02	231	0.96	86	0.99	84
242	Univ Adelaide	1.02	1.00	257	1.01	242	0.99	235
243	Univ Politècnica València	1.02	0.98	270	0.98	303	0.95	371
244	Univ Western Australia	1.02	0.99	259	1.04	182	0.99	195
245	Aalto Univ	1.02	1.03	217	0.95	330	1.01	340
246	Univ Texas - Medical Branch	1.02	0.99	258	1.03	285	1.00	274
247	Univ Tennessee - Knoxville	1.02	1.01	244	0.98	159	1.05	138
248	George Mason Univ	1.02	1.00	251	1.06	401	1.09	413
249	Univ Western Ontario	1.02	1.01	243	1.02	138	1.07	127
250	Kiel Univ	1.02	1.01	235	1.03	260	1.08	218
251	Univ Med & Dent New Jersey	1.02	1.00	252	1.05	227	1.04	217
252	Univ Münster	1.02	0.99	261	1.00	185	1.03	169
253	Kansas State Univ	1.02	0.99	263	0.98	322	1.00	330
254	Wayne State Univ	1.02	1.00	255	1.02	181	1.06	154
255	Hebrew Univ Jerusalem	1.01	0.98	276	1.02	102	1.06	103
256	Laval Univ	1.01	0.97	279	0.99	193	0.99	190
257	Pohang Univ Sci & Technol	1.01	1.02	226	1.03	280	1.06	302

Rank M^F	University	M^F (1)	M^M (2)	Rank M^M (3)	T^F (4)	Rank T^F (5)	T^M (6)	Rank T^M (7)
258	Tech Univ Dresden	1.01	0.98	278	1.08	222	1.03	228
259	Vienna Univ Technol	1.01	1.01	237	1.10	352	1.14	370
260	Univ Kansas	1.01	0.97	282	0.92	235	0.90	238
261	Univ Coll Dublin	1.01	1.05	194	0.98	263	1.01	268
262	Giessen Univ	1.01	0.97	286	1.02	319	1.01	306
263	Hannover Med Sch	1.01	1.02	227	1.00	357	1.04	309
264	Univ Calgary	1.01	1.01	242	1.02	120	1.05	118
265	Univ Wollongong	1.01	0.99	265	1.03	375	1.06	391
266	Univ Coll Cork	1.00	0.99	264	1.01	359	1.05	356
267	Univ Buffalo - SUNY	1.00	0.96	287	0.97	189	0.93	223
268	Univ Victoria	1.00	1.06	172	0.98	355	1.11	333
269	Uppsala Univ	1.00	1.00	249	0.99	135	1.01	123
270	Umeå Univ	1.00	1.00	250	1.03	279	1.04	252
271	Univ Trieste	1.00	0.95	298	0.96	423	1.01	354
272	Univ Parma	1.00	0.96	289	0.86	386	0.86	365
273	Univ Liège	1.00	1.02	233	0.96	296	1.05	268
274	Montpellier 1 Univ	1.00	1.01	246	0.99	441	1.08	361
275	Queensland Univ Technol	1.00	0.99	269	0.91	404	0.91	435
276	Univ Newcastle	0.99	0.96	295	0.98	385	1.01	388
277	Univ Rennes 1	0.99	0.99	262	0.98	337	1.00	318
278	Univ Cape Town	0.99	1.04	199	1.00	334	1.13	298
279	Friedrich Schiller Univ Jena	0.99	0.96	292	0.99	267	0.95	282
280	Queen's Univ Belfast	0.99	1.00	253	0.92	278	0.95	287
281	Univ Nebraska - Lincoln	0.99	0.96	294	1.01	244	1.04	249
282	Univ Autónoma Barcelona	0.99	0.96	290	0.92	184	0.92	162
283	Univ Padova	0.99	0.94	305	0.92	142	0.97	110
284	Macquarie Univ	0.99	0.98	274	0.96	407	0.98	427
285	Politecnico Torino	0.99	0.96	288	0.96	376	0.96	414
286	Politecnico Milano	0.98	0.97	283	0.97	326	0.92	373
287	Univ Strathclyde Glasgow	0.98	0.98	277	0.90	369	0.93	394
288	Univ Missouri - Columbia	0.98	0.97	281	0.89	195	0.96	187
289	Univ Ulm	0.98	0.98	271	0.90	315	0.96	296
290	Dalhousie Univ	0.98	0.96	296	1.01	234	0.99	236
291	Saarland Univ	0.98	0.95	300	0.87	364	0.86	367
292	Univ Bremen	0.97	1.01	239	0.98	406	1.13	403
293	Nanyang Technol Univ	0.97	0.96	291	0.91	126	0.93	177
294	Tech Univ Darmstadt	0.97	0.95	297	1.02	321	1.01	352
295	Innsbruck Med Univ	0.97	0.92	315	0.92	392	0.87	364
296	Univ Autónoma Madrid	0.97	0.96	293	0.87	223	0.88	224
297	Univ Pavia	0.96	0.94	307	0.89	345	0.93	292
298	Univ Ferrara	0.96	0.90	330	0.83	421	0.87	358
299	Chinese Univ Hong Kong	0.96	0.92	319	0.92	158	0.91	168
300	Univ Rostock	0.95	0.89	337	0.95	373	0.91	376
301	Univ Kentucky	0.95	0.94	301	0.91	161	0.93	165
302	Univ Milan Bicocca	0.95	1.03	219	0.99	473	1.06	452
303	Temple Univ	0.95	0.92	318	0.90	346	0.90	346
304	Univ Milan	0.95	0.93	309	0.92	106	0.96	85
305	KTH Royal Inst Technol	0.95	0.98	273	0.92	251	0.97	281
306	York Univ	0.95	0.93	312	0.97	378	0.93	401
307	Univ Oklahoma	0.95	0.94	306	0.91	257	0.97	234
308	Univ Zaragoza	0.94	0.94	302	0.88	317	0.86	338
309	Univ Louisville	0.94	0.93	310	0.93	295	1.00	271

Rank M^F	University	M^F (1)	M^M (2)	Rank M^M (3)	T^F (4)	Rank T^F (5)	T^M (6)	Rank T^M (7)
310	Univ Guelph	0.94	0.93	311	0.95	266	1.00	287
311	Hong Kong Polytech Univ	0.94	0.94	304	0.86	238	0.93	263
312	Leibniz Univ Hannover	0.94	0.97	280	0.85	481	0.94	478
313	Louisiana State Univ	0.93	0.95	299	0.86	254	0.93	262
314	Clemson Univ	0.93	0.92	313	0.91	363	0.94	378
315	Univ Seville	0.93	0.92	317	0.93	318	0.97	323
316	Massey Univ	0.93	0.90	328	0.85	414	0.93	424
317	Indian Inst Technol Kharagpur	0.93	0.88	344	0.84	332	0.81	412
318	Loughborough Univ	0.93	0.91	321	0.93	349	0.91	408
319	Univ Nova Lisboa	0.93	0.89	342	0.89	428	0.85	429
320	Univ Surrey	0.93	0.91	322	0.94	356	0.97	384
321	Univ Torino	0.93	0.92	314	0.93	224	0.97	173
322	Univ Warsaw	0.93	0.84	373	0.63	425	0.75	418
323	Hunan Univ	0.92	0.87	358	0.87	417	0.88	465
324	Israel Inst Technol	0.92	0.90	329	0.85	163	0.88	175
325	Univ Bologna	0.92	0.91	323	0.85	137	0.89	129
326	Univ Porto	0.92	0.89	338	0.87	282	0.90	245
327	Univ Manitoba	0.92	0.91	324	0.86	270	0.88	265
328	Univ Burgundy	0.92	0.90	331	0.86	433	0.92	417
329	Univ Turku	0.92	0.86	362	0.84	336	0.79	279
330	Univ Tokyo	0.92	0.93	308	0.88	26	0.94	23
331	Univ Leipzig	0.92	0.92	316	0.88	272	0.90	257
332	Lanzhou Univ	0.92	0.87	355	0.83	340	0.78	397
333	Tel Aviv Univ	0.91	0.86	360	0.84	108	0.82	111
334	Univ Mississippi	0.91	0.89	336	0.83	391	0.88	366
335	Univ Santiago de Compostela	0.91	0.89	335	0.81	310	0.83	321
336	Henri Poincaré Univ	0.91	0.90	332	0.88	374	0.88	362
337	von-Guericke Univ Magdeburg	0.91	0.91	320	0.86	396	0.89	392
338	Oklahoma State Univ - Stillwater	0.90	0.97	285	0.83	410	0.86	422
339	Auburn Univ	0.90	0.89	341	0.81	362	0.82	389
340	Univ Valencia	0.90	0.88	349	0.84	240	0.86	225
341	Tech Univ Lisbon	0.90	0.90	327	0.85	333	0.92	319
342	Univ Lübeck	0.90	0.87	356	0.85	448	0.85	381
343	Univ Florence	0.90	0.88	347	0.86	212	0.87	179
344	Univ Sci & Technol China	0.90	0.87	353	0.92	150	0.92	189
345	Korea Adv Inst Sci & Technol	0.89	0.88	346	0.86	215	0.88	254
346	Univ Tasmania	0.89	0.91	325	0.86	438	0.90	432
347	Univ Halle-Wittenberg	0.89	0.89	334	0.75	395	0.81	393
348	Griffith Univ	0.89	0.90	326	0.85	413	0.85	443
349	Univ Eastern Finland	0.89	0.87	350	0.76	427	0.78	339
350	Univ Perugia	0.89	0.86	359	0.83	384	0.91	334
351	Sun Yat-sen Univ	0.89	0.85	368	0.83	255	0.80	280
352	Natl Tsing Hua Univ	0.89	0.84	375	0.81	277	0.80	307
353	Univ Genoa	0.89	0.94	303	0.77	331	0.86	267
354	Linköping Univ	0.88	0.87	354	0.74	354	0.80	327
355	Peking Univ	0.88	0.87	352	0.85	111	0.86	125
356	Indian Inst Technol Madras	0.88	0.85	370	0.94	348	0.87	438
357	Univ Aveiro	0.88	0.85	364	0.80	393	0.82	390
358	Dalian Univ Technol	0.88	0.86	361	0.86	287	0.84	344
359	Univ Modena & Reggio Emilia	0.88	0.89	340	0.81	403	0.86	379
360	Pontificia Univ Católica Chile	0.87	0.89	343	0.75	464	0.81	456
361	Stellenbosch Univ	0.87	0.90	333	0.81	432	0.90	426

Rank M^F	University	M^F (1)	M^M (2)	Rank M^M (3)	T^F (4)	Rank T^F (5)	T^M (6)	Rank T^M (7)
362	Univ Oulu	0.87	0.85	369	0.74	394	0.79	335
363	Natl Sun Yat-sen Univ	0.87	0.81	388	0.78	415	0.66	454
364	Univ Napels Federico II	0.87	0.85	366	0.76	239	0.78	197
365	Harbin Inst Technol	0.87	0.85	365	0.78	281	0.80	348
366	Univ Basque Country	0.87	0.85	363	0.79	347	0.84	345
367	Flinders Univ	0.87	0.89	339	0.74	465	0.87	446
368	Kyoto Univ	0.87	0.85	367	0.77	48	0.79	55
369	Univ Witwatersrand	0.86	0.87	351	0.78	430	0.82	437
370	Sharif Univ Technol	0.86	0.84	372	0.78	431	0.82	473
371	Amirkabir Univ Technol	0.86	0.81	390	0.78	484	0.71	494
372	Univ Lisbon	0.85	0.81	386	0.77	419	0.73	407
373	Univ Pisa	0.85	0.88	348	0.76	253	0.79	230
374	Natl Tech Univ Athens	0.85	0.84	371	0.72	381	0.76	439
375	Seoul Natl Univ	0.85	0.82	384	0.72	77	0.72	73
376	W Virginia Univ	0.85	0.83	377	0.71	402	0.72	420
377	Tsinghua Univ	0.85	0.83	378	0.83	76	0.83	132
378	Univ Cattolica Sacro Cuore	0.85	0.81	392	0.75	420	0.73	405
379	Natl Taiwan Univ	0.84	0.79	404	0.70	98	0.68	89
380	Fudan Univ	0.84	0.82	380	0.76	180	0.77	204
381	Texas Tech Univ	0.84	0.81	391	0.71	387	0.73	395
382	Univ Granada	0.84	0.88	345	0.76	311	0.73	328
383	Nankai Univ	0.84	0.81	389	0.80	292	0.80	337
384	Indian Inst Sci	0.83	0.80	396	0.74	293	0.69	374
385	Univ Nantes	0.83	0.97	284	0.79	436	1.00	369
386	Univ Roma Tor Vergata	0.83	0.81	387	0.70	367	0.74	315
387	Aristotle Univ Thessaloniki	0.82	0.77	416	0.78	216	0.74	272
388	Univ KwaZulu-Natal	0.82	0.87	357	0.69	478	0.84	475
389	Nagoya Univ	0.82	0.79	400	0.69	169	0.70	158
390	Complutense Univ	0.82	0.79	399	0.66	247	0.66	247
391	Osaka Univ	0.82	0.83	379	0.71	79	0.78	78
392	Tokyo Med & Dent Univ	0.82	0.81	385	0.76	412	0.83	359
393	Univ Murcia	0.82	0.80	395	0.68	437	0.71	461
394	Univ Bari Aldo Moro	0.81	0.80	397	0.71	379	0.72	341
395	Cent S Univ	0.81	0.79	403	0.63	424	0.64	458
396	Sapienza Univ Roma	0.81	0.82	382	0.71	146	0.79	104
397	Univ Patras	0.81	0.76	419	0.74	361	0.62	415
398	E China Univ Sci & Technol	0.81	0.84	374	0.66	426	0.76	445
399	Univ Ulsan	0.81	0.74	430	0.66	440	0.60	433
400	Xiamen Univ	0.81	0.84	376	0.72	429	0.81	430
401	Natl Cent Univ	0.81	0.80	394	0.76	408	0.82	409
402	Nanjing Univ	0.81	0.78	406	0.77	192	0.71	244
403	S China Univ Technol	0.81	0.77	412	0.66	442	0.65	476
404	Natl Chung Hsing Univ	0.80	0.77	414	0.70	398	0.70	419
405	Shanghai Jiao Tong Univ	0.80	0.78	405	0.69	124	0.68	184
406	Univ Oviedo	0.80	0.81	393	0.70	397	0.71	425
407	Wuhan Univ	0.80	0.77	411	0.75	283	0.73	320
408	Bar-Ilan Univ	0.79	0.82	381	0.76	400	0.86	410
409	S E Univ	0.79	0.79	401	0.84	382	0.85	428
410	Univ Fed Santa Catarina	0.79	0.78	409	0.63	479	0.66	479
411	Natl Chiao Tung Univ	0.79	0.75	423	0.70	288	0.71	303
412	Tokyo Inst Technol	0.78	0.82	383	0.71	175	0.80	188
413	Univ Coimbra	0.78	0.79	402	0.65	439	0.74	404

Rank M^F	University	M^F (1)	M^M (2)	Rank M^M (3)	T^F (4)	Rank T^F (5)	T^M (6)	Rank T^M (7)
414	Univ Siena	0.78	0.76	417	0.61	435	0.66	406
415	Tohoku Univ	0.78	0.80	398	0.68	90	0.72	93
416	Natl Cheng Kung Univ	0.77	0.74	431	0.61	217	0.60	232
417	E China Normal Univ	0.77	0.78	407	0.66	477	0.69	483
418	Mahidol Univ	0.77	0.76	418	0.62	449	0.62	416
419	Middle East Tech Univ	0.77	0.78	410	0.68	416	0.72	459
420	Yonsei Univ	0.77	0.75	422	0.64	207	0.60	215
421	Ewha Womans Univ	0.76	0.77	415	0.63	485	0.67	466
422	Univ Catania	0.76	0.78	408	0.60	444	0.62	431
423	Univ Palermo	0.75	0.75	427	0.58	409	0.58	421
424	Univ Saskatchewan	0.75	0.76	421	0.59	368	0.60	380
425	Zhejiang Univ	0.75	0.74	429	0.65	96	0.65	147
426	Univ Ljubljana	0.75	0.71	440	0.65	343	0.64	355
427	Ben-Gurion Univ Negev	0.75	0.75	425	0.60	308	0.65	295
428	Tech Univ Madrid	0.75	0.76	420	0.65	447	0.72	460
429	Kyushu Univ	0.75	0.73	432	0.64	165	0.63	171
430	Shanghai Univ	0.75	0.75	424	0.69	434	0.75	450
431	Keio Univ	0.75	0.77	413	0.64	342	0.70	316
432	Shandong Univ	0.75	0.71	437	0.64	290	0.62	329
433	Natl & Kapodistrian Univ Athens	0.74	0.70	444	0.63	202	0.60	211
434	Jilin Univ	0.74	0.74	428	0.62	309	0.64	351
435	Xi'an Jiaotong Univ	0.74	0.73	433	0.65	341	0.64	386
436	China Agr Univ	0.73	0.72	434	0.55	459	0.59	467
437	Cairo Univ	0.72	0.71	438	0.57	475	0.56	486
438	Tongji Univ	0.72	0.69	447	0.56	469	0.57	485
439	Chiba Univ	0.72	0.69	450	0.57	380	0.59	357
440	Chulalongkorn Univ	0.71	0.71	441	0.51	466	0.49	470
441	Univ Buenos Aires	0.71	0.71	442	0.51	377	0.58	347
442	Univ Sains Malaysia	0.71	0.64	480	0.71	467	0.61	487
443	Univ Sci & Technol Beijing	0.71	0.68	460	0.59	490	0.60	489
444	Univ Chile	0.70	0.72	436	0.48	458	0.54	434
445	Hokkaido Univ	0.70	0.70	446	0.54	198	0.55	213
446	Korea Univ	0.70	0.72	435	0.58	304	0.64	275
447	Sichuan Univ	0.70	0.68	456	0.55	328	0.55	360
448	Beijing Normal Univ	0.70	0.71	439	0.58	463	0.62	469
449	Univ Tsukuba	0.70	0.75	426	0.57	335	0.65	290
450	Univ São Paulo	0.69	0.69	452	0.50	117	0.52	116
451	Natl Yang-Ming Univ	0.69	0.64	479	0.47	461	0.47	372
452	Fed Univ Rio Grande Sul	0.69	0.67	463	0.51	405	0.51	399
453	Hiroshima Univ	0.69	0.70	445	0.56	338	0.61	308
454	Chonbuk Natl Univ	0.69	0.67	468	0.52	486	0.54	474
455	Hanyang Univ	0.69	0.68	459	0.57	360	0.59	353
456	Univ Fed Minas Gerais	0.69	0.69	449	0.46	457	0.49	447
457	Sungkyunkwan Univ	0.69	0.69	448	0.56	306	0.64	264
458	State Univ Campinas	0.69	0.68	461	0.52	302	0.55	317
459	Tianjin Univ	0.68	0.68	458	0.55	388	0.58	441
460	Kyung Hee Univ	0.68	0.69	455	0.56	470	0.60	455
461	Ege Univ	0.68	0.64	478	0.56	445	0.51	468
462	Univ Tehran	0.68	0.67	469	0.54	443	0.56	463
463	Jagiellonian Univ Krakow	0.68	0.69	454	0.52	411	0.59	400
464	Tarbiat Modares Univ	0.68	0.66	475	0.58	492	0.60	491
465	Chang Gung Univ	0.67	0.65	476	0.48	460	0.49	423

Rank M^F	University	M^F (1)	M^M (2)	Rank M^M (3)	T^F (4)	Rank T^F (5)	T^M (6)	Rank T^M (7)
466	Chonnam Natl Univ	0.67	0.66	474	0.48	462	0.49	444
467	Kanazawa Univ	0.67	0.69	453	0.48	455	0.54	442
468	Fed Univ Rio de Janeiro	0.67	0.66	473	0.44	390	0.48	368
469	Univ Pretoria	0.66	0.70	443	0.51	487	0.62	481
470	Kobe Univ	0.66	0.68	457	0.46	422	0.53	396
471	Waseda Univ	0.66	0.67	465	0.51	453	0.59	440
472	Chungnam Natl Univ	0.66	0.67	467	0.51	482	0.54	471
473	Natl Autonomous Univ Mexico	0.66	0.67	466	0.46	289	0.47	299
474	Okayama Univ	0.65	0.64	477	0.44	399	0.50	385
475	Northwestern Polytech Univ	0.65	0.63	482	0.54	488	0.52	497
476	Charles Univ Prague	0.65	0.67	464	0.48	353	0.57	270
477	Banaras Hindu Univ	0.64	0.68	462	0.48	489	0.51	493
478	Univ Estadual Paulista	0.64	0.62	486	0.39	450	0.38	457
479	Gazi Univ	0.64	0.57	498	0.41	472	0.35	484
480	Lomonosov Moscow State Univ	0.64	0.66	470	0.52	389	0.57	363
481	King Saud Univ	0.64	0.64	481	0.44	498	0.50	499
482	Istanbul Univ	0.63	0.59	492	0.44	418	0.41	435
483	Kyungpook Natl Univ	0.63	0.66	472	0.47	452	0.59	398
484	St Petersburg State Univ	0.63	0.69	451	0.50	494	0.62	488
485	Pusan Natl Univ	0.63	0.61	488	0.37	474	0.39	464
486	Tehran Univ Med Sci	0.62	0.58	496	0.40	497	0.36	495
487	Hacettepe Univ	0.62	0.59	491	0.36	451	0.39	448
488	Catholic Univ Korea	0.62	0.57	497	0.35	496	0.35	492
489	Univ Zagreb	0.61	0.63	483	0.40	471	0.51	450
490	Fed Univ São Paulo	0.61	0.60	490	0.41	483	0.37	482
491	Univ Nacl La Plata	0.61	0.66	471	0.39	491	0.55	477
492	Huazhong Univ Sci & Technol	0.60	0.61	487	0.45	358	0.51	383
493	Fed Univ Paraná	0.59	0.62	484	0.36	499	0.44	496
494	Inha Univ	0.59	0.62	485	0.47	454	0.49	472
495	Nihon Univ	0.58	0.59	493	0.39	468	0.44	462
496	Fed Univ Viçosa	0.58	0.60	489	0.42	500	0.50	500
497	Univ Belgrade	0.57	0.58	494	0.42	456	0.46	453
498	Ankara Univ	0.57	0.55	499	0.38	476	0.37	480
499	Konkuk Univ	0.56	0.58	495	0.36	495	0.36	490
500	Univ Malaya	0.50	0.52	500	0.44	493	0.43	498
	Union of LR universities[a]	1.09	1.08		1.14		1.16	
	Average	1.01	1.00		1.01		1.02	
	SD	0.24	0.23		0.36		0.35	
	CV	0.23	0.23		0.35		0.34	

[a] Weighted average of values in each column, with weights equal to the relative importance of each university's articles in the total number of articles according to the fractional or the multiplicative approach. University articles in the fractional and the multiplicative approach are in columns 1 and 3 in Table A. The total number of articles in the fractional and the multiplicative approach are 3.6 and 8.3 million, respectively

Table C. Regression results for selected universities

	Dependent variable = ΔM_i			Dependent variable = ΔT_i		
Expl. Variables	**Coefficient**	**Std. Error**	**t-value**	**Coefficient**	**Std. Error**	**t-value**
CRM_i	1.1381	0.4627	2.4*	1.2407	0.7118	1.7
$(CRM_i)^2$	-1.1202	0.2979	-3.8*	-1.4508	0.4501	-3.2*
CRM^T_i	-0.6699	0.3522	-1.9	-0.9453	0.5228	-1.8
$(CRM^T_i)^2$	0.7822	0.221	3.5*	1.2571	0.3287	3.8*
DH_i	-0.0167	0.0032	-5.3*	-0.0196	0.0047	-4.2*
DL_i	0.0086	0.003	2.8*	0.0113	0.0045	2.5*
S_i	-1.06E-06	1.20E-06	-0.8	-4.36E-05	1.90E-06	-1.9
Constant	-0.185	0.1046	-1.8	-0.1211	0.1572	-0.8
N	424			410		
Adjusted R^2	0.423			0.488		

Marginal effects on ΔM_i and ΔT_i caused by the variables RCM_i and RCM^T_i

CRM_i	CRM^T_i
$\partial \Delta M_i / \partial CRM_i = \beta_1 + 2\,\beta_2 CRM_i =$ -0.7281	$\partial \Delta M_i / \partial CRM^T_i = \beta_3 + 2\,\beta_4 CRM^T_i =$ 0.8945
$\partial \Delta T_i / \partial CRM_i = \beta'_1 + 2\beta'_2\, CRM_i =$ -1.1763	$\partial \Delta T_i / \partial CRM^T_i = \beta'_3 + 2\beta'_4\, CRM^T_i =$ 1.1918

Table 1. Example involving a single field

Distinct publications	Authors	Number of raw citations
Publication 1	Unit A	3
Publication 2	Unit A	6
Publication 3	Unit B	1
Publication 4	Units A and B	10

Table 2. Distribution by number of address lines and mean normalized citations of the total number and the top 10% of distinct articles

Addresslines	All distinct articles			Top 10% distinct articles		
	Articles	%	Mean citation	Articles	%	Mean citation
	(1)	(2)	(3)	(4)	(5)	(6)
1	725,608	30.0	8.2	65,403	27.0	37.1
2	742,510	30.7	8.7	69,050	28.5	38.0
3	462,539	19.1	9.7	44,388	18.3	40.6
4	238,882	9.9	11.4	25,155	10.4	46.3
5	115,454	4.8	13.1	13,925	5.8	49.8
6	57,340	2.4	15.0	7,900	3.3	54.8
7	29,649	1.2	17.3	4,766	2.0	58.7
8	16,208	0.7	19.2	2,955	1.2	61.9
≥ 9	31,864	1.3	113.6	8,463	3.5	185.8
Total	2,420,054	100	106.5	242,006	100	175.3

Tables 3.A. Re-rankings between universities classified by co-authorship rate when moving from the fractional to the multiplicative approach

	First 100 universities	Remaining 400 universities	Total	%
> 50 positions	21	90	111	22.2
26 – 50	32	60	92	18.4
16 – 25	23	119	142	28.4
6 – 15	20	93	113	22.6
≤ 5 positions	2	20	22	4.4
No change	2	18	20	4.0
Total	100	400	500	100.0

Table 3.B. Changes in university co-authorship rate when moving from the fractional to the multiplicative approach

	First 100 universities	Remaining 400 universities	Total	%
> 0.20	0	3	3	0.6
> 0.10 and ≤0.2	8	33	41	8.2
> 0.05 and ≤0.1	24	118	142	28.4
≤ 0.05	68	246	314	62.8
Total	100	400	500	100.0

Table 4.A. University ranking differences according to the *MNCS* indicator in the move from the fractional to the multiplicative approach

	First 100 universities	Remaining 400 universities	Total	%
> 50 positions	4	61	65	13.0
26 – 50	9	68	77	15.4
16 – 25	28	141	169	33.8
6 – 15	52	96	148	29.6
≤ 5 positions	7	12	19	3.8
No change	0	22	22	4.4
Total	100	400	500	100

Median	9
Mean	14.5
SD	15.6
CV	1.08
Max	101

Table 4.B. University differences in *MNCS* values in the move from the fractional to the multiplicative approach

	First 100 universities	Remaining 400 universities	Total	%
> 0.20	0	0	0	0.0
> 0.10 and ≤ 0.2	6	1	7	1.4
> 0.05 and ≤ 0.1	21	39	60	12.0
≤ 0.05	73	360	433	86.6
Total	100	400	500	100

Median	0.02
Mean	0.03
SD	0.02
CV	0.83
Max	0.19

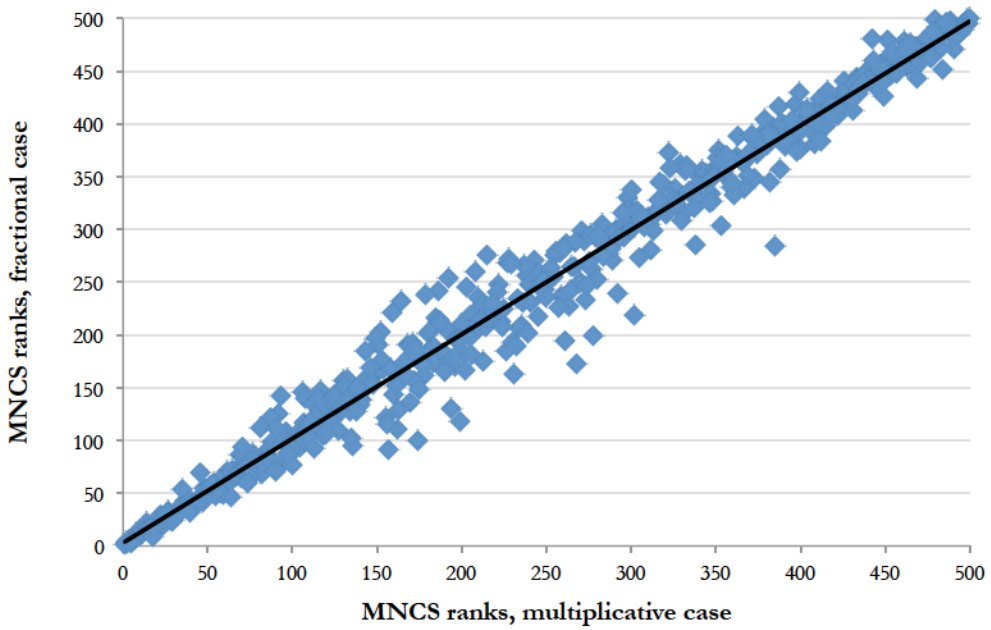

Figure 1.A. Scatter plot of the 500 LR universities' *MNCS* ranks according to the fractional and the multiplicative approaches

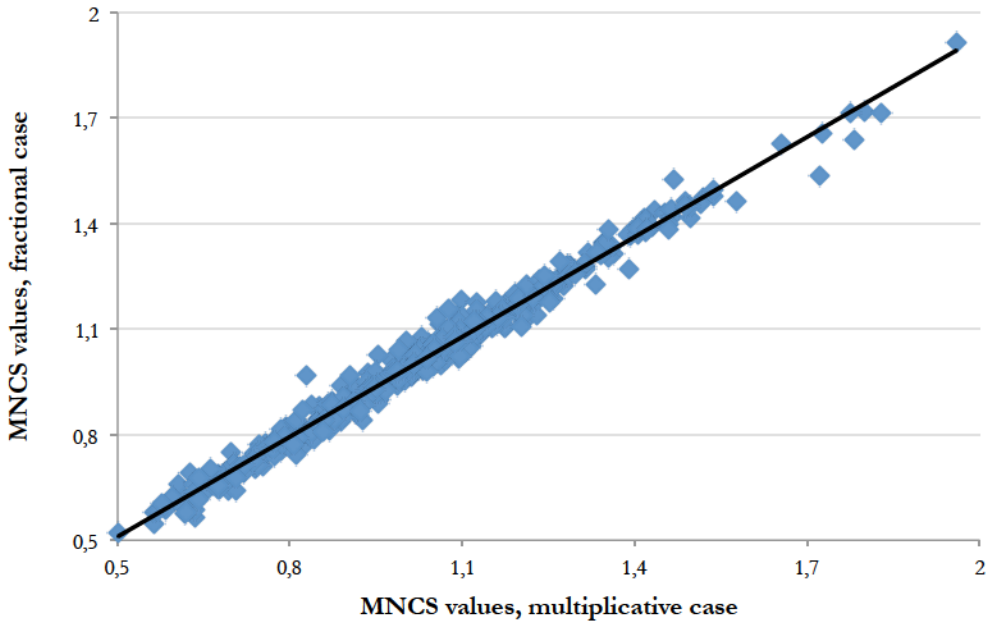

Figure 1.B. Scatter plot of the 500 LR universities' *MNCS* values according to the fractional and the multiplicative approaches

Table 5.A. University ranking differences according to the *Top 10%* indicator in the move from the fractional to the multiplicative approach

	First 100 universities	Remaining 400 universities	Total	%
> 50 positions	16	96	112	22.4
26 – 50	13	79	92	18.4
16 – 25	24	115	139	27.8
6 – 15	39	65	104	20.8
≤ 5 positions	7	7	14	2.8
No change	1	38	39	7.8
Total	100	400	500	100

Median	15
Mean	20.0
SD	18.0
CV	0.90
Max	93

Table 5.B. University differences in *Top 10%* values in the move from the fractional to the multiplicative approach

	First 100 universities	Remaining 400 universities	Total	%
> 0.20	1	1	2	0.4
> 0.10 and ≤ 0.2	7	18	25	5.0
> 0.05 and ≤ 0.1	18	88	106	21.2
≤ 0.05	74	293	367	73.4
Total	100	400	500	100

Median	0.03
Mean	0.04
SD	0.03
CV	0.82
Max	0.21

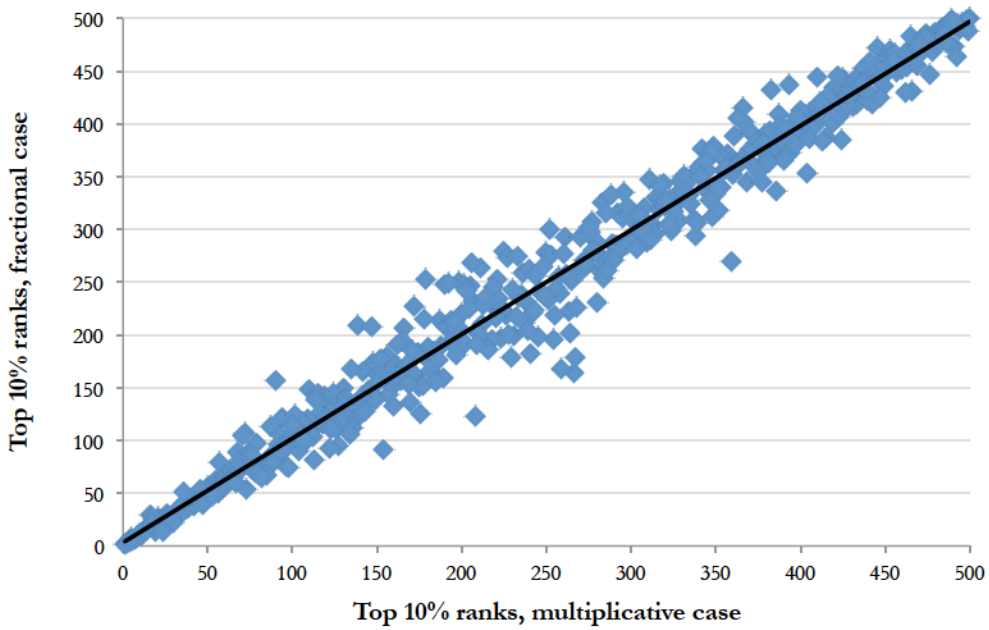

Figure 2.A. Scatter plot of the 500 LR universities' *Top 10%* ranks according to the fractional and the multiplicative approaches

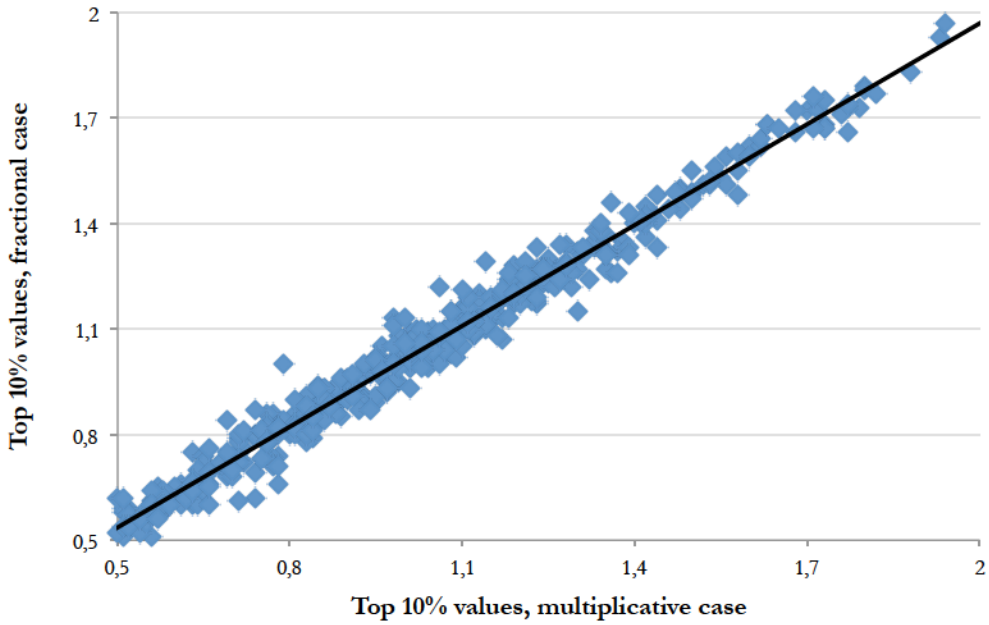

Figure 2.B. Scatter plot of the 500 LR universities' *Top 10%* values according to the fractional and the multiplicative approaches

Table 6.A. Descriptive statistics

	Sample mean	Std. deviation
ΔM_i	-0.0172	0.0321
ΔT_i	0.0127	0.0487
CRM_i	0.8174	0.0644
$(CRM_i)^2$	0.6722	0.1015
CRM^T_i	0.8422	0.0719
$(CRM^T_i)^2$	0.7144	0.1146
DH_i	0.3040	0.4604
DL_i	0.3120	0 .4638
DTH_i	0.3020	0 .4596
DTL_i	0.2880	0 .4533
S_i	1451.3	1022.9

Table 6.B. Regression results

	Dependent variable = ΔM_i			Dependent variable = ΔT_i		
Expl. variables	**Coefficient**	**Std. Error**	**t-value**	**Coefficient**	**Std. Error**	**t-value**
$CRMi$	0.9868	0.4607	2.1*	1.5170	0.6383	2.4*
$(CRMi)^2$	-1.0246	0.2906	-3.5*	-1.6328	0.4026	-4.1*
$CRMT_1$	-0.5624	0.3499	-1.6	-1.1176	0.4844	-2.3*
$(CRMTi)^2$	0.7173	0.2196	3.3*	1.3684	0.304	4.5*
DHi	-0.0154	0.0029	-5.3*	-0.0214	0.004	-5.4*
DLi	0.0091	0.0027	3.3*	0.009	0.0038	2.4*
Si	-1.53E-06	1.20E-06	-1.3	-4.21E-06	1.70E-06	-2.5*
Constant	-0.1699	0.0999	-1.7	-0.1562	0.1377	-1.1
N	500			500		
Adjusted R^2	0.392			0.492		

Table 6.C. Marginal effects on ΔM_i and ΔT_i caused by the variables CRM_i and CRM^T_i

CRM_i	CRM^T_i
$\partial \Delta M_i / \partial CRM_i = \beta_1 + 2\beta_2 CRM_i = -0.6882$	$\partial \Delta M_i / \partial CRM^T_i = \beta_3 + 2\beta_4 CRM^T_i = 0.6458$
$\partial \Delta T_i / \partial CRM_i = \beta'_1 + 2\beta'_2 CRM_i = -1.0993$	$\partial \Delta T_i / \partial CRM^T_i = \beta'_3 + 2\beta'_4 CRM^T_i = 1.1873$
