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"FIELD NORMALIZATION AT DIFFERENT AGGREGATION LEVELS"

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Abstract

This paper studies the impact of differences in citation practices using the model introduced in Crespo *et al.* (2012) according to which the number of citations received by an article depends on its underlying scientific influence and the field to which it belongs. Using a dataset of about 4.4 million articles published in 1998-2003 with a five-year citation window, the main results are the following four. Firstly, we estimate a set of exchange rates (*ER*s) to express the citation counts of articles in a wide quantile interval into the equivalent counts in the all-sciences case. For example, in the fractional case we find that in 187 out of 219 sub-fields the *ER*s are reliable in the sense that the coefficient of variation is smaller than or equal to 0.10. *ER*s are estimated over the [660, 978] interval that, on average, covers about 62% of all citations. Secondly, in the fractional case the normalization of the raw data using the *ER*s (or the sub-field mean citations) as normalization factors reduces the importance of the differences in citation practices from 18% to 3.8% (3.4%) of overall citation inequality. Thirdly, the results in the fractional case are essentially replicated when we adopt the multiplicative approach. Fourthly, whenever we are restricted to an intermediate aggregate level with 19 fields, the estimation of the *ER*s and the linear normalization procedures also offer good results. However, the aggregation of normalized distributions at the lowest aggregate level using sub-field *ER*s (or sub-field mean citations) as normalization factors, lead to similar or slightly better results at the field level.

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I. INTRODUCTION

From the beginning of Scientometrics as a field of study, scholars have been very aware of the field dependence of reference and citation counts in scientific articles (see *inter alia* Pinski and Narin, 1976, Murugesan and Moravcsik, 1978, and Garfield, 1979). There are two types of normalization procedures: target or "cited side", and source or "citing side". Since our dataset lacks citing side information, applying the latter is beyond the scope of this paper. Among the former, we must briefly comment on two recent proposals.

Firstly, using about three million papers, Radicchi and Castellano's (2012) find that the best transformation of raw citation numbers that makes the different citation distributions collapse on top of each other, is a non-linear function that depends on only two parameters for every field: the best estimates of the prefactor a and the exponent α of a power-law transformation that seems to be rather stable over different publication years from 1980 to 2004.

Secondly, in Crespo *et al.*'s (2012), three of us introduce a simple model in which the number of citations received by an article is a function of two variables: the article's underlying scientific influence, and the field to which it belongs. Consequently, the citation inequality of the distribution consisting of all articles in all fields –the *all-sciences case*– is the result of two forces: differences in scientific influence within homogeneous fields, and differences in citation practices across fields. In the implementation of this model using an additively decomposable inequality index, the citation inequality attributed to the second force is captured by a between-group inequality term in a certain partition by field and citation quantile. We denote it as the *IDCP* (*I*nequality attributable to *D*ifferent *C*itation *P*ractices) term. Thus, independently of the characteristics of citation distributions, the impact of any normalization procedure can be evaluated by the reduction in the *IDCP* term before and after normalization. From an empirical point of view, the similarity of citation distributions (Albarrán and Ruiz-Castillo, 2011, Albarrán *et al.*, 2011, and Radicchi and Castellano,

2012) causes the citation inequality attributable to differences in citation practices across fields to be approximately constant over a wide range of quantiles. This allows the effect of idiosyncratic citation practices to be rather well estimated over that interval. In particular, using a dataset of 4.4 million articles published in 1998-2003 with a five-year citation window, Crespo *et al.* (2012) estimate a set of exchange rates (*ER*s hereafter) for every field that serves two purposes: the translation of citation counts of articles in any field within that interval into the equivalent number of citations in a reference situation, and the normalization of the raw citation data in the all-sciences case.

One of the differences between the two papers is that while Radicchi and Castellano (2012) cover 172 Web of Science subject-categories, Crespo *et al.* (2012) only cover the 22 broad fields distinguished by Thomson Reuters. This could be important, since there are large differences in citation practices not only between fields, but also between research areas within a single field. Therefore, the first aim of this paper is to extend the analysis in Crespo *et al.* (2012) to the lowest aggregation level permitted by our data, namely, the 219 Web of Science categories, or *sub-fields* also distinguished by Thomson Scientific.

As is well known, a practical problem is that in the Thomson Reuters (and Scopus) databases publications in the periodical literature are assigned to sub-fields via the journal in which they have been published. Many journals are assigned to a single sub-field, but many others are assigned to two, three, or more sub-fields. As a result, only about 58% of all articles in our dataset are assigned to a single sub-field. To solve this problem, in this paper we adopt a *fractional* strategy according to which each publication is fractioned into as many equal pieces as necessary, with each piece assigned to a corresponding sub-field. However, we also study the robustness of the results at the lowest aggregate level when adopting a *multiplicative* strategy in which each paper is wholly counted as many times as necessary in the several sub-fields to which it is assigned.

The second aim of the paper is to study the issue of normalization at different aggregation levels. As is well known, there is no generally agreed-upon Map of Science or aggregation scheme that allows us to climb from the sub-field up to other aggregate levels (see *inter alia* Small, 1999, Boyack *et al.*, 2005, Leydesdorff, 2004, 2006, Leydersdorff and Rafols, 2009, and Waltman *et al.*, 2010 as well as the references they contain). Among the many alternatives, for the purpose of this paper we consider an intermediate level consisting of 19 broad *fields*.[1] Thus, at the bottom, the intermediate, and the top aggregate levels we have what we call sub-fields, fields, and the all-sciences case. To distinguish between the first two, we denote by $IDCP^F$ and ER^Fs the term that captures differences between citation practices, and the exchange rates at the field level.

We study the following five empirical issues: (i) the size of the $IDCP$ and $IDCP^F$ terms for the raw data; (ii) the reliability of the 219 ERs, and the 19 ER^Fs in terms of their coefficient of variation; (iii) the consequences of normalization at both levels using the corresponding exchange rates, in comparison with the traditional procedure in which sub-field and field mean citations are used as normalization factors; (iv) the reduction of the $IDCP^F$ term when using the field citation distributions that result from the aggregation of the normalized sub-field distributions, and (v) similarly, the reduction in the $IDCP$ term after the normalization of the raw sub-field data using the field ER^Fs and mean citations as normalization factors.

The rest of the paper consists of three Sections. Section II summarizes the model for the measurement of the effect of differences in citation practices. Section III presents the estimation of average-based ERs and their standard deviations (StDevs hereafter) over a large quantile interval in the fractional case, discusses the consequences of using them or the sub-field mean citations as normalization factors, and studies the

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[1] The 19 fields are taken from Albarrán *et al.* (2011), which borrow from the schemes recommended by Tijssen and van Leeuwen (2003) and Glänzel and Schubert (2003) with the aim of maximizing the possibility that a power law represents the upper tail of each of the corresponding citation distributions. It is not claimed that this scheme provides an accurate representation of the structure of science. It is rather a convenient simplification for the discussion of aggregation issues in this paper.

robustness of these results under the multiplicative approach. Section IV presents the results at the field level, while Section V contains some concluding comments.

II. THE MODEL

II. 1. The Sub-field Level

Suppose we have an initial citation distribution $Q = \{c_l\}$ consisting of N distinct articles, indexed by $l = 1,\ldots, N$, where c_l is the number of citations received by article l. The total number of citations is denoted by $\gamma = \Sigma_l\, c_l$. A sub-field is said to be *homogeneous* if the number of citations received by its papers is comparable independently of the journal where each has been published. Assume that here are S sub-fields, indexed by $s = 1,\ldots, S$. Let N_s be the number of distinct articles, indexed by $i = 1,\ldots, N_s$, which are assigned to sub-field s. As indicated in the Introduction, the problem is that about 42% of all articles in our dataset are assigned to two or more sub-fields.

Let X_l be the non-empty set of sub-fields to which article l is assigned, and denote by x_l the cardinal of this set, that is, $x_l = |X_l|$. Since, at most, an article is assigned to six sub-fields, we have that $x_l \in [1, 6]$. In the fractional strategy, sub-field s's citation distribution can be described by $\boldsymbol{c}_s = \{w_{si}\, c_{si}\}$, where $w_{si} = (1/x_l)$ for all $s \in X_l$ and some article l in the initial distribution for which $c_{si} = c_l$. Therefore, $\Sigma_{s\in Xl}\, w_{si} = 1$. The fractional number of articles in sub-field s is $n_s = \Sigma_i\, w_{si}$, the citations received by each fractional article are $w_{si}\, c_{si}$, and the fractional number of citations in sub-field s is $\Sigma_i\, w_{si}\, c_{si}$. It should be noted that $\Sigma_s\, n_s = \Sigma_s\, \Sigma_i\, w_{si} = \Sigma_l \Sigma_{s\in Xl}\, w_{si} = N$ and $\Sigma_s\, \Sigma_i\, w_{si}\, c_{si} = \gamma$, that is, in the fractional strategy the total number of articles and citations in the original dataset, and hence the mean citation, are preserved at the sub-field level.

Any distinct article i in sub-field s, with $c_{si} = c_l$ for some l in the initial distribution Q, is assumed to have a scientific influence q_{si} that, for simplicity, is taken to be a single-dimensional variable. We assume that the citations received c_{si} are a function of two variables: the sub-field s to which the article belongs, and the scientific influence of the article in question, q_{si}. Thus, for every s we write:

$$c_{si} = \phi(s, q_{si}),\ i = 1,\dots, N_s. \tag{1}$$

Let $\boldsymbol{q_s} = (w_{s1}\, q_{s1}, w_{s2}\, q_{s2},\dots, w_{sN_s}\, q_{sN_s})$ with $q_{s1} \leq q_{s2} \leq\dots\leq q_{sN_s}$ be the ordered distribution of scientific influence in every sub-field in the fractional case. Each distribution $\boldsymbol{q_s}$ is assumed to be a characteristic of sub-field s. No restriction is *a priori* imposed on distributions $\boldsymbol{q_s}$, $s = 1,\dots, S$. Consequently, for any two articles i and j in two different fields s and t the values $w_{si}\, q_{si}$ and $w_{tj}\, q_{tj}$ cannot be directly compared. To overcome this difficulty, we adopt the following key assumption.

<u>Assumption 1</u> (A1). *Articles at the same quantile* $\boldsymbol{\pi}$ *of any sub-field scientific influence distribution have the same degree of scientific influence in their respective field.*

Typically, scientific influence is an unobservable variable. However, although the form of ϕ in Eq. 1 is unknown, we adopt the following assumption about it:

<u>Assumption 2</u> (A2). *The function* ϕ *in expression (1) is assumed to be monotonic in scientific influence, that is, for every pair of articles i and j in sub-field s, if* $q_{si} \leq q_{sj}$, *then* $c_{si} \leq c_{sj}$.

Under A2, the degree of scientific influence uniquely determines the location of an article in its sub-field citation distribution. In other words, for every s, the partition of distribution $\boldsymbol{q_s} = (\boldsymbol{q_s}^{\boldsymbol{1}},\dots, \boldsymbol{q_s}^{\boldsymbol{\pi}},\dots, \boldsymbol{q_s}^{\boldsymbol{\Pi}})$ into $\boldsymbol{\Pi}$ quantiles $\boldsymbol{q_s}^{\boldsymbol{\pi}}$ of size $n_s/\boldsymbol{\Pi}$, induces a corresponding partition of the citation distribution $\boldsymbol{c_s} = (\boldsymbol{c_s}^{\boldsymbol{1}},\dots, \boldsymbol{c_s}^{\boldsymbol{\pi}},\dots, \boldsymbol{c_s}^{\boldsymbol{\Pi}})$ into $\boldsymbol{\Pi}$ quantiles, where $\boldsymbol{c_s}^{\boldsymbol{\pi}}$ is the vector of the number of citations received by the $n_s/\boldsymbol{\Pi}$ articles in the π-th quantile $\boldsymbol{q_s}^{\boldsymbol{\pi}}$. Note that $\boldsymbol{c_s}^{\boldsymbol{\pi}} = \{w_{sk}^{\pi}\ c_{sk}^{\pi}\}$, with $c_{sk}^{\pi} = c_{si} = c_l$, and $w_{sk}^{\pi} = 1/x_l$ for some $i = 1,.., N_s$ and some l in Q. Assume for a moment that we disregard the citation inequality within every vector c_s^{π} by assigning to every article in that vector the (fractional) mean citation of the vector itself, μ_s^{π}, defined by

$$\mu_s^{\pi} = (\Sigma_{i\in\pi}\, w_{si}\, c_{si})/\Sigma_{i\in\pi}\, w_{si}.$$

Since the quantiles of citation impact correspond –as we have already seen– to quantiles of the underlying scientific influence distribution, holding constant the degree of scientific influence at any level as in A1 is equivalent to holding constant the degree of citation impact at that level. Thus, for any π, the difference between μ_s^{π} and μ_t^{π} for articles with the same degree of scientific influence is entirely attributable to differences in citation practices between the two sub-fields.

To implement our measurement framework, it is convenient to work with additively decomposable citation inequality indices. For reasons explained in Crespo *et al.* (2012), we choose a member of the so-called Generalized Entropy family of inequality indices that are the only measures of relative inequality that satisfy the usual properties required from any inequality index and, in addition, are decomposable by population subgroup. This is the first Theil index, denoted by I_1, and defined by:

$$I_1(Q) = (1/N)\ \Sigma_l\, (c_l/\mu)\ \log\,(c_l/\mu), \tag{2}$$

where μ is the mean of distribution Q. Let c be the union of distributions c_s, that is, $c = \cup_s c_s$. As we have seen already, the number of articles and the mean citation of distributions Q and c coincide. Clearly, citation inequality is also the same, that is, $I_1(c) = I_1(Q)$. Therefore, in the sequel we will work with distribution c.

For each π, let $c^{\pi} = (c_1^{\pi},\ldots, c_s^{\pi},\ldots\ c_S^{\pi})$. Clearly, the set of vectors c^{π}, for $\pi = 1,\ldots, \Pi$ form a partition of distribution c. As in Crespo *et al.* (2012), applying the decomposability property of citation inequality index

I_1 first to the partition $\mathbf{c} = (\mathbf{c}^1,\dots, \mathbf{c}^{\pi},\dots, \mathbf{c}^{\Pi})$, and then to the partition $\mathbf{c}^{\pi} = (c_1^{\pi},\dots, c_s^{\pi},\dots c_S^{\pi})$ for each π, the overall citation inequality $I_1(\mathbf{c})$ can be seen to be decomposable into the following three terms:

$$I_1(\mathbf{c}) = W + S + IDCP, \tag{3}$$

where:

$$W = \Sigma_{\pi} \Sigma_s v^{\pi,s} I_1(\mathbf{c}_s^{\pi})$$

$$S = I_1(\boldsymbol{\mu}^1,\dots, \boldsymbol{\mu}^{\Pi})$$

$$IDCP = \Sigma_{\pi} v^{\pi} I_1(\boldsymbol{\mu}_1^{\pi},\dots, \boldsymbol{\mu}_S^{\pi}) = \Sigma_{\pi} v^{\pi} I(\pi),$$

where $v^{\pi,s}$ is the share of total citations in quantile π of sub-field s, and and $v^{\pi} = \Sigma_s v^{\pi,s}$ is the share of total citations in vector $\mathbf{c}^{\pi}$. The term W is a within-group term that captures the weighted citation inequality within each quantile in every sub-field. The term S is the citation inequality of the distribution $\mathbf{m} = (\boldsymbol{\mu}^1,\dots, \boldsymbol{\mu}^{\Pi})$ in which each article in a given vector $\mathbf{c}^{\pi}$ is assigned the vector's citation mean, $\boldsymbol{\mu}^{\pi} = \Sigma_s\, [(n_s/N]\boldsymbol{\mu}_s^{\pi}$. Thus, S is a measure of citation inequality at different degrees of citation impact that captures well the skewness of science in the all-sciences case. Finally, for any π, the expression $I_1(\boldsymbol{\mu}_1^{\pi},\dots, \boldsymbol{\mu}_S^{\pi})$, abbreviated as $I(\pi)$, is the citation inequality attributable to differences in citation practices according to I_1. Thus, the weighted average that constitutes the third term in expression (3), denoted by *IDCP* (*I*nequality due to *D*ifferences in *C*itation *P*ractices), provides a good measure of the citation inequality due to such differences at the sub-field level.

II. 2. The Field Level

Assume that there is only another aggregation level consisting of $F < S$ fields, indexed by $f = 1,\dots, F$, as well as a rule that indicates the field to which each sub-field belongs. Given this rule, there is no particular problem in associating the sub-field fractional numbers of articles and citations to the corresponding field. As a matter of fact, for each f, the field citation distribution in the fractional strategy, $\mathbf{c}_f$, is equal to the union of the corresponding sub-field distributions, that is, $\mathbf{c}_f = \cup_{s\in f}\mathbf{c}_s$. Let N_f be the number of distinct articles in field f, indexed by $j = 1,\ldots, N_f$, so that we can write the field citation distribution in the fractional case as $\mathbf{c}_f = \{w_{fj}\, c_{fj}\}$, where for each j there is some $i = 1,.., N_s$, $s \in f$, and some l in $\mathcal{Q}$ such that $c_{sfj} = c_{si} = c_l$ and $w_{fj} = 1/x_l$. Again, the number of articles and citations in a particular field, $n_f = \Sigma_{s\in f}\Sigma_i w_{si} = \Sigma_{s\in f} n_s$ and $\Sigma_{s\in f}\Sigma_i w_{si}\ c_{is}$, may typically be fractional. However, the sum of these numbers over all fields necessarily coincides with the original ones: $\Sigma_f n_f = N$, and $\Sigma_f \Sigma_{s\in f}\Sigma_i w_{si}\ c_{is} = \gamma$. Similarly, it can be shown that distribution $\mathbf{c}$ is also the union of field citation distributions, that is, $\mathbf{c} = \cup_f \mathbf{c}_f$.

Order each field citation distribution and, for each f, consider the partition into $\boldsymbol{\Pi}$ quantiles $\mathbf{c}_f^{\boldsymbol{\pi}}$ of size $n_f/\boldsymbol{\Pi}$, $\mathbf{c}_f = (\mathbf{c}_f^{\mathbf{1}},\ldots, \mathbf{c}_f^{\boldsymbol{\pi}},\ldots, \mathbf{c}_f^{\boldsymbol{\Pi}})$. Let $\mathbf{C}^{\boldsymbol{\pi}} = (\mathbf{c}_1^{\boldsymbol{\pi}},\ldots, \mathbf{c}_f^{\boldsymbol{\pi}},\ldots\ \mathbf{c}_F^{\boldsymbol{\pi}})$. As before, applying the decomposability property of citation inequality index I_1 first to the partition $\mathbf{c} = (\mathbf{C}^1,\ldots, \mathbf{C}^{\boldsymbol{\pi}},\ldots, \mathbf{C}^{\boldsymbol{\Pi}})$, and then to the partition $\mathbf{C}^{\boldsymbol{\pi}} = (\mathbf{c}_1^{\boldsymbol{\pi}},\ldots, \mathbf{c}_f^{\boldsymbol{\pi}},\ldots\ \mathbf{c}_F^{\boldsymbol{\pi}})$ for each π, we would have an expression entirely analogous to Eq. 3, namely:

$$I_1(\mathbf{c}) = W^F + S^F + IDCP^F, \tag{4}$$

where:

$$W^F = \Sigma_\pi \Sigma_f v^{\pi,f} I_1(\mathbf{c}_f^{\boldsymbol{\pi}})$$

$$S^F = I_1(\boldsymbol{\mu}^{F1},..., \boldsymbol{\mu}^{F\boldsymbol{\Pi}})$$

$$IDCP^F = \Sigma_\pi v^{\boldsymbol{\pi}}\, I_1(\boldsymbol{\mu}_1^{\boldsymbol{\pi}},\ldots, \boldsymbol{\mu}_F^{\boldsymbol{\pi}}) = \Sigma_p v^{\boldsymbol{\pi}}\, I^F(\pi),$$

where $v^{\pi,f}$ and $v^{\pi} = \Sigma_s v^{\pi,f}$ are now the share of total citations in quantile π of field f, and in vector $\mathbf{C}^{\boldsymbol{\pi}}$, respectively. The term W^F is a within-group term that captures the weighted citation inequality within each quantile in every field. The term S^F is the citation inequality of the distribution $(\boldsymbol{\mu}^{F1},..., \boldsymbol{\mu}^{F\boldsymbol{\Pi}})$ in which each article in a given vector C^{π} is assigned the vector's citation mean, $\mu^{F\pi} = \Sigma_f \Sigma_{s\in f} [(n_s/N]\mu_s^{\pi}$. Finally, let $\mu_f^{\pi} = \Sigma_{s\in f} [(n_s/N]\mu_s^{\pi}$. For any π, the expression $I_1(\mu_1^{\pi},\ldots, \mu_F^{\pi})$, abbreviated as $I^F(\pi)$, is the citation inequality attributable to differences in citation practices across fields according to I_1. Thus, the weighted average that constitutes the third term in expression (4), denoted by $IDCP^F$, provides a good measure of the citation inequality due to such differences at the field level.

III. EMPIRICAL RESULTS AT THE SUB-FIELD LEVEL

In this paper only research articles or, simply, articles, are studied. Our dataset consists of 4.4 million articles published in 1998-2003, and the 35 million citations they receive after a common five-year citation window for every year. Table A in the Appendix presents the number of articles and mean citation rates in the fractional case.[2] For convenience, fields and sub-fields are classified in terms of four large groups: Life Sciences, Physical Sciences, Other Natural Sciences, and Social Sciences, which represent, respectively, 40.1%, 30.2%, 25.8%, and 3.9% of all articles.

This Section analyzes two empirical problems in the fractional case: (i) how to compare the citations received by two articles in any pair of the 219 sub-fields in our dataset by using *ER*s that are approximately constant over a large quantile interval, (ii) how much the *IDCP* term is reduced when these *ER*s, or the field mean citations are used as normalization factors. In the third place, we study the robustness of these results in the multiplicative approach.

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[2] It should be noted that, due to some missing variables, this dataset has only 4,465,348 articles, or 6,984 articles less than the dataset in Crespo *et al.* (2012).

III. 1. The Comparison of Citation Counts Across Different Fields

Figure 1 represents how the effect of differences in citation practices, measured by $I(\pi)$, changes with π when $\Pi = 1{,}000$ (since $I(\pi)$ is very high for $\pi < 260$, for clarity these quantiles are omitted from Figure 1).[3] It is observed that $I(\pi)$ is particularly high until $\pi \approx 600$, as well as for a few quantiles at the very upper tail of citation distributions. However, $I(\pi)$ is strikingly similar for a wide range of intermediate values.[4] In this situation, for each s it is reasonable to define an average-based *exchange rate* (*ER*) over some interval $[\pi_m, \pi^M]$ in that range as

$$e_s = [1/(\pi^M - \pi_m)] \, [\Sigma_\pi \, e_s(\pi)], \tag{5}$$

where, for each π,

$$e_s(\pi) = \mu_s^\pi / \mu^\pi.$$

Figure 1 around here

We find that the choice $[\pi_m, \pi^M] = [661, 978]$ –where $I(\pi)$ for most π is equal to $I(\pi_m) = 0.1356$ and $I(\pi^M) = 0.1392$– is a good one. The *ER*s e_s, as well as the StDev, and the coefficient of variation (*CV* hereafter) are in columns 1 to 3 in Table 1. For convenience, *ER*s are multiplied by 10. Thus, for example, the first row indicates that 10.3 citations with a StDev of 0.3 for an article in Biology between, approximately, the 66st and the 98th percentile of its citation distribution, are equivalent to 10 citations for an article in that interval in the all-sciences case. We find it useful to divide fields into four groups according to the *CV*. Group I (colored in dark green in Table 1), consisting of 69 sub-fields, has a *CV* smaller than or equal to 0.05. This means that the StDev of the exchange rate is less than or equal to five percent of the exchange rate itself. Hence, we consider *ER*s in this group as highly reliable. Group II (pale green), consisting of 118 sub-

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[3] As in Crespo *et al.* (2012), in the definition of the inequality index I_1 in expressions (3) and (4), we have followed the convention 0 log(0) = 0 for articles without citations.

[4] It is important to emphasize that this is consistent with the stylized facts characterizing citation distributions documented in Albarrán and Ruiz-Castillo (2011), Albarrán *et al.* (2012), and Crespo *et al.* (2012).

fields, has a *CV* between 0.05 and 0.10. We consider *ER*s in this group as fairly reliable. Group III (orange), consists of 22 sub-fields, has a *CV* between 0.10 and 0.15. This group includes some important sub-fields, such as *Physics, Particles and Fields, Information and Library Science*, and *Political Science* (sub-fields 97, 210, and 189), as well seven out of eight sub-fields within the broad field *Computer Science* (the exception is *Mathematical and Computational Biology*) that is known to behave as an outlier (Herranz and Ruiz-Castillo, 2012, and Crespo *et al.*, 2012). Some would find exchange rates in this group as minimally reliable, while others will find them quite unreliable. Finally, Group IV (red), consisting of nine sub-fields, has a *CV* greater than 0.15. This group includes *Multidisciplinary Sciences* and *Physics, Multidisciplinary*, hybrid sub-fields some of which also behave badly in Radicchi and Castellano (2012). Exchange rates in this group can be considered unreliable.

As is observed in column 4 in Table 1, on average the [661, 978] interval includes 62.2% of all citations (with a StDev of 3.0). Although this is a relatively large percentage, expanding the interval in either direction would bring a larger percentage of citations. It turns out that, when we do this, the *ER*s do not change much. However, they exhibit greater variability. For example, moving the upper bound π^M to quantile 986 or 995 would increase the percentage of citations to 66.7% (StDev = 3.3) or 73.1% (StDev = 3.9). However, the CV would increase in all but five and two sub-fields, the number of sub-fields in Group I would decrease from 69 in the reference case down to 63 or 52, while the number of sub-fields in Groups III and IV would increase from 32 to 34 and 39. In the other direction, moving the lower bound π_m to quantiles 637, or 614, for example, would slightly increase the percentage of citations to 64.3%, (StDev = 3.0) and 66.2% (StDev = 2.9). However, relative to the initial choice, in these two instances the *CV* would increase in one sub-field, the number of fields in Groups I would decrease from 69 to 64 and 58, while the number of sub-fields in Groups III and IV would increase from 32 to 39 and 42. On the other hand, after normalization by the *ER*s corresponding to the four alternatives [706, 986], [706, 995], [637, 978], and [614, 978], the *IDCP* term represents essentially the same percentage of the overall citation inequality in the normalized distributions (see below). Therefore, we retain the interval [661, 978] in the sequel.

Table 1 around here

III. 2. Normalization Results

In the first place, we want to assess the normalization procedure based on *ER*s whereby the citations received by any article *i* in sub-field *s*, c_{si}, are converted into normalized citations c_{si}^* as follows: $c_i^* = c_{si}/e_s$. The numerical results before and after this normalization are in Panels A and B in Table 2.[5] The first thing to note is that the *IDCP* term with 22 fields in Crespo *et al.* (2012) represented 13.95% of overall citation inequality. As expected, the importance of the *IDCP* term when working with 219 sub-fields increases four percentage points, up to 17.95%. However, as in Crespo *et al.* (2012), the term *W* is small, while the term *S* is large, and both terms remain essentially constant after normalization by the *ER*s. In absolute terms the *IDPC* term is reduced from 0.1552 to 0.0293, a 81.1% difference. Of course, total citation inequality after normalization is also reduced. On balance, the *IDPC* term after normalization only represents 3.85% of total citation inequality –an important reduction from the 17.95% with the raw data.

Table 2 around here

However, it should be recognized that in the last 22 quantiles and, above all, in the [1, 660] interval normalization results quickly deteriorate. Figure 2, which focuses on the product $v^{\pi} I(\pi)$ as a function of π, illustrates the situation. Of course, the term *IDCP* introduced in Eq. 3 is equal to the integral of this expression (for clarity, quantiles $\pi < 600$, and $\pi > 994$, are omitted from Figure 2). Relative to the blue curve, the red curve illustrates the correction achieved by normalization with the 219 *ER*s: the size of the *IDCP* term is very much reduced, particularly in the [661, 978] interval.

Figure 2 around here

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[5] Because of the slight change in the total number of articles mentioned in note 2, overall citation inequality is 0.8644 rather than 0.8755 as in Crespo *et al.* (2012).

As in Crespo *et al.* (2012), it is interesting to examine the consequences of the traditional procedure in which sub-field mean citations are taken as normalization factors. The *ER*s based on mean citations, $e_s(\mu_s) = \mu_s/\mu$, are in column 5 in Table 1. As illustrated in Figure 3, they are very close indeed to our own e_s. As a matter of fact, they are between one StDev of the e_s for 50 sub-fields out of 69 in Group I, 102 out of 118 in Group II, 22 out of 23 in Group III, and in all nine cases in Group IV. When sub-field mean citations are used as normalization factors, the *IDCP* term only represents 3.45% of total citation inequality (see Panel C in Table 2). The two solutions are so near that we refrain to illustrate the latter in Figure 2 because it will be indistinguishable with the red curve after normalization by our *ER*s.[6]

Figure 3 around here

The similarity between the results of the two normalization procedures lies in the fact that, as we have seen in Figure 1, sub-field citation distributions appear to differ by a set of scale factors only in the [660, 978] interval. These scale factors are well captured by any average-based measure of what takes place in that interval –such as our *ER*s. However, as documented in Herranz and Ruiz-Castillo (2012), sub-field mean citations in the fractional approach, μ_s, are reached, on average, at the 68.3 percentile with a StDev of 3.4, that is, in the interior of the [661, 978] interval. This is the reason why the *ER*s based on mean citations do also work so well.

Finally, we have also estimated the consequences of adopting the normalization advocated by Glänzel (2011), and discussed in Crespo *et al.* (2012). The *IDCP* term is reduced from 18.95% to 5.41%, about 1.5 percentage points above what can be accomplished by our own *ER*s or those based in sub-field mean citations.

III.3. The Multiplicative Approach

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[6] This confirms the results in both Crespo *et al.* (2012) and Radicchi and Castellano (2012).

In the multiplicative approach each article is wholly counted as many times as necessary in the several sub-fields to which it is assigned. In this way, the space of articles is expanded as much as necessary beyond the initial size in what we call the *sub-field extended count*. In our dataset, the extended count is 7,027,037, or 57.4% larger than the total number of articles in the fractional approach (details about the distribution of sub-fields by size and mean citation are available on request). Otherwise, an expression as (3) also applies to this case, and the search for an appropriate set of *ER*s proceeds exactly as before.

The information about the evolution of $I(\pi)$ as a function of π (available on request), as well as the aim of facilitating the comparison with the fractional case justifies the same choice as before: $[\pi_m, \pi^M] = [661, 978]$. The corresponding *ER*s, StDevs, and *CV*s are in columns 1 to 3 in Table 3. As observed in column 4 of this Table, on average the percentage of citations covered in this interval is 62.3% (with a StDev equal to 3.0). The *ER*s based on sub-field citation means appear in column 5 in Table 3, while the consequences of the normalization using both sets of *ER*s are in Table 4.

Tables 3 and 4 around here

This massive information deserves the following four comments. Firstly, the *IDCP* term in the multiplicative case represents 18.1% of overall citation inequality, a figure remarkably close to the corresponding one in the fractional case. Secondly, Groups I, II, III, and IV consist now of 77, 113, 19, and 10 sub-fields –figures that slightly improves those obtained in the fractional case. Thirdly, the normalization using our own *ER*s or those based on sub-field mean citations reduces the *IDCP* term to 3.57% and 3.27%, respectively. Thus, in both cases normalization results slightly improve what was obtained under the fractional approach. Fourthly, except for two sub-fields, the multiplicative *ER*s are always within one StDev of the fractional ones (see the illustration in Figure 4).

Figure 4 around here

In brief, the results in the fractional and the multiplicative cases are extremely similar. As indicated in Herranz and Ruiz-Castillo (2012), the similarity of the citation characteristics of articles published in journals assigned to one or several sub-fields guarantees that choosing one of the two strategies may not lead to a radically different picture in practical applications. Given that in the multiplicative approach the total number of articles decreases as we climb in any aggregation scheme, while in the fractional approach this quantity is preserved at any aggregation level, we will follow the latter in the remaining of the paper.

IV. EMPIRICAL RESULTS AT THE FIELD LEVEL

IV.1. Exchange Rates

Following the same approach as before, we find that the choice $[\pi_m, \pi^M] = [620, 998]$ –where $I(\pi)$ for most π is equal to or smaller than $I(\pi_m) = 0.1039$ and $I(\pi^M) = 0.1186$– is a good one. The ER^Fs, defined as in Eq. 5, as well as the StDev, and the *CV*s are in columns 1 to 3 in Table 5. For convenience, ER^Fs are multiplied by 10. As before, we find it useful to divide fields into four groups according to the *CV*. Groups I and II (colored in dark green and pale green in Table 5), consists of nine and eight fields, respectively. Group III (orange) includes *Computer Science*, while Group IV (red) includes *Multidisciplinary Sciences*, two fields whose analogues in Crespo *et al.* (2012) were also badly behaved.

Table 5 around here

As is observed in column 4 in Table 5, on average the interval [620, 998] includes 80.2% of all citations (with a StDev of 2.6). In general, expanding the interval brings a larger percentage of citations, does not change much the $IDCP^F$ term, and the ER^Fs exhibit greater variability reducing the number of fields in Group I (to save space, detailed results are available on request). Therefore, we retain the interval [620, 998] in the sequel.

The numerical results before and after the normalization by the ER^Fs are in Panels A and B in Table 6. The first thing to note is that the $IDCP^F$ term with 19 fields represents 12.48% of overall citation inequality, very close to the 13.95% for 22 comparable broad fields in Crespo *et al.* (2012). As expected, the term W is small, while the term S is large, and both terms remain essentially constant after normalization. In absolute terms the $IDPC^F$ term is reduced from 0.1079 to 0.0135, a 87.5% difference. On balance, the $IDPC^F$ term after normalization only represents 1.71% of total citation inequality –an important reduction from the 12.48% with the raw data. Finally, the ER^Fs based on field mean citations (see column 5 in Table 6) are always between one StDev from our own ER^Fs except for *Biosciences*. When field mean citations are used as normalization factors, the $IDCP^F$ term only represents 1.67% of total citation inequality (see Panel C in Table 7).

Table 6 around here

IV.2. Reciprocal Normalization Procedures

In this Sub-section we explore two questions. Firstly, consider the possibility of first constructing normalized sub-field citation distributions using sub-field *ER*s (or sub-field mean citations) as normalization factors, and then aggregating them into the corresponding fields. How good would be the normalization at the field level in this case? In other words, by how much is the $IDPC^F$ term reduced when using such normalized field distributions? The answer is in Panels D and E in Table 6. When using sub-field *ER*s, the $IDPC^F$ term is reduced from 12.48% to 1.79%, in comparison with 1.71% when using field *ER*s. However, when using sub-field mean citations the $IDPC^F$ term is reduced to 1.62%, below the 1.67% reduction when using field mean citations.

Secondly, we ask: how good is the normalization at the sub-field level when using field *ER*s (or field mean citations) as normalization factors? In other words, by how much is the *IDPC* term reduced in these cases? The answer is in Panels D and E in Table 2. When using field *ER*s (mean citations) the *IDPC* term is reduced from 17.95% to 7.90% (7.87%). Therefore, after this normalization the *IDPC* term is about 50% of the *IDCP* term with the raw data, and twice as large as after the corresponding normalization using sub-field *ER*s (or sub-field mean citations) as normalization factors.

These results establish the expected superiority of procedures that use normalization factors at the sub-field rather than the field level.

V. CONCLUSIONS

The lessons that can be drawn from this paper can be summarized in the following six points.

1. As expected, the relative importance of the citation inequality attributable to differences in citation practices is larger at lower aggregation levels. In particular, the *IDCP* term that represents about 14% of overall citation inequality in the case of 22 broad fields (Crespo *et al.*, 2012), represents about 18% with the 219 sub-fields identified with the Web of Science subject-categories distinguished by Thomson Reuters, or about 12.5% with the 19 fields in the aggregation scheme used in this paper.

2. The regularities found in Crespo *et al.* (2012) for 22 fields characterize also the two aggregate levels studied in this paper. The citation inequality attributable to differences in citation practices is very high and variable for both a long lower tail –consisting of uncited and poorly cited articles below the mean– and a small number of quantiles at the very upper tail of citation distributions where citation excellence possibly resides. However, the *IDCP* term remains relatively constant for wide range of intermediate quantiles. The conjecture is that this constancy reflects the fact that, approximately, citation distributions over that range differ only by a scale factor. This allows us to estimate a set of *ER*s to express the citation counts of articles in that interval into the equivalent counts in a reference situation, namely, the all-sciences case.

For example, in the fractional case we find that in 187 out of 219 sub-fields, or 85% of the total, the *ER*s have a tolerably low coefficient of variation, that is, a coefficient of variation smaller than or equal to 0.10. The *ER*s are estimated over a [660, 978] interval that, on average, covers about 62% of all citations in each sub-field. In turn, at the field level, except for *Computer Science* and the *Mutidisciplinary* case that are known to behave differently from the others, we find reliable estimates for the ER^Fs of the remaining 17 fields over the $[620, 998]$ interval that, on average, covers about 80% of all citations.

3. The normalization of the raw data using the *ER*s as normalization factors is rather successful: in the fractional case, we find that the *IDCP* term at the sub-field level is reduced from 18% to 3.8%, while the $IDCP^F$ term at the field level is reduced from 12.5% to 1.7%.

4. As in Crespo *et al.* (2012), the procedure using mean citations as normalization factors achieves even slightly better results. The reason for this coincidence is that mean citations are essentially located at the 69th percentile of citation distributions, very near the lower bound or inside the quantile interval where citation distributions appear to differ only by a scale factor.

5. Interestingly enough, our results at the lowest aggregate level about the *ER*s and their role as normalization factors in the fractional case are essentially replicated when we adopt the multiplicative approach.

6. We have seen that, whenever we are restricted to an intermediate aggregate level, the estimation of the *ER*s and the linear normalization procedures offer good results. However, we confirm that, whenever we have information at the lowest aggregate level, the aggregation of normalized distributions at that level using sub-field *ER*s (or sub-field mean citations) as normalization factors, lead to similar or slightly better results.

Among the possible extensions of our work, we will comment on the following four. Firstly, as already pointed out in Crespo *et al.* (2012), since the citation process evolves at different velocity in different scientific domains, using variable citation windows to ensure that the process has reached a similar stage in all domains should improve the comparability of citation distributions at the lower tail. Secondly, it would be interesting to investigate by how much the *IDCP* term is reduced when using two alternative normalization procedures: the non-linear transformation advocated by Radicchi and Castellano (2012), and the source or "citing side" procedure recently discussed, *inter alia*, in Zitt and Small (2008), Moed (2010), and Leydesdorff and Opthof (2010). Thirdly, we should test our results on the selection of *ER*s and normalization in a statistical framework using, for example, a bootstrap approach. Fourthly, we should study the robustness of our results with other datasets.

Nevertheless, it should be concluded that the striking similarity of citation distributions at different aggregate levels seems to provide firm basis for the solution of the following two crucial practical problems: the comparison of citation counts across different scientific disciplines, and the normalization of the raw citation data before aggregating heterogeneous fields into larger categories.

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STATISTICAL APPENDIX

Table A. Number of Articles and Mean Citation Rates in the 219 Sub-fields and the 19 Fields in the Fractional Case

	Number of Articles (1)	% (2)	Mean Citation (3)	Standard Deviation (4)
A. LIFE SCIENCES				
I. BIOSCIENCES	**342,480.5**	**7.67**	**15.8**	**20.1**
1. BIOLOGY	19,590.7	0.44	7.3	8.4
2. BIOLOGY, MISCELLANEOUS	277.1	0.01	3.3	0.9
3. EVOLUTIONARY BIOLOGY	5,953.0	0.13	12.6	11.5
4. BIOCHEMICAL RESEARCH METHODS	17,636.6	0.39	9.6	10.7
5. BIOCHEMISTRY & MOLECULAR BIOLOGY	161,192.8	3.61	17.4	19.7
6. BIOPHYSICS	28,162.4	0.63	10.9	8.3
7. CELL BIOLOGY	53,873.7	1.21	21.2	20.3
8. GENETICS & HEREDITY	43,311.1	0.97	15.8	20.3
9. DEVELOPMENTAL BIOLOGY	12,483.3	0.28	20.0	17.6
II. BIOMEDICAL RESEARCH	**247,383.6**	**5.54**	**9.0**	**9.9**
10. PATHOLOGY	22,487.5	0.50	9.9	11.7
11. ANATOMY & MORPHOLOGY	4,835.0	0.11	5.5	5.2
12. ENGINEERING, BIOMEDICAL	12,047.9	0.27	7.1	4.8
13. BIOTECHNOLOGY & APPLIED MICROBIOLOGY	37,682.5	0.84	9.2	11.4
14. MEDICAL LABORATORY TECHNOLOGY	8,619.5	0.19	6.6	8.9
15. MICROSCOPY	3,376.8	0.08	6.3	6.4
16. PHARMACOLOGY & PHARMACY	77,316.8	1.73	8.5	8.8
17. TOXICOLOGY	19,485.3	0.44	7.3	5.8
18. PHYSIOLOGY	29,551.8	0.66	10.9	7.9
19. MEDICINE, RESEARCH & EXPERIMENTAL	31,980.5	0.72	12.2	18.0
III. CLINICAL MEDICINE I (INTERNAL)	**440,082.7**	**9.86**	**12.6**	**22.8**
20. CARDIAC & CARDIOVASCULAR SYSTEMS	44591.9	1.00	10.2	12.3
21. RESPIRATORY SYSTEM	19873.3	0.45	10.1	8.9
22. ENDOCRINOLOGY & METABOLISM	47015.3	1.05	13.8	17.2
23. ANESTHESIOLOGY	16604.1	0.37	6.8	7.9
24. CRITICAL CARE MEDICINE	9488.3	0.21	11.5	11.4
25. EMERGENCY MEDICINE	5752.0	0.13	4.7	5.6

26. GASTROENTEROLOGY & HEPATOLOGY	35192.5	0.79	11.1	16.3
27. MEDICINE, GENERAL & INTERNAL	68428.2	1.53	13.6	51.5
28. TROPICAL MEDICINE	3793.3	0.08	5.4	3.4
29. HEMATOLOGY	33278.8	0.75	15.9	17.0
30. ONCOLOGY	74461.9	1.67	15.0	22.6
31. ALLERGY	5783.1	0.13	8.3	6.3
32. IMMUNOLOGY	53757.7	1.20	16.7	18.9
33. INFECTIOUS DISEASES	22062.3	0.49	11.3	9.2
IV. CLINICAL MEDICINE II (NON-INTERNAL)	**490,198.0**	**10.98**	**7.8**	**9.2**
34. GERIATRICS & GERONTOLOGY	6,566.1	0.15	7.9	6.2
35. OBSTETRICS & GYNECOLOGY	27,665.7	0.62	6.6	6.9
36. ANDROLOGY	1,663.5	0.04	5.7	6.8
37. REPRODUCTIVE BIOLOGY	10,972.9	0.25	10.2	7.6
38. GERONTOLOGY	4,473.6	0.10	6.8	5.1
39. DENTISTRY & ORAL SURGERY	22,405.0	0.50	5.3	6.1
40. DERMATOLOGY	21,692.7	0.49	6.2	8.1
41. UROLOGY & NEPHROLOGY	36,395.5	0.82	9.4	13.7
42. OTORHINOLARYNGOLOGY	16,012.2	0.36	4.0	3.7
43. OPHTHALMOLOGY	28,190.0	0.63	7.2	10.2
44. INTEGRATIVE & COMPLEMENTARY MEDICINE	1,708.3	0.04	4.2	4.0
45. CLINICAL NEUROLOGY	46,788.9	1.05	9.7	10.2
46. PSYCHIATRY	29,982.2	0.67	10.3	11.3
47. RADIOLOGY, NUCLEAR MED. & MED. IMAGING	45,722.9	1.02	8.0	9.5
48. ORTHOPEDICS	17,814.0	0.40	5.7	5.0
49. RHEUMATOLOGY	12,684.5	0.28	11.3	16.6
50. SPORT SCIENCES	15,515.9	0.35	5.8	5.4
51. SURGERY	74,364.1	1.67	6.4	6.5
52. TRANSPLANTATION	9,570.3	0.21	7.0	4.2
53. PERIPHERAL VASCULAR DISEASE	26,002.3	0.58	13.8	13.3
54. PEDIATRICS	34,007.5	0.76	6.1	7.7
V. CLINICAL MEDICINE III	**86,658.5**	**1.94**	**5.9**	**6.0**
55. HEALTH CARE SCIENCES & SERVICES	7,940.6	0.18	5.7	4.1
56. HEALTH POLICY & SERVICES	4,799.4	0.11	5.9	4.1
57. MEDICINE, LEGAL	3,991.6	0.09	4.4	5.1
58. NURSING	9,202.2	0.21	3.1	3.6
59. PUBLIC, ENV. & OCCUPATIONAL HEALTH	37,040.0	0.83	7.7	7.8

60. REHABILITATION	10,015.6	0.22	4.1	3.5
61. SUBSTANCE ABUSE	6,574.7	0.15	7.5	6.6
62. EDUCATION, SCIENTIFIC DISCIPLINES	4,667.8	0.10	2.9	2.3
63. MEDICAL INFORMATICS	2,426.8	0.05	4.1	2.1
VI. NEUROSCIENCES & BEHAVIORAL	**184,618.5**	**4.13**	**9.8**	**10.1**
64. NEUROIMAGING	2,603.3	0.06	10.8	5.6
65. NEUROSCIENCES	89,408.4	2.00	14.2	15.6
66. BEHAVIORAL SCIENCES	7,069.2	0.16	9.2	4.1
67. PSYCHOLOGY, BIOLOGICAL	1,760.5	0.04	7.5	3.4
68. PSYCHOLOGY	7,229.1	0.16	7.9	3.9
69. PSYCHOLOGY, APPLIED	6,307.8	0.14	5.0	5.0
70. PSYCHOLOGY, CLINICAL	14,166.8	0.32	7.1	6.9
71. PSYCHOLOGY, DEVELOPMENTAL	7,866.2	0.18	7.4	6.7
72. PSYCHOLOGY, EDUCATIONAL	4,820.3	0.11	4.8	5.3
73. PSYCHOLOGY, EXPERIMENTAL	11,416.3	0.26	7.0	6.2
74. PSYCHOLOGY, MATHEMATICAL	910.0	0.02	5.6	3.9
75. PSYCHOLOGY, MULTIDISCIPLINARY	16,339.0	0.37	4.3	7.7
76. PSYCHOLOGY, PSYCHOANALYSIS	2,109.6	0.05	2.2	2.9
77. PSYCHOLOGY, SOCIAL	9,586.7	0.21	6.6	8.4
78. SOCIAL SCIENCES, BIOMEDICAL	3,025.5	0.07	5.6	3.5
B. PHYSICAL SCIENCES				
VII. CHEMISTRY	**513,159.1**	**11.49**	**7.4**	**8.7**
79. CHEMISTRY, MULTIDISCIPLINARY	99,218.4	2.22	9.3	14.7
80. CHEMISTRY, INORGANIC & NUCLEAR	42,292.0	0.95	6.9	7.2
81. CHEMISTRY, ANALYTICAL	51,764.0	1.16	7.8	8.7
82. CHEMISTRY, APPLIED	17,483.2	0.39	4.8	2.8
83. ENGINEERING, CHEMICAL	44,458.1	1.00	4.1	4.2
84. CHEMISTRY, MEDICINAL	14,015.7	0.31	8.9	7.6
85. CHEMISTRY, ORGANIC	76,098.6	1.70	8.1	8.9
86. CHEMISTRY, PHYSICAL	95,580.2	2.14	8.0	7.9
87. ELECTROCHEMISTRY	15,409.6	0.35	7.1	6.2
88. POLYMER SCIENCE	56,839.4	1.27	6.5	8.8
VIII. PHYSICS	**522,921.8**	**11.71**	**6.4**	**11.2**
89. PHYSICS, MULTIDISCIPLINARY	92,884.0	2.08	8.5	20.2
90. SPECTROSCOPY	19,435.0	0.44	5.5	4.6

91. ACOUSTICS	10,604.0	0.24	4.1	3.8
92. OPTICS	45,132.7	1.01	5.4	6.9
93. PHYSICS, APPLIED	100,099.9	2.24	6.6	9.2
94. PHYSICS, ATOMIC, MOLECULAR & CHEMICAL	43,633.8	0.98	9.3	8.2
95. THERMODYNAMICS	7,968.4	0.18	3.4	1.8
96. PHYSICS, MATHEMATICAL	22,179.4	0.50	5.7	5.3
97. PHYSICS, NUCLEAR	18,519.7	0.41	5.7	7.4
98. PHYSICS, PARTICLES & SUB-FIELDS	28,648.3	0.64	10.1	20.6
99. PHYSICS, CONDENSED MATTER	86,321.6	1.93	6.3	8.6
100. PHYSICS OF SOLIDS, FLUIDS & PLASMAS	17,900.6	0.40	6.9	5.8
101. CRYSTALLOGRAPHY	29,594.6	0.66	4.0	28.9
IX. SPACE SCIENCES	**61,173.1**	**1.37**	**12.0**	**19.2**
102. ASTRONOMY & ASTROPHYSICS	61,173.1	1.37	12.0	19.2
X. MATHEMATICS	**139,956.3**	**3.13**	**2.8**	**9.4**
103. MATHEMATICS, APPLIED	41,617.9	0.93	2.7	3.2
104. STATISTICS & PROBABILITY	19,012.8	0.43	3.6	7.7
105. MATH., INTERDISCIPLINARY APPLICATIONS	8,159.0	0.18	4.1	2.6
106. SOCIAL SCIENCES, MATHEMATICAL METHODS	2,598.8	0.06	4.2	3.1
107. PURE MATHEMATICS	68,567.8	1.54	2.0	2.9
XI. COMPUTER SCIENCE	**113,370.0**	**2.54**	**3.4**	**5.8**
108. COMP. SCIENCE, ARTIFICIAL INTELLIGENCE	21,725.7	0.49	3.2	5.0
109. COMPUTER SCIENCE, CYBERNETICS	2,965.5	0.07	2.4	2.7
110. COMP. SCIENCE, HARDWARE & ARCHITECTURE	6,329.8	0.14	2.7	2.4
111. COMPUTER SCIENCE, INFORMATION SYSTEMS	12,870.5	0.29	3.1	3.6
112. COMP. SC., INTERDISCIPLINARY APPLICATIONS	13,659.9	0.31	4.2	5.3
113. COMP. SCIENCE, SOFTWARE ENGINEERING	12,780.8	0.29	2.7	3.3
114. COMPUTER SCIENCE, THEORY & METHODS	39,914.7	0.89	1.8	3.3
115. MATHEMATICAL & COMPUTATIONAL BIOLOGY	3,123.1	0.07	8.1	9.7
C. OTHER NATURAL SCIENCES				
XII. ENGINEERING	**288,058.5**	**6.45**	**3.3**	**3.4**
116. ENGINEERING, ELECTRICAL & ELECTRONIC	83,565.7	1.87	3.5	4.3
117. TELECOMMUNICATIONS	12,247.1	0.27	2.7	3.2
118. CONSTRUCTION & BUILDING TECHNOLOGY	4,639.8	0.10	2.5	1.7
119. ENGINEERING, CIVIL	12,516.2	0.28	2.2	1.8

120. ENGINEERING, ENVIRONMENTAL	9,672.1	0.22	7.1	5.0
121. ENGINEERING, MARINE	357.0	0.01	1.1	0.7
122. TRANSPORTATION SCIENCE & TECHNOLOGY	3,547.8	0.08	1.3	1.2
123. ENGINEERING, INDUSTRIAL	6,285.9	0.14	2.2	1.3
124. ENGINEERING, MANUFACTURING	6,932.4	0.16	2.4	1.5
125. ENGINEERING, MECHANICAL	26,333.2	0.59	2.6	2.4
126. MECHANICS	27,838.5	0.62	3.9	3.4
127. ROBOTICS	2,104.7	0.05	2.4	2.3
128. INSTRUMENTS & INSTRUMENTATION	17,583.1	0.39	3.5	2.2
129. IMAGING SCIENCE & PHOTOGR. TECHNOLOGY	2,679.8	0.06	4.3	3.1
130. ENERGY & FUELS	12,929.4	0.29	3.7	3.0
131. NUCLEAR SCIENCE & TECHNOLOGY	21,161.0	0.47	2.8	2.6
132. ENGINEERING, PETROLEUM	3,566.8	0.08	1.0	1.1
133. AUTOMATION & CONTROL SYSTEMS	9,343.5	0.21	2.8	2.7
134. ENGINEERING, MULTIDISCIPLINARY	11,279.3	0.25	2.6	2.2
135. ERGONOMICS	1,382.3	0.03	3.2	1.5
136. OPERATIONS RES. & MANAGEMENT SCIENCE	12,092.9	0.27	2.9	2.6
XIII. MATERIALS SCIENCE	**185,225.7**	**4.15**	**4.4**	**5.1**
137. MATERIALS SCIENCE, MULTIDISCIPLINARY	90,734.1	2.03	4.5	4.7
138. MATERIALS SCIENCE, BIOMATERIALS	3,953.5	0.09	10.2	5.8
139. MATERIALS SCIENCE, CERAMICS	18,866.3	0.42	3.5	4.8
140. MAT. SC., CHARACTERIZATION & TESTING	5,159.8	0.12	1.4	2.4
141. MATERIALS SCIENCE, COATINGS & FILMS	10,519.9	0.24	5.6	3.3
142. MATERIALS SCIENCE, COMPOSITES	7,957.8	0.18	2.9	3.9
143. MATERIALS SCIENCE, PAPER & WOOD	6,000.6	0.13	1.8	2.4
144. MATERIALS SCIENCE, TEXTILES	3,656.8	0.08	1.8	2.0
145. METALL. & METALLURGICAL ENGINEERING	29,468.1	0.66	2.8	3.3
146. NANOSCIENCE & NANOTECHNOLOGY	8,908.6	0.20	6.1	4.1
XIV. GEOSCIENCES	**144,907.0**	**3.25**	**6.0**	**7.0**
147. GEOCHEMISTRY & GEOPHYSICS	27,878.1	0.62	7.4	10.4
148. GEOGRAPHY, PHYSICAL	4,368.3	0.10	7.0	3.8
149. GEOLOGY	7,291.2	0.16	6.5	7.3
150. ENGINEERING, GEOLOGICAL	2,717.6	0.06	2.8	1.8
151. PALEONTOLOGY	5,862.2	0.13	3.9	3.5
152. REMOTE SENSING	2,389.6	0.05	5.6	3.4
153. OCEANOGRAPHY	13,918.8	0.31	7.6	6.6

154. ENGINEERING, OCEAN	1,928.3	0.04	2.6	2.6
155. METEOROLOGY & ATMOSPHERIC SCIENCES	23,267.3	0.52	9.2	11.0
156. ENGINEERING, AEROSPACE	10,028.8	0.22	1.8	2.4
157. MINERALOGY	5,410.5	0.12	5.3	4.8
158. MINING & MINERAL PROCESSING	3,672.2	0.08	2.4	1.9
159. GEOSCIENCES, MULTIDISCIPLINARY	36,174.3	0.81	5.5	5.9
XV. AGRICULTURAL & ENVIRONMENT	**180,472.2**	**4.04**	**5.6**	**6.1**
160. AGRICULTURAL ENGINEERING	3,675.5	0.08	3.2	2.9
161. AGRICULTURE, MULTIDISCIPLINARY	11,518.7	0.26	3.5	3.3
162. AGRONOMY	16,837.2	0.38	3.8	3.5
163. LIMNOLOGY	2,742.4	0.06	7.3	3.8
164. SOIL SCIENCE	11,948.1	0.27	5.4	5.7
165. BIODIVERSITY CONSERVATION	3,507.3	0.08	5.6	3.3
166. ENVIRONMENTAL SCIENCES	44,640.7	1.00	6.6	5.4
167. ENVIRONMENTAL STUDIES	5,592.3	0.13	3.5	2.3
168. FOOD SCIENCE & TECHNOLOGY	31,783.8	0.71	4.7	3.9
169. NUTRITION & DIETETICS	19,574.3	0.44	9.2	10.8
170. AGRICULTURE, DAIRY & ANIMAL SCIENCE	20,968.0	0.47	3.6	4.4
171. HORTICULTURE	7,683.9	0.17	3.3	2.6
XVI. BIOLOGY (ORGANISMIC AND SUPRAORGONISMIC LEVEL)	**323,550.6**	**7.25**	**7.0**	**8.0**
172. ORNITHOLOGY	5,141.0	0.12	4.2	7.7
173. ZOOLOGY	28,223.6	0.63	4.9	4.5
174. ENTOMOLOGY	20,111.8	0.45	3.6	4.0
175. WATER RESOURCES	13,317.7	0.30	4.4	2.8
176. FISHERIES	12,410.6	0.28	4.7	3.5
177. MARINE & FRESHWATER BIOLOGY	23,026.3	0.52	5.7	3.9
178. MICROBIOLOGY	44,835.5	1.00	11.0	9.8
179. PARASITOLOGY	9,784.2	0.22	6.1	6.3
180. VIROLOGY	19,375.5	0.43	15.1	14.8
181. FORESTRY	10,665.6	0.24	5.2	5.5
182. MYCOLOGY	5,700.2	0.13	4.3	5.4
183. PLANT SCIENCES	53,680.8	1.20	7.4	9.0
184. ECOLOGY	28,265.6	0.63	8.6	7.3
185. VETERINARY SCIENCES	49,012.4	1.10	3.2	4.0

XVII. MULTIDISCIPLINARY	**27,218.9**	**0.61**	**3.2**	**6.5**
186. MULTIDISCIPLINARY SCIENCES	27,218.9	0.61	3.2	6.5
D. SOCIAL SCIENCES				
XVIII. SOCIAL SCIENCES, GENERAL	**118,297.3**	**2.65**	**3.0**	**3.6**
187. CRIMINOLOGY & PENOLOGY	2,777.0	0.06	3.5	4.2
188. LAW	8,529.8	0.19	3.5	4.7
189. POLITICAL SCIENCE	10,838.3	0.24	2.5	4.1
190. PUBLIC ADMINISTRATION	3,036.5	0.07	2.6	3.1
191. ETHNIC STUDIES	701.3	0.02	1.7	1.1
192. FAMILY STUDIES	3,166.8	0.07	4.0	3.0
193. SOCIAL ISSUES	2,771.7	0.06	2.6	3.2
194. SOCIAL WORK	3,880.8	0.09	2.4	2.2
195. SOCIOLOGY	10,554.0	0.24	3.0	4.7
196. WOMEN'S STUDIES	2,656.7	0.06	2.4	2.3
197. EDUCATION & EDUCATIONAL RESEARCH	14,580.3	0.33	2.2	3.0
198. EDUCATION, SPECIAL	2,076.2	0.05	3.4	2.7
199. AREA STUDIES	3,197.6	0.07	1.3	1.8
200. GEOGRAPHY	4,487.6	0.10	4.3	4.9
201. PLANNING & DEVELOPMENT	4,041.8	0.09	3.2	2.9
202. TRANSPORTATION	1,050.8	0.02	3.0	1.7
203. URBAN STUDIES	2,802.9	0.06	3.1	2.4
204. ETHICS	2,208.6	0.05	2.1	1.6
205. MEDICAL ETHICS	305.3	0.01	3.8	1.2
206. ANTHROPOLOGY	5,620.2	0.13	2.7	3.2
207. COMMUNICATION	4,085.0	0.09	3.1	3.2
208. DEMOGRAPHY	1,749.8	0.04	4.2	4.9
209. HISTORY OF SOCIAL SCIENCES	867.0	0.02	1.3	1.0
210. INFORMATION SCIENCE & LIBRARY SCIENCE	7,034.7	0.16	2.4	2.9
211. INTERNATIONAL RELATIONS	4,820.8	0.11	2.3	3.6
212. LINGUISTICS	3,921.7	0.09	3.8	3.0
213. SOCIAL SCIENCES, INTERDISCIPLINARY	6,534.3	0.15	2.3	2.5
XIX. ECONOMICS & BUSINESS	**55,615.8**	**1.25**	**4.1**	**5.1**
214. AGRICULTURAL ECONOMICS & POLICY	1,005.5	0.02	2.8	1.8
215. ECONOMICS	30,439.6	0.68	3.5	5.2
216. INDUSTRIAL RELATIONS & LABOR	1,917.7	0.04	3.0	3.5
217. BUSINESS	7,255.2	0.16	5.0	5.1

218. BUSINESS, FINANCE	5,351.8	0.12		4.9	6.7
219. MANAGEMENT	9,646.2	0.22		4.5	4.3
Total	**4,465,348**	**100.00**	**Mean**	**5.9**	**3.6**
			Std	**6.4**	**5.6**

$I\ (\pi)$

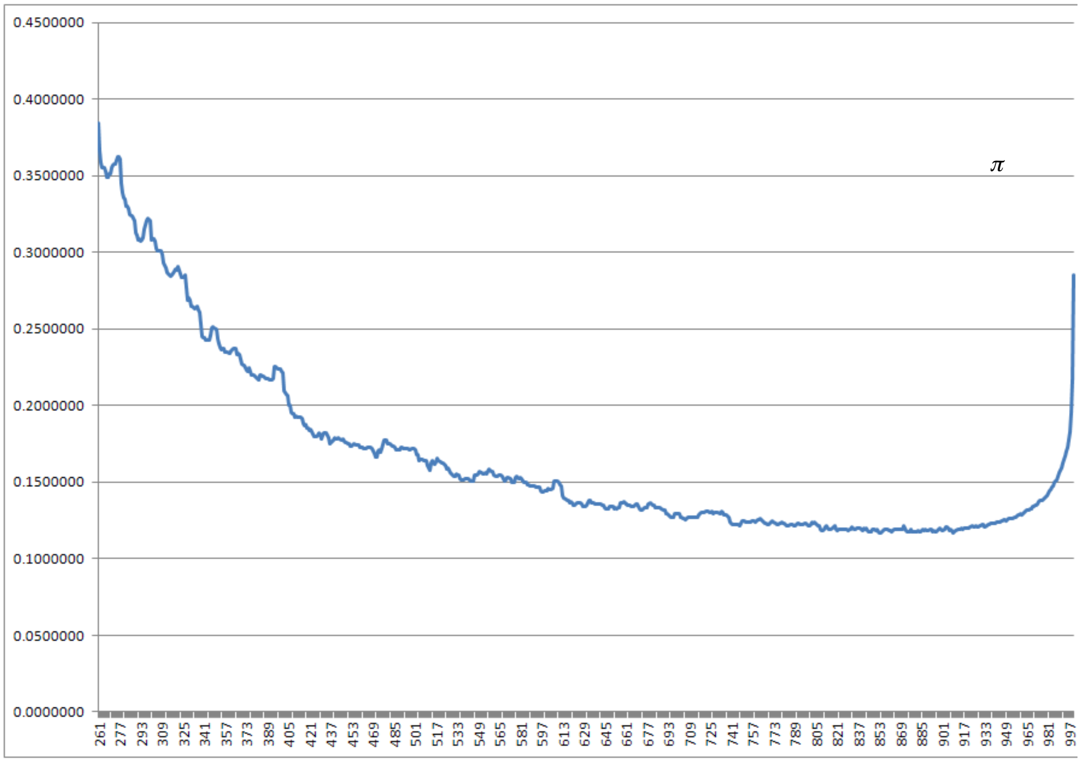


Figure 1. Citation Inequality Due to Differences in Citation Practices, $I(\pi)$ versus π. Raw Data

Table 1. Exchange Rates, Standard Deviations, and Coefficients of Variation for the [661, 978] Interval

		Exchange Rates (1)	Standard Deviation (2)	Coefficient of Variation (3)	% of Citations (4)	Exch. Rates Based on Mean Citations (5)
	A. LIFE SCIENCES					
	I. BIOSCIENCES					
1	BIOLOGY	10.3	0.3	0.032	64.1	9.8
2	BIOLOGY, MISCELLANEOUS	5.0	0.3	0.063	65.4	4.6
3	EVOLUTIONARY BIOLOGY	16.1	1.8	0.109	56.3	16.4
4	BIOCHEMICAL RESEARCH METHODS	11.5	0.7	0.060	52.9	12.8
5	BIOCHEMISTRY & MOLECULAR BIOLOGY	20.6	0.5	0.023	58.2	21.2
6	BIOPHYSICS	14.0	0.7	0.053	58.7	14.1
7	CELL BIOLOGY	26.9	0.9	0.032	60.3	27.3
8	GENETICS & HEREDITY	19.4	0.4	0.022	57.7	20.5
9	DEVELOPMENTAL BIOLOGY	23.4	0.4	0.016	59.0	24.0
	II. BIOMEDICAL RESEARCH					
10	PATHOLOGY	11.8	0.3	0.023	62.3	11.5
11	ANATOMY & MORPHOLOGY	7.7	0.5	0.066	60.9	7.4
12	ENGINEERING, BIOMEDICAL	9.5	0.5	0.053	61.3	9.1
13	BIOTECHNOLOGY & APPLIED MICROBIOLOGY	11.5	0.3	0.024	58.0	11.9
14	MEDICAL LABORATORY TECHNOLOGY	8.1	0.3	0.031	62.0	7.9
15	MICROSCOPY	8.6	0.7	0.077	60.8	8.3
16	PHARMACOLOGY & PHARMACY	10.6	0.5	0.046	60.0	10.5
17	TOXICOLOGY	9.7	0.7	0.071	58.9	9.6
18	PHYSIOLOGY	14.0	1.4	0.102	59.4	13.5
19	MEDICINE, RESEARCH & EXPERIMENTAL	15.4	2.6	0.171	61.2	16.5
	III. CLINICAL MEDICINE I (INTERNAL)					
20	CARDIAC & CARDIOVASCULAR SYSTEMS	14.9	1.0	0.070	61.6	15.1
21	RESPIRATORY SYSTEM	13.7	0.7	0.051	60.6	13.4
22	ENDOCRINOLOGY & METABOLISM	16.9	1.1	0.066	58.3	16.9
23	ANESTHESIOLOGY	9.2	0.3	0.037	62.8	8.8
24	CRITICAL CARE MEDICINE	14.8	0.5	0.036	61.9	14.2
25	EMERGENCY MEDICINE	5.8	0.3	0.050	62.8	5.5
26	GASTROENTEROLOGY & HEPATOLOGY	13.5	0.3	0.022	60.1	13.6
27	MEDICINE, GENERAL & INTERNAL	12.0	4.9	0.405	52.1	16.7
28	TROPICAL MEDICINE	7.2	0.5	0.074	62.1	6.8
29	HEMATOLOGY	22.2	0.3	0.014	60.2	22.3
30	ONCOLOGY	18.0	0.6	0.031	58.6	18.3
31	ALLERGY	12.2	0.5	0.038	63.1	11.5
32	IMMUNOLOGY	17.8	0.3	0.017	59.0	18.3
33	INFECTIOUS DISEASES	15.4	1.0	0.068	59.6	15.1

	IV. CLINICAL MEDICINE II (NON-INTERNAL)					
34	GERIATRICS & GERONTOLOGY	11.2	0.6	0.051	60.9	10.9
35	OBSTETRICS & GYNECOLOGY	9.2	0.4	0.044	62.3	8.8
36	ANDROLOGY	7.3	0.5	0.068	60.3	7.1
37	REPRODUCTIVE BIOLOGY	12.5	1.1	0.089	59.0	12.3
38	GERONTOLOGY	10.2	0.5	0.049	62.7	9.6
39	DENTISTRY & ORAL SURGERY	7.2	0.6	0.077	60.6	6.9
40	DERMATOLOGY	8.2	0.3	0.038	62.1	7.9
41	UROLOGY & NEPHROLOGY	12.3	0.3	0.025	61.6	12.0
42	OTORHINOLARYNGOLOGY	6.0	0.4	0.069	62.5	5.6
43	OPHTHALMOLOGY	9.5	0.3	0.034	61.7	9.2
44	INTEGRATIVE & COMPLEMENTARY MEDICINE	6.3	0.6	0.097	61.4	5.9
45	CLINICAL NEUROLOGY	12.4	0.3	0.023	61.3	12.1
46	PSYCHIATRY	13.1	0.3	0.019	62.0	12.7
47	RADIOLOGY, NUCLEAR MED. & MED. IMAGING	10.1	0.3	0.026	61.5	9.9
48	ORTHOPEDICS	7.9	0.3	0.043	61.6	7.6
49	RHEUMATOLOGY	14.6	0.6	0.041	59.7	14.5
50	SPORT SCIENCES	8.1	0.5	0.064	62.2	7.7
51	SURGERY	8.5	0.2	0.028	61.9	8.3
52	TRANSPLANTATION	9.5	0.2	0.026	61.9	9.2
53	PERIPHERAL VASCULAR DISEASE	20.2	0.3	0.013	59.8	20.4
54	PEDIATRICS	7.7	0.3	0.035	62.1	7.5
	V. CLINICAL MEDICINE III					
55	HEALTH CARE SCIENCES & SERVICES	7.9	0.5	0.061	60.3	7.7
56	HEALTH POLICY & SERVICES	8.4	0.4	0.042	59.3	8.5
57	MEDICINE, LEGAL	5.8	0.4	0.072	60.5	5.6
58	NURSING	4.3	0.4	0.090	61.9	4.1
59	PUBLIC, ENV. & OCCUPATIONAL HEALTH	9.7	0.3	0.034	60.8	9.5
60	REHABILITATION	5.9	0.4	0.065	62.2	5.6
61	SUBSTANCE ABUSE	9.8	0.9	0.096	59.2	9.6
62	EDUCATION, SCIENTIFIC DISCIPLINES	4.0	0.3	0.068	64.9	3.7
63	MEDICAL INFORMATICS	5.7	0.3	0.045	62.9	5.5
	VI. NEUROSCIENCES & BEHAVIORAL					
64	NEUROIMAGING	14.6	0.4	0.025	63.1	14.0
65	NEUROSCIENCES	16.9	0.5	0.031	59.6	16.9
66	BEHAVIORAL SCIENCES	11.5	1.4	0.119	56.0	11.7
67	PSYCHOLOGY, BIOLOGICAL	9.9	0.9	0.086	56.9	10.1
68	PSYCHOLOGY	10.3	0.7	0.068	60.6	9.9
69	PSYCHOLOGY, APPLIED	6.4	0.4	0.070	62.4	6.0
70	PSYCHOLOGY, CLINICAL	9.9	0.4	0.042	60.6	9.7
71	PSYCHOLOGY, DEVELOPMENTAL	10.6	0.5	0.051	60.8	10.2
72	PSYCHOLOGY, EDUCATIONAL	6.8	0.3	0.040	64.2	6.5
73	PSYCHOLOGY, EXPERIMENTAL	10.2	0.5	0.046	61.2	9.9
74	PSYCHOLOGY, MATHEMATICAL	6.9	0.3	0.038	61.3	6.8

75	PSYCHOLOGY, MULTIDISCIPLINARY	6.2	0.5	0.087	63.3	6.2
76	PSYCHOLOGY, PSYCHOANALYSIS	3.7	0.4	0.106	67.8	3.4
77	PSYCHOLOGY, SOCIAL	8.3	0.3	0.032	61.5	8.2
78	SOCIAL SCIENCES, BIOMEDICAL	7.2	0.3	0.047	61.2	7.0
	B. PHYSICAL SCIENCES					
	VII. CHEMISTRY					
79	CHEMISTRY, MULTIDISCIPLINARY	11.9	1.2	0.103	65.4	11.5
80	CHEMISTRY, INORGANIC & NUCLEAR	9.2	0.7	0.074	61.4	8.8
81	CHEMISTRY, ANALYTICAL	9.9	0.4	0.044	60.5	9.7
82	CHEMISTRY, APPLIED	7.6	0.5	0.070	62.3	7.2
83	ENGINEERING, CHEMICAL	6.0	0.3	0.044	63.7	5.7
84	CHEMISTRY, MEDICINAL	9.8	0.8	0.083	59.4	9.6
85	CHEMISTRY, ORGANIC	10.7	1.0	0.096	59.3	10.4
86	CHEMISTRY, PHYSICAL	10.5	0.5	0.047	60.5	10.3
87	ELECTROCHEMISTRY	10.2	0.8	0.076	60.4	9.9
88	POLYMER SCIENCE	8.2	0.3	0.031	61.4	8.1
	VIII. PHYSICS					
89	PHYSICS, MULTIDISCIPLINARY	10.0	1.7	0.169	61.8	10.5
90	SPECTROSCOPY	7.6	0.4	0.050	62.1	7.3
91	ACOUSTICS	5.5	0.3	0.055	63.3	5.2
92	OPTICS	7.3	0.3	0.036	62.7	7.0
93	PHYSICS, APPLIED	7.5	0.4	0.048	60.7	7.6
94	PHYSICS, ATOMIC, MOLECULAR & CHEMICAL	11.0	0.8	0.074	59.8	10.7
95	THERMODYNAMICS	4.8	0.4	0.080	61.6	4.6
96	PHYSICS, MATHEMATICAL	7.3	0.3	0.035	61.7	7.2
97	PHYSICS, NUCLEAR	6.2	0.4	0.065	62.0	6.2
98	PHYSICS, PARTICLES & SUB-FIELDS	10.8	1.1	0.102	59.8	11.4
99	PHYSICS, CONDENSED MATTER	7.4	0.3	0.045	61.4	7.4
100	PHYSICS OF SOLIDS, FLUIDS & PLASMAS	9.3	0.6	0.063	59.8	9.1
101	CRYSTALLOGRAPHY	5.1	0.3	0.053	58.8	5.2
	IX. SPACE SCIENCES					
102	ASTRONOMY & ASTROPHYSICS	14.8	0.3	0.018	60.6	14.8
	X. MATHEMATICS					
103	MATHEMATICS, APPLIED	3.9	0.2	0.062	65.7	3.6
104	STATISTICS & PROBABILITY	5.2	0.5	0.098	52.5	6.2
105	MATH., INTERDISCIPLINARY APPLICATIONS	5.6	0.3	0.045	60.8	5.6
106	SOCIAL SCIENCES, MATHEMATICAL METHODS	5.5	0.3	0.045	61.4	5.5
107	PURE MATHEMATICS	2.8	0.2	0.087	66.4	2.6
	XI. COMPUTER SCIENCE					
108	COMP. SCIENCE, ARTIFICIAL INTELLIGENCE	5.4	0.6	0.118	63.3	5.4
109	COMPUTER SCIENCE, CYBERNETICS	3.6	0.4	0.108	66.7	3.4
110	COMP. SCIENCE, HARDWARE & ARCHITECTURE	4.0	0.5	0.124	61.4	4.1

111	COMPUTER SCIENCE, INFORMATION SYSTEMS	4.4	0.6	0.143	62.4	4.5
112	COMP. SC., INTERDISCIPLINARY APPLICATIONS	5.5	0.6	0.102	58.1	6.0
113	COMP. SCIENCE, SOFTWARE ENGINEERING	3.6	0.4	0.107	65.5	3.4
114	COMPUTER SCIENCE, THEORY & METHODS	3.1	0.4	0.115	65.5	3.0
115	MATHEMATICAL & COMPUTATIONAL BIOLOGY	9.8	0.4	0.044	52.9	11.4

C. OTHER NATURAL SCIENCES

XII. ENGINEERING

116	ENGINEERING, ELECTRICAL & ELECTRONIC	4.7	0.4	0.077	63.1	4.6
117	TELECOMMUNICATIONS	3.8	0.5	0.144	62.2	3.9
118	CONSTRUCTION & BUILDING TECHNOLOGY	3.5	0.3	0.090	65.4	3.1
119	ENGINEERING, CIVIL	3.4	0.3	0.086	67.0	3.1
120	ENGINEERING, ENVIRONMENTAL	9.1	0.3	0.035	62.4	8.7
121	ENGINEERING, MARINE	1.6	0.3	0.212	71.5	1.4
122	TRANSPORTATION SCIENCE & TECHNOLOGY	2.1	0.5	0.227	69.9	2.0
123	ENGINEERING, INDUSTRIAL	3.3	0.3	0.091	66.6	2.9
124	ENGINEERING, MANUFACTURING	3.6	0.3	0.089	64.8	3.2
125	ENGINEERING, MECHANICAL	3.9	0.2	0.060	63.7	3.7
126	MECHANICS	5.2	0.3	0.050	63.8	4.9
127	ROBOTICS	3.8	0.2	0.065	65.0	3.6
128	INSTRUMENTS & INSTRUMENTATION	5.1	0.3	0.051	65.0	4.7
129	IMAGING SCIENCE & PHOTOGR. TECHNOLOGY	7.4	0.4	0.061	64.6	7.0
130	ENERGY & FUELS	5.0	0.3	0.064	64.9	4.7
131	NUCLEAR SCIENCE & TECHNOLOGY	4.4	0.3	0.061	64.0	4.1
132	ENGINEERING, PETROLEUM	1.7	0.4	0.255	73.5	1.5
133	AUTOMATION & CONTROL SYSTEMS	4.1	0.2	0.059	63.8	3.9
134	ENGINEERING, MULTIDISCIPLINARY	3.9	0.4	0.089	66.0	3.7
135	ERGONOMICS	4.8	0.4	0.088	63.0	4.4
136	OPERATIONS RES. & MANAGEMENT SCIENCE	4.1	0.2	0.060	63.6	3.8

XIII. MATERIALS SCIENCE

137	MATERIALS SCIENCE, MULTIDISCIPLINARY	6.4	0.4	0.056	60.7	6.4
138	MATERIALS SCIENCE, BIOMATERIALS	13.0	1.1	0.085	59.3	12.7
139	MATERIALS SCIENCE, CERAMICS	4.7	0.3	0.074	68.3	4.2
140	MAT. SC., CHARACTERIZATION & TESTING	2.2	0.4	0.167	70.6	2.0
141	MATERIALS SCIENCE, COATINGS & FILMS	7.5	0.4	0.057	61.0	7.3
142	MATERIALS SCIENCE, COMPOSITES	3.4	0.3	0.087	65.9	3.1
143	MATERIALS SCIENCE, PAPER & WOOD	2.9	0.3	0.092	68.1	2.6
144	MATERIALS SCIENCE, TEXTILES	2.9	0.3	0.095	65.5	2.7
145	METALL. & METALLURGICAL ENGINEERING	4.7	0.4	0.089	63.5	4.7

146	NANOSCIENCE & NANOTECHNOLOGY	8.0	0.3	0.036	60.0	8.1
	XIV. GEOSCIENCES					
147	GEOCHEMISTRY & GEOPHYSICS	9.7	0.6	0.066	61.5	9.3
148	GEOGRAPHY, PHYSICAL	9.1	0.9	0.097	59.8	8.8
149	GEOLOGY	8.0	0.5	0.061	62.4	7.5
150	ENGINEERING, GEOLOGICAL	3.8	0.3	0.093	62.1	3.6
151	PALEONTOLOGY	6.5	0.4	0.057	63.7	6.1
152	REMOTE SENSING	7.8	0.3	0.037	60.8	7.8
153	OCEANOGRAPHY	10.1	1.0	0.101	61.6	9.5
154	ENGINEERING, OCEAN	3.6	0.4	0.106	66.7	3.4
155	METEOROLOGY & ATMOSPHERIC SCIENCES	10.9	0.5	0.047	61.3	10.5
156	ENGINEERING, AEROSPACE	2.5	0.2	0.095	68.4	2.2
157	MINERALOGY	6.9	0.4	0.060	61.4	6.6
158	MINING & MINERAL PROCESSING	4.0	0.3	0.069	65.5	3.7
159	GEOSCIENCES, MULTIDISCIPLINARY	7.3	0.4	0.055	62.7	6.9
	XV. AGRICULTURAL & ENVIRONMENT					
160	AGRICULTURAL ENGINEERING	5.0	0.4	0.073	61.6	4.7
161	AGRICULTURE, MULTIDISCIPLINARY	6.8	0.3	0.045	63.8	6.6
162	AGRONOMY	5.8	0.3	0.050	62.9	5.5
163	LIMNOLOGY	9.7	0.8	0.078	60.8	9.3
164	SOIL SCIENCE	6.9	0.5	0.072	62.5	6.5
165	BIODIVERSITY CONSERVATION	8.8	0.4	0.046	62.1	8.5
166	ENVIRONMENTAL SCIENCES	8.9	0.5	0.056	60.1	8.8
167	ENVIRONMENTAL STUDIES	5.0	0.4	0.072	61.4	4.8
168	FOOD SCIENCE & TECHNOLOGY	7.1	0.5	0.075	61.9	6.7
169	NUTRITION & DIETETICS	11.4	0.4	0.037	61.3	11.1
170	AGRICULTURE, DAIRY & ANIMAL SCIENCE	5.4	0.3	0.051	66.5	4.9
171	HORTICULTURE	6.0	0.3	0.045	62.9	5.8
	XVI. BIOLOGY (ORGANISMIC AND SUPRAORGONISMIC LEVEL)					
172	ORNITHOLOGY	5.5	0.5	0.082	59.7	5.4
173	ZOOLOGY	7.5	0.5	0.068	61.8	7.1
174	ENTOMOLOGY	5.5	0.4	0.071	62.9	5.1
175	WATER RESOURCES	6.3	0.5	0.075	61.7	5.9
176	FISHERIES	7.1	0.8	0.115	59.3	6.9
177	MARINE & FRESHWATER BIOLOGY	8.2	0.9	0.115	59.2	7.9
178	MICROBIOLOGY	14.3	1.1	0.077	59.3	14.0
179	PARASITOLOGY	8.1	0.6	0.070	59.6	8.0
180	VIROLOGY	18.8	1.6	0.083	57.7	18.9
181	FORESTRY	7.2	0.6	0.089	60.0	7.0
182	MYCOLOGY	6.8	0.3	0.046	62.1	6.5
183	PLANT SCIENCES	9.6	0.3	0.029	60.1	9.8
184	ECOLOGY	11.4	1.0	0.087	59.7	11.0
185	VETERINARY SCIENCES	5.2	0.3	0.056	65.9	4.8

	XVII. MULTIDISCIPLINARY					
186	MULTIDISCIPLINARY SCIENCES	4.0	0.6	0.158	64.3	4.0
	D. SOCIAL SCIENCES					
	XVIII. SOCIAL SCIENCES, GENERAL					
187	CRIMINOLOGY & PENOLOGY	4.8	0.3	0.058	66.5	4.4
188	LAW	4.3	0.3	0.076	65.1	4.1
189	POLITICAL SCIENCE	3.3	0.4	0.119	65.5	3.2
190	PUBLIC ADMINISTRATION	3.6	0.3	0.075	66.2	3.3
191	ETHNIC STUDIES	2.5	0.3	0.115	65.7	2.4
192	FAMILY STUDIES	5.7	0.3	0.057	62.1	5.5
193	SOCIAL ISSUES	3.4	0.3	0.091	64.4	3.3
194	SOCIAL WORK	3.9	0.3	0.078	63.2	3.7
195	SOCIOLOGY	4.2	0.3	0.065	65.6	3.9
196	WOMEN'S STUDIES	4.1	0.2	0.061	63.8	3.8
197	EDUCATION & EDUCATIONAL RESEARCH	3.3	0.3	0.085	64.6	3.1
198	EDUCATION, SPECIAL	5.0	0.3	0.065	62.7	4.7
199	AREA STUDIES	1.9	0.3	0.157	67.0	1.8
200	GEOGRAPHY	5.8	0.3	0.057	60.5	5.7
201	PLANNING & DEVELOPMENT	4.4	0.3	0.059	61.3	4.4
202	TRANSPORTATION	5.3	0.4	0.079	61.8	5.0
203	URBAN STUDIES	4.4	0.3	0.068	61.7	4.2
204	ETHICS	3.3	0.3	0.092	65.6	3.0
205	MEDICAL ETHICS	5.2	0.4	0.075	62.1	4.9
206	ANTHROPOLOGY	4.4	0.3	0.074	66.3	4.1
207	COMMUNICATION	4.6	0.3	0.060	64.1	4.3
208	DEMOGRAPHY	5.5	0.3	0.053	61.8	5.3
209	HISTORY OF SOCIAL SCIENCES	2.1	0.3	0.140	69.2	1.8
210	INFORMATION SCIENCE & LIBRARY SCIENCE	4.1	0.4	0.103	65.2	3.9
211	INTERNATIONAL RELATIONS	2.9	0.4	0.134	65.4	2.8
212	LINGUISTICS	6.1	0.3	0.049	63.0	5.8
213	SOCIAL SCIENCES, INTERDISCIPLINARY	3.6	0.4	0.100	66.7	3.3
	XIX. ECONOMICS & BUSINESS					
214	AGRICULTURAL ECONOMICS & POLICY	3.8	0.3	0.082	63.9	3.5
215	ECONOMICS	4.6	0.3	0.074	61.9	4.6
216	INDUSTRIAL RELATIONS & LABOR	4.6	0.4	0.086	63.3	4.2
217	BUSINESS	6.7	0.3	0.047	64.0	6.4
218	BUSINESS, FINANCE	6.3	0.5	0.087	63.6	6.2
219	MANAGEMENT	6.4	0.4	0.055	63.5	6.2
	Mean			**0.071**	**62.2**	
	StDev			**0.043**	**3.0**	

Table 2. Citation Inequality Decomposition at the Sub-field Level

	Quantiles	Within-group Term, W (1)	Skew. of Sc. Term, S (2)	*IDCP* Term (3)	Total Citation Inequality (4)	Percentages In %: (1)/(4) (5)	(2)/(4) (6)	(3)/(4) (7)
A. Raw Data	1,000	0.0030	0.7062	0.1552	0.8644	0.35	81.70	17.95
	[1, 660]			0.0463				5.36
	[661, 978]			0.0750				8.68
	[979, 1000]			0.0338				3.91
B. Sub-field ER	1,000	0.0032	0.7301	0.0293	0.7627	0.42	95.73	3.85
Normalization	[1, 660]			0.0162				2.13
	[661, 978]			0.0027				0.35
	[979, 1000]			0.0104				1.37
C. Sub-field Mean	1,000	0.0030	0.7240	0.0260	0.7531	0.40	96.14	3.45
Normalization	[1, 660]			0.0168				2.23
	[661, 978]			0.0026				0.35
	[979, 1000]			0.0066				0.87
D. Field ER	1,000	0.0031	0.7236	0.0623	0.7890	0.39	91.71	7.90
Normalization	[1, 660]			0.0245				3.10
	[661, 978]			0.0222				2.81
	[979, 1000]			0.0157				1.99
E. Field Mean	1,000	0.0031	0.7225	0.0620	0.7876	0.39	91.74	7.87
Normalization	[1, 660]			0.0247				3.13
	[661, 978]			0.0223				2.83
	[979, 1000]			0.0150				1.91

${}_{v}^{\pi}I(\pi)$

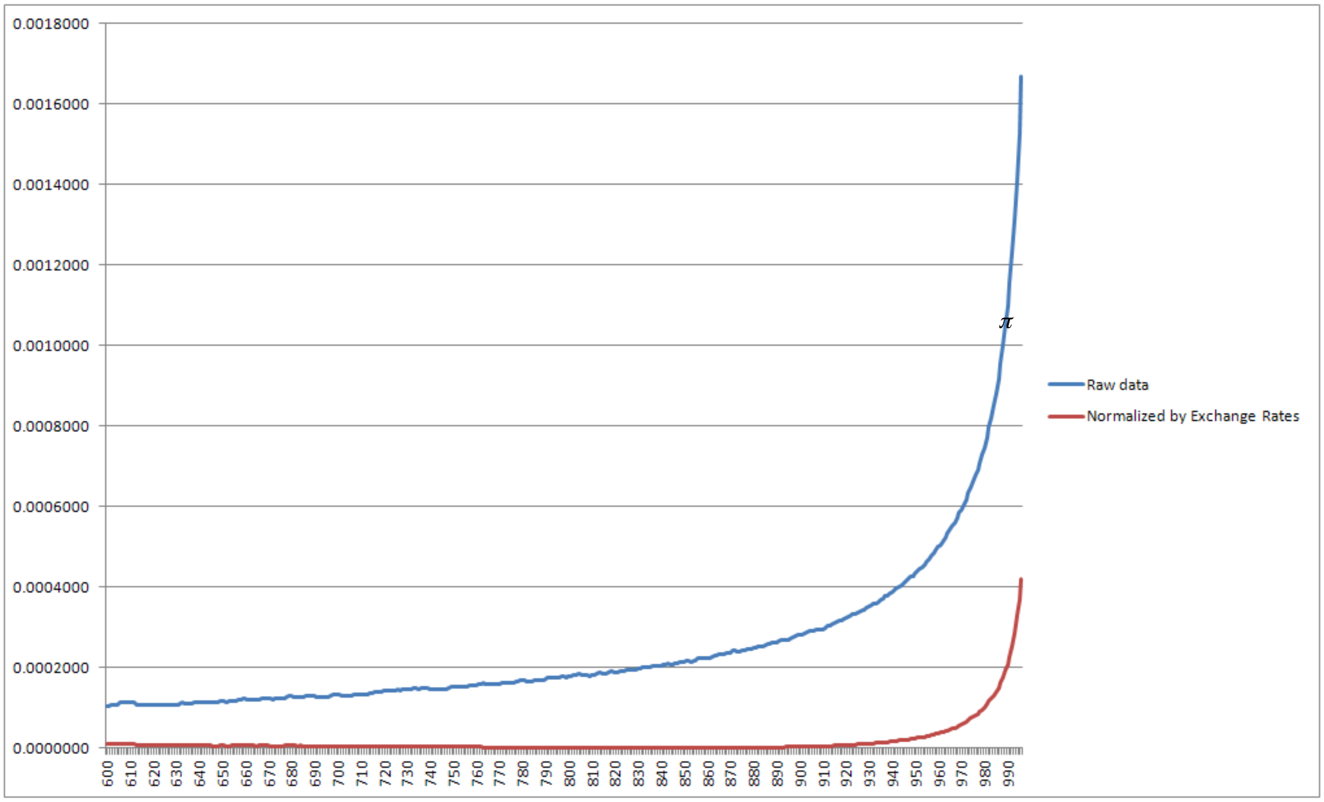
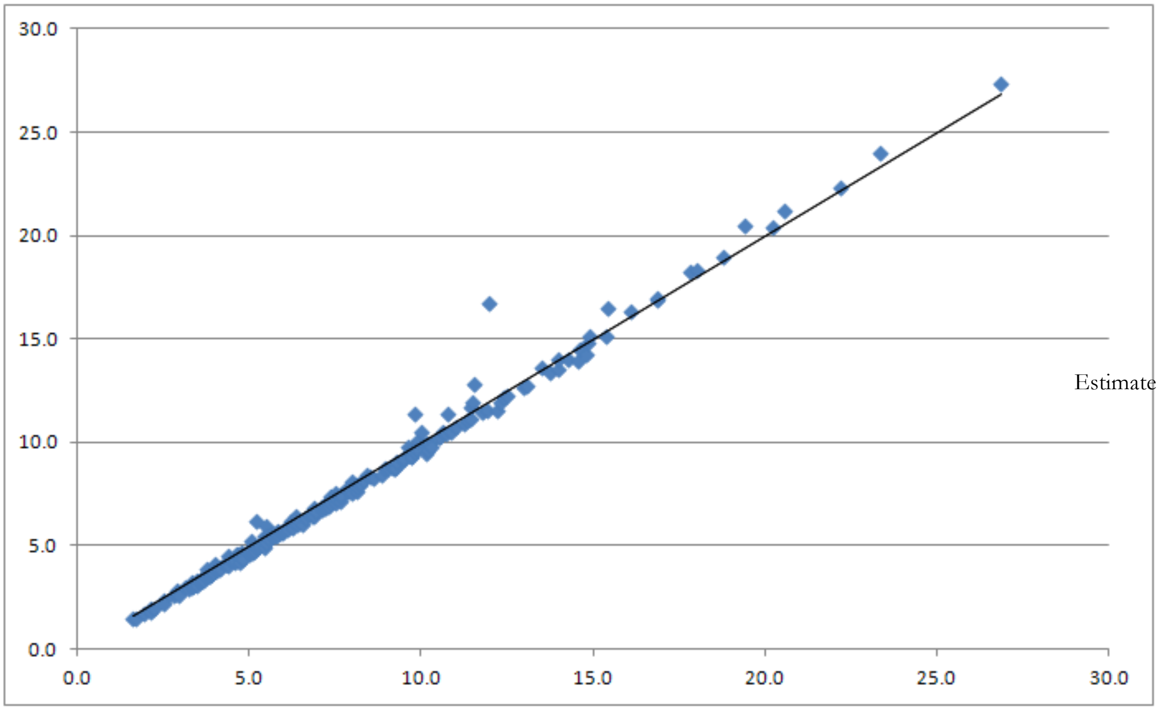


Figure 2. Weighted Citation Inequality Due to Differences in Citation Practices, ${}_{v}^{\pi}I(\pi)$ vs. π. Raw *vs.* Normalized Data



Estimated Exchange Rates

Figure 3. A Comparison at the Sub-field Level of the Estimated Exchange Rates Over the [661, 978] Interval *versus* the Exchange Rates Based on Mean Citations. The Fractional Case.

Table 3. Exchange Rates, Standard Deviations, and Coefficients of Variation for the [661, 978] Interval. Multiplicative case.

		Exchange Rates (1)	Standard Deviation (2)	Coefficient of Variation (3)	% of Citations (4)	Exch. Rates Based on Mean Citations (5)
	A. LIFE SCIENCES					
	I. BIOSCIENCES					
1	BIOLOGY	10.5	0.4	0.035	63.8	10.0
2	BIOLOGY, MISCELLANEOUS	4.7	0.3	0.067	64.7	4.4
3	EVOLUTIONARY BIOLOGY	16.1	1.7	0.108	56.7	16.3
4	BIOCHEMICAL RESEARCH METHODS	11.5	0.6	0.054	54.7	12.4
5	BIOCHEMISTRY & MOLECULAR BIOLOGY	20.6	0.4	0.021	58.4	21.2
6	BIOPHYSICS	14	0.7	0.050	58.4	14.1
7	CELL BIOLOGY	27	1	0.038	60.4	27.5
8	GENETICS & HEREDITY	19.7	0.4	0.021	58.5	20.5
9	DEVELOPMENTAL BIOLOGY	24.4	0.5	0.021	60.4	24.6
	II. BIOMEDICAL RESEARCH					
10	PATHOLOGY	11.7	0.3	0.024	62	11.5
11	ANATOMY & MORPHOLOGY	7.8	0.5	0.064	60.9	7.6
12	ENGINEERING, BIOMEDICAL	9.6	0.5	0.048	61.2	9.2
13	BIOTECHNOLOGY & APPLIED MICROBIOLOGY	11.6	0.3	0.022	57.9	12.1
14	MEDICAL LABORATORY TECHNOLOGY	8.1	0.3	0.031	61.3	8.0
15	MICROSCOPY	8.5	0.6	0.068	60.6	8.3
16	PHARMACOLOGY & PHARMACY	10.7	0.4	0.041	59.8	10.6
17	TOXICOLOGY	9.6	0.6	0.067	59.2	9.5
18	PHYSIOLOGY	14.1	1.4	0.101	59.3	13.7
19	MEDICINE, RESEARCH & EXPERIMENTAL	15.7	2.8	0.180	59.9	17.2
	III. CLINICAL MEDICINE I (INTERNAL)					
20	CARDIAC & CARDIOVASCULAR SYSTEMS	14.9	1.1	0.076	61.3	15.2
21	RESPIRATORY SYSTEM	13.5	0.6	0.042	60.6	13.2
22	ENDOCRINOLOGY & METABOLISM	16.7	1.1	0.066	58.2	16.9
23	ANESTHESIOLOGY	9.4	0.3	0.032	62.8	8.9
24	CRITICAL CARE MEDICINE	14.6	0.4	0.030	61.5	14.2
25	EMERGENCY MEDICINE	5.8	0.3	0.050	62.2	5.6
26	GASTROENTEROLOGY & HEPATOLOGY	13.7	0.4	0.027	60.4	13.8
27	MEDICINE, GENERAL & INTERNAL	12.1	5	0.411	52.2	16.9
28	TROPICAL MEDICINE	7.2	0.5	0.069	62.1	6.8
29	HEMATOLOGY	21.9	0.4	0.020	61	21.8
30	ONCOLOGY	18	0.5	0.027	58.8	18.3
31	ALLERGY	12.2	0.4	0.033	62.7	11.7
32	IMMUNOLOGY	17.8	0.3	0.016	58.9	18.3
33	INFECTIOUS DISEASES	15.3	0.9	0.060	59.4	15.2

IV. CLINICAL MEDICINE II (NON-INTERNAL)

34	GERIATRICS & GERONTOLOGY	11.1	0.6	0.054	61.5	10.7
35	OBSTETRICS & GYNECOLOGY	9.2	0.4	0.042	62.1	8.8
36	ANDROLOGY	7.4	0.6	0.079	60.1	7.2
37	REPRODUCTIVE BIOLOGY	12.6	1.1	0.088	58.7	12.4
38	GERONTOLOGY	10	0.4	0.038	63.3	9.4
39	DENTISTRY & ORAL SURGERY	7.2	0.5	0.073	60.6	7.0
40	DERMATOLOGY	8.1	0.3	0.036	62.1	7.8
41	UROLOGY & NEPHROLOGY	12.4	0.3	0.022	61.9	12.0
42	OTORHINOLARYNGOLOGY	6.1	0.4	0.069	62.4	5.7
43	OPHTHALMOLOGY	9.5	0.3	0.030	61.3	9.3
44	INTEGRATIVE & COMPLEMENTARY MEDICINE	6.2	0.6	0.090	61.2	5.9
45	CLINICAL NEUROLOGY	12.4	0.3	0.021	61.4	12.2
46	PSYCHIATRY	13.1	0.3	0.020	62	12.8
47	RADIOLOGY, NUCLEAR MED. & MED. IMAGING	10.4	0.3	0.025	61.4	10.3
48	ORTHOPEDICS	7.9	0.3	0.038	61.4	7.7
49	RHEUMATOLOGY	14.6	0.6	0.038	59.7	14.6
50	SPORT SCIENCES	8.2	0.5	0.056	62.5	7.7
51	SURGERY	8.6	0.2	0.028	62	8.4
52	TRANSPLANTATION	9.3	0.3	0.029	61.9	9.1
53	PERIPHERAL VASCULAR DISEASE	20.4	0.3	0.013	60.3	20.5
54	PEDIATRICS	7.7	0.3	0.035	61.8	7.5

V. CLINICAL MEDICINE III

55	HEALTH CARE SCIENCES & SERVICES	7.8	0.4	0.049	60.7	7.6
56	HEALTH POLICY & SERVICES	8.2	0.3	0.039	59.3	8.2
57	MEDICINE, LEGAL	5.8	0.4	0.069	60.5	5.6
58	NURSING	4.4	0.4	0.091	62.4	4.1
59	PUBLIC, ENV. & OCCUPATIONAL HEALTH	9.6	0.3	0.035	60.7	9.5
60	REHABILITATION	5.9	0.4	0.060	62.5	5.6
61	SUBSTANCE ABUSE	10	0.9	0.090	59.1	9.8
62	EDUCATION, SCIENTIFIC DISCIPLINES	4	0.3	0.071	64.8	3.8
63	MEDICAL INFORMATICS	5.7	0.3	0.046	61.6	5.6

VI. NEUROSCIENCES & BEHAVIORAL

64	NEUROIMAGING	14.6	0.4	0.026	63.1	14.0
65	NEUROSCIENCES	17	0.5	0.029	59.5	17.1
66	BEHAVIORAL SCIENCES	11.5	1.3	0.115	56	11.7
67	PSYCHOLOGY, BIOLOGICAL	9.9	0.8	0.084	57.3	10.0
68	PSYCHOLOGY	10.6	0.7	0.069	60.1	10.3
69	PSYCHOLOGY, APPLIED	6.5	0.4	0.063	61.9	6.2
70	PSYCHOLOGY, CLINICAL	10	0.4	0.038	61.2	9.8
71	PSYCHOLOGY, DEVELOPMENTAL	10.4	0.5	0.052	60.8	10.1
72	PSYCHOLOGY, EDUCATIONAL	7.1	0.3	0.043	64	6.7
73	PSYCHOLOGY, EXPERIMENTAL	10.2	0.4	0.042	61	10.0
74	PSYCHOLOGY, MATHEMATICAL	7	0.3	0.038	61	6.9
75	PSYCHOLOGY, MULTIDISCIPLINARY	6.4	0.6	0.092	62.6	6.4
76	PSYCHOLOGY, PSYCHOANALYSIS	3.8	0.4	0.100	66.3	3.5
77	PSYCHOLOGY, SOCIAL	8.3	0.3	0.031	61.6	8.1

78	SOCIAL SCIENCES, BIOMEDICAL	7.4	0.3	0.039	60.7	7.3
	B. PHYSICAL SCIENCES					
	VII. CHEMISTRY					
79	CHEMISTRY, MULTIDISCIPLINARY	12	1.3	0.108	65	11.7
80	CHEMISTRY, INORGANIC & NUCLEAR	9.1	0.6	0.062	61.6	8.7
81	CHEMISTRY, ANALYTICAL	10	0.5	0.046	60.6	9.8
82	CHEMISTRY, APPLIED	7.7	0.5	0.063	61.9	7.3
83	ENGINEERING, CHEMICAL	6	0.3	0.045	63.9	5.7
84	CHEMISTRY, MEDICINAL	9.8	0.8	0.078	59	9.7
85	CHEMISTRY, ORGANIC	10.7	1	0.090	59.1	10.5
86	CHEMISTRY, PHYSICAL	10.5	0.4	0.043	60	10.4
87	ELECTROCHEMISTRY	10.4	0.7	0.072	60.6	10.0
88	POLYMER SCIENCE	8.3	0.3	0.031	61.3	8.1
	VIII. PHYSICS					
89	PHYSICS, MULTIDISCIPLINARY	10.1	1.7	0.169	62.2	10.6
90	SPECTROSCOPY	7.7	0.3	0.043	61.8	7.4
91	ACOUSTICS	5.6	0.3	0.052	62.7	5.3
92	OPTICS	7.3	0.3	0.038	62.8	7.1
93	PHYSICS, APPLIED	7.5	0.4	0.049	60.9	7.6
94	PHYSICS, ATOMIC, MOLECULAR & CHEMICAL	11.1	0.8	0.071	59.1	11.0
95	THERMODYNAMICS	4.8	0.4	0.081	61.7	4.6
96	PHYSICS, MATHEMATICAL	7.5	0.3	0.037	61.6	7.4
97	PHYSICS, NUCLEAR	6.6	0.4	0.067	63.3	6.4
98	PHYSICS, PARTICLES & SUB-FIELDS	11.1	1.2	0.106	60.7	11.6
99	PHYSICS, CONDENSED MATTER	7.5	0.3	0.039	62	7.4
100	PHYSICS OF SOLIDS, FLUIDS & PLASMAS	9.4	0.6	0.064	60	9.2
101	CRYSTALLOGRAPHY	5.2	0.2	0.046	56.4	5.6
	IX. SPACE SCIENCES					
102	ASTRONOMY & ASTROPHYSICS	14.9	0.3	0.018	60.7	14.9
	X. MATHEMATICS					
103	MATHEMATICS, APPLIED	3.7	0.3	0.075	65	3.5
104	STATISTICS & PROBABILITY	5.4	0.5	0.097	54.1	6.2
105	MATH., INTERDISCIPLINARY APPLICATIONS	5.6	0.2	0.044	61.6	5.5
106	SOCIAL SCIENCES, MATHEMATICAL METHODS	5.6	0.3	0.047	61.4	5.5
107	PURE MATHEMATICS	2.8	0.2	0.087	66	2.6
	XI. COMPUTER SCIENCE					
108	COMP. SCIENCE, ARTIFICIAL INTELLIGENCE	4.8	0.5	0.107	63.4	4.8
109	COMPUTER SCIENCE, CYBERNETICS	3.7	0.4	0.102	67.1	3.4
110	COMP. SCIENCE, HARDWARE & ARCHITECTURE	3.9	0.5	0.123	62.9	4.0
111	COMPUTER SCIENCE, INFORMATION SYSTEMS	4.3	0.7	0.154	62.5	4.5
112	COMP. SC., INTERDISCIPLINARY APPLICATIONS	5.7	0.6	0.099	56.6	6.3
113	COMP. SCIENCE, SOFTWARE ENGINEERING	3.7	0.4	0.114	65	3.5
114	COMPUTER SCIENCE, THEORY & METHODS	2.9	0.4	0.130	65.6	2.8

115	MATHEMATICAL & COMPUTATIONAL BIOLOGY	9.8	0.5	0.047	49.7	12.2
	C. OTHER NATURAL SCIENCES					
	XII. ENGINEERING					
116	ENGINEERING, ELECTRICAL & ELECTRONIC	4.8	0.4	0.077	63	4.7
117	TELECOMMUNICATIONS	3.7	0.5	0.147	63.6	3.8
118	CONSTRUCTION & BUILDING TECHNOLOGY	3.5	0.3	0.088	65.5	3.2
119	ENGINEERING, CIVIL	3.4	0.3	0.087	66.3	3.2
120	ENGINEERING, ENVIRONMENTAL	9	0.3	0.034	62.5	8.7
121	ENGINEERING, MARINE	1.5	0.3	0.210	71.5	1.4
122	TRANSPORTATION SCIENCE & TECHNOLOGY	2.1	0.5	0.233	70.9	1.9
123	ENGINEERING, INDUSTRIAL	3.3	0.3	0.088	66.2	3.0
124	ENGINEERING, MANUFACTURING	3.6	0.3	0.087	65.3	3.2
125	ENGINEERING, MECHANICAL	4	0.2	0.060	63.9	3.8
126	MECHANICS	5.2	0.3	0.049	63.4	4.9
127	ROBOTICS	3.7	0.3	0.069	65	3.5
128	INSTRUMENTS & INSTRUMENTATION	5.2	0.2	0.046	64.4	4.9
129	IMAGING SCIENCE & PHOTOGR. TECHNOLOGY	7.5	0.4	0.058	63.8	7.2
130	ENERGY & FUELS	5.2	0.3	0.056	64.5	4.9
131	NUCLEAR SCIENCE & TECHNOLOGY	4.4	0.3	0.059	62.9	4.2
132	ENGINEERING, PETROLEUM	1.7	0.4	0.257	73.5	1.5
133	AUTOMATION & CONTROL SYSTEMS	4.1	0.2	0.060	64.5	3.8
134	ENGINEERING, MULTIDISCIPLINARY	3.9	0.4	0.101	65.9	3.6
135	ERGONOMICS	4.8	0.4	0.080	62.4	4.5
136	OPERATIONS RES. & MANAGEMENT SCIENCE	4	0.2	0.061	63.9	3.8
	XIII. MATERIALS SCIENCE					
137	MATERIALS SCIENCE, MULTIDISCIPLINARY	6.5	0.4	0.061	60.6	6.6
138	MATERIALS SCIENCE, BIOMATERIALS	13	1.1	0.084	59.1	12.8
139	MATERIALS SCIENCE, CERAMICS	4.8	0.4	0.075	68.1	4.3
140	MAT. SC., CHARACTERIZATION & TESTING	2.2	0.4	0.189	69.5	2.0
141	MATERIALS SCIENCE, COATINGS & FILMS	7.5	0.5	0.065	61.4	7.2
142	MATERIALS SCIENCE, COMPOSITES	3.5	0.3	0.084	65.1	3.3
143	MATERIALS SCIENCE, PAPER & WOOD	3	0.3	0.091	68	2.6
144	MATERIALS SCIENCE, TEXTILES	2.9	0.3	0.089	65.5	2.7
145	METALL. & METALLURGICAL ENGINEERING	4.6	0.4	0.082	64.5	4.4
146	NANOSCIENCE & NANOTECHNOLOGY	8.2	0.4	0.044	59.6	8.4
	XIV. GEOSCIENCES					
147	GEOCHEMISTRY & GEOPHYSICS	9.8	0.6	0.060	61.7	9.4
148	GEOGRAPHY, PHYSICAL	9	0.8	0.088	59.9	8.7
149	GEOLOGY	8	0.4	0.055	62.7	7.6
150	ENGINEERING, GEOLOGICAL	3.7	0.3	0.088	62.5	3.5
151	PALEONTOLOGY	6.4	0.4	0.055	63.1	6.0
152	REMOTE SENSING	7.4	0.3	0.043	60.6	7.3
153	OCEANOGRAPHY	10	0.9	0.090	61.2	9.5
154	ENGINEERING, OCEAN	3.8	0.4	0.098	64.8	3.6
155	METEOROLOGY & ATMOSPHERIC SCIENCES	10.6	0.4	0.037	61.3	10.3

156	ENGINEERING, AEROSPACE	2.6	0.2	0.091	68.7	2.3
157	MINERALOGY	7.2	0.4	0.060	61.7	6.8
158	MINING & MINERAL PROCESSING	4.1	0.3	0.065	65.8	3.9
159	GEOSCIENCES, MULTIDISCIPLINARY	7.3	0.4	0.050	62.6	6.9

XV. AGRICULTURAL & ENVIRONMENT

160	AGRICULTURAL ENGINEERING	4.9	0.4	0.072	62	4.7
161	AGRICULTURE, MULTIDISCIPLINARY	6.9	0.3	0.038	64.7	6.4
162	AGRONOMY	5.9	0.3	0.046	63	5.6
163	LIMNOLOGY	9.5	0.6	0.065	61	9.2
164	SOIL SCIENCE	6.9	0.5	0.074	62.1	6.5
165	BIODIVERSITY CONSERVATION	8.8	0.3	0.037	62.7	8.4
166	ENVIRONMENTAL SCIENCES	8.9	0.5	0.051	60.8	8.7
167	ENVIRONMENTAL STUDIES	4.9	0.3	0.071	61.7	4.7
168	FOOD SCIENCE & TECHNOLOGY	7.1	0.5	0.067	61.8	6.8
169	NUTRITION & DIETETICS	11.4	0.3	0.030	61.3	11.1
170	AGRICULTURE, DAIRY & ANIMAL SCIENCE	5.4	0.3	0.048	65.9	5.0
171	HORTICULTURE	6.2	0.3	0.044	62.9	6.0

XVI. BIOLOGY (ORGANISMIC AND SUPRAORGONISMIC LEVEL)

172	ORNITHOLOGY	5.5	0.4	0.077	59.8	5.4
173	ZOOLOGY	7.5	0.5	0.065	61.4	7.2
174	ENTOMOLOGY	5.5	0.4	0.067	63	5.1
175	WATER RESOURCES	6.2	0.4	0.068	62.2	5.8
176	FISHERIES	7.1	0.8	0.110	60	6.8
177	MARINE & FRESHWATER BIOLOGY	8.2	0.9	0.113	59.2	7.9
178	MICROBIOLOGY	14.3	1	0.071	58.9	14.2
179	PARASITOLOGY	8.1	0.6	0.072	60	7.9
180	VIROLOGY	18.7	1.5	0.082	57.6	18.8
181	FORESTRY	7	0.6	0.079	60.2	6.8
182	MYCOLOGY	6.8	0.3	0.046	62.3	6.5
183	PLANT SCIENCES	9.6	0.3	0.027	60.7	9.6
184	ECOLOGY	11.4	1	0.085	59.7	11.1
185	VETERINARY SCIENCES	5.2	0.3	0.054	65.4	4.8

XVII. MULTIDISCIPLINARY

186	MULTIDISCIPLINARY SCIENCES	4.1	0.6	0.161	64.2	4.1

D. SOCIAL SCIENCES

XVIII. SOCIAL SCIENCES, GENERAL

187	CRIMINOLOGY & PENOLOGY	4.9	0.3	0.065	66.5	4.5
188	LAW	4.4	0.4	0.083	64.7	4.2
189	POLITICAL SCIENCE	3.3	0.4	0.119	65.7	3.2
190	PUBLIC ADMINISTRATION	3.7	0.3	0.075	65.9	3.4
191	ETHNIC STUDIES	2.6	0.3	0.103	66	2.4
192	FAMILY STUDIES	5.8	0.3	0.055	62	5.6
193	SOCIAL ISSUES	3.6	0.3	0.088	65.5	3.4
194	SOCIAL WORK	3.9	0.3	0.069	63.4	3.6
195	SOCIOLOGY	4.2	0.3	0.067	65.1	4.0
196	WOMEN'S STUDIES	4	0.3	0.063	64	3.8

197	EDUCATION & EDUCATIONAL RESEARCH	3.3	0.3	0.088	64.3	3.1
198	EDUCATION, SPECIAL	5.1	0.3	0.059	62.5	4.9
199	AREA STUDIES	2	0.3	0.154	67.4	1.8
200	GEOGRAPHY	5.8	0.3	0.054	60.8	5.7
201	PLANNING & DEVELOPMENT	4.3	0.3	0.060	62.4	4.2
202	TRANSPORTATION	5.1	0.4	0.073	62.2	4.9
203	URBAN STUDIES	4.3	0.3	0.064	62.3	4.1
204	ETHICS	3.5	0.3	0.080	65.3	3.2
205	MEDICAL ETHICS	5.2	0.4	0.071	62.1	4.9
206	ANTHROPOLOGY	4.3	0.3	0.075	65.9	4.0
207	COMMUNICATION	4.3	0.3	0.065	63.4	4.0
208	DEMOGRAPHY	5.6	0.3	0.048	61.3	5.5
209	HISTORY OF SOCIAL SCIENCES	2.1	0.3	0.145	69.1	1.8
210	INFORMATION SCIENCE & LIBRARY SCIENCE	3.9	0.5	0.127	64.1	3.8
211	INTERNATIONAL RELATIONS	2.9	0.4	0.140	65.5	2.9
212	LINGUISTICS	6	0.3	0.046	63.5	5.7
213	SOCIAL SCIENCES, INTERDISCIPLINARY	3.5	0.3	0.098	66.1	3.3

XIX. ECONOMICS & BUSINESS

214	AGRICULTURAL ECONOMICS & POLICY	3.8	0.3	0.073	63.6	3.6
215	ECONOMICS	4.6	0.4	0.077	62	4.6
216	INDUSTRIAL RELATIONS & LABOR	4.5	0.3	0.077	64.1	4.1
217	BUSINESS	6.7	0.4	0.056	64.3	6.4
218	BUSINESS, FINANCE	6.4	0.6	0.094	64.3	6.3
219	MANAGEMENT	6.4	0.4	0.061	63.6	6.2
	Mean			**0.07**	**62.2**	

Table 4. Citation Inequality Decomposition Sat the Sub-field level. The Multiplicative Case.

	Quantiles	Within-group Term, $\mathbb{W}$ (1)	Skew. of Sc. Term, S (2)	$IDCP$ Term (3)	Total Citation Inequality (4)	Percentages In %: (1)/(4) (5)	(2)/(4) (6)	(3)/(4) (7)
A. Raw Data	All quantiles	0.0030	0.6950	0.1544	0.8524	0.35	81.54	18.11
	[1, 660]			0.0469				5.50
	[661, 978]			0.0766				8.98
	[979, 1000]			0.0310				3.63
B. Sub-field ER Normalization	All quantiles	0.0030	0.7212	0.0268	0.7510	0.41	96.03	3.57
	[1, 660]			0.0160				2.13
	[661, 978]			0.0023				0.31
	[979, 1000]			0.0085				1.13
C. Sub-field Mean Normalization	All quantiles	0.0029	0.7168	0.0243	0.7440	0.39	96.34	3.27
	[1, 660]			0.0164				2.20
	[661, 978]			0.0023				0.31
	[979, 1000]			0.0056				0.76

hange Rates. Multiplicative Case

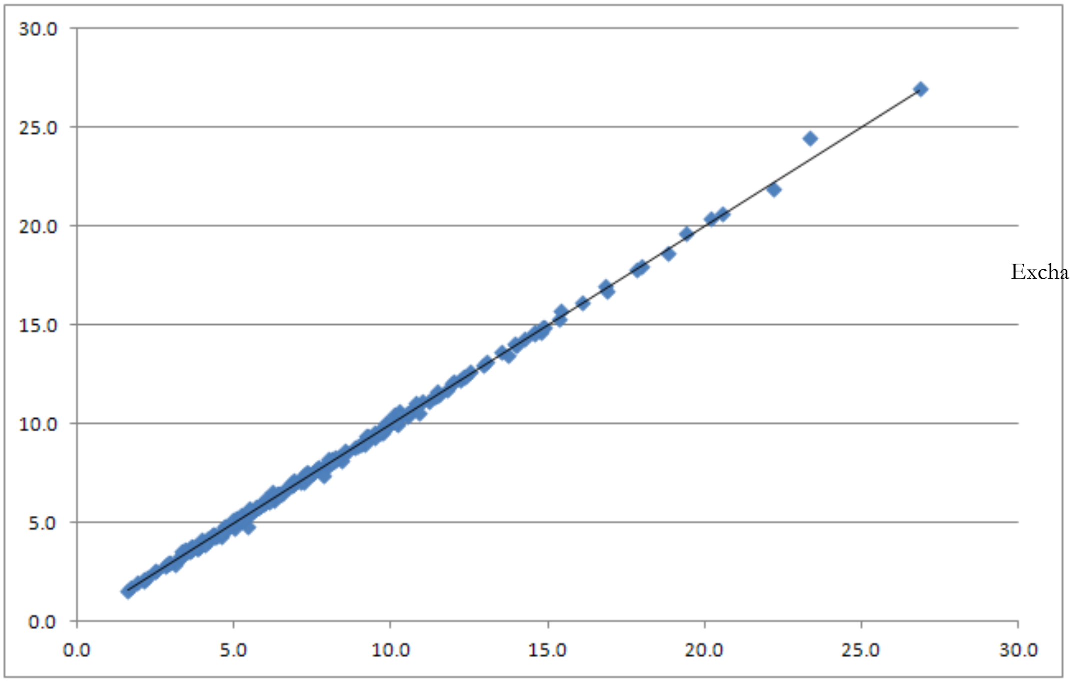


Figure 4. A Comparison at the Sub-field level of Exchange Rates in the Fractional *versus* the Multiplicative Case

Table 5. Exchange Rates, Standard Deviations and Coefficients of Variation for the [620, 998] Interval. Field Level.

	Exchange Rates	Standard Deviation	Coefficient of Variation	% of Citations	Exch. Rates Based on Mean Citations
	(1)	**(2)**	**(3)**	**(4)**	**(5)**
I. BIOSCIENCES	19.8	0.3	**0.016**	76.6	24.0
II. BIOMEDICAL RESEARCH	11.5	0.4	**0.032**	77.1	11.6
III. CLINICAL MEDICINE I (INTERNAL)	15.8	0.6	**0.039**	78.3	16.3
IV. CLINICAL MED. II (NON-INTERNAL)	10.2	0.3	**0.028**	78.9	10.1
V. CLINICAL MEDICINE III	7.9	0.4	**0.050**	78.3	7.7
VI. NEUROSCIENCES & BEHAVIORAL	12.8	0.4	**0.031**	78.4	12.6
VII. CHEMISTRY	9.8	0.4	**0.041**	78.8	9.6
VIII. PHYSICS	8.1	0.4	0.054	80.2	8.2
IX. SPACE SCIENCES	14.9	0.3	**0.022**	78.8	14.8
X. MATHEMATICS	3.6	0.3	**0.089**	80.5	3.6
XI. COMPUTER SCIENCE	4.2	0.6	0.141	83.1	4.4
XII. ENGINEERING	4.5	0.3	**0.062**	83.1	4.3
XIII. MATERIALS SCIENCE	5.8	0.4	**0.067**	82.3	5.7
XIV. GEOSCIENCES	8.1	0.5	**0.066**	79.4	7.7
XV. AGRICULTURAL & ENVIRONMENT	7.6	0.4	**0.059**	78.9	7.3
XVI. BIOLOGY (ORG. & SUPRAORGANISMIC LEVEL)	9.3	0.5	**0.050**	78.2	9.1
XVII. MULTIDISCIPLINARY	4.0	0.7	**0.175**	87.1	4.0
XVIII. SOCIAL SCIENCES, GENERAL	4.0	0.3	**0.082**	83.1	3.8
XIX. ECONOMICS & BUSINESS	5.3	0.4	**0.071**	82.1	5.2
Mean				**80.2**	

Table 6. Citation Inequality Decomposition at the Field level

	Quantile Choice, P	Within-group Term, $\mathbb{W}$ (1)	Skew. of Sc. Term, S (2)	$IDCP$ Term (3)	Total Citation Inequality (4)	Percentages In %: (1)/(4) (5)	(2)/(4) (6)	(3)/(4) (7)
A. Raw Data	1,000	0.0045	0.7520	0.1079	0.8644	0.52	87.00	12.48
	[1, 619]			0.0284				3.28
	[620, 998]			0.0726				8.40
	[999, 1000]			0.0069				0.80
B. Field ER Normalization	1,000	0.0051	0.7704	0.0135	0.7890	0.65	97.64	1.71
	[1, 619]			0.0098				1.24
	[620, 998]			0.0017				0.21
	[999, 1000]			0.0020				0.25
C. Field Mean Normalization	1,000	0.0051	0.7694	0.0131	0.7876	0.64	97.69	1.67
	[1, 619]			0.0098				1.25
	[620, 998]			0.0016				0.20
	[999, 1000]			0.0017				0.22
D. Sub-field ER Normalization	1,000	0.0051	0.7439	0.0136	0.7627	0.67	97.54	1.79
	[1, 619]			0.0092				1.21
	[620, 998]			0.0019				0.25
	[999, 1000]			0.0025				0.33
E. Sub-field Mean Normalization	1,000	0.0044	0.7364	0.0122	0.7531	0.59	97.79	1.62
	[1, 619]			0.0092				1.22
	[620, 998]			0.0015				0.20
	[999, 1000]			0.0015				0.19