UNIVERSIDAD CARLOS III DE MADRID working papers

Working Paper 09-06
Economic Series (02)
March 2009

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

THE PREVALENCE OF POWER LAWS IN THE CITATIONS TO SCIENTIFIC PAPERS

Pedro Albarrán*, Juan A. Crespo, Ignacio Ortuño*, and Javier Ruiz-Castillo***

*** Departamento de Economía, Universidad Carlos III**
**** Departamento de Economía Cuantitativa, Universidad Autónoma de Madrid**

Abstract

This paper presents some preliminary evidence about the existence of power laws representing the upper tail of the citation distributions among 221 scientific sub-fields or Web of Science categories distinguished by Thomson Scientific within the natural and the social sciences. The main finding is that, in a sample consisting of 767,828 articles published in 1998 with a 5-year citation window, in 181 out of 221 sub-fields (representing approximately 77% of the sample of articles) the existence of a power law cannot be rejected. In most sub-fields, the upper tail that can be represented by a power law is small but captures a considerable proportion of the total citations received. The value of the scale parameter is between 2 and 3 for only 21 sub-fields or 6% of the total, greater than 3 for 114 sub-fields or 67%, and greater than 4 for the remaining 46 sub-fields that represent 27% of the total. The estimation of the parameters of the power laws has been done with a novel procedure for citation distributions that is shown to perform better than the standard maximum likelihood methods in the presence of extreme observations.

The authors acknowledge financial support from the Spanish MEC, Grants SEJ2007-67436, SEJ2007-63098 and SEJ2006-05710. The database of Thomson Scientific (formerly Thomson-ISI; Institute for Scientific Information) has been acquired with funds from Santander Universities Global Division of Banco Santander. This paper is part of the SCIFI-GLOW Collaborative Project supported by the European Commission's Seventh Research Framework Programme, Contract no. SSH7-CT-2008-217436.

INTRODUCTION

As originally suggested in Price (1965), it is generally believed that the citation process in the periodical literature is one of the aspects of science in which power laws (or other extreme distributions) are prevalent.[1] However, the available evidence about the existence of a power law characterizing the citations received by articles published in academic journals is very scant indeed. As far as we know, there are only results on the existence of power laws representing the upper tail of the citations distribution in a few samples of articles belonging to certain scientific fields, like Physics, or all fields combined (see *inter alia* Seglen, 1992, Redner, 1998, 2005, and Clauset *et al.*, 2007; Laherrère and Sornette, 1998, study the citation record of the most cited physicists).

The main aim of this paper is to provide massive evidence in this respect using a large sample acquired from Thomson Scientific (abbreviated as TS in the sequel), consisting of almost 8,500,000 million of articles published in 1998-2007, as well as the approximate 65,000,000 million citations received by them during that period. The articles belong to the 20 natural sciences, the 2 social sciences, and the Arts and the Humanities distinguished by TS. In particular, the research questions asked are the following two. Firstly, under what conditions (sample size, citation window, minimum number of citations, etc.) does there exist a power law characterizing the citations received by a large number of sub-fields, say the 250 Web of Science (WoS) categories distinguished by TS? Secondly, under what conditions does there exist a power law characterizing broader aggregates, such as the above mentioned 23 fields, other groups of disciplines, or the whole of science?

From a statistical point of view, the estimation of a power law and the evaluation of the goodness-of-fit is known to be a much more complex problem than the direct linear fit of the log-log plot of the full raw histogram of the data, let alone the mere inspection of the histogram

[1] An extensive discussion of the properties of power laws can be found in the reviews by Mitzenmacher (2004) and Newman (2005), and references therein.

plotted on logarithmic scales to check whether it looks as a straight line (see *inter alia* Pickering *et al.*, 1995, Clark *et al.*, 1999, Goldstein *et al.*, 2004, Bauke, 2007, Clauset *et al.*, 2007, White *et al.*, 2008).

In this respect, there seems to be unanimity that a maximum likelihood (ML) approach provides the best solution to the estimation problem. However, the ML approach might be quite vulnerable to the existence of a few extreme observations consisting of a few highly cited articles at the very end of the citation distribution. In our contribution to this literature, this paper suggests an estimation method for a citation distribution that uses the relationship that, for a sample following a power law, has been shown to exist between the Hirsh or *h*-index for that sample, the sample size, and the scale parameter of the power law (Glänzel, 2006, and Egghe and Rousseau, 2006). When applied to the articles published in 1998 and a 5-year citation window, this method is shown to perform better or equal than ML in 19 of the 23 TS fields.

It would be very convenient for this project to have a hierarchical Map of Science organizing sub-fields, scientific fields, disciplines and the like in a way agreed upon by the international scientific community. Unfortunately, one should not expect a unique Map of Science, but a number of possible representations. It is true that the citation map, viewed as a directed graph or a matrix of aggregate journal-journal citations, is extremely sparse, with regions oh high linkage density. Many journals can be unambiguously assigned to one core set or another, but the remainder, which is also a large group, only admits a heterogeneous assignment.[2] As a result, each Map of Science necessarily contains a projection from a specific perspective (see *inter alia* the important contributions by Small, 1999, Boyack *et al.*, 2005, Leydesdorff, 2004, 2006, and Leydersdorff and Rafols, 2009, as well as the references they contain).

[2] To appreciate at a glance the complex pattern of inter-relationships between subfields, and even among larger aggregates, whenever large samples are considered, it suffices to inspect, for instance, Figure 1 in Small (1999), Figure 5 in Boyack *et al.* (2005), or Figures 3 and 4 in Leydersdorff and Rafols (2009).

The situation can be illustrated in our data set where we must confront two different problems. In the first place, each article is assigned to one or more WoS categories, up to a maximum of 6. In particular, only about 5,000,000 articles, or 59% of the total is assigned to a single WoS category. What should be done with the remaining 41% of multi-WoS category articles? In other words, how should we define the collection of articles that form the sub-fields at the lowest level of aggregation? The question is important because the more homogeneous are the citation practices among the articles that form each sub-field, the easier should be the fitting of a power law to its citation distribution. In the second place, each article is assigned to a single TS field but, precisely because of the inexistence of a Map of Science generally accepted by all, TS does *not* provide a link between the 250 WoS categories and the 23 fields. It turns out that, when articles are classified by fields, the percentage of articles assigned to a single WoS category ranges from 95% and 90% for the Multidisciplinary field and Arts and Humanities, respectively, to only about 40% for Material Sciences, Environmental and Ecology, or Engineering and 43-45% for Molecular Biology and Genetics, and Neurosciences and Behavioral Sciences. Thus, the connection between many WoS categories and the fields is not obvious at all. In brief, the task of deciding what a sub-field should be at the lowest level of aggregation, as well as the drawing of the lines connecting each sub-field to a single broader scientific category, constitute a formidable practical problem that must be solved in conjunction with the study of the existence of power laws at different aggregation levels.

In this paper, we identify the notion of sub-fields with that of a WoS category. Articles belonging to several WoS categories are assigned to the corresponding sub-fields in a multiplicative or fractional way. The link between each sub-field and one of the 23 TS fields is established according to a majority criterion that will be explained below.

The main results in this preliminary report at the lowest level of aggregation can be summarized as follows. Consider the sample of 767,828 articles published in 1998 with a 5-year citation window in the 221 sub-fields or WoS categories distinguished by TS within the natural and social sciences. That the upper tail of the citation distribution is drawn from a power law cannot be rejected in 181 sub-fields, which represent approximately 77% of the sample. Contrary to what has been found before for many natural and social phenomena, the scale parameters have a value between 2 and 3 for only 21 sub-fields representing 6% of the total number of articles. The rest ranges from 3 to 5.5. Across the 181 sub-fields, the proportion of sample sizes represented by power laws ranges from 0.4% to 37.5%, while the proportion of citations captured by the power laws ranges from 4.8% to 80.3%. Finally, except in one case, the existence of a power law in the remaining 40 scientific sub-fields cannot be rejected when the 5-year citation window is either expanded or reduced to 10 or 3 years, respectively. Thus, it can be concluded that the existence of a power law representing the upper tail of the citation distribution is a rather universal phenomenon among scientific sub-fields.

The rest of the paper is organized in four Sections and an Appendix. Section II presents the data and the statistical methods we advocate. Section III is devoted to the construction of the Map of Science used in the paper. Section IV summarizes the main features of some provisional results for 221 scientific sub-fields. The results themselves for these 221 sub-fields and the remaining 28 sub-fields belonging to Arts and Humanities are reported in the Appendix. Finally, Section V discusses the main findings and a number of possible extensions.

II. DATA AND STATISTICAL PROCEDURES

II.1. The Dataset

TS indexed journal articles include research articles, reviews, proceedings papers and research notes. In this paper, only research articles, or simply articles, are studied, so that 390,097 review articles and 3 notes are disregarded. Table 1 informs about the multi-WoS category structure of the 23 TS fields. Knowledge of the WoS categories is essential for the construction of a Map of Science. Therefore, the 52,785 articles without a WoS category in Table 1 (in 42,887 of which the TS field was also missing) must be eliminated from the analysis.

Taking into account 4 articles with incomplete information for which the number of authors was missing, our sample size consists of 8,470,666 articles, or 95% of the number of items in the original database. The 20 fields in the natural sciences are organized in three large disciplines: Life Sciences, Physical Sciences, and Other Natural Sciences. The last two represent, approximately, 28% and 26% of the total, while Life Sciences represent about 37%. The remaining 9% correspond to the two Social Sciences and Arts and Humanities.

Table 1 around here

The dataset consists of articles published in a certain year and the citations they receive from that year until 2007, that is, articles published in 1998 and its citations during the 10-year period 1998-2007, articles published in 1999 and its citations in the 9-year period 1999-2007, and so on until articles published in 2007 and its citations during that same year. For our purposes in Sections III and IV, a sample of 767,828 articles published in 1998 and the citations they received during a common 5-year window from 1998 to 2002 is selected. At least for most fields, the sample size is rather large: 13 fields have more than 30,000 articles; 8 fields have between this number and 10,000 articles, and only 2 fields have less than 10,000 articles. The choice of a 5-year citation window is standard in the literature, perhaps because this length seems large enough for most natural sciences. It must be recognized, however, that the time pattern of the citation process varies a lot among different disciplines. Because the results of this paper are restricted to this fixed sample size and citation window, they should be taken as provisional. Further research will include enlarging the sample size, and investigating criteria for the most appropriate selection of a citation window for each field and/or sub-field. At any rate, as can be observed in Table 2, the distribution of articles by field in the 1998 sample is very close to the one for the dataset as a whole. Moreover, as will be presently seen, in most fields the basic structure of the reference and citation distributions in the sample is very similar to the one for the entire dataset.

Table 2 around here

For each field, Table 3 presents descriptive statistics about the two sides of the citation process: citations received, as well as references made. This is done for two samples: the entire set of articles published in 1998-2007, together with the entire mass of citations received and references made during this period (panel A), and the sample of articles published in 1998, the references they made and the citations they received during a 5-year citation window (panel B).

Table 3 around here

It should be understood that the citations received by the articles in a certain field will depend on the reference distribution in that field. In particular, the higher the median (or the mean, not shown in Table 3), the higher will be the total citations received –and, presumably, the smaller will be the percentage of articles with zero citations. But references are made to many different items: articles in TS indexed journals, but also articles in conference volumes, books, and other documents neither of them covered by TS. Moreover, some references to TS journals will be to articles published before 1998 and, hence, outside of our dataset. The larger the number of references made to recently published articles, the larger will tend to be the number of citations received, and the smaller the ratio references made/citations received in the last column of Table 3.

Consider first Panel A in Table 3 about the entire dataset. All fields can be classified in 3 groups according to the value of the references/citations ratio: (i) 6 of the 8 Life Sciences, characterized by a relatively low value (between 2 and 3) of the ratio; (ii) the 2 remaining Life Sciences and another 8 natural sciences with a ratio between 3 and 5, and (iii) a group of 7 fields wit a ratio equal or greater than 5, including Agricultural Sciences, Plant and Animal Sciences, Engineering, Mathematics, Computer Sciences, the 2 Social Sciences, plus Arts and Humanities with a value equal to 33.3. With few exceptions, the medians of the reference distributions are relatively small in group (iii), ranging from 14 to 30, and relative high in group (i), ranging from 24 to 38, with intermediate values in group (ii). Thus, fields in group (iii) make fewer references on average and receive fewer citations. Correspondingly, they are characterized by a relatively high percentage of articles with no citations at all. For 6 of these 7 fields the percentage of un-cited articles ranges from 30% to 55%, while for the remaining field in group (iii), Arts and Humanities, that percentage is an astronomical 83%. In turn, the larger is this percentage, the larger is expected to be the percentage of citations received by the 5% most cited articles. This is exactly what is observed, with such upper tail containing from 36% to 55% and a maximum of 84.6% of all citations. With few exceptions, the opposite is the case for Life Science fields in group (i): the percentage of articles with zero citations ranges from 13% to 23%, and the proportion of citations accounted for the 5% most cited articles ranges from 31% to 41%. Group (ii) is characterized by intermediate values.

These differences are important. In particular, it is clear that Arts and Humanities constitute an entirely different, or an extreme case of a scholarly field that makes relatively few references, a very small part of which appear as citations received by articles published only a few years later in TS indexed journals. However, it can be concluded that overall all fields share a common basic structure. A considerable proportion of articles receive no citations at all, the median of the citation distribution ranges from 1 to 7, and the 5% most cited articles account for at least 31% of all citations.

Interestingly enough, as anticipated above, in most fields the basic structure of the reference and citation distributions in the 1998 sample (see Panel B in Table 3) is very similar to the one just analyzed. The percentage of un-cited articles and, correspondingly, the percentage of citations concentrated in the upper tail are both somewhat smaller in the 1998 sample. But the median of the citation distribution is the same in 12 cases, and has only one citation less in the sample in 10 other fields (the exception is Chemistry, where the median goes from 7 citations in the sample to 3 citations in the entire dataset). Similarly, the citations needed to belong to the 5% most cited articles increase from 2 to 7 citations in 13 fields, from 8 to 10 in 7 others, remains the same in 2 cases (Molecular Biology and Genetics, and Arts and Humanities), and decreases in the remaining field, Chemistry. That is to say, a 5-year citation window for the articles published in 1998 appears to be enough for the sample's citation distribution to closely resemble the one for the entire dataset. Taking also into account that the sample's distribution by field is also very similar to the one for the dataset (see Table 2), we are confident that the 1998 sample constitutes a good testing bank to explore alternative estimation strategies.

III. 2. The Maximum Likelihood Approach

Let x be the number of citations received by an article in a given field. This quantity is said to obey a power law if it is drawn from a probability density $p(x)$ such that

$$p(x)\mathrm{d}x = \Pr\left(x \le X \le x + \mathrm{d}x\right) = Cx^{-\alpha},$$

where X is the observed value, C is a normalization constant, and α is known as the exponent or scaling parameter. This density diverges as $x \to 0$, so that there must be some lower bound to the power law behavior, denoted by ρ. Then, provided $\alpha > 1$, it is easy to recover the normalization constant, which in the continuous case is shown to be

$$C = \left(\alpha - 1\right)\rho^{\alpha-1}$$

Assuming that in each field our data are drawn from a distribution that follows a power law exactly for $x \geq \rho$, and assuming for the moment that ρ is known, the MLE (maximum likelihood estimator) of the scaling parameter can be derived (see Appendix B in Clauset *et al.*, 2007). The MLE is shown to be

$$\hat{\alpha}_{MLE} = 1 + n\left[\sum_{i=1}^{n} \ln \frac{x_i}{\rho}\right] \qquad (1)$$

These authors test the ability of the MLEs to extract the known scaling parameters of synthetic power law data, finding that the MLEs give the best results when compared with several competing methods based on linear regression. Nevertheless, for very small data sets the MLEs can be significantly biased. Clauset *et al.* (2007) suggest that $n \geq 50$ is a reasonable rule of thumb for extracting reliable parameter estimates. The large percentage of articles with no citations at all, as well as the low value of the median in all fields (see Table 3), indicate that we are in the typical case where there is some non-power law behavior at the lower end of the citation distributions. In such cases, it is essential to have a reliable method for estimating the parameter ρ, that is, the power law's starting point. In this paper, e the approach advocated by Clauset *et al.* (2007) is used. They choose the value of ρ that makes the probability distributions of the measured data and the best-fit power law as similar as possible above ρ. To quantify the distance to be minimized between the two probability distributions the Kolmogorov-Smirnov, or KS statistic is used. Again, Clauset *et al.* (2007) generate synthetic data and examine their method's ability to recover the known values of ρ. They obtain good results provided the power law is followed by at least 1,000 observations.[3]

The method described allows us to fit a power law distribution to a given data set and provides good estimates of the parameters involved. An entirely different question is to decide whether the power law distribution is even a reasonable hypothesis to begin with, that is, whether the data we observe could possibly have been drawn from a power law distribution. The standard way to answer this question is to compute a *p*-value, defined as the probability that a data set of the same size that is truly drawn from the hypothesized distribution would have a goodness of fit as bad or worse than the observed one. Thus, the *p*-value quantifies the probability that the data were drawn from the hypothesized distribution, based on the observed goodness of fit. Therefore, if the p-value is very small, then it is unlikely that the data are drawn from a power law.

To implement this procedure, we again follow Clauset *et al.* (2007). First, take the value of the KS statistic minimized in the estimation procedure as a measure of its goodness of fit. Second, using a semi-parametric approach described in Clauset *et al.* (2007), generate a large number of synthetic data sets that follow a perfect power law with scaling parameter equal to

[3] As a matter of fact, to estimate the parameters α and ρ we use the program that Clauset *et al.* (2007) have made available in http://www.santafe.edu/~aaronc/powerlaws/.

the estimated α above the estimated ρ, but have the same non-power law behavior as the observed data below it. Third, fit each synthetic data set according to the estimation method already described, and calculate the KS statistic for each fit. Fourth, calculate the *p*-value as the fraction of the KS statistics for the synthetic data sets whose value exceeds the KS statistic for the real data. If the *p*-value is sufficiently small, say below 0.1, then the power law distribution can be ruled out.

III. 3. A Superior Estimation Strategy

As in other statistical contexts, one should ask whether a given estimation method is vulnerable to the presence of extreme observations. Citation distributions are a case in point. A few very highly-cited articles may very well distort the ML approach whose results have just been presented. The problem, of course, is that such observations are very much a part of reality and cannot be treated as "outliers" whose impact on the estimation process needs to be curtailed or eliminated. Fortunately, the following estimation strategy for citation distributions may protect us from this problem.

Consider the *h*-index originally suggested by Hirsh (2005) to assess an individual's research performance. In our context, an *h*-index equal to 70 for a given field means that there are 70 articles in the field that have received at least 70 citations, while all remaining articles have received less than 70 citations. In the continuous case, in the presence of a power law $p(x) = Cx^{-\alpha} = (\alpha - 1)\rho^{\alpha-1}x^{-\alpha}$ for $x \geq \rho$, we have

$$h = T\,\Pr(X \geq h) = T\int_{h}^{\infty}(\alpha - 1)\rho^{\alpha-1}x^{-\alpha}dx$$

where T is the number of articles in the upper tail of the citation distribution when $x \geq \rho$. The former expression becomes the equation $h = T\rho^{\alpha-1}h^{-\alpha+1}$, the unique solution of which is

$$h = T^{\frac{1}{\alpha}}\rho^{\frac{\alpha-1}{\alpha}} \qquad (2)$$

or

$$\alpha = \left(\log T + \log \rho\right) \Big/ \left(\log h + \log \rho\right).$$ [4]

In this expression, parameters ⟨ and ⟩ are seen to be a function of two "characteristics" of the distribution: the *h*-index and *T*, the number of articles for which a power law distribution holds. This suggests the Principle of Analogy or Method of Moments (MM) as an alternative to Maximum Likelihood in order to estimate the parameters α and ρ. These parameters can be estimated as the sample analog of the above expression using an estimate $\hat{H}$ of *h* obtained from the data as follows:

$$\hat{\alpha}_{MM} = \left(\log T + \log \tilde{\rho}\right) \Big/ \left(\log \hat{H} + \log \tilde{\rho}\right)$$

The advantage of this approach is that the computed sample value of *h,* $\hat{H}$, is not very much altered by the existence of extreme values and, therefore, the estimated value of α is less sensitive to them.[5] Beirlant and Einmahl (2007) have shown that the estimator $\hat{H}$ is consistent and asymptotically normal (although at a non-standard rate of convergence).[6] Therefore, we can simply apply the Delta Method to derive the asymptotic distribution of $\hat{\alpha}_{MM}$ for a given value $\tilde{\rho}$. In practice, a procedure similar to the one followed for the MLEs is used to obtain the *p*-values.

An alternative strategy would be to estimate what Clauset *et al.* (2007) call a "power law with exponential cut off", namely, a distribution

$$p(x) = Cx^{-\alpha} e^{-\lambda x}$$

---

[4] For ρ = 1, expression (2) is in Glänzel (2006), and Egghe and Rousseau (2006).

[5] Since the expectation of x_i under a power law is $(\alpha-1)/(\alpha-2)\rho$ (for α >2), one could obtain another Method of Moment estimator of α as a function of the sample mean; but this would also be affected by extreme values.

The discrete case is similar, although no analytical closed form solution exists either for the MLE or for the Method of Moments Estimator.

6 We thank Oliver Linton for helpful suggestions on the characterization of the asymptotic properties of our novel estimator.

However, our proposal should be *a priori* preferable because the alternative involves estimating an additional parameter λ. For the sample of 1998 articles with a 5-year citation window, the results of the ML approach and the alternative strategy are presented in Table 4.

Table 4 around here

Judging by the *p*-value, the results of the ML approach are rather mixed: in 10 fields –including some as important as Clinical Medicine, Physics, or Mathematics– the existence of a power law must be rejected. These fields represent 60% of all articles in the natural and the social sciences. However, in 9 of these cases (all but Engineering) the alternative strategy leads to a *p*-value above the critical value 0.1. It should be noted that, except for Neurosciences and Behavioral Sciences, in the remaining 8 cases the MLE of ρ is considerably smaller than the one obtained by the alternative method. This is important, because if we choose too high a value of ρ we are effectively throwing away legitimate data points with less than citations, but if we choose too low a value for it we might get a biased estimate of the scaling parameter. As a matter of fact, in all 8 cases where the latter is the case, the MLE of α is smaller than the alternative one (as could be expected, the opposite is the case for Neurosciences and Behavioral Sciences).

For 8 other scientific fields, plus Arts and Humanities, where the ML method indicates that a power law cannot be rejected the *p*-value also increases with the MM approach. Interestingly enough, in 7 of these cases the estimates of both parameters ρ and α coincide or are very similar indeed. In Social Sciences, General the MLE of ρ, and hence of α, are again too low, while Molecular Biology and Genetics provides the exception where the MLE of ρ is too low but the one for α is too high. In 3 scientific fields –Psychiatry and Psychology, Geosciences, and Environment and Ecology– the *p*-value decreases but remains above 0.1, and the estimated parameters do not differ very much. In only one instance, Agricultural Sciences, the *p*-value decreases below the critical value.

In brief, apart from Arts and Humanities, in 20 fields representing 90% of all scientific articles the hypothesis of the power law according to the MM approach cannot be rejected. The conclusion is inescapable: for this particular sample, the strategy we advocate clearly outperforms the ML approach. The explanation must possibly be found in the vulnerability of MLE to the existence of a few extreme values in most fields. If this were to be confirmed in further research, then it would be very interesting to study the consequences of using our estimation strategy in the many cases in Clauset *et al.* (2007) where the best fit to the data is provided by a power law with cut-off.[7]

With regard to the 20 fields (plus Arts and Humanities) for which the existence of a power law cannot be ruled out, the following three comments are in order:

1. Only for Arts and Humanities and the Multidisciplinary field the estimated scale parameter is between 2 and 3. For 13 fields $\hat{\alpha}$ is between 3 and 4, and for the remaining 6 fields $\hat{\alpha}$ is equal or greater than 4.[8]

2. The estimated value of ρ that determines the beginning of the power law is rather low in 10 fields, ranging from 16 to 36 citations, and rather high in 10 others, ranging from 45 in Chemistry to 168 in Molecular Biology and Genetics. As expected, all fields with a small citation rate belonging to group (iii) above have a relatively low value of ρ. At the other extreme, all Life Sciences (except Microbiology) with high mean references and a low references/citations ratio have among the highest ρ values.

3. Perhaps more interestingly, all power laws are of a relatively small size but account for a considerable percentage of all citations in their field. The power laws in 9 fields, including the 2 Social Sciences, represent between 0.6% and 1.1% of all articles in their field and account for 9% to 13% of all citations. For other 6 fields those percentages range from 1.3% to 3.5%, and

[7] The cut-off is clearly favored in almost a dozen data sets: forest fires, solar flares, earthquakes, web hits, web links, telephone calls, Internet, email address books, and mammal species (see Clauset *et al.*, 2007, p. 20).

[8] For the very different 17 phenomena for which a power law cannot be rejected in Clauset *et al.* (2007), in 8 cases the scale parameter is between 2 and 3, in 5 cases above 3, and in 4 cases below 2.

15% to 25%, respectively. The power laws of the remaining 3 fields –Space Sciences, Microbiology, and Immunology– represent more than 5% of all articles in their field and account for 22% to 33% of all citations.[9]

The next question is under what conditions does there exist a power law representing the upper tail of the citation distribution at the lowest level of aggregation. The smaller the sub-field we consider, the more homogeneous the citation practices of their practitioners are expected to be, and hence the easier should be the fitting of a power law to them. The problem is how articles should be assigned to a single sub-field in a scenario in which half of them are assigned two or more WoS categories. This problem, as well as how to draw a link between each sub-field and one of the 23 TS fields, is discussed in the next Section.

III. THE CONSTRUCTION OF A MAP OF SCIENCE

For every field, Table 5 informs about the percentage of articles with 1 or more WoS categories. As indicated in the Introduction, only about 5,000,000 of all articles are assigned a single WoS category. These represent as much as 95% and 90% of the Multidisciplinary field and Arts and Humanities, respectively, to only about 40% for Material Sciences, Environmental and Ecology, and Engineering and 43-45% for Molecular Biology and Genetics, and Neurosciences and Behavioral Sciences.

Table 5 around here

II. Alternative Maps of Science

This sub-Section describes the Map of Science used in this paper to classify a number of sub-fields into the 23 TS fields, where sub-fields coincide with WoS categories. The first problem is how multi-WoS categories articles should be classified into sub-fields. We consider

[9] There are 7 phenomena in Clauset *et al.* (2007) where the sample size is larger than 10,000 observations and a power law cannot be rejected. Ordered by sample size, these are solar flair intensity, count of words use, population of cities, Internet degree, papers authored, citations to papers from all sciences, and telephone calls received. In the last 3, the size of the power law is less than 1% of the sample size; in 2 cases this percentage is between 1% and 3%, and in the remaining 3 cases this percentage is between 8% and 16%.

two alternatives. In the first one, referred to as *Multiplicative*, each article is classified into as many sub-fields as WoS categories in the original dataset. An article assigned to 3 WoS categories, for instance, is classified in the 3 corresponding sub-fields; this means that this article would be counted three times. In this way, the space of articles is expanded as much as necessary above the initial size. As a matter of fact, the total number of articles is now 13,263,217. In the second alternative, referred to as *Fractional*, each article is again classified into as many sub-fields as WoS categories in the original dataset, but in a fractional manner. An article assigned to 2 or 3 WoS categories, for instance, is counted in the corresponding sub-fields with a weight of ½ or 1/3, respectively. Naturally, this assignment does not alter the original number of articles.

Once articles have been classified into sub-fields in these two alternative ways, the next step is the classification of sub-fields into fields. The problem is the following. We have information on the sub-fields an article belongs to and on the single field each article has been assigned to by TS. But we do not have a link between WoS categories and fields. Obviously, TS has a criterion to classify each article in a field regardless of the complexity of the multi-WoS category structure such an article may have. Essentially, TS assigns each journal, and hence all articles published in it, to one or more WoS categories. But in every case, TS uses citation information to and from this journal to classify its articles into one of the 23 fields. Lacking this information, we must appeal to a majority criterion in order to assign each sub-field, or WoS category to a single field. To recognize the complexity of the situation, we distinguish among the following nine quality levels.

We start by classifying all articles in a given sub-field in the 23 fields. If it turns out that all of them belong to a single field, then the link between the WoS category and the field in question is obvious. This link is said to be of quality 1. Otherwise, that is, when some of the articles in a sub-field belong to two or more fields, we partition the whole set into at most 6 subsets taking into account the number of WoS categories with which they may appear: articles that appear alone, that is, articles exclusively belonging to the sub-field in question; those that appear with one more WoS category; those that appear with two more WoS categories, and so on until the case in which the articles appear with 5 more WoS categories. When at least 80% of the articles that stand alone are associated with a certain field, and 80% of the articles in each of the remaining subsets are also associated with that field, the link between the sub-field and the majority field is said to be of quality 2. When at least 80% of the articles that stand alone are associated with a certain field, and 80%, 70%, 60%, and 50% of the articles in the remaining subsets taken as a whole are also associated with that field, the link is said to be of quality 3, 4, 5, and 6, respectively. When at least 70% of the articles that stand alone are associated with a certain field, and more than 50% of the articles in the remaining subsets taken as a whole are also associated with that field, the link is said to be of quality 7. When at least 50% of all articles in the sub-field taken as a whole are associated with a certain field, the link is said to be of quality 8. Otherwise, that is, in all cases that do not satisfy the previous criteria, a decision is taken after studying the association between the sub-field and a certain field in the larger subsets, in which case the link is said to be of quality 9.

Two questions can be asked about this way of constructing a Map of Science. First, which fields consist of articles whose sub-field/field link was judged to be of high or low quality? Second, how far apart is the distribution of the articles by field in the Multiplicative and the Fractional alternatives relative to the distribution in the original dataset? The relevant information is in Tables 6 and 7.

Tables 6 and 7 around here

In the first place, it is observed in Table 6 that Arts and Humanities is the only field for which the link sub-fields/field of quality 1 is of some importance. If we take index values 1 to 3 as representing high quality of that link, then Arts and Humanities, Economics, Plant and Animal Sciences, and Clinical Medicine are characterized by a high quality link. Note that, not surprisingly, Psychiatry and Psychology behaves like another of the Social Sciences. At the other extreme, if we take index values 7 to 9 as representing difficulties in establishing a clear link between sub-fields and fields, then 100% of Pharmacology and Toxicology articles are characterized by a link of low quality. This means that all articles in the sub-fields ultimately linked with that field are typically published in journals assigned by TS to several WoS categories, and in which the prevalence of Pharmacology and Toxicology is rather scarce. Not surprisingly, other fields for which the link to their sub-fields is weak are Microbiology, and Biology and Biochemistry. It should be noted that two fields are clearly polarized with an important percentage of articles characterized with a strong link and a similarly important percentage with a weak link; these are the Neurosciences and Behavioral Sciences, and Mathematics. This situation means that there must be certain journals clearly assigned to the field in question, and many others of mixed assignment to, say, Mathematics, and to other fields as well. Finally, it is worth emphasizing that for the dataset as a whole the link we have established following the majority criterion is of high and low quality 42.7% and 19.9% of the time, respectively (see the last row in Table 6).

In the second place, Table 7 shows that, in spite of the difficulties just studied in constructing a Map of Science, the distribution of articles by field according to the Multiplicative and Fractional alternatives are not very different from each other and from the same distribution in the original dataset provided by TS. There are certainly other ways of constructing a Map of Science from the available information (see the concluding Section in this respect). However, the procedures followed this far indicate that our way of dealing with multiple-WoS category and of establishing a link between subfields and fields lead to distributions of articles by field very similar to the one advocated by TS. Nevertheless, there are discrepancies between the importance that certain fields receive in the TS distribution and in ours. A field may get too large in the Multiplicative or Fractional alternatives when it appears very often in sub-fields belonging to other fields, in which case it will get many entire or weighted "votes" from them. But the opposite will happen the greater is the percentage of articles with a single WoS category in Table 5, and/or the higher the quality between the field and its own sub-fields in Table 6. This is exactly what happens in the field with the largest discrepancy, namely, Clinical Medicine that is considerably more heavily represented in the TS distribution. Other similar cases are Physics and Plant and Animal Sciences. Other fields with a relatively low percentage of articles with a single WoS category and no so high quality in Table 6 that receive a greater weight in our Maps than in the TS distribution are Biology and Biochemistry, Neuroscience and Behavioral Sciences, Pharmacology and Toxicology, Chemistry, Engineering (in the Multiplicative case), and Environment and Ecology.

Be it as it may, these are the two Maps of Science that will be analyzed in the sequel.

IV. EMPIRICAL RESULTS AT THE LOWEST LEVEL OF AGGREGATION

Given the previous discussion, empirical results for sub-fields are obtained using (1) the sample of papers published in 1998 with a 5-year window for citations, (2) the Multiplicative assignment for papers with multiple sub-fields, and (3) the MM estimation procedure. The full set of results is presented in the Appendix. In this section, only the estimation results for 221 sub-fields are discussed. These are all the sub-fields in the natural and social sciences, plus two sub-fields in Arts and Humanities -Archeology and History and Philosophy of Science- whose citation process appears to be similar to the one for many sub-fields in the Social Sciences.[10] The following comments are worth noting.

(1) There is again massive evidence in favor of power laws. In 181 of the 221 sub-fields, or 77% of the sample, the presence of a power law cannot be rejected. As a matter of fact, when the 5-year citation window is either expanded or reduced to 10 or 3 years, respectively, the existence of a power law cannot be rejected either for 39 additional sub-fields[11][12] Thus, it turns

[10] As previously shown in Table 3, the median and 95-percentile of citations for Arts and Humanities are well below the usual figures in the rest of TS fields: the median citations for most sub-fields in Arts and Humanities is zero and the 95-percentile is between 2 and 3. However, Archaeology and History and Philosophy of Sciences have values similar to many sub-fields in the Social Sciences: median around 2, and 95-percentile between 12 and 15.
[11] The only exception is a small sub-field, "Biology, Miscellaneous", with 423 papers published in 1998.

out that the prevalence of power laws is quite independent of whether the sub-field/field link was judged to be of high or low quality in the Map of Science used in this paper.

(2) As for TS fields, it is again found that the scale parameter α has a value between 2 and 3 for only 21 sub-fields representing 5% of the total number of articles. For most sub-fields, 114, parameter values range from 3 to 4, and for the 46 remaining ones among the 181 with a 5 year window for which a power law cannot be rejected, the estimates for α vary between 4 and 5.5 (see footnote 8 in this respect).

(3) As expected, power laws characterize the upper tails of citation distributions (recall the discussion for TS fields and footnote 9). On average, for the 181 sub-fields with a 5 years citation window power laws represent 6% of the articles, although this percentage varies from 0.4% to 37.5%, depending on the particular sub-field we look at. However, the region where a power law holds accounts on average for 37% of all citations, ranging from 4.8% to 80.3% for different sub-fields.

(4) Some robustness checks have been also carried out. In particular, in most sub-fields parameter estimates under the Fractional assignment are around or less than 1% with respect to the ones obtained for the Multiplicative one.

(5) Given the small size of many sub-fields in the sample of articles published in 1998, the more problematic aspect of our results has to do with the actual size of the power laws. In 57 of the 181 sub-fields representing 9% of all articles in the sample, the size of the power law is less than 100 articles; in 118 fields representing 61% of all articles the size is between 100 and 500 and in 6 fields representing 7% of all articles the size is between 500 and 1,000.[13]

[12] As can be seen in the Appendix, the existence of a power law cannot be rejected in 21 of the 25 sub-fields in Arts and Humanities not referred to here, and when the 5-year citation window is either extended or reduced the same can be said of the remaining 4 cases.

[13] For comparison purposes, the distribution of 17 power law sizes in Clauset *et al.* (2007) is the following: 4 have less than 100 observations, 5 between 100 and 500, 4 between 500 and 1,000, and 4 more than 1,000.

V. DISCUSSION AND FURTHER RESEARCH

This paper has addressed two issues. First, how best to fit a power law to data in the presence of a few but potentially influential extreme values, that is, a few very highly cited articles. The answer is in terms of a novel estimation strategy that performs better than present ML methods. Second, how prevalent is a power law structure representing the upper tail of the citation distribution at the lowest level of aggregation. Results have been presented for the case in which sub-fields are made to coincide with WoS categories and multi-WoS category articles are assigned to a single sub-field in a multiplicative fashion. For the sample of articles in 221 scientific sub-fields published in 1998 and a 5-year citation window, in 181 sub-fields including 77% of the articles in the sample the presence of a power law cannot be rejected. Values of the scale parameter α are well above the usual 2-3 range; upper tails with a power law distribution represent from 0.4% to 37.5% of the articles in their sub-field, and account for 4.8% to 80.3% of all citations received. When citation windows are allowed to vary, the existence of a power law in the upper tail of the remaining 40 sub-fields cannot be rejected either. Therefore, as indicated in the Introduction it appears that the existence of a power law representing the upper tail of the citation distribution is a rather universal phenomenon among scientific sub-fields. This is important when for seven of the data sets rigorously investigated in Clauset *et al.* (2007) the *p*-value is sufficiently small that the power law model can be firmly ruled out.[14]

These preliminary results provide the most complete evidence available in the Scientometrics literature about the prevalence of power laws in the citation distributions arising from the academic periodicals indexed by TS (or other comparable periodicals collections). However, the following 6 points are left for further research.

1. The comparison of the ML approach to the novel estimation strategy presented in this paper requires extensions in two directions. First, the formal definition (and possibly the graphically representation) of what an extreme observation is. Second, the asymptotic and finite

[14] This is the case of HTTP connections, earthquakes, web links, fires, wealth, web hits, and the metabolic network.

sample properties of both methods (ML and MM); in particular, Monte Carlo experiments must be carried out to analyze their performance under the presence of extreme observations.

2. The conclusion that a power law structure cannot be ruled out in a majority of sub-fields has been obtained using a certain sample in the Multiplicative assignment –767,828 articles published in 1998– and a certain 5-year window. It should be investigated whether the sample size can be increased by including articles published in contiguous years, and whether it is sensible to maintain a common 5-year window for all sub-fields.

3. As pointed out in Clauset *et al.* (2007), the fact that a power law cannot be rejected does not guarantee that a power law is the best distribution that fits the data. New tests must be applied confronting power laws with alternative distributions, such as the log-normal or the exponential distributions. Moreover, confidence intervals around the parameter estimates obtained with the new methodology must be obtained. In either case, it should be checked that sub-field sizes are large enough.

4. Once we finally establish the conditions under which a power law is the best distribution that can be fitted to a (large) number of sub-fields, a systematic aggregation procedure should be devised in order to answer the second substantive question posed in the Introduction: under what conditions does there exist a power law characterizing broader aggregates –such as the 23 TS fields– other groups of disciplines, or the whole of science?

5. As mentioned in the text, the Map of Science constructed in Section III is not the only one that can be obtained from our data. It is also possible to start from an extended sub-field space as follows. First, articles belonging to a single WoS category may constitute a first sub-field type. Next, articles belonging to two WoS categories may constitute a second sub-field type. And so on until the case of articles belonging to a six WoS categories is reached. This procedure gives rise to 2,239 sub-fields, many of which are too small for statistical analysis. However, in the sample of articles published in 1998 there are 580 sub-fields with 200 or more articles. Adding up several years of data, it is conceivable that a large number of sub-fields can

be appropriately defined. In the next step, each sub-field can be assigned to a single TS field by a majority criterion akin to the one used in this paper. It is expected that this link between sub-field and field will be of even a greater quality than the one already used.

6. Working in the 221-dimensional sub-field space defined in this paper or in the extended space described in the previous point does not require that the only field structure is the one provided by TS. Other Maps of Science where, for instance, the fields are defined as in Glänzel and Schubert (2003), Tijssen and van Leeuwen (2003), or Adam *et al.* (1998) can also be explored. Within alternative Maps of Science, the aggregation from the sub-field to the field level (and beyond) may proceed in a more appropriate manner than working within the TS field set.

REFERENCES

Adams, J., T. Bailey, L. Jackson, P. Scott, D. Pendlebury and H. Small (1997), "Benchmarking of the International Standing of Research in England. Report of a Consultancy Study on Bibliometric Analysis", *mimeo*, University of Leeds.

Bauke, H. (2007), "Parameter Estimation for Power-law Distributions By Maximum Likelihood Methods", *Theoretical Physics*.

Beirlant, J. and J.H.J. Einmahl (2007), "Asymptotics for the Hirsch Index", *CentER Discussion Paper Series No. 2007-86*.

Boyack, K., R. Klavans, and K. Börner (2005), "Mapping the Backbone of Science", *Scientometrics*, **64**: 351-374.

Clark, R. M., S. J. D. Cox, and G. M. Laslett (1999), "Generalizations of Power-law Distributions Applicable to Sampled Fault-trace Lengths: Model Choice, Parameter estimates, and Caveats", *Geophysical Journal International*, **136**: 357-372.

Clauset, A., C. R. Shalizi, and M. E. J. Newman (2007), "Power-law Distributions In Empirical Data", http://arxiv.org/abs/0706.1062.

Egghe, L. and R. Rousseau (2006), "An Informetric Model for the Hirsch-index", *Scientometrics*, **69**: 121-129.

Glänzel, W. (2006), "On the H-index –A Mathematical Approach To a New Measure of Publication Activity and Citation Impact", *Scientometrics*, **67**: 315-321.

Glänzel W. and A. Schubert (2003), "A new classification scheme of science fields and subfields designed for scientometric evaluation purposes", *Scientometrics,* **56**:357-367.

Goldstein, M. L., S. A. Morris, and G. G. Yen (2004), "Problems With Fitting To the Power-law Distribution", *The European Physicval Journal B*, **41**: 255.

Hirsch, J. (2005), "An index to quantify an individual's scientific research output", *Proceedings of the national Academy of Sciences of the United Status of America*, **102**: 16569-16572.

Laherrère, J and D. Sornette (1998), "Stretched Exponential Distributions in Nature and Economy: Fat tails with Characteristic Scales", *European Physical Journal B*, **2**: 525-539.

Leydesdorff, L. (2004), "Top-down Decomposition of the Journal Citation Report of the Social Science Citation Index: Graph- and Factor Analytical Approaches", *Scientometrics*, **60**: 159-180.

Leydesdorff, L. (2006), "Can Scientific Journals Be Classified in Terms of Aggregated Journal-Journal Citation Relations Using the Journal Citation Reports?", *Journal of the American Society for Information Science and Technology*, **57**: 601-613.

Leydesdorff, L. and I. Rafols (2009), "A Global Map of Science Based on the ISI Categories", *Journal of the American Society for Information Science and Technology*, **60**: 348-362.

Mitzenmacher, M. (2004), "A Brief History of Generative Models for Power Law and Lognormal Distributions", *Internet Mathematics*, **1**: 226-251.

Newman, M. E. J. (2005), "Power Laws, Pareto Distributions, and Zipf's law", *Contemporary Physics*, **46**: 323-351.

Price, D. J de S. (1965), "Networks of Scientific Papers", *Science*, **149**: 510-515.

Redner, S. (1998), "How Popular Is Your Paper? An Empirical Study of the Citation Distribution", *European Physical Journal B*, **4**: 131-134.

Pickering, G., J. M. Bull, and D. J. Sanderson (1995), "Sampling Power-law Distributions", *Tectonophysics*, **248**: 1-20.

Redner, S. (2005), "Citation Statistics from 110 years of *Physical Review*", *Physics Today*: 49-54.

Seglen, P. (1992), "The Skewness of Science", *Journal of the American Society for Information Science*, **43**: 628-638.

Small, H. (1999), "Visualizing Science by Citation Mapping", *Journal of the American Society for Information Science*, **50**: 799-813.

Tijssen, R.J.W. and van Leeuwen, T.N. (2003), "Bibliometric Analyses of World Science, Extended technical annex to chapter 5 of the Third European Report on Science & Technology Indicators", *mimeo*, Leiden University.

White, E., B. Enquist, and J. Green (2008), "On Estimating the Exponent of Power-law Frequency Distributions", *Ecology*, **89**: 905-912.

Table 1. Number of Articles In the Database, By TS Fields and Number of WoS Categories, 1998-2007

	Field	Number of WoS Categories 1	2	3	4	5	6	Total
LIFE SCIENCES		**1,837,960**	**927,489**	**332,817**	**58,178**	**9,290**	**0**	**3,165,734**
(1)	**Clinical Medicine**	1,071,574	419,978	144,147	27,600	4,063	0	**1,667,362**
(2)	**Biol & Biochemistry**	256,855	143,908	57,858	8,514	3,348	0	**470,483**
(3)	**Neurosci & Beha Sci**	110,234	94,358	35,082	3,978	856	0	**244,508**
(4)	**Molec Biol & Genetics**	92,265	94,236	25,955	4,379	0	0	**216,835**
(5)	**Psychiatry/Psychology**	110,972	53,929	25,584	6,717	1,023	0	**198,225**
(6)	**Pharma & Toxicology**	71,172	43,803	17,347	2,794	0	0	**135,116**
(7)	**Microbiology**	76,388	45,835	4,418	3,817	0	0	**130,458**
(8)	**Immunology**	48,500	31,442	22,426	379	0	0	**102,747**
PHYSICAL SCIENCES		**1,579,173**	**584,078**	**165,482**	**30,353**	**5,318**	**680**	**2,365,084**
(9)	**Chemistry**	683,762	235,517	69,682	14,243	1,154	477	**1,004,835**
(10)	**Physics**	511,336	225,701	68,846	3,347	71	0	**809,301**
(11)	**Computer Science**	131,878	69,408	20,804	7,371	4,093	203	**233,757**
(12)	**Mathematics**	158,844	48,761	4,867	24	0	0	**212,496**
(13)	**Space Science**	93,353	4,691	1,283	5,368	0	0	**104,695**
OTHER NATURAL SCI		**1,094,935**	**677,026**	**290,655**	**111,648**	**11,650**	**961**	**2,186,875**
(14)	**Engineering**	281,549	247,716	106,432	57,269	7,496	961	**701,423**
(15)	**Plant & Animal Sci**	303,132	123,768	28,509	11,178	0	0	**466,587**
(16)	**Material Science**	152,936	144,973	51,775	34,418	4,116	0	**388,218**
(17)	**Geosciences**	150,395	55,046	19,015	3,727	38	0	**228,221**
(18)	**Environment / Ecol**	81,795	63,796	58,032	4,172	0	0	**207,795**
(19)	**Agricultural Sciences**	87,792	39,997	26,793	884	0	0	**155,466**
(20)	**Multidisciplinary**	37,336	1,730	99	0	0	0	**39,165**
SOCIAL SCIENCES		259,690	158,855	36,191	12,776	2,287	0	**469,799**
(21)	**Social Sci, General**	184,830	117,573	23,605	8,746	2,287	0	**337,041**
(22)	**Econ & Business**	74,860	41,282	12,586	4,030	0	0	**132,758**
ARTS & HUMANITIES								
(23)	**Arts & Humanities**	**253,677**	**26,482**	**2,370**	**239**	**406**	**0**	283,174
TOTAL		**5,025,435**	**2,373,930**	**827,515**	**213,194**	**28,951**	**1,641**	**8,470,666**

Articles Without a WoS Category	**9,898**
Articles Without Both a TS Field and a WoS Category	**42,887**
Articles With No information About the Number of Authors	**4**
Reviews and Notes	**390,100**
Number of "Items" In the Original Database	**8,913,555**

Table 2. Articles by TS Field In the Entire 1998-2007 Dataset, and In the 1998 Sample With a 5-year Citation Window

		1998-2007 Dataset	%	1998 Sample	%
LIFE SCIENCES		**3,165,734**	**37.4**	**300,538**	**39.1**
(1)	**Clinical Medicine**	1,667,362	19.7	157,960	20.6
(2)	**Biology & Biochemistry**	470,483	5.6	46,200	6.0
(3)	**Neurosci & Beha Sci**	244,508	2.9	22,978	3.0
(4)	**Molec Biol & Genetics**	216,835	2.6	20,507	2.7
(5)	**Psychiatry/Psychology**	198,225	2.3	18,196	2.4
(6)	**Pharma & Toxicology**	135,116	1.6	12,613	1.6
(7)	**Microbiology**	130,458	1.5	11,842	1.5
(8)	**Immunology**	102,747	1.2	10,242	1.3
PHYSICAL SCIENCES		**2,365,084**	**27.9**	**202,977**	**26.4**
(9)	**Chemistry**	1,004,835	11.9	88,587	11.5
(10)	**Physics**	809,301	9.5	73,316	9.6
(11)	**Computer Science**	233,757	2.8	13,716	1.8
(12)	**Mathematics**	212,496	2.5	18,879	2.5
(13)	**Space Science**	104,695	1.2	8,479	1.1
OTHER NATURAL SCIENCES		**2,186,875**	**25.8**	**174,349**	**22.7**
(14)	**Engineering**	701,423	8.3	63,179	8.2
(15)	**Plant & Animal Science**	466,587	5.5	43,964	5.7
(16)	**Material Science**	388,218	4.6	32,215	4.2
(17)	**Geosciences**	228,221	2.7	18,246	2.4
(18)	**Environment / Ecology**	207,795	2.5	16,745	2.2
(19)	**Agricultural Sciences**	155,466	1.8	13,729	1.8
(20)	**Multidisciplinary**	39,165	0.5	5,656	0.7
SOCIAL SCIENCES		**469,799**	**5.5**	**43,587**	**5.7**
(21)	**Social Sciences, General**	337,041	4.0	31,044	4.0
(22)	**Economics & Business**	132,758	1.6	12,543	1.6
ARTS&HUMANITIES					
(23)	**Arts & Humanities**	283,174	3.3	26,992	3.5
TOTAL		**8,470,666**	**100.0**	**767,828**	**100.0**

Table 3. **The Distribution of Citations Received and References Made**

Panel A: The Entire Dataset

	Citations				References		Refs./Citat
	% of zeroes	Median	%5 Most cited		Median	95-Percetile	
			95-Percetile	% Over Total			
LIFE SCIENCES							
(1) **Clinical Medicine**	23.7	3	39	41.3	24	57	2.6
(2) **Biol & Biochemistry**	17.1	6	48	34.2	33	67	2.7
(3) **Neurosci & Behav Sci**	15.5	7	54	33.1	37	76	2.7
(4) **Molec Biol & Genetics**	14.9	8	79	38.6	38	73	2.0
(5) **Psychiatry/Psychology**	27.0	3	33	38.8	34	76	4.6
(6) **Pharma & Toxicology**	21.2	4	31	33.9	28	59	3.6
(7) **Microbiology**	16.5	6	43	30.9	32	65	2.9
(8) **Immunology**	12.8	8	60	32.8	35	66	2.2
PHYSICAL SCIENCES							
(9) **Chemistry**	25.6	3	31	35.6	23	60	3.4
(10) **Physics**	28.9	2	28	41.7	18	50	3.2
(11) **Computer Science**	55.7	0	11	55.4	16	44	7.2
(12) **Mathematics**	44.4	1	11	42.4	15	39	6.7
(13) **Space Science**	23.2	4	42	37.2	30	74	3.0
OTHER NATURAL							
(14) **Engineering**	45.2	1	14	42.6	15	43	5.5
(15) **Plant & Animal Sci**	30.1	2	22	36.3	28	64	5.4
(16) **Material Science**	38.9	1	19	43.2	16	43	4.0
(17) **Geosciences**	29.4	2	28	36.2	30	76	4.9
(18) **Environment/Ecology**	24.8	3	30	34.3	31	70	4.4
(19) **Agricultural Sciences**	33.3	2	21	36.7	24	53	5.0
(20) **Multidisciplinary**	45.0	1	20	50.9	14	56	4.4
SOCIAL SCIENCES							
(21) **Social Sci, General**	42.4	1	15	41.3	30	78	9.6
(22) **Econ & Business**	44.3	1	18	47.8	24	71	6.7
ARTS&HUMANITIES							
(23) **Arts & Humanities**	83.0	0	2	84.6	14	67	33.3

Panel B: The 1998 Sample With A 5-year Window

	Citations				References		Refs./Cit
			5% Most cited		Median	95 Percetile	
	% of zeroes	Median	95 Percetile	% Over Total			
LIFE SCIENCES							
(1) **Clinical Medicine**	18.6	4	32	36.6	22	55	2.8
(2) **Biol & Biochemistry**	11.4	6	41	30.1	31	63	2.7
(3) **Neurosci & Behav Sci**	8.1	8	43	28.4	34	73	2.9
(4) **Molec Biol & Genetics**	7.6	9	79	33.8	37	72	1.8
(5) **Psychiatry/Psychology**	21.1	3	23	32.8	30	74	5.5
(6) **Pharma & Toxicology**	15.6	4	24	28.8	25	56	4.0
(7) **Microbiology**	8.4	7	36	26.4	29	62	2.9
(8) **Immunology**	5.3	9	51	27.9	34	64	2.2
PHYSICAL SCIENCES							
(9) **Chemistry**	8.4	7	36	26.4	29	62	2.9
(10) **Physics**	24.0	3	24	37.3	17	46	3.2
(11) **Computer Science**	46.1	1	9	42.5	14	42	7.4
(12) **Mathematics**	40.3	1	8	37.8	14	37	7.5
(13) **Space Science**	20.8	5	35	32.8	25	68	3.0
OTHER NATURAL							
(14) **Engineering**	42.8	1	10	36.6	12	39	6.2
(15) **Plant & Animal Sci**	23.6	2	16	31.4	25	59	5.9
(16) **Material Science**	34.3	1	13	36.1	14	40	4.8
(17) **Geosciences**	23.1	3	22	29.0	27	73	5.0
(18) **Environment/Ecology**	16.1	4	20	28.3	27	65	4.8
(19) **Agricultural Sciences**	28.9	2	14	29.4	20	48	5.9
(20) **Multidisciplinary**	47.0	1	12	50.2	10	50	5.4
SOCIAL SCIENCES							
(21) **Social Sci, General**	38.3	1	10	38.5	26	76	11.0
(22) **Econ & Business**	42.8	1	12	40.1	19	65	8.0
ARTS&HUMANITIES							
(23) **Arts & Humanities**	83.3	0	2	70.2	13	66	55.9

Table 4. Power Law Estimation Results for TS Field using Different Estimation Methods. 1998, 5 years window

		α		P-value		ρ		Perc. Articles		Perc. Cites	
		MLE	MM	MLE	MM	MLE	MM	MLE	MM	MLE	MM
LIFE SCIENCES											
(1)	**Clinical Medicine**	3.04	3.31	0.00	0.60	48	93	2.4	0.6	24.8	12.3
(2)	**Biol & Biochemistry**	3.80	3.82	0.53	0.65	67	68	1.8	1.7	15.5	15.1
(3)	**Neurosci & Behav Sci**	3.80	3.56	0.03	0.15	67	55	2.0	3.1	15.4	20.9
(4)	**Molec Biol & Genetics**	3.74	3.64	0.58	0.77	156	168	1.3	1.1	15.0	13.0
(5)	**Psychiatry/Psychology**	3.31	4.27	0.00	0.69	23	52	5.3	0.8	32.8	9.5
(6)	**Pharma & Toxicology**	4.61	4.76	0.81	0.55	48	48	0.9	0.9	9.0	9.0
(7)	**Microbiology**	3.55	3.58	0.22	0.29	36	36	5.2	5.2	26.4	26.4
(8)	**Immunology**	3.33	3.33	0.30	0.41	48	48	5.8	5.8	30.3	30.3
PHYSICAL SCIENCES											
(9)	**Chemistry**	4.00	3.99	0.35	0.64	45	45	1.1	1.1	11.0	11.0
(10)	**Physics**	3.16	3.43	0.03	0.75	31	56	3.3	0.9	29.3	14.8
(11)	**Computer Science**	2.82	3.19	0.01	0.25	7	16	8.7	1.9	53.0	25.0
(12)	**Mathematics**	3.57	4.11	0.06	0.80	11	20	3.3	0.8	25.1	9.6
(13)	**Space Science**	3.34	3.41	0.75	0.99	34	35	5.5	5.1	34.1	32.8
OTHER NATURAL SCIENCES											
(14)	**Engineering**	3.48	3.78	0.00	0.04	15	20	2.3	1.1	22.0	14.4
(15)	**Plant & Animal Sci**	3.50	5.37	0.03	0.18	21	53	3.1	0.3	22.0	4.6
(16)	**Material Science**	3.30	3.56	0.01	0.33	15	26	4.4	1.3	31.0	14.5
(17)	**Geosciences**	3.63	3.70	0.65	0.35	26	26	3.5	3.5	22.9	22.9
(18)	**Environment/Ecology**	3.61	3.71	0.45	0.26	24	25	3.6	3.3	22.1	20.8
(19)	**Agricultural Sciences**	3.47	3.65	0.18	0.03	13	13	6.1	6.1	32.9	32.9
(20)	**Multidisciplinary**	2.85	2.83	0.19	0.53	18	18	3.1	3.1	38.7	38.7
SOCIAL SCIENCES											
(21)	**Social Sci, General**	3.46	3.69	0.58	0.75	16	27	2.3	0.6	21.6	9.8
(22)	**Econ & Business**	2.94	4.38	0.00	0.40	11	33	6.3	0.8	43.3	12.0
ARTS&HUMANITIES											
(23)	**Arts & Humanities**	2.62	2.66	0.51	0.68	2	3	6.1	2.8	70.2	51.9

Table 5. Distribution of Articles According to the Number of WoS Categories, By TS Fields, 1998-2007

	Number of WoS Categories						
	1	2	3	4	5	6	Total
LIFE SCIENCES	**58.1**	**29.3**	**10.5**	**1.8**	**0.3**	**0.0**	**100.0**
(1) **Clinical Medicine**	64.3	25.2	8.6	1.7	0.2	0.0	**100.0**
(2) **Biol & Biochemistry**	54.6	30.6	12.3	1.8	0.7	0.0	**100.0**
(3) **Neurosci & Behav Sci**	45.1	38.6	14.3	1.6	0.4	0.0	**100.0**
(4) **Molec Biol & Genetics**	42.6	43.5	12.0	2.0	0.0	0.0	**100.0**
(5) **Psychiatry/Psychology**	56.0	27.2	12.9	3.4	0.5	0.0	**100.0**
(6) **Pharma & Toxicology**	52.7	32.4	12.8	2.1	0.0	0.0	**100.0**
(7) **Microbiology**	58.6	35.1	3.4	2.9	0.0	0.0	**100.0**
(8) **Immunology**	47.2	30.6	21.8	0.4	0.0	0.0	**100.0**
PHYSICAL SCIENCES	**66.8**	**24.7**	**7.0**	**1.3**	**0.2**	**0.0**	**100.0**
(9) **Chemistry**	68.0	23.4	6.9	1.4	0.1	0.0	**100.0**
(10) **Physics**	63.2	27.9	8.5	0.4	0.0	0.0	**100.0**
(11) **Computer Science**	56.4	29.7	8.9	3.2	1.8	0.1	**100.0**
(12) **Mathematics**	74.8	22.9	2.3	0.0	0.0	0.0	**100.0**
(13) **Space Science**	89.2	4.5	1.2	5.1	0.0	0.0	**100.0**
OTHER NATURAL	**50.1**	**31.0**	**13.3**	**5.1**	**0.5**	**0.0**	**100.0**
(14) **Engineering**	40.1	35.3	15.2	8.2	1.1	0.1	**100.0**
(15) **Plant & Animal Sci**	65.0	26.5	6.1	2.4	0.0	0.0	**100.0**
(16) **Material Science**	39.4	37.3	13.3	8.9	1.1	0.0	**100.0**
(17) **Geosciences**	65.9	24.1	8.3	1.6	0.0	0.0	**100.0**
(18) **Environment/Ecology**	39.4	30.7	27.9	2.0	0.0	0.0	**100.0**
(19) **Agricultural Sciences**	56.5	25.7	17.2	0.6	0.0	0.0	**100.0**
(20) **Multidisciplinary**	95.3	4.4	0.3	0.0	0.0	0.0	**100.0**
SOCIAL SCIENCES	**55.3**	**33.8**	**7.7**	**2.7**	**0.5**	**0.0**	**100.0**
(21) **Social Sci, General**	54.8	34.9	7.0	2.6	0.7	0.0	**100.0**
(22) **Econ & Business**	56.4	31.1	9.5	3.0	0.0	0.0	**100.0**
ARTS&HUMANITIES							
(23) **Arts & Humanities**	**89.6**	**9.4**	**0.8**	**0.1**	**0.1**	**0.0**	**100.0**
TOTAL	**59.3**	**28.0**	**9.8**	**2.5**	**0.3**	**0.0**	**100.0**

Table 6. TS Fields Classified By the Quality of the Link To Their Sub-fields (According to the Majority Criterion Described In the Text)

Fields	Quality of the Sub-field/field Link (The Lower the Index Value, the Higher the Quality)									
	1	2	3	4	5	6	7	8	9	
LIFE SCIENCES										
(1) **Clinical Medicine**	1.3	45.9	31.5	6.6	0.8	3.1	5.2	1.9	3.8	100.0
(2) **Biol & Biochemistry**	0.0	0.8	10.4	5.5	44.5	0.0	2.8	0.0	36.0	100.0
(3) **Neurosci & Behav Sci**	0.0	3.1	51.8	0.0	0.0	0.0	0.0	3.4	41.7	100.0
(4) **Molec Biol & Genetics**	0.0	0.0	0.0	10.2	38.8	51.0	0.0	0.0	0.0	100.0
(5) **Psychiatry/Psychology**	1.5	0.0	51.7	5.7	39.9	0.0	0.0	1.2	0.0	100.0
(6) **Pharma & Toxicology**	0.0	0.0	0.0	0.0	0.0	0.0	76.8	0.0	23.2	100.0
(7) **Microbiology**	0.0	0.0	0.0	23.3	0.0	12.3	64.4	0.0	0.0	100.0
(8) **Immunology**	0.0	0.0	0.0	0.0	0.0	70.1	0.0	0.0	29.9	100.0
PHYSICAL SCIENCES										
(9) **Chemistry**	0.0	14.1	20.0	24.3	19.6	3.6	8.6	0.0	9.8	100.0
(10) **Physics**	0.0	35.1	16.0	20.1	28.8	0.0	0.0	0.0	0.0	100.0
(11) **Computer Science**	0.0	0.0	32.6	11.0	21.6	13.1	0.0	0.0	21.7	100.0
(12) **Mathematics**	0.0	44.7	0.0	0.0	16.6	0.0	38.7	0.0	0.0	100.0
(13) **Space Science**	0.0	0.0	0.0	100.0	0.0	0.0	0.0	0.0	0.0	100.0
OTHER NATURAL SCIENCES										
(14) **Engineering**	1.0	4.5	19.0	7.8	40.4	7.7	11.9	4.0	3.8	100.0
(15) **Plant & Animal Sci**	0.0	14.5	73.4	5.7	0.0	0.0	4.3	0.0	2.1	100.0
(16) **Material Science**	0.0	3.9	21.4	49.4	4.2	1.7	0.0	9.1	10.3	100.0
(17) **Geosciences**	0.0	4.3	22.6	42.3	5.5	4.0	0.0	7.7	13.5	100.0
(18) **Environment/Ecology**	0.0	0.0	0.0	23.1	53.9	0.0	0.0	0.0	23.0	100.0
(19) **Agricultural Sciences**	0.0	0.0	55.3	0.0	0.0	20.2	0.0	0.0	24.5	100.0
(20) **Multidisciplinary**	0.0	0.0	0.0	0.0	0.0	0.0	100.0	0.0	0.0	100.0
SOCIAL SCIENCES										
(21) **Social Sci, General**	0.0	10.6	48.3	16.9	2.2	4.5	10.4	2.8	4.2	100.0
(22) **Econ & Business**	2.0	13.3	77.9	0.0	0.0	0.0	0.0	6.8	0.0	100.0
ARTS&HUMANITIES										
(23) **Arts & Humanities**	21.3	26.1	42.6	5.0	0.0	0.0	2.0	0.0	3.0	100.0
TOTAL	**0.9**	**16.2**	**25.6**	**14.4**	**17.3**	**5.5**	**7.8**	**1.7**	**10.3**	**100.0**

Table 7. Articles by TS Field under Different Assignments, 1998-2007

Fields	Number of articles			Percentage of articles		
	Original Assignment	Multiplicative Assignment	Fractional Assignment	Original Assignment	Multiplicative Assignment	Fractional Assignment
LIFE SCIENCES	**3,165,734**	**5,005,823**	**3,183,771**	**37.4**	**37.7**	**37.6**
(1) Clinical Medicine	1,667,362	2,212,906	1,513,984	19.7	16.7	17.9
(2) Biol & Biochemistry	470,483	978,921	584,161	5.6	7.4	6.9
(3) Neurosci & Behav Sci	244,508	452,971	266,506	2.9	3.4	3.1
(4) Molec Biol & Genetics	216,835	339,015	191,122	2.6	2.6	2.3
(5) Psychiatry/Psychology	198,225	323,832	198,03	2.3	2.4	2.3
(6) Pharma & Toxicology	135,116	276,926	168,767	1.6	2.1	2.0
(7) Microbiology	130,458	189,384	131,968	1.5	1.4	1.6
(8) Immunology	102,747	231,868	129,233	1.2	1.8	1.5
PHYSICAL SCIENCES	**2,365,084**	**3,628,336**	**2,441,598**	**27.9**	**27.4**	**28.8**
(9) Chemistry	1,004,835	1,666,086	1,109,076	11.9	12.6	13.1
(10) Physics	809,301	1,124,387	756,364	9.5	8.5	8.9
(11) Computer Science	233,757	393,35	234,111	2.8	3.0	2.8
(12) Mathematics	212,496	316,019	235,545	2.5	2.4	2.8
(13) Space Science	104,695	128,494	106,502	1.2	1.0	1.3
OTHER NATURAL SCIENCES	**2,186,875**	**3,638,131**	**2,125,890**	**25.8**	**27.4**	**25.1**
(14) Engineering	701,423	1,277,427	661,666	8.3	9.6	7.8
(15) Plant & Animal Sci	466,587	591,016	428,778	5.5	4.5	5.1
(16) Material Science	388,218	652,796	357,961	4.6	4.9	4.2
(17) Geosciences	228,221	396,051	252,571	2.7	3.0	3.0
(18) Environment/Ecology	207,795	414,046	215,618	2.5	3.1	2.5
(19) Agricultural Sciences	155,466	245,491	154,267	1.8	1.9	1.8
(20) Multidisciplinary	39,165	61,304	55,029	0.5	0.5	0.6
SOCIAL SCIENCES	**469,799**	**676,694**	**438,519**	**5.5**	**5.1**	**5.2**
(21) Social Sci, General	337,041	493,245	315,9	4.0	3.7	3.7
(22) Econ & Business	132,758	183,449	122,619	1.6	1.4	1.4
ARTS&HUMANITIES						
(23) Arts & Humanities	283,174	314,233	280,887	3.3	2.4	3.3
TOTAL	**8,470,666**	**13,263,217**	**8,470,666**	**100.0**	**100.0**	**100.0**

APPENDIX

RESULTS ON THE ESTIMATION OF A POWER LAW IN THE UPPER TAIL OF THE CITATION DISTRIBUTION FOR 249 SUB-FIELDS

Sample Characteristics:

Size: Number of scientific articles published in 1998

Citation Window: 3, 5 and 10 years

Power Law Characteristics:

$$p(x) = (\alpha - 1)\, \rho^{\alpha - 1}\, x^{-\alpha},\ x \geq \rho,$$

where: ρ = number of citations at the lower bound of the power law behavior

$\alpha > 1$ is known as the exponent or scaling parameter

Power law size = number of articles with at least ρ citations

Information for each sub-Sub-field in the following pages:

- Sample size

For each citation window equal to 3, 5, and 10 years:

- Estimated values for α, and ρ

- p-value, which summarizes the sample evidence for the hypothesis that the data is drawn from a power law. Values below 0.10 indicate that the hypothesis should be rejected

- Ratio = power law size/sample size

Sub-field	Size	10 years				5 years				3 years			
		α	ρ	p value	Ratio	α	ρ	p value	Ratio	α	ρ	p value	Ratio
		CLINICAL MEDICINE											
SURGERY	217,581	3.59	75	0.08	0.020	3.79	36	0.69	0.019	4.05	21	0.41	0.011
ONCOLOGY	179,008	3.22	98	0.94	0.036	3.86	94	0.91	0.009	3.81	37	0.93	0.014
MEDICINE, GENERAL & INTERNAL	124,622	2.63	175	0.85	0.027	2.61	87	0.58	0.025	2.90	75	0.76	0.011
CARDIAC & CARDIOVASCULAR SYSTEMS	116,161	2.98	82	0.52	0.048	3.10	51	0.69	0.032	3.26	30	0.72	0.022
RADIOLOGY, NUCLEAR MEDICINE & MEDICAL IMAGING	115,385	3.26	59	0.23	0.039	3.59	34	0.34	0.025	3.92	19	0.27	0.016
PUBLIC, ENVIRONMENTAL & OCCUPATIONAL HEALTH	114,640	3.18	51	0.97	0.055	3.56	26	0.48	0.036	3.75	12	0.42	0.040
PEDIATRICS	91,367	3.12	45	0.52	0.044	3.61	26	0.56	0.031	3.77	18	0.44	0.013
MEDICINE, RESEARCH & EXPERIMENTAL	90,522	2.56	89	0.00	0.073	2.80	56	0.01	0.056	4.08	63	0.52	0.013
HEMATOLOGY	87,719	3.04	82	0.77	0.086	3.10	40	0.09	0.092	3.50	35	0.82	0.028
PERIPHERAL VASCULAR DISEASE	75,607	2.79	77	0.07	0.087	2.98	47	0.30	0.062	3.19	23	0.50	0.063
GASTROENTEROLOGY & HEPATOLOGY	74,696	3.20	83	0.26	0.035	3.03	32	0.48	0.058	3.18	17	0.69	0.049
UROLOGY & NEPHROLOGY	73,403	3.29	59	0.38	0.054	3.34	28	0.66	0.060	4.03	22	0.49	0.020
OBSTETRICS & GYNECOLOGY	69,299	3.60	46	0.44	0.049	4.38	31	0.10	0.023	3.95	17	0.81	0.018
RESPIRATORY SYSTEM	58,583	3.25	56	0.03	0.069	3.55	34	0.73	0.046	3.94	21	0.68	0.026
OPHTHALMOLOGY	57,978	3.15	42	0.31	0.065	4.00	27	0.07	0.033	3.70	12	0.14	0.042
PATHOLOGY	56,873	3.21	54	0.59	0.062	3.26	27	0.16	0.064	3.91	25	0.75	0.017
ORTHOPEDICS	55,471	2.96	35	0.17	0.093	3.42	20	0.53	0.044	3.65	7	0.01	0.066
DENTISTRY, ORAL SURGERY & MEDICINE	47,224	3.34	38	0.34	0.048	4.01	16	0.60	0.054	4.69	9	0.24	0.033
SPORT SCIENCES	46,719	3.95	50	0.80	0.042	3.80	20	0.07	0.043	5.50	14	0.18	0.014
ENGINEERING, BIOMEDICAL	44,927	3.58	43	0.10	0.073	3.94	22	0.49	0.039	4.44	9	0.17	0.054
DERMATOLOGY	43,664	4.08	44	0.51	0.042	3.84	21	0.13	0.044	4.12	13	0.59	0.028
TRANSPLANTATION	42,850	3.39	49	0.64	0.039	3.37	22	0.44	0.054	3.79	16	0.62	0.022
OTORHINOLARYNGOLOGY	36,131	3.24	23	0.18	0.096	3.63	14	0.46	0.056	4.32	10	0.86	0.025
REPRODUCTIVE BIOLOGY	33,993	4.30	59	0.24	0.047	3.93	25	0.88	0.071	3.98	15	0.50	0.049

Sub-field	Size	10 years				5 years				3 years			
		α	ρ	p value	Ratio	α	ρ	p value	Ratio	α	ρ	p value	Ratio
HEALTH CARE SCIENCES & SERVICES	33,700	2.87	23	0.03	0.148	3.25	16	0.96	0.077	3.98	13	0.51	0.027
ANESTHESIOLOGY	33,385	3.61	48	0.92	0.047	4.26	30	0.61	0.027	4.27	14	0.08	0.036
CRITICAL CARE MEDICINE	27,674	2.82	37	0.39	0.171	3.36	25	0.02	0.094	3.24	12	0.39	0.091
RHEUMATOLOGY	25,236	2.82	32	0.16	0.198	3.38	26	0.88	0.080	3.32	12	0.10	0.084
GERIATRICS & GERONTOLOGY	21,127	3.39	37	0.13	0.087	3.88	18	0.02	0.082	3.57	9	0.69	0.075
MEDICAL LABORATORY TECHNOLOGY	21,055	2.60	26	0.03	0.116	3.02	18	0.12	0.071	3.19	8	0.02	0.090
EDUCATION, SCIENTIFIC DISCIPLINES	17,394	3.27	22	0.56	0.047	3.81	13	0.78	0.035	3.67	5	0.04	0.064
ALLERGY	17,373	3.52	56	0.31	0.046	4.00	30	0.93	0.042	3.54	9	0.42	0.105
EMERGENCY MEDICINE	14,962	2.96	18	0.37	0.128	2.76	7	0.35	0.173	2.89	5	0.12	0.103
TROPICAL MEDICINE	14,412	3.23	23	0.32	0.116	3.94	17	0.43	0.053	5.50	13	0.38	0.022
MEDICAL INFORMATICS	13,263	2.66	27	0.85	0.080	2.93	12	0.76	0.086	2.92	5	0.23	0.121
MEDICINE, LEGAL	9,051	3.26	15	0.88	0.149	3.83	11	0.27	0.076	5.50	9	0.26	0.028
INTEGRATIVE & COMPLEMENTARY MEDICINE	6,755	3.09	16	0.94	0.202	2.85	5	0.02	0.265	3.81	4	0.32	0.121
ANDROLOGY	3,096	2.97	14	0.77	0.263	5.50	12	0.29	0.096	4.37	5	0.28	0.183
BIOLOGY & BIOCHEMISTRY													
BIOCHEMISTRY & MOLECULAR BIOLOGY	436,030	3.02	112	0.50	0.046	3.31	78	0.01	0.027	3.70	67	0.25	0.009
BIOTECHNOLOGY & APPLIED MICROBIOLOGY	145,624	3.09	45	0.09	0.077	3.37	35	0.71	0.032	3.66	19	0.99	0.028
ENDOCRINOLOGY & METABOLISM	105,625	3.29	65	0.58	0.073	3.54	33	0.01	0.071	3.45	17	0.24	0.067
BIOPHYSICS	101,459	3.40	73	0.12	0.045	3.32	33	0.29	0.060	3.48	20	0.11	0.043
PHYSIOLOGY	87,995	4.08	69	0.36	0.041	4.37	34	0.04	0.041	5.46	24	0.26	0.016
BIOLOGY	53,741	3.26	57	0.54	0.048	3.29	23	0.11	0.060	3.58	14	0.74	0.037
EVOLUTIONARY BIOLOGY	27,518	2.93	46	0.36	0.171	3.62	38	0.59	0.051	3.59	14	0.50	0.094
ANATOMY & MORPHOLOGY	12,743	3.32	28	0.46	0.083	3.81	15	0.17	0.071	3.39	9	0.50	0.051
MICROSCOPY	7,763	3.35	22	0.00	0.147	3.23	11	0.05	0.158	5.48	11	0.67	0.054
BIOLOGY, MISCELLANEOUS	423	2.89	10	0.05	0.285	2.55	4	0.04	0.375	3.10	4	0.06	0.195

Sub-field	Size	10 years				5 years				3 years			
		α	ρ	p value	Ratio	α	ρ	p value	Ratio	α	ρ	p value	Ratio
NEUROSCIENCE & BEHAVIOR													
NEUROSCIENCES	234,556	3.84	142	0.63	0.019	3.50	52	0.23	0.033	3.63	30	0.18	0.025
CLINICAL NEUROLOGY	146,953	4.03	142	0.22	0.011	4.08	67	0.30	0.012	4.19	38	0.58	0.008
BEHAVIORAL SCIENCES	33,445	3.55	39	0.18	0.108	4.10	17	0.04	0.104	4.64	11	0.80	0.051
NEUROIMAGING	15,260	2.21	17	0.15	0.333	2.83	20	0.51	0.113	2.96	10	0.81	0.098
SOCIAL SCIENCES, BIOMEDICAL	14,260	3.24	29	0.28	0.098	4.06	12	0.03	0.099	3.68	8	0.66	0.041
PSYCHOLOGY, BIOLOGICAL	8,497	2.73	19	0.84	0.261	3.12	12	0.67	0.139	3.83	8	0.50	0.070
MOLECULAR BIOLOGY & GENETICS													
CELL BIOLOGY	172,888	3.40	260	0.41	0.021	3.12	80	0.01	0.058	3.72	86	0.61	0.013
GENETICS & HEREDITY	131,559	3.13	162	0.58	0.024	2.75	33	0.00	0.112	3.15	40	0.42	0.029
DEVELOPMENTAL BIOLOGY	34,568	3.31	142	0.87	0.058	3.00	55	0.09	0.099	3.48	40	0.14	0.061
PSYCHIATRY/PSYCHOLOGY													
PSYCHIATRY	95,591	3.42	82	0.05	0.043	4.08	48	0.20	0.022	4.32	23	0.43	0.020
PSYCHOLOGY, MULTIDISCIPLINARY	39,510	3.34	52	0.18	0.034	3.02	16	0.37	0.056	2.97	7	0.44	0.062
PSYCHOLOGY, CLINICAL	39,056	3.21	50	0.34	0.081	4.16	31	0.32	0.033	3.88	13	0.29	0.037
PSYCHOLOGY, EXPERIMENTAL	34,522	3.25	51	0.43	0.072	3.87	27	0.94	0.037	5.50	16	0.39	0.018
PSYCHOLOGY	33,632	3.32	49	0.72	0.084	3.81	23	0.58	0.060	3.84	9	0.05	0.078
PSYCHOLOGY, DEVELOPMENTAL	22,248	3.52	62	0.24	0.058	4.18	27	0.97	0.040	3.89	10	0.12	0.052
PSYCHOLOGY, SOCIAL	20,771	2.91	40	0.27	0.101	4.44	25	0.48	0.037	3.75	9	0.22	0.041
PSYCHOLOGY, APPLIED	18,320	3.11	28	0.36	0.087	5.46	20	0.59	0.019	5.50	9	0.47	0.018
PSYCHOLOGY, EDUCATIONAL	11,406	2.45	17	0.30	0.204	3.38	13	0.58	0.086	4.23	7	0.41	0.069
PSYCHOLOGY, PSYCHOANALYSIS	4,794	2.30	8	0.04	0.181	2.56	5	0.51	0.145	3.43	4	0.12	0.094
PSYCHOLOGY, MATHEMATICAL	3,982	3.00	21	0.32	0.169	3.23	9	0.46	0.167	3.17	5	0.98	0.137
PHARMACOLOGY & TOXICOLOGY													
PHARMACOLOGY & PHARMACY	212,562	3.88	76	0.03	0.020	4.67	49	0.41	0.009	4.17	19	0.20	0.020
TOXICOLOGY	64,364	3.68	44	0.52	0.052	3.98	28	0.12	0.026	3.67	9	0.03	0.069

Sub-field	Size	10 years				5 years				3 years			
		α	ρ	p value	Ratio	α	ρ	p value	Ratio	α	ρ	p value	Ratio
			IMMUNOLOGY										
IMMUNOLOGY	162,635	3.24	115	0.67	0.031	3.29	59	0.93	0.034	3.29	32	0.56	0.030
INFECTIOUS DISEASES	69,233	4.27	142	0.22	0.005	4.59	45	0.20	0.032	3.96	24	0.84	0.027
			MICROBIOLOGY										
MICROBIOLOGY	122,030	3.63	76	0.73	0.039	3.61	35	0.87	0.043	3.78	19	0.57	0.034
VIROLOGY	44,141	3.37	67	0.47	0.086	3.82	51	0.54	0.043	3.67	24	0.93	0.057
PARASITOLOGY	23,213	2.96	22	0.10	0.141	3.22	14	0.55	0.097	3.45	7	0.04	0.113
			CHEMISTRY										
CHEMISTRY, PHYSICAL	282,286	3.28	53	0.64	0.043	4.94	52	0.62	0.005	5.37	22	0.07	0.009
CHEMISTRY, MULTIDISCIPLINARY	230,157	3.56	112	0.37	0.015	3.89	53	0.62	0.015	4.62	34	0.51	0.009
CHEMISTRY, ORGANIC	165,474	4.10	49	0.01	0.036	4.57	31	0.39	0.022	5.50	24	0.15	0.007
ENGINEERING, CHEMICAL	148,237	4.01	52	0.60	0.019	5.50	35	0.26	0.004	4.16	10	0.87	0.018
CHEMISTRY, ANALYTICAL	144,115	3.39	41	0.63	0.062	3.86	24	0.03	0.042	5.50	28	0.38	0.005
PHYSICS, ATOMIC, MOLECULAR & CHEMICAL	128,644	3.23	53	0.44	0.048	4.40	38	0.40	0.022	4.90	22	0.45	0.019
POLYMER SCIENCE	122,452	3.29	49	0.79	0.042	3.37	19	0.29	0.056	4.23	32	0.27	0.002
CHEMISTRY, INORGANIC & NUCLEAR	103,139	3.68	47	0.80	0.034	4.26	27	0.30	0.026	5.50	22	0.23	0.008
BIOCHEMICAL RESEARCH METHODS	82,515	3.34	39	0.78	0.076	3.44	27	0.87	0.034	3.68	12	0.63	0.053
CHEMISTRY, APPLIED	80,446	3.39	31	0.62	0.074	3.91	21	0.41	0.023	3.91	8	0.75	0.047
CRYSTALLOGRAPHY	69,089	2.90	17	0.92	0.112	3.04	11	0.90	0.081	3.85	14	0.87	0.015
CHEMISTRY, MEDICINAL	59,423	4.09	60	0.73	0.027	4.91	31	0.02	0.023	4.75	16	0.43	0.029
ELECTROCHEMISTRY	50,109	3.35	39	0.34	0.077	4.01	19	0.97	0.059	4.11	9	0.91	0.068

Sub-field	Size	10 years				5 years				3 years			
		α	ρ	p value	Ratio	α	ρ	p value	Ratio	α	ρ	p value	Ratio
PHYSICS													
PHYSICS, APPLIED	292,009	3.38	87	0.67	0.010	3.45	31	0.08	0.020	4.40	28	0.59	0.006
PHYSICS, CONDENSED MATTER	225,465	3.23	43	0.00	0.040	3.88	35	0.60	0.015	4.63	25	0.46	0.006
PHYSICS, MULTIDISCIPLINARY	181,685	2.74	66	0.06	0.043	3.06	53	0.77	0.021	3.34	26	0.52	0.026
OPTICS	127,315	3.44	44	0.53	0.034	3.92	22	0.05	0.035	5.11	22	0.92	0.007
PHYSICS, PARTICLES & SUB-FIELDS	85,142	2.80	59	0.96	0.034	2.97	30	0.92	0.049	3.28	20	0.51	0.040
PHYSICS, MATHEMATICAL	73,780	2.90	27	0.84	0.100	3.33	17	0.47	0.067	3.59	10	0.25	0.054
PHYSICS, NUCLEAR	54,158	3.12	26	0.03	0.075	3.33	21	0.35	0.039	3.55	12	0.12	0.039
PHYSICS, FLUIDS & PLASMAS	52,910	3.03	28	0.39	0.121	3.79	27	0.46	0.031	3.59	11	0.29	0.055
ACOUSTICS	31,923	3.15	25	0.24	0.076	4.02	18	0.68	0.023	4.35	7	0.13	0.054
COMPUTER SCIENCE													
COMPUTER SCIENCE, THEORY & METHODS	128,090	2.72	22	0.82	0.047	3.76	13	0.63	0.022	5.50	11	0.77	0.005
COMPUTER SCIENCE, INTERDISCIPLINARY APPLICATIONS	64,294	2.71	25	0.43	0.067	2.88	7	0.00	0.134	3.33	8	0.65	0.033
TELECOMMUNICATIONS	55,889	2.45	27	0.38	0.041	2.99	13	0.30	0.033	3.90	10	0.61	0.011
COMPUTER SCIENCE, INFORMATION SYSTEMS	51,706	2.43	21	0.27	0.070	2.59	7	0.26	0.100	2.74	5	0.66	0.056
COMPUTER SCIENCE, SOFTWARE ENGINEERING	43,346	2.91	17	0.06	0.076	3.36	11	0.71	0.034	4.00	5	0.00	0.040
COMPUTER SCIENCE, HARDWARE & ARCHITECTURE	28,988	2.65	27	0.62	0.042	3.22	15	0.71	0.022	3.52	4	0.03	0.061
MATHEMATICAL & COMPUTATIONAL BIOLOGY	21,037	2.88	32	0.54	0.122	3.18	13	0.49	0.131	3.16	8	0.85	0.084
MATHEMATICS													
MATHEMATICS	141,355	4.10	35	0.74	0.011	4.43	13	0.07	0.013	5.50	9	0.55	0.004
MATHEMATICS, APPLIED	122,342	3.49	40	0.53	0.018	3.64	11	0.03	0.043	4.34	12	0.74	0.007
STATISTICS & PROBABILITY	52,322	2.92	33	0.45	0.056	3.37	18	0.69	0.031	3.92	13	0.94	0.012
SPACE SCIENCE													
ASTRONOMY & ASTROPHYSICS	128,494	2.97	51	0.17	0.077	3.23	34	0.78	0.058	3.42	21	0.69	0.047

Sub-field	Size	10 years				5 years				3 years			
		α	ρ	p value	Ratio	α	ρ	p value	Ratio	α	ρ	p value	Ratio
ENGINEERING													
ENGINEERING, ELECTRICAL & ELECTRONIC	276,940	2.90	31	0.20	0.039	3.44	23	0.63	0.013	3.75	11	0.85	0.015
MECHANICS	96,915	3.37	29	0.64	0.048	4.12	21	0.63	0.013	4.28	11	0.30	0.011
ENGINEERING, MECHANICAL	90,933	3.91	32	0.51	0.019	4.16	12	0.63	0.020	5.50	10	0.31	0.003
INSTRUMENTS & INSTRUMENTATION	87,423	4.25	43	0.09	0.014	4.39	21	0.60	0.013	3.91	9	0.53	0.023
NUCLEAR SCIENCE & TECHNOLOGY	76,498	3.54	21	0.01	0.046	3.92	22	0.85	0.009	3.74	8	0.36	0.024
ENERGY & FUELS	67,956	3.69	40	0.86	0.017	4.65	17	0.10	0.014	4.40	9	0.85	0.011
SPECTROSCOPY	64,160	3.41	37	0.76	0.051	4.29	24	0.26	0.031	3.94	14	0.63	0.026
COMPUTER SCIENCE, ARTIFICIAL INTELLIGENCE	64,079	2.49	26	0.36	0.081	3.29	16	0.87	0.035	4.03	8	0.16	0.027
ENGINEERING, CIVIL	57,062	3.08	18	0.55	0.068	3.26	7	0.35	0.065	3.55	4	0.50	0.056
ENGINEERING, MULTIDISCIPLINARY	50,976	3.25	25	0.82	0.038	3.94	11	0.04	0.034	5.50	10	0.86	0.007
MATHEMATICS, INTERDISCIPLINARY APPLICATIONS	41,460	3.25	34	0.98	0.048	4.74	18	0.05	0.027	4.69	10	0.10	0.022
OPERATIONS RESEARCH & MANAGEMENT SCIENCE	41,144	3.57	23	0.46	0.056	3.67	8	0.19	0.058	3.60	4	0.61	0.052
THERMODYNAMICS	39,102	3.35	15	0.04	0.119	4.41	12	0.04	0.034	4.72	6	0.17	0.034
AUTOMATION & CONTROL SYSTEMS	37,943	2.65	13	0.29	0.125	3.93	11	0.02	0.037	5.50	10	0.18	0.007
ENGINEERING, AEROSPACE	35,604	3.75	20	0.49	0.017	5.50	12	0.22	0.007	5.50	7	0.80	0.005
ENGINEERING, MANUFACTURING	34,053	4.48	23	0.26	0.029	4.43	9	0.71	0.025	4.32	3	0.11	0.057
ENGINEERING, INDUSTRIAL	30,712	3.82	19	0.12	0.043	3.73	6	0.86	0.055	4.25	3	0.89	0.050
CONSTRUCTION & BUILDING TECHNOLOGY	21,509	5.50	23	0.23	0.027	4.02	7	0.26	0.058	3.28	3	0.35	0.088
TRANSPORTATION SCIENCE & TECHNOLOGY	14,697	2.97	12	0.71	0.144	4.37	8	0.99	0.050	3.77	2	0.05	0.134
ENGINEERING, GEOLOGICAL	11,533	3.70	18	0.46	0.078	3.27	5	0.69	0.163	3.86	4	0.83	0.050
COMPUTER SCIENCE, CYBERNETICS	9,792	2.20	7	0.32	0.232	2.77	6	0.10	0.113	3.93	6	0.77	0.031
ENGINEERING, OCEAN	7,682	2.40	8	0.97	0.209	2.75	6	0.45	0.107	3.06	5	0.57	0.053
ERGONOMICS	6,893	2.66	14	0.15	0.162	2.85	5	0.27	0.208	4.19	4	0.32	0.079
ROBOTICS	6,675	3.69	16	0.68	0.082	4.15	9	0.77	0.048	3.73	4	0.80	0.058
ENGINEERING, MARINE	5,686	1.75	1	0.26	0.080	2.85	2	0.45	0.027	2.49	1	0.30	0.036

Sub-field	Size	10 years				5 years				3 years			
		α	ρ	p value	Ratio	α	ρ	p value	Ratio	α	ρ	p value	Ratio
MATERIALS SCIENCE													
MATERIALS SCIENCE, MULTIDISCIPLINARY	322,630	3.13	56	0.61	0.017	3.65	30	0.42	0.011	4.20	18	0.57	0.006
METALLURGY & METALLURGICAL ENGINEERING	92,789	3.03	37	0.64	0.025	3.38	14	0.05	0.032	3.60	6	0.02	0.043
NANOSCIENCE & NANOTECHNOLOGY	59,170	3.13	24	0.00	0.090	3.57	14	0.54	0.058	4.16	10	0.88	0.025
MATERIALS SCIENCE, COATINGS & FILMS	49,109	3.17	24	0.20	0.113	3.66	16	0.92	0.053	3.91	11	0.62	0.025
MATERIALS SCIENCE, CERAMICS	46,827	2.80	23	0.23	0.084	4.03	22	0.85	0.020	3.69	10	0.75	0.022
MATERIALS SCIENCE, COMPOSITES	25,608	3.52	16	0.53	0.108	4.97	10	0.06	0.050	5.50	7	0.49	0.017
MATERIALS SCIENCE, BIOMATERIALS	17,805	3.34	43	0.49	0.139	4.04	20	0.75	0.087	4.91	9	0.20	0.080
MATERIALS SCIENCE, PAPER & WOOD	13,967	3.21	12	0.46	0.075	5.50	11	0.95	0.014	4.61	4	0.36	0.041
MATERIALS SCIENCE, CHARACTERIZATION & TESTING	13,671	3.49	12	0.42	0.053	5.50	9	0.18	0.020	4.39	4	0.38	0.023
MATERIALS SCIENCE, TEXTILES	11,220	2.70	8	0.68	0.162	3.60	6	0.71	0.079	3.27	3	0.55	0.091
PLANT & ANIMAL SCIENCE													
PLANT SCIENCES	133,084	4.33	86	0.31	0.016	5.09	53	0.68	0.008	5.17	33	0.89	0.004
VETERINARY SCIENCES	110,967	3.81	31	0.68	0.040	3.52	14	0.76	0.039	3.59	8	0.84	0.032
ZOOLOGY	72,754	3.58	39	0.45	0.052	3.95	17	0.14	0.056	3.98	9	0.42	0.051
MARINE & FRESHWATER BIOLOGY	70,841	4.41	55	0.63	0.022	4.56	20	0.26	0.032	4.44	9	0.76	0.044
AGRICULTURE, DAIRY & ANIMAL SCIENCE	46,283	3.44	32	0.28	0.047	4.59	17	0.84	0.028	5.50	10	0.18	0.016
ENTOMOLOGY	42,082	3.46	27	0.12	0.052	4.10	15	0.20	0.033	4.92	11	0.71	0.014
FISHERIES	34,440	3.80	31	0.63	0.082	5.50	20	0.14	0.021	4.47	9	0.77	0.032
FORESTRY	25,260	3.72	30	0.47	0.087	3.68	17	0.78	0.036	4.10	8	0.21	0.043
HORTICULTURE	20,970	3.10	28	0.31	0.076	3.50	15	0.25	0.058	5.50	13	0.95	0.013
LIMNOLOGY	12,644	2.99	38	0.30	0.123	3.17	15	0.81	0.133	3.34	8	0.36	0.112
MYCOLOGY	12,427	2.72	17	0.04	0.178	3.96	16	0.57	0.067	3.49	8	0.56	0.063
ORNITHOLOGY	9,264	3.19	16	0.34	0.165	3.52	10	0.78	0.091	3.96	6	0.79	0.067

Sub-field	Size	10 years				5 years				3 years			
		α	ρ	p value	Ratio	α	ρ	p value	Ratio	α	ρ	p value	Ratio
ENVIRONMENT/ECOLOGY													
ENVIRONMENTAL SCIENCES	165,600	3.37	47	0.63	0.048	3.62	20	0.28	0.043	3.95	19	0.79	0.007
ECOLOGY	95,604	3.27	42	0.49	0.107	3.60	23	0.36	0.058	3.85	11	0.09	0.052
WATER RESOURCES	57,439	4.43	52	0.90	0.022	5.11	19	0.10	0.020	4.24	6	0.05	0.072
ENGINEERING, ENVIRONMENTAL	48,450	3.34	50	0.90	0.056	3.73	24	0.72	0.036	3.59	10	0.35	0.052
SOIL SCIENCE	30,340	3.65	34	0.72	0.071	3.78	14	0.80	0.059	3.98	8	0.71	0.035
BIODIVERSITY CONSERVATION	16,613	2.97	35	0.49	0.100	3.29	15	0.70	0.099	3.43	7	0.23	0.098
GEOSCIENCES													
GEOSCIENCES, MULTIDISCIPLINARY	105,721	3.44	35	0.02	0.069	3.54	22	0.51	0.031	3.91	12	0.34	0.026
METEOROLOGY & ATMOSPHERIC SCIENCES	61,820	3.31	69	0.27	0.039	3.41	23	0.03	0.064	3.43	10	0.01	0.090
GEOCHEMISTRY & GEOPHYSICS	58,156	3.35	53	0.56	0.060	4.34	25	0.07	0.043	4.23	12	0.82	0.044
OCEANOGRAPHY	41,126	4.07	65	0.60	0.035	3.99	22	0.26	0.057	3.88	9	0.07	0.081
ENGINEERING, PETROLEUM	21,948	3.62	17	0.52	0.019	3.92	9	0.60	0.017	3.78	6	0.64	0.013
GEOGRAPHY, PHYSICAL	20,143	3.69	33	0.24	0.089	3.43	14	0.41	0.081	3.46	6	0.15	0.107
GEOLOGY	17,141	4.24	34	0.10	0.093	4.13	13	0.12	0.119	4.09	7	0.30	0.091
MINERALOGY	15,897	3.39	34	0.88	0.074	3.56	13	0.71	0.101	5.09	11	0.95	0.028
MINING & MINERAL PROCESSING	15,780	2.44	11	0.55	0.154	2.67	7	0.97	0.093	2.70	3	0.22	0.091
PALEONTOLOGY	15,433	2.72	16	0.09	0.203	2.89	11	0.73	0.105	3.61	7	0.62	0.068
REMOTE SENSING	12,352	2.47	18	0.71	0.201	2.92	11	0.92	0.112	3.57	6	0.23	0.089
IMAGING SCIENCE & PHOTOGRAPHIC TECHNOLOGY	10,534	2.39	18	0.20	0.170	3.25	12	0.53	0.080	3.32	6	0.35	0.068
AGRICULTURAL SCIENCES													
FOOD SCIENCE & TECHNOLOGY	102,422	3.40	31	0.60	0.069	3.73	16	0.62	0.043	4.29	11	0.23	0.017
NUTRITION & DIETETICS	50,167	3.22	43	0.04	0.080	3.28	17	0.02	0.106	3.42	11	0.70	0.062
AGRONOMY	49,553	3.13	26	0.32	0.070	3.34	11	0.03	0.072	5.50	14	0.62	0.007
AGRICULTURE, MULTIDISCIPLINARY	33,446	3.32	29	0.33	0.067	3.31	11	0.95	0.085	3.43	6	0.97	0.073
AGRICULTURAL ENGINEERING	9,903	3.98	22	0.41	0.084	4.24	7	0.18	0.116	5.41	6	0.59	0.034

Sub-field	Size	10 years				5 years				3 years			
		α	ρ	p value	Ratio	α	ρ	p value	Ratio	α	ρ	p value	Ratio
MULTIDISCIPLINARY													
MULTIDISCIPLINARY SCIENCES	61,304	3.01	43	0.29	0.018	2.66	9	0.02	0.072	2.96	7	0.13	0.044
SOCIAL SCIENCES, GENERAL													
POLITICAL SCIENCE	34,890	2.56	11	0.01	0.100	3.16	10	0.30	0.036	3.40	7	0.59	0.017
EDUCATION & EDUCATIONAL RESEARCH	34,469	3.20	18	0.68	0.054	3.98	10	0.41	0.032	5.50	8	0.35	0.010
REHABILITATION	31,463	2.93	21	0.57	0.132	3.69	13	0.48	0.059	4.85	9	0.93	0.022
SOCIOLOGY	27,298	3.29	28	0.58	0.058	3.53	10	0.53	0.069	4.43	7	0.31	0.034
LAW	27,221	3.75	23	0.85	0.049	3.82	14	0.71	0.037	4.11	8	0.31	0.045
ENVIRONMENTAL STUDIES	23,128	3.26	21	0.66	0.077	4.00	9	0.12	0.081	5.50	8	0.44	0.020
INFORMATION SCIENCE & LIBRARY SCIENCE	22,386	2.86	21	0.48	0.047	3.04	8	0.93	0.066	3.19	4	0.39	0.076
NURSING	21,636	3.73	17	0.64	0.095	3.64	8	0.78	0.068	4.70	4	0.02	0.064
HEALTH POLICY & SERVICES	21,372	2.99	28	0.50	0.104	3.10	16	0.98	0.068	3.29	8	0.17	0.072
SOCIAL SCIENCES, INTERDISCIPLINARY	20,653	4.45	33	0.85	0.023	3.47	7	0.04	0.073	3.33	4	0.69	0.054
SUBSTANCE ABUSE	17,201	3.03	33	0.15	0.126	3.21	13	0.26	0.145	3.44	7	0.02	0.108
INTERNATIONAL RELATIONS	16,742	2.46	11	0.01	0.102	2.64	9	0.46	0.057	3.58	9	0.79	0.022
ANTHROPOLOGY	16,551	2.70	12	0.04	0.153	5.02	14	0.63	0.026	4.87	7	0.95	0.029
GERONTOLOGY	14,682	3.06	33	0.13	0.114	3.77	20	0.70	0.067	3.81	9	0.68	0.069
PLANNING & DEVELOPMENT	13,899	2.90	15	0.98	0.089	3.13	7	1.00	0.078	3.22	4	0.88	0.057
LINGUISTICS	13,691	3.63	45	0.61	0.048	3.28	14	0.15	0.072	4.20	7	0.07	0.063
GEOGRAPHY	12,916	2.96	17	0.08	0.134	3.98	10	0.93	0.100	3.86	5	0.56	0.110
COMMUNICATION	11,449	2.64	12	0.53	0.147	3.57	9	0.70	0.057	4.08	3	0.00	0.119
FAMILY STUDIES	11,072	3.35	27	0.85	0.101	3.50	12	0.94	0.081	3.81	6	0.51	0.061
SOCIAL ISSUES	10,721	3.18	12	0.41	0.092	5.50	11	0.45	0.022	3.78	5	0.46	0.048
ETHICS	10,664	3.91	16	0.40	0.064	5.50	12	0.66	0.026	3.12	3	0.51	0.130
SOCIAL WORK	10,049	2.79	11	0.39	0.183	3.11	5	0.77	0.168	4.08	5	0.74	0.036
URBAN STUDIES	9,773	2.79	11	0.37	0.203	2.98	5	0.12	0.196	3.55	5	0.90	0.048
AREA STUDIES	9,028	3.23	7	0.39	0.103	3.69	5	0.27	0.057	5.50	4	0.19	0.022

Sub-field	Size	10 years				5 years				3 years			
		α	ρ	p value	Ratio	α	ρ	p value	Ratio	α	ρ	p value	Ratio
WOMEN'S STUDIES	8,656	2.81	13	0.96	0.138	3.00	5	0.52	0.163	5.10	5	0.08	0.041
CRIMINOLOGY & PENOLOGY	8,322	2.21	10	0.10	0.210	2.53	5	0.07	0.190	5.31	6	0.22	0.046
PUBLIC ADMINISTRATION	7,899	3.44	17	0.81	0.060	2.93	5	0.09	0.143	3.24	3	0.45	0.111
EDUCATION, SPECIAL	6,627	2.69	13	0.80	0.158	3.18	7	0.75	0.141	3.48	5	0.67	0.071
TRANSPORTATION	4,998	2.54	11	0.40	0.277	3.05	4	0.05	0.280	3.82	4	0.67	0.057
DEMOGRAPHY	4,947	2.68	20	0.17	0.155	3.60	11	0.29	0.110	3.73	6	0.17	0.088
HISTORY OF SOCIAL SCIENCES	3,587	2.65	7	0.79	0.111	3.98	6	0.86	0.058	3.48	2	0.07	0.199
MEDICAL ETHICS	3,083	3.17	13	0.89	0.170	4.46	13	0.31	0.049	2.65	3	0.26	0.264
ETHNIC STUDIES	2,172	2.42	4	0.10	0.230	2.58	2	0.37	0.247	4.12	3	0.62	0.062
		ECONOMICS & BUSINESS											
ECONOMICS	80,021	2.86	39	0.73	0.041	3.15	16	0.12	0.031	4.87	14	0.58	0.006
MANAGEMENT	30,712	2.61	27	0.50	0.117	3.18	14	0.63	0.061	3.02	4	0.13	0.116
BUSINESS	27,817	2.55	32	0.35	0.091	2.89	12	0.28	0.073	2.98	4	0.05	0.101
BUSINESS, FINANCE	24,332	2.42	19	0.21	0.084	3.01	12	0.66	0.040	5.50	12	0.79	0.009
SOCIAL SCIENCES, MATHEMATICAL METHODS	12,460	2.71	18	0.33	0.173	3.03	8	0.64	0.139	3.36	5	0.17	0.080
INDUSTRIAL RELATIONS & LABOR	4,384	3.49	18	0.95	0.096	4.31	8	0.39	0.094	4.16	4	0.74	0.092
AGRICULTURAL ECONOMICS & POLICY	3,723	2.82	9	0.60	0.245	3.21	5	0.65	0.167	3.09	3	0.61	0.118
		ARTS & HUMANITIES											
HISTORY	42,006	2.80	4	0.15	0.050	3.91	7	0.81	0.006	3.15	1	0.00	0.132
LITERATURE	26,408	2.56	2	0.22	0.100	2.57	3	0.43	0.016	2.95	1	0.21	0.083
PHILOSOPHY	26,219	2.82	8	0.44	0.044	4.21	6	0.02	0.022	5.50	5	0.88	0.008
HUMANITIES, MULTIDISCIPLINARY	24,428	3.07	7	0.88	0.020	3.00	2	0.14	0.074	3.28	3	0.74	0.014
ART	24,063	2.71	3	0.66	0.029	2.87	2	0.48	0.026	5.50	2	0.86	0.012
LITERARY REVIEWS	17,898	3.19	1	0.02	0.094	3.66	1	0.12	0.062	3.33	1	0.44	0.041

Sub-field	Size	10 years				5 years				3 years			
		α	ρ	p value	Ratio	α	ρ	p value	Ratio	α	ρ	p value	Ratio
MUSIC	17,200	2.51	3	0.66	0.078	2.60	2	0.88	0.066	2.46	1	0.46	0.097
RELIGION	16,858	3.44	8	0.20	0.027	3.01	2	0.11	0.112	2.84	1	0.18	0.191
ARCHITECTURE	16,118	4.09	2	0.55	0.010	3.58	1	0.40	0.015	2.79	1	0.64	0.008
LANGUAGE & LINGUISTICS	15,610	2.24	5	0.27	0.107	3.54	7	0.80	0.023	4.30	4	0.34	0.016
LITERATURE, ROMANCE	12,401	5.50	3	0.23	0.027	3.68	1	0.00	0.096	3.28	1	0.53	0.058
HISTORY & PHILOSOPHY OF SCIENCE	9,512	2.87	7	0.26	0.147	3.22	4	0.05	0.137	4.92	5	0.42	0.032
ARCHAEOLOGY	9,310	3.66	15	0.14	0.056	3.47	6	0.19	0.069	3.27	3	0.16	0.075
FILM, RADIO, TELEVISION	7,134	1.82	1	0.79	0.161	2.35	2	0.68	0.046	4.09	2	0.71	0.018
THEATER	6,193	4.02	3	0.23	0.046	5.50	2	0.35	0.043	4.84	1	0.40	0.083
CLASSICS	6,162	5.50	6	0.40	0.031	3.04	1	0.01	0.237	5.13	1	0.39	0.114
ASIAN STUDIES	6,155	3.29	2	0.17	0.085	2.52	1	0.74	0.151	5.30	1	0.42	0.106
LITERATURE, GERMAN, DUTCH, SCANDINAVIAN	4,306	3.53	1	0.00	0.218	5.18	1	0.39	0.153	4.61	1	0.48	0.100
LITERARY THEORY & CRITICISM	4,134	2.02	1	0.68	0.180	2.04	1	0.60	0.091	2.13	1	0.62	0.066
DANCE	3,958	1.84	1	0.37	0.027	2.66	1	0.73	0.025	2.36	1	0.70	0.019
MEDIEVAL & RENAISSANCE STUDIES	3,937	4.53	2	0.00	0.166	3.58	1	0.01	0.244	4.73	1	0.41	0.116
LITERATURE, BRITISH ISLES	2,971	5.50	3	0.61	0.053	3.32	1	0.58	0.205	4.58	1	0.50	0.120
LITERATURE, AMERICAN	2,534	3.74	3	0.29	0.089	2.99	2	0.86	0.074	4.03	1	0.52	0.100
POETRY	2,321	4.41	2	0.71	0.062	4.30	1	0.43	0.136	3.58	1	0.88	0.078
LITERATURE, SLAVIC	2,269	2.92	1	0.54	0.181	3.71	1	0.49	0.091	1.95	1	0.05	0.052
FOLKLORE	2,216	2.39	2	0.91	0.131	2.54	2	0.52	0.083	3.52	2	0.98	0.060
LITERATURE, AFRICAN, AUSTRALIAN, CANADIAN	1,912	2.54	1	0.56	0.257	2.13	1	0.51	0.131	3.65	1	0.41	0.090