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"THE SKEWNESS OF SCIENTIFIC PRODUCTIVITY"

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Abstract

This paper exploits a unique 2003-2011 large dataset, indexed by Thomson & Reuters, consisting of 17.2 million disambiguated authors classified into 30 broad scientific fields, as well as the 48.2 million articles resulting from a multiplying strategy in which any article co-authored by two or more persons is wholly assigned as many times as necessary to each of them. The dataset is characterized by a large proportion of authors who have their *oeuvre* in several fields. We measure individual productivity in two ways that are uncorrelated: as the number of articles per person, and as the mean citation per article per person in the 2003-2011 period. We analyze the shape of the two types of individual productivity distributions in each field using size- and scale-independent indicators. For productivity inequality, we use the coefficient of variation. To assess the skewness of productivity distributions we use a robust index of skeweness, as well as the Characteristic Scores and Scales approach. For productivity inequality, we use the coefficient of variation. In each field, we study two samples: the entire population, and what we call "successful authors", namely, the subset of scientists whose productivity is above their field average. The main result is that, in spite of wide differences in production and citation practices across fields, the shape of field productivity distributions are very similar across fields. The parallelism of the results for the population as a whole and for the subset of successful authors when productivity is measured as mean citation per article per person, reveals the fractal nature of the skewness of scientific productivity in this case. These results are essentially maintained when any article co-authored by two or more persons is fractionally assigned to each of them.

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I. INTRODUCTION

In this paper, we study the size and the mean of individual citation distributions in a given period of time for all authors in a number of scientific fields. Naturally, the size of individual citation distributions, that is, the number of publications per author, is a standard measure of individual productivity. The productivity of individual scientists has been studied extensively since Lotka's (1926) pioneer contribution, in which the probability of an author publishing a certain number of articles in Chemistry was estimated to be an inverse square function of the number of publications (Alvarado, 2012, counts 651 publications concerning the so-called *Lotka's law* from that date until 2010). However, most of these contributions analyze a relatively small number of scientists and, to the best of our knowledge, do not systematically study productivity distributions using comparable and large datasets for several scientific disciplines.[1]

On the other hand, the mean citation per article per author is a standard (size-independent) measure of the citation impact achieved by any researcher in her field of study. Nevertheless, to simplify the exposition, we will refer to this indicator of citation impact as a second definition of individual productivity. At any rate, we do not know of systematic studies concerning the distribution of this variable within and between representative samples for a variety of scientific disciplines.

As in any other scientific discipline, in Scientometrics we should clearly establish the stylized facts that characterize basic constructs in all fields. Consequently, this paper studies the productivity of individual scientists –in the two senses indicated above– in 30 broad fields using a large dataset, indexed by Thomson Reuters, consisting of 7.7 million distinct articles published in the period 2003-2011 in academic journals. Applying a variable citation window from the publication year until 2012, these articles receive 78.9 million citations.

Regardless of how we measure individual productivity, a study of this type must confront the following three four methodological problems: (i) the classification of articles into scientific fields;

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[1] Kyvik (1989) compares the productivity between three very broad scientific disciplines –the Medical, the Natural, and the Social Sciences– and the Humanities, using a relatively small dataset. A key exemption is the important contribution by Ioannidis *et al.* (2014), which studies 15.1 million authors that have published at least one indexed item in the entire Scopus database in the period 1996-2011. See below for a comparison of our methods and results with those of

(ii) the identification of the author(s) of each article, and (iii) the allocation of authors to fields, and (iv) the attribution of individual responsibility in cases of multiple authorship. After these problems are solved (see the a data methodological Section below), we end up with a dataset consisting of 17.2 million authors and 48.2 million articles.

Of course, we know *a priori* that fields are very differentthe between-field variability with respect to several basic characteristics. is typically very large. Firstly, the size of productivity distributions, namely, the number of authors per field, is bound to be very different across fields. Secondly, because of well-known differences in production and citation practices, the average number of articles per author, as well as the average mean citation per article per author are also expected to be very different across fields.

Therefore, what we should study is the shape of field productivity distributions abstracting from size and scale differences across fields. To simplify the presentation, we focus on the skewness of productivity distributions. NaturallyTwo characteristics will be investigated: the inequality and the skewness of productivity distributions. Intuitively, large individual variability in authors' productivity within each field should yield high values of any productivity inequality index we care to use. On the other hand, the extensive literature on Lotka's law leads us to expect that productivity distributions according to the first definition are highly skewed in all fields, in the sense that a majority of individuals publish very little, while a large proportion of the total number of publications must be attributed to a small number of authors. Finally, if only by analogy with the skewness of science in so many dimensions (see Lotka, 1926, De Solla Price, 1963, and Seglen, 1992, to cite only a few classics), we expect that all field productivity distributions in all fields according to the second definition are also highly skewed.

In this scenario, the main aim of this paper is to investigate the between-field variation of the high inequality and skewness of productivity distributions that isare expected to be prevalent in each field. For the reasons already explained, we need size- and scale-independent indicators. As far as productivity inequality is concerned, we use the coefficient of variation. In turn, the of skewness. We follow of productivity distributions is assessed following two complementary approaches. In the first place, we study the broad features of this phenomenon by simply partitioning productivity distributions into three classes of individuals with low, fair, and very high productivity. For this purpose, we follow adopt the Characteristic Scores and Scale (CSS hereafter) approach first introduced in Scientometrics by Schubert *et al.* (1987). In the second place, we are interested in summarizing the skewness of productivity distributions with a single scalar. Among the size- and scale-independent skewness measures that are also robust to extreme observations, in this paper we use the one suggested by Groeneveld & Meeden (1984) that has been used before in Albarrán *et al.* (2014), and Perianes & Ruiz-Castillo (2014). .

Finally, for reasons that will be apparent in the sequel, we analyze the shape of productivity distributions in each field for two samples: the entire population, and what we call *successful authors*, namely, the subset of scientists whose productivity is above their field average.

The main result of the paper is that the shape of productivity distributions is very similar across fields. The similarity of field productivity distributions is important for two reasons. Firstly, it indicates that we need a single explanation, valid simultaneously for all sciencesdisciplines, concerning the within-field variability of our two productivity measuresnotions. Secondly, we know that differences in production and citation practices makes impossible the direct comparison of the number of publications or the mean citation per article for authors belonging to different fields. However, the similarity of the distributions of these two variables opens the possibility of meaningful comparisons of individual productivity across heterogeneous fields.

The rest of this paper is organized into five Sections. Section II describes the data, while Sections III and IV present the results concerning the characteristics of productivity distributions when individual productivity is measured by the number of publications and the mean citations per article, respectively. Section V compares our results with those obtained in the previous literature, while Section VI while Section VI discusses the robustness of our results to an alternative way of attributing individual responsibility in cases of multiple authorship. Finally, Section VII summarizes the paper, and suggests possible extensions.

II. METHODOLOGICAL ISSUES

II.1. Measurement Issues

Since we wish to address a homogeneous population, in this paper only research articles published in academic journals or, simply, *articles* are studied.[2] As indicated in the Introduction, we begin with a large sample, consisting of 7,721,132 distinct articles published in the period 2003-2011. In what follows, we discuss the solutions we have adopted for the three four methodological problems mentioned in the Introduction.

1. Given the well-known differences in publication and citation practices across scientific disciplines, the performance of any pair of authors can only be compared if they belong to the same field. The problem, of course, is that Thomson Reuters assigns publications in the periodical literature to Web of Science subject categories via the journal in which they have been published. Many journals are assigned to a single category, but many others are assigned to two, three, or even more categories up to a maximum of six. In particular, in our dataset 2,246,435 articles, or 29.1% of the total, are assigned to two or more of our 30 fields.

There are two approaches to tackle the problem created by the assignment of publications to two or more Web of Science subject categories in Thomson Reuters datasets. The first is a fractional strategy, according to whichwhere each publication is fractioned into as many equal pieces as necessary, with each piece assigned to its corresponding sub-field. The second approach follows a multiplicative strategy in which each paper is counted as many times as necessary in the several sub-fields to which it is assigned. In this way, the space of articles is expanded as much as necessary beyond the initial size in what we call the *extended count*. Fortunately, previous results indicate that for many purposes journals assigned to a single or to several subject categories share similar characteristics, so that the strategy choice is not that crucial. Among other issues in citation analysis, the study of the skewness of citation distributions across fields at different aggregation levels, or the evaluation of the gap in citation impact between the U.S. and the European Union using different

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[2] Following Waltman & van Eck (2013a, b), we exclude publications in local journals, as well as magazine and trade journals.

indicators, are very robust to the strategy selected (Herranz & Ruiz-Castillo, 2012a, 2012b, 2012c, and 2013, and Crespo *et al.*, 20143b). All in all, in this paper we follow a multiplicative strategy. Consequently, the number of articles in the corresponding extended count is 10,355,901, or 34.1% larger than the number of distinct articles (cf. Table A in the Appendix).

On the other hand, it is well known that there is no generally agreed-upon Map of Science or aggregation scheme that allows us to ascend from Web of Science categories up to other aggregate levels. Among the many alternatives, we classify all articles into 30 broad fields, namely,take as our starting point the partition of scientific activity into the 35 broad fields distinguished inintroduced by Tijssen *et al.* (2010) except the following five that, which hasve been used in Buter & van Raan (2011), Hoekman, *et al.* (2010, 2013), and Schneider & Costas, R. (2013). We exclude the following five fields from this list excluded because of their limited coverage in the Web of Science database used in this paper: Creative Arts, Culture & Music; History, Philosophy & Religion; Language & Linguistics; Literature; Political Science & Public Administration. Therefore, we end up with the remaining 30 fields.[3]

2. The accurate assignment of articles to individual authors is known to be plagued with formidable obstacles (Lindsey, 1980, and Costas *et al.*, 2010). In this paper, we solve this problem using the algorithm recently generated by Caron & van Eck (2014). This is an author disambiguation algorithm for large bibliometric databases that belongs to what is known in the literature as the class of unsupervised learning approaches. The method, inspired in Levin *et al.* (2012), that clustersuses rule-based scoring and clustering of the individuals' publications of individuals, thus detecting their *oeuvres* in a systematic and accurate way. Although the clustering is not perfect, we believe that we are working with quite realistic data concerning the assignment of articles to individual scholars.[4] Overall, there are 9,631,769 distinct researchers associated to the 7.7 million distinct articles of the dataset. approximately 9.6 million distinct researchers associated to the 7.7 million distinct articles of

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[3] It is not claimed that this scheme provides an accuratethe best possible representation of the structure of science. It is rather a convenient simplification for the discussion of field comparability issues in this paper..

[4] Tests of this clustering show values of precision and recall higher than 95% and 90%, respectively (cf. Caron & van Eck, 2014).

the dataset. In the extended count, the number of authors goes up to 17,199,433 individuals, a 79% increase relative to the original number of distinct authors.

3. Given the allocation of articles to fields in a multiplicative way, in this paper the authors of each article are allocated to fields in the same multiplicative way. Therefore, in the extended count the number of authors goes up to 17,199,433 individuals, a 78.6% increase relative to the original number of distinct authors. In order to facilitate the interpretation of our results, it is important to clarify the consequences of this procedure for the extent in which researchers appear as authors in several fields.[5]

Consider the 5,474,693 articles, or 70.9% of the total, that are assigned to a single field in our dataset. These articles are written by 7,555,176 distinct authors, or 78.4% of the total. However, some of these researchers are authors of articles that belong to different fields. Therefore, the total number of authors assigned to the 30 fields is somewhat larger: 9,472,725. In our view, this poses no problem of interpretation: for the purpose of analyzing the characteristics of authors in a number of different fields, as we do in this paper, researchers who write articles in several fields should be treated as independent, different authors in their respective fields.

Consider now the 2,246,439 distinct articles assigned to two o more of the 30 fields. In the multiplicative approach, this subset gives rise to 4,881,208 extended articles. The total number of scholars writing them in the different fields is 7,726,708. Together with the 9.5 million authors introduced in the previous paragraph, this gives rise to the 17.2 million authors in the extended count. Naturally, by construction, these 7.7 million authors appear in two or more fields –a situation that would directly increase the proportion of authors whose *oeuvre* appears in several fields. Moreover, some of these 7.7 million researchers would be part of the 9.5 million already studied. Consequently, some of the scholars who had all their publications in one field would now have some articles in several fields. The end result is that only 5,306,383 authors in the extended count, or 30.8% of the total, have all their *oeuvre* in a single field. The situation –which we have not seen discussed before– is illustrated in Figure 1.

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[5] We thank one referee for pointing to us out the importance of this issue.

Figure 1 around here

It could be argued that, given any classification system that distinguishes between a minimum number of scientific fields, there are *some* publications that must be simultaneously classified into several fields. Although we have no means of knowing the true extent of this phenomenon, the percentage of authors in several fields in a classification system where each article is assigned to a single field would give us a lower bound for the true situation. Instead, in the case of our Thomson Reuters dataset, where an important percentage of articles are assigned to two or more fields, it is likely that the percentage of authors whose *oeuvre* appears in several fields –which is equal to 69.2% of the total– exaggerates the true situation.[6] In the extended count, the number of authors goes up to 17,199,433 individuals, a 79% increase relative to the original number of distinct authors.

4. A fundamental difficulty in the study of scientists' productivity is the definition of the individual contribution to an article in a world dominated by multiple authorship in all fields (Cronin, 2001). The maximum and the mean number of authors for all fields are presented in Table C in the Appendix. The following two points should be noted. Firstly, the mean number of authors per article ranges from 1.7 or 1.9 in six fields to 4.5 or 4.8 in five fields, with a maximum of 5.3 in Astronomy & Astrophysics. The average over the 30 fields is 3.1 with a relatively high coefficient of variation of 0.35 (meaning that the standard deviation is 35% of the average). Secondly, the maximum number of authors per article reveals several truly extreme observations: it is greater than 3,000 in Physics & Materials Sciences, Multidisciplinary Journals, and Astronomy & Astrophysics, and greater than 2,450 in Instruments & Instrumentation, and Clinical Medicine. At the opposite end, the maximum number of authors in Mathematics is 36, while in General & Industrial Engineering, and Information & Communication Sciences it is 26.

In this situation, arbitrarily choosing a single author per article without even the assurance that s/he is the "leading author" is out of the question. On the other hand, an adjusted or fractional count introduces measurement on a continuous scale, perhaps inappropriate for a phenomenon that

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[6] Note that the large percentage of authors with publications in several fields in our dataset is independent of the multiplicative or fractional approach one adopts to articles assigned by Thomson Reuters to several subject categories.

is clearly discrete, and perhaps even representing a scale with a degree of precision greater than we are actually capable of measuring (Nicholls, 1989). Finally, as shown by Rousseau (1992) and confirmed by Burrell and Rousseau (1995), adjusted counting leads to a breakdown in the estimation of Lotka's law.

Therefore, in this paper we follow Nicholls's (1989) recommendation of using what is known as the *complete count*, namely, a multiplicative strategy in which any article co-authored by two or more persons scholars is wholly assigned as many times as necessary to each of them. Of course, this means that the set of articles actually studied increases quite dramatically: the total number of articles in what we call the *double extended count* becomes 48,200,834, or 4.6 times larger than the number of distinct articles, and 2.8 times larger than the 17.2 million authors in the extended count –a fraction approximately equal to the average number of authors per article in the dataset.

Next, by way of comparison, we briefly review the characteristics of the dataset used in Ioannidis *et al.* (2014), as well as the way these authors tackle the above methodological problems. To begin with, it should be noted that these authors use a Scopus database that includes all genres of published items in 1996-2011 among which, nevertheless, journal articles predominate. Instead, our dataset consists only of research articles published in academic journals, excluding publications in local journals, as well as magazine and trade journals.

With regard to the four methodological issues, Ioannidis *et al.*'s (2014) approach can be summarized as follows. (i) These authors use a classification system –previously developed in Börner *et al.* (2012) and Boyack & Klavans (2014)– that allocates each paper to a separate scientific discipline. They distinguish between 13 broad fields. (ii) Rather that attempting to disambiguate authors on their own, as we have done, Ioannidis *et al.* (2014) use Scopus author identifiers. (iii) This contribution approaches the problem of allocating authors to fields in a different way to ours. In the first place, because in Ioannidis *et al.* (2014) every publication belongs to a single field, the percentage of authors with publications in several fields is expected to be considerable smaller than in our extended count. In any case, each author is allocated to a specific field depending on what is the most common field of the papers he/she has authored. However, the dismissal of available information (e.g. the smaller contribution of authors to fields that are not their main field) is not generally accepted as a good statistical practice. (iv) Finally, nothing is said about the assignment of individual responsibilities in the case of a publication with multiple authors.

Before we finish this Section on methodological issues, we want to clarify that the between-field variation of any characteristic will be measured by means of the coefficient of variation (CV hereafter) of the characteristic in question over the 30 fields. The CV is defined as the ratio of the standard deviation over the mean. There is no generally agreed criterion in Statistics concerning when a CV is "large" or "small", possibly because this distinction is context dependent. Although any reader is free to apply a different criterion, in this paper we will use the following convention. We say that the between-field variability of any characteristic is

- "Small", if $CV \leq 0.10$, meaning that the standard deviation of this characteristic over the 30 fields is smaller than or equal to 10% of the mean.
- "Intermediate", if $0.10 < CV \leq 0.30$
- "Large", if $0.30 < CV \leq 0.60$
- "Very large", if $CV > 0.60$.

II.2. Some Descriptive Statistics

The distribution of articles and authors by field in the extended count, as well as the distribution of articles actually studied in the paper in the double extended count are in Table 1. Three points should be emphasized.

Table 1 around here

Firstly, according to the field size measure we are interested in for this paper –that is, the number of authors in the extended count– fields can be classified into three groups (see column 3 in Table 1). (i) Five fields with more than 1.5 million distinct authors or more than 9.5% of the total number of authors (Clinical Medicine; Biomedical Sciences; Basic Life Sciences; Physics & Materials Science, and Chemistry & Chemical Engineering). The largest is Clinical Medicine that has 3.3 million authors and 18.9% of the total. (ii) Ten intermediate fields with 375,000 to 785,000 authors, or 2.2% to 4.7% of the total. (iii) The remaining fifteen fields only have fewer than 310,000 authors or 1.8% of the total. The smallest is Information & Communication Sciences with 43,614 authors, or 0.25% of the total.

Secondly, comparing the percentage distributions in columns 2 and 4 in Table 1, we observe that some small fields (such as Multidisciplinary, and Instruments & Instrumentation) and some large ones (Clinical Medicine, Basic Life Sciences, and Biomedical Sciences) have relatively more authors than articles. The opposite is the case for some small fields (Mathematics, Astronomy & Astrophysics, and Economics & Business) as well as Physics & Materials Science. In turn, the increase in the total number of articles in the double extended count varies a lot across fields. Comparing columns 2 and 6 in Table 1, we observe that the percentage of the number of articles in the double extended count is greater than in the original count in only eight fields whose mean number of authors per article (column 1 in Table A in the Appendix) is well above the average for all fields (Astronomy & Astrophysics; Basic Life Sciences; Basic Medical Sciences; Biomedical Sciences; Clinical Medicine; Instruments & Instrumentation; Multidisciplinary Journals, and Physics & Materials Science).

Thirdly, for our purposes in this paper we should emphasize that the dispersion observed in the different field size distributions is very large: the coefficient of variation over the 30 fields for the number of authors and articles in the extended count is 1.3, while it is 1.5 for the number of articles in the double extended count.

III. PRODUCTIVITY AS THE NUMBER OF ARTICLES PER PERSON

III.1. Some Characteristics of Productivity Distributions

In this Section, we define individual productivity as the number of distinct articles written by each individual independently of the number of authors involved. Some of the key characteristics of productivity distributions are presented in Table 2. This information should be analyzed from the point of view of the individual field, and of the 30 fields as a whole.

Table 2 around here

Four aspects will be discussed at the individual level. Firstly, taking into account that we study the publication performance of individuals over a period of nine years, field mean productivity values are generally low (column 1 in Table 2). On one hand, researchers in Astronomy & Astrophysics or Physics & Materials Science who, on average, publish 8.2 and 4.3 papers, are seen to publish one article every 9/8.2 = 1.1 or 9/4.3 = 2.1 years, respectively. On the other hand, researchers in a number of fields (such as Social and Behavioral Sciences; Information & Communication Sciences; Educational Sciences; Sociology & Anthropology, and perhaps not surprisingly, Multidisciplinary Journals) publish one paper, approximately, only every six years (i.e. 9 years/~1.5). Secondly, such low mean values are easily understood when we realize that, on average, about 69% of authors in all fields publish a single article during this nine-year period (column 2 in Table 2).[7] Thirdly, maximum productivity levels are very high in all fields (column 3 in Table 2). In six fields, the maximum number of publications ranges from 39 to 99 articles, or 4.3 to 11 articles per year. In sixteen other fields, people publish at a maximum between 101 and 274 articles over the nine years, while in seven fields maximum productivity ranges from 336 to 687 articles. In Physics & Materials Science, the author with maximum productivity publishes 1,547 articles, or more than 170 articles per year. Fourth, not surprisingly, productivity inequality measured by the coefficient of variation is very high in all fields (column 4 in Table 2): in twenty six fields the coefficient of variation is between one and two, in three (Clinical Medicine, Chemistry & Chemical Engineering, and Astronomy & Astrophysics), and in Physics & Materials Science it is greater than three.

For our purposes, it is important to emphasize the high variability across fields exhibited by productivity inequality and, above all, by mean productivity (with coefficients of variation equal to 0.31 and 0.5, respectively).

III.2. The Skewness of Productivity Distributions

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[7] We should acknowledge that this result may be partly influenced by the fact that the author name disambiguation algorithm promotes precision over recall, thus splitting the oeuvres of authors When there is no sufficient information to cluster the publications of a certain author, the algorithm may occasionally split the *ouvre* of an author into clusters with only one publication. Future research will focus on the exploration of more refined datasets that do not suffer from this phenomena.

Consider a population of N individuals, indexed by $i = 1,\ldots, N$. Assume that we have information about a certain individual characteristic, say x_i for each i; in other words, assume that we have information about the ordered distribution $x = (x_1,\ldots, x_i,\ldots, x_N)$ with $x_1 \leq x_2 \ldots \leq x_i \ldots \leq x_N$. Let $X = \Sigma_i x_i$ be the total amount of this characteristic in the population. In our application of the CSS technique, two *characteristic scores* are determined: μ_1 = mean of x, and μ_2 = mean over the individuals with $x_i > \mu_1$. Then we partition the population into three categories: (i) individuals with $x_i \leq \mu_1$; (iii) individuals with $\mu_1 < x_i \leq \mu_2$; (iii) individuals with $x_i > \mu_2$. The CSS technique allows us to describe distribution x by means of two sets of results: the percentages of individuals in the three categories, and the percentages of X attributed to the individuals in each category.

In the case where x_i is the number of publications per author in a certain field, μ_1 is the mean number of publications for the entire productivity distribution, μ_2 is the mean number of publications for authors with a number of articles above μ_1, and X is the total number of publications in the field. We partition the productivity distribution into three classes: (i) authors with low productivity that publish a number of articles smaller than or equal to μ_1; (iii) fairly productive authors, with productivity greater than μ_1 and smaller than or equal to μ_2; (iii) authors with remarkable or outstanding productivity above μ_2. For each field, Table D in the Appendix includes the percentage of authors in the three classes, and the corresponding percentages of the total number of articles accounted for by each class. The average (the standard deviation), and the coefficient of variation of the six values over the 30 fields appear in row I in Table 3.

Table 3 around here

The results are remarkable. The research productivity of scientists in every field and, consequently, the shape of their citation distributions, are determined by a complex set of factors whose study is beyond the scope of this paper. However, the relatively small standard deviations and coefficient of variations in Row I indicate that field productivity distributions tend to share some fundamental characteristics. Figure 2 (where fields are ordered according to the percentage of people in category 1) illustrates the similarity of the partition of authors into the three classes in the different fields. Specifically, we find that, on average, 79.3% of all individuals have productivity below μ_f and account for approximately 40% of all publications, while individuals with a remarkable or outstanding productivity represent 5.9% of the total and account for 35% of all publications. Thus, we can conclude that field productivity distributions are both similar and very highly skewed indeed in the sense that a large proportion of researchers have below average productivity, while a small percentage of them account for a disproportionate amount of all publications.

Figure 2

Compare the CSS approach with the procedure followed by Ioannidis *et al.* (2014). The latter identifies how many authors have published at least once in each and every year in the 16 year period 1996-2011. These authors are said to have an uninterrupted, continuous presence (UCP) in the scientific literature over this period. There are 150,608 UCP authors in a dataset of 15,153,100 scholars, or 0.99% of the total. Based on random samples of 10,000 researchers for each pattern, Ioannidis *et al.* (2014) find that, contrary to our results, the relative proportion of UCP authors across scientific disciplines is different than the respective distribution for non-UCP authors.

This difference in results can be explained by two factors. Firstly, recall that we each solve the four methodological problems discussed in this paper in a different way (see Section II). Secondly, and more importantly, Ioannidis *et al.* (2014) define the UCP condition equally for all fields. However, fields with a large average number of publications per author will tend to have a larger percentage of UCP authors. In our case, the procedure to partition authors into three categories abstracts from these well-known differences in average productivity across fields. Thus, it should come as no surprise that "*The presence of the UCP pattern is relatively enriched in Medical Research, but also in Mathematics/Physics and Chemistry, while the presence of the non-UCP pattern is relatively enriched in Social Sciences and Humanities (the UCP pattern is practically non-existent in the Humanities), as well as Engineering and Computer Sciences/Electrical Engineering.*" (p. 4).

On the other hand, as indicated in the Introduction we have also considered the computation of numerical skewness indexes for all fields. The problem, of course, is that extreme observations with a very large number of citations are known to be prevalent in citation distributions (see *inter alia*

Herranz & Ruiz-Castillo, 2012a, and Li & Ruiz-Castillo, 20143). This presents a challenge for conventional measures of skewness that are very sensitive to extreme observations.[8] Fortunately, robust measures of skewness based on quartiles have been developed in the statistics literature. In particular, given a process $\{y_t\}$, $t = 1, \ldots, T$, where the y_t's are independent and identically distributed with a cumulative distribution function F, the Groeneveld & Meeden (1984) robust measure is

$$GM = (\mu - Q_2)/\mathrm{E}\angle\,|y_t - Q_2\angle\,| ,$$

where $Q_2 = \mathrm{F}^{-1}(0.5)$ is the second quartile of y_t, or the median of the distribution, and the expectation in the index denominator is estimated by the sample mean of the deviations from the median in absolute value.

For the interpretation of results, the following three properties should be taken into account. Firstly, like the CSS approach, the *GM* index is scale- and size-independent. Secondly, whenever the mean is greater than the median –as it is always the case in our dataset– the *GM* index takes positive values. Thirdly, the *GM* index is bounded in the interval [-1, 1]. However, whenever the process consists of natural numbers and the lower 50% of the observations are equal to, say, a value z, then the median is z, and the *SKGM* index reaches its upper bound of 1. Thus, extreme distributions of this sort drives the *GM* index to its upper bound. As we will see presently, this is a useful property to have in our case. Note also that, like the CSS approach, *GM* is scale- and size-independent.[9]

Recall that the percentage of authors with a single publication in the period 2003-2011 is greater than 50% (column 2 in Table 3) for all fields. Therefore, the median and the *GM* index are equal to 1 in all cases. This clearly reinforces the idea that we are facing an unusual situation in which field productivity distributions are extremely skewed, as well as very similar to each other.

III.4. Successful Authors

So far we have studied the productivity of all authors measured by the number of their publications in the 2013-2011 period. Given the high percentage of authors with a single

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[8] Naturally, extreme observations can also affect any measure of productivity inequality, such as the field coefficients of variation presented in column 4 in Table 2.

[9] The Groeneveld and Meeden (1984) measure improves upon the extension of Bowley's (1920) measure due to Hinkley (1975), and has better properties than the well-known measure of Kendall and Stuart (1977).

publication, the low values of μ_1, and the fact that in 29 out of 30 fields the *GM* index reaches its upper bound, it seems interesting to study the behavior of relatively productive authors. Specifically, we define *successful authors* as those with above average productivity. Their total number is 3,291,299, or 31.8% of the population as a whole. The distribution of successful authors by field is in columns 1 and 2 in Table E in the Appendix.

Given the similarity across fields in the percentage of authors with a single publication (column 2 in Table 2), the percentage distribution by fields in column 2 in Table E is very similar to the one for the entire population in column 3 in Table 1. The main difference is the increase in the relative importance of Basic Life Sciences and Biological Sciences, and the decrease in Chemical & Chemical Engineering, Clinical Medicine, and Physics & Materials Science. As before, almost 60% of successful authors belong to five large fields, while there are fifteen fields whose size is less than 1.6% of the total. The largest is Clinical Medicine that has close to 530,000 authors and 16.1% of the total, and the smallest is Information & Communication Sciences with 9,815 authors, or 0.3% of the total. A coefficient of variation of 1.2 summarizes the large variability of field sizes.

Naturally, the mean productivity of successful authors coincides with μ_2, already defined above. For the CSS approach, we need a third mean, denoted by μ_3, which is the mean productivity of authors with productivity above μ_2. The information concerning μ_2 and μ_3 is in columns 3 and 4 in Table E in the Appendix. At the upper tail, the values of μ_2 and μ_3 are 20.4 and 55.2 for Physics & Materials Science, and 36.1 and 82.7 for Astronomy & Astrophysics. At the lower tail, μ_2 and μ_3 are 3.3 and 6.3 for Multidisciplinary Journals, Social & Behavioral Sciences, and Sociology & Anthropology.

The information for the *GM* index is in column 5 in Table E. Median productivity for successful authors is equal to two in six fields (Educational Sciences; General & Industrial Engineering; Information & Communication Sciences; Law & Criminality; Social & Behavioral Sciences, and Sociology & Anthropology). Consequently, their *GM* index reaches again its upper bound. The lowest values are 0.41 and 0.47 for Management & Planning and Economics &

Business. For the remaining 12 fields, *GM* ranges from 0.52 to 0.97. Thus, we conclude that most field productivity distributions are again highly skewed according to the *GM* criterion. However, note that the coefficient of variation of *GM* values is 0.25, a magnitude considerably smaller than for μ_2 and μ_3 that are equal to 0.8 and 0.92, respectively.

The results of the CSS approach for successful authors are in Table F in the Appendix. A summary is presented in row II in Table 3. The comparison with the population as a whole (Table D in the Appendix, and row I in Table 3) yields three very interesting results. Firstly, all standard deviations and coefficients of variation are smaller in row II than in row I, indicating that productivity distributions are now even more similar than before. The situation for the percentage of successful authors in the three categories is illustrated in Figure 3 (where fields are ordered according to the percentage of people in category 1). Secondly, on average, the percentage of people in category 1 (with productivity below μ_2) is eight points smaller than before (with productivity below μ_1). Furthermore, the percentage of successful people in categories 2 and 3 is five and three points greater than for the population as a whole. This agrees with the results obtained with the *GM* criterion: field productivity distributions are still highly skewed, but the degree of skewness is considerably lower than the extraordinary high levels reached for the entire population in each field. Thirdly, relative to the previous situation, the percentage of publications accounted for by all categories remains essentially constant. Thus, on average, 71.4% of all successful individuals in category 1 account for approximately 41.4% of all publications, while individuals in category 3 represent 8.8% of the total and account for 31.1% of all publications.

Figure 3 around here

IV. PRODUCTIVITY AS THE MEAN CITATION PER ARTICLE PER PERSON

IV.1. Characteristics of Productivity Distributions

Measuring productivity as the number of publications per author in a certain period has a long history in Scientometrics. However, in the dataset used in this paper it is possible to take into account each author's citation impact. Therefore, in this Section, we define individual productivity as the mean citation per article per person during 2003-2011. The correlation coefficient between the two measures in the entire sample is 0.02, and ranges from -0.03 and -0.01 in Instruments & Instrumentation and Energy Science & Technology, to 0.13 in Management & Planning. This reveals that, as we know from previous research (Costas *et al.*, 2010), the most prolific authors need not be those with the highest impact. Thus, the two concepts, although related, are best treated separately. Some of the key characteristics of the distribution of individual productivity in each field are in Table 4. This information deserves three comments.

Table 4 around here

Firstly, mean productivity varies widely, ranging from 3.2 and 3.7 in Mathematics and Computer Sciences, to 13.3 or 15 in Clinical Medicine and Basic Life Sciences. Not surprisingly, the highest value, 49.3, is reached in Multidisciplinary Journals (column 1 in Table 4). As usual for mean productivity variables, the coefficient of variation is high: 0.95.

Secondly, the percentage of authors without any citations in 2003-2011 ranges from 6.3% in Multidisciplinary Journals to 32.3% in Computer Sciences (column 2 in Table 4). The average is 17.1%, not a small number. On the other hand, the maximum mean citation per article shows truly extreme observations in many fields (column 3 in Table 4). The highest value is 8,483 citations per article in Multidisciplinary Journals, but it is greater than 3,000 in six other fields, greater than 2,000 in three others, and greater than 1,000 in seven other cases. Given these two features, it is not surprising that productivity inequality, measured by the coefficient of variation, is greater than 1.6 everywhere, while the average over all fields is 2.14 (column 4 in Table 4). Interestingly enough, the coefficient of variation of this measure of field productivity inequality is only 0.29, indicating that this characteristic exhibits much less variation than mean productivity.

Thirdly, according to the *GM* index, productivity distributions are highly skewed in all fields: this measure ranges from 0.54 in Basic Medical Sciences to 0.80 in Multidisciplinary Journals. However, for our purposes, it is important to emphasize that the coefficient of variation is only 0.11, indicating considerable similarity among all fields around an average *GM* value of 0.66.

In the case where x_i is the mean citation per article per author in a certain field, m_2 is the mean productivity for authors with mean citation per article above m_1, and X is the sum of the mean citations per article over all authors in the field, abbreviated as the total of the mean citations. Consider again the partition of the distribution into three broad classes: (i) authors with productivity smaller than or equal to m_1; (ii) authors with productivity between m_1 and m_2 and (iii) authors with a remarkable or outstanding productivity above m_2. Table G in the Appendix includes the results for all fields. The average (the standard deviation), and the coefficient of variation over the 30 fields of the percentage of authors in the three classes, as well as the corresponding percentages of the total of the mean citations accounted for by each class appear in row III in Table 3.

The results are again remarkable. Firstly, the standard deviations and coefficients of variation in row III are generally smaller than in Rows I and II, indicating that field distributions under the second productivity definition share some fundamental characteristics even more strongly than before. Figure 4 (where fields are ordered according to the percentage of people in category 1), illustrates the similarity of the percentage of authors in the three classes across fields. Secondly, the main difference between the average results for the population as a whole in rows I and II is the following. The percentage of researchers in category 1 according to the first productivity notion (79.3%) is considerably larger than according to the second notion (71.0%). Correspondingly, the percentage of the total accounted for by the low productivity people according to the first definition (44.4%) is also larger than for the second definition (22-8%). Naturally, the opposite is the case on both grounds at the upper tail of the distribution.

Figure 4 around here

IV.2. Successful Authors

Just as before, it is interesting to study successful authors, namely, scientists with above average productivity. Their total number is 4,868,030, or 47% of the population as a whole. The distribution of authors by field, the means m_2 and m_3, as well as the skewness index *GM* are in Table H in the Appendix. The following three points should be emphasized.

Firstly, the percentage distribution of authors by field in column 2 in Table H is very similar to the one for the entire population in column 3 in Table 1. The main difference is the increase in Biomedical Sciences and Basic Life Sciences (from 8.8% to 11.9% and 11.1%, respectively), as well as the decrease in Physics and Materials Science (from 13.4% to 9.1%). Three small fields increase their relative size (Agriculture and Food Science; Basic Medical Sciences, and Multidisciplinary Journals), while the opposite is the case for three equally small fields (Astronomy & Astrophysics; Economics & Business, and Mathematics). As before, almost 60% of successful authors belong to five large fields, while there are seventeen fields whose size is less than 1.9% of the total. The largest is again Clinical Medicine with almost 850,000 authors and 17.4% of the total, and the smallest is Information & Communication Sciences with 12,539 authors, or 0.3% of the total. A coefficient of variation of 1.3 indicates the large variability of field sizes.

Secondly, on one hand the values of m_2 and m_3 are 163 and 362 in Multidisciplinary Journals, as well as 39 and 82 in Basic Life Sciences, and 38 and 94 in Clinical Medicine (columns 3 and 4 in Table H). On the other hand, m_2 and m_3 are approximately 10 and 20 in Mathematics, followed by Computer Sciences and General & Industrial Engineering. The coefficient of variation over the 30 fields for these two variables are very high indeed: 1.1 and 1.2, respectively.

Thirdly, the skewness of productivity distributions according to the *GM* index ranges from 0.55 in Law & Criminology to 0.75 in Physics & Materials Science, with an average of 0.66 that is exactly equal to the one for the population as a whole. However, the coefficient of variation is even smaller than before: 0.07.

The results of the CSS approach are in Table I in the Appendix, while a summary is presented in row IV in Table 3. The comparison with the population as a whole (Table G in the Appendix and row III in Table 3) yields a first fundamental result: on average, the partition of both populations over the three CSS categories is exactly the same. Furthermore, judging from the coefficients of variation, the similarity across fields is again the same as before. Therefore, we can conclude that, according to both the CSS approach and the *GM* criterion, the distributions of mean citation per article per person for the population as a whole and for successful authors are very similar and highly skewed across fields. This clearly illustrates the fractal nature of individual productivity distributions when productivity is measured as the mean citation per article per person (for a graphical illustration, compare Figures 4 and 5). On the other hand, the results for successful authors according to both productivity definitions are practically the same (compare rows II and IV in Table 3, as well as Figures 3 and 5)

Figure 5 around here

We find interesting to inform also about the allocation of the *total number of citations* into the three categories when individual productivity is measured as mean citation per article per person. For reasons of space, we only present the aggregate results in rows V and VI in Table 3 (the results for each field are available on request). Two comments are in order.

Firstly, the main difference between the results for the population as a whole in the right-hand side of rows III and V is that category 2 accounts for a greater percentage of total citations (40.2%) than of total mean citations (33.2%). The explanation lies in the fact that category 2 includes authors with a relatively large number of publications per capita. Specifically, on average for all fields, the mean number of articles per person in categories 1, 2, and 3 is 2.1, 3.5, and 2.6, respectively. Given the high correlation between number of publications and citations received, which is 0.67 on average for all fields, we find that category 2 accounts for a large percentage of total citations (To save space, details by field of the mean number of articles per person and the correlation between publications and citations are available on request).

Secondly, note that, independently of the individual productivity definition, category 2 in the population as a whole becomes category 1 in the subset of successful authors. Therefore, it is not surprising that category 1 among successful authors accounts again for a greater percentage of total citations (52.0%) than of total mean citations (43.0%). On the other hand, independently of the individual productivity definition, the percentage of the total accounted for by category 3 in the population as a whole must be split between the new categories 2 and 3 for successful authors. Since this percentage is smaller in row V than in row III, and category 2 of successful authors account for the same percentage of the total in rows IV and VI (approximately 27%), we have necessarily that category 3 accounts for a smaller percentage of total citations (20.3%) than of total mean citations (29.3%). The explanation of the differences between the sequence of percentages of total citations and total mean citations in rows IV and VI is the following. On average over all fields, the mean number of publications per person among successful authors in categories 1 to 3 are 3.5, 2.8, and 2.0; in turn, the percentage of papers accounted for by the three categories are 76.2%, 18.3%, and 5.5% (details by field are available on request).

In brief, the less productive among successful authors have relatively many publications, and hence, plenty of total citations, while truly productive authors in terms of mean citations per article have fewer but highly cited publications that, nevertheless, account for a relatively low percentage of total citations. However, note that people with outstanding productivity above m_3, representing 8.3% of all successful authors, account for 5.5% of all publications and 20.3% of all citations, while those with productivity at most equal to m_2, representing 71.0% of all successful authors, account for 76.2% of all publications and 252.0% of all citations.

V. COMPARISON OF RESULTS WITH THE PREVIOUS LITERATURE

Before we conclude, it is interesting to compare our results with those obtained in the previous literature. Two types of comparisons are worth while.

Firstly, the results for the total population (rows I and III in Table 3) can be compared with those concerning citation distributions –namely, the distributions of the number of citations received by articles published in a certain period– in previous research. For brevity, we focus on the dataset analyzed in Albarrán *et al.* (2011), consisting of 3.7 million articles published in the period 1998-2002 in 219 Web of Science subject-categories with a fixed, five-year citation window (see row VII in Table 3).[10] In this case, on average 68.6% of all articles receive citations below the mean and account for 29.1% of all citations, while articles with a remarkable or outstanding number of citations represent 10% of the total, and account for approximately 45% of all citations. These

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[10] These results are of the same order of magnitude as those obtained for field citation distributions in the multiplicative case for different time periods, at different aggregation levels, and with a fixed or a variable citation window (Albarrán and Ruiz-Castillo, 2011, and Li *et al.*, 2013). For the fractional case, see Herranz and Ruiz-Castillo (2012a).

aggregate results for 219 scientific sub-fields, as well as the corresponding standard deviations and coefficients of variation, are extremely similar as those found in this paper for the definition of individual productivity as mean citation per article per person and authors are classified in 30 broad fields (row III in Table 3).

Secondly, Kyvic (1989) conducts an interesting study with a relatively small and weak dataset. This author compares the productivity of tenured faculty members in Norway's four universities working in four academic disciplines: Medical sciences, Natural sciences, Social sciences, and Humanities. The data is drawn from a 1982 questionnaire study among all tenured academics in Norway. The response rate was 78%, and the total number of authors is 1,569. Productivity is measured in two ways: as the number of publications (articles, books, reports), and as an index of *equivalent articles* that takes into account the type of publication and multiple co-authorship.

Then main result is that, as in this paper, there are only small differences in productivity –however measured– across fields of learning. On average in all fields, 18% (20%) of the authors publish 50% of the total publications (total article equivalents).[11] Using this measure, productivity distributions in our case are considerably more skewed: on average over all fields, 14.5% (11.5%) of the authors account for 50% of the total publications (total mean citations) according to our two definitions of individual productivity.

VI. CONCLUSIONS AND EXTENSIONS

VI.1. Conclusions and Discussion

This paper has exploited a unique large dataset consisting of 7.7 million distinct articles published in the period 2003-2011 in academic journals, with a variable citation window from the publication year until 2012. We had to overcome the obstacles posed by four methodological problems: the multiple assignment by Thomson Reuters of articles to multiple journal subject categories, for which we followed a multiplicative approach; the identification of authors in articles,

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[11] The non-responding population has no effect on this pattern, as the proportion of non-respondents –whose productivity is estimated to be 25-30% lower tan among the respondents– is about the same in all fields.

which we solved applying a novel author disambiguation algorithm; the allocation of authors to fields, for which we follow the rule that researchers who write articles in several fields should be treated as independent, different authors in their respective fields[12]; and the definition of the individual contribution to an article in the case of multiple authorship, for which we also followed a multiplicative approach. After coping with these problems, we end up with a final dataset consisting of 17.2 million authors classified into 30 broad fields.

We have measured individual productivity in two ways that are essentially uncorrelated in our dataset: the number of articles per person, and the mean citation per article per person. In both cases, we have studied, not only the entire population, but also what we call successful authors, defined as researchers with a number of articles above the mean in their own field.

The main result of the paper is that the skewness and productivity inequality of field productivity distributions is very similar across fields for all samples. In particular, except for the entire population when productivity is measured as the number of publications per person, in the remaining three samples the percentage of scholars that have a low, fair, or outstanding productivity is of the same order of magnitude. It should be added that all these results are robust to the treatment of articles co-authored by two or more persons following a fractional approach.

The results thus summarized are useful to devise the following research strategy for the future. Firstly, Firstly, field size differences, measured by number of articles or number of authors, requires an explanation based on the interaction between scientists' preferences and the structure of incentives that determines the relative attractiveness of pursuing a scientific career in different fields, where the latter is influenced by a complex set of factors including, *inter alia*, intellectual traditions, the evolution of research technology, public opinion concerning the relative importance of different fields, and scientific and business policies in different parts of the world that determine differential

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[12] The problem of the assignment of authors to fields is a relatively under researched problem, at least from a quantitative point of view. Even when we consider authors of articles assigned by Thomson Reuters to a single field, we find that one third of researchers have their oeuvre in several fields, introducing the idea that publication in different fields (even broad fields as considered in this study) is quite common among scholars. Given the assignment of articles to multiple fields that characterizes Thomson Reuters datasets, the percentage of scholars with activity in more than one field increases to, approximately, two thirds of the 17.2 million authors in the final dataset, a magnitude that is exaggerating the true extent of the phenomenon.

wages, and other resources and facilities across fields. Secondly, rather than a set of models for different types of sciences, we need a single explanation of within-field variation of scientists' productivity. Thirdly, the between-field mean productivity differences in our dataset can be attributed to idiosyncratic differences in production and citation practices. However, just as the similarities between field citation distributions at different aggregation levels have recently paved the way for meaningful comparisons of citations for articles belonging to heterogeneous fields (Crespo *et al.*, 2013, 2014, and Li *et al.*, 2013), the similarities documented in this paper between field productivity distributions open the possibility of establishing meaningful comparisons of productivity for authors belonging to heterogeneous fields. In order to explore this possibility in our case, we have normalized field productivity distributions by computing the ratio between mean productivities in every field and mean productivity in Chemistry & Chemical Engineering, taken as the reference field. The results are in Table 5. When productivity is measured as the number of articles per person, the similarity between columns 2 and 3 in Table 5 indicates that this normalization strategy is very promising. For example, publishing 10 articles in Chemistry & Chemical Engineering in 2003-2011 is equivalent to successful authors publishing 6.2 or 5.8 in Agriculture & Food Science, or 30.6 in Astronomy & Astrophysics. When productivity is measured as the mean citation per article per person, the similarity between columns 4, 5, and 6 in Table 5, verifies the above intuition. For example, having an average of 10 citations per article in Chemistry & Chemical Engineering in 2003-2011 is equivalent to having an average of 8.3, 7.4, or 6.7 in Agriculture & Food Science, or 11.1, 11.7, or 14.3 in Astronomy & Astrophysics. However, rigorously studying this normalization strategy must be left for further research.

Table 5 around here

VI.2. The fractional assignment of responsibility in the case of co-authorship

In spite of the reasons in favor of the multiplicative treatment of articles co-authored by two or more persons (see Section II.1), we should investigate the robustness of our results to an adjusted or fractional approach in these cases. To save space, we present the results of the CSS approach for the two measures of productivity and, in each case, for the entire population and for the subset of successful authors (the results for other characteristics of productivity distributions are available on request). Aggregate results in these four instances are presented in rows I to IV in Table 6 (field results are in Tables J to M in the Appendix). The conclusion is inescapable: in the four cases, the skewness of productivity distributions in each field, and the similarity of productivity distributions across fields when using the complete approach (rows I to IV in Table 3) or the adjusted approach (Table 6), are essentially indistinguishable.

Table 6 around here

However, one should ask: does this means that the ratios between mean productivities in every field and mean productivity in Chemistry & Chemical Engineering examined in Table 5 are expected to remain unchanged after adopting the adjusted approach? The results in the latter case are in Table 7. The answer to this question must be radically different for the two definitions of individual productivity.

Firstly, recall the different co-authorship patterns across fields documented in Table A in the Appendix. When productivity is measured as the number of articles per person, we should expect fields with a high mean number of authors per article, such as Astronomy & Astrophysics with a mean equal to 5.3 to have a *lower* mean productivity relative to Chemistry & Chemical Engineering (with a mean equal to 3.7) after applying the fractional approach. Similarly, we expect fields with a low mean number of authors per article, such as Mathematics with a mean equal to 1.8 to have a *greater* mean productivity relative to Chemistry & Chemical Engineering after applying the fractional approach. This is exactly what we find when we compare the left-hand side of Tables 5 and 7. For example, as we saw before, publishing 10 articles in Chemistry & Chemical Engineering in 2003-2011 is equivalent to successful authors publishing 30.6 in Astronomy & Astrophysics, and 6.8 or 5.7 in Mathematics when we follow the complete approach (Table 5), while these figures become 16.9 and 14.0 for Astronomy & Astrophysics and 19.6 and 15.6 in Mathematics when we follow the adjusted approach (Table 7).

Table 7 around here

Secondly, things are very different when we define individual productivity as the mean citation per article per person. The reason is clear: the fractional approach tends to diminish both the numerator (number of citations) and the denominator (number of publications) in the mean formula. However, which are the consequences of this double change? The answer is extremely reassuring for our purposes: the right-hand sides of Tables 5 and 7 are essentially the same.

Therefore, our results on the skewness of productivity distributions in each field, and the similarity of productivity distributions across fields in every case, as well as our results on the comparability of field productivities when productivity is measured as the mean citation per article per person are completely robust to the counting method we adopt for assigning individual responsibility in publications co-authored by two or more scientists.

VI.3. Other Possible Extensions

In addition, within the methodological framework defined in Section II there are three issues for further research. Firstly, it would be relevant to investigate whether the productivity distributions studied in this paper follow a simple functional form. In the case of the number of publications per person, this exercise should start by verifying whether productivity distributions satisfy the generalized Lotka's law. Secondly, it would be interesting to study the distribution of individual mean citations *conditional* on the number of publications in each field. Since, as we have seen, the number of publications and the mean citation per article per person are largely uncorrelated in every field, the conjecture is that conditional distributions are very similar to the marginal distribution, that is, to the distribution of the mean citation per article per person studied in Section IV. Thirdly, in this paper we have studied the size and the mean of individual citation distributions. For authors with a minimum number of articles in each field, we could investigate other size- and scale-independent characteristics at the individual level, such as citation inequality and citation skewness. This analysis leads to investigating the possibility of accounting for the characteristics of citation distributions at the field level in terms of the characteristics of citation distributions at the individual level.

Finally, among the extensions that involve methodological changes or new pieces of information, we mention the following four.

1. It would be important to study the robustness of our results using a classification system where every article is assigned to a single scientific field –a possibility is the publication-level algorithmic methodology introduced by Waltman & Van Eck (2012), and further studied in Ruiz-Castillo and Waltman (2014). In view of the discussion in Section II, this would tend to reduce the degree in which scholars appear as authors in several fields. On the other hand, the new classification system will typically consist of a similar number of broad fields that, however, would be quite different to the ones we have studied here. Thus, we could test the robustness of our results to a change in the set of fields considered.

2. We should study the issues researched in this paper using an author name disambiguation algorithm different from Caron & van Eck (2014).

3. So far, we have studied a rich dataset informing about publications, authors, and citations during a nine year period. However, as in most of the studies in the productivity literature, we do not have information concerning authors' ages. This poses two problems. Firstly, because of age and/or cohort effects our measures of productivity for authors of different ages and/or cohorts are not actually comparable. Secondly, some young (old) people are only observed during a reduced number of years at the end (beginning) of the period. Consequently, even in the absence of age and cohort effects, the censored productivity measures of these people are not comparable with the productivity of scientists keeping on publishing during the entire period.[13]

4. In this paper we have studied a large set of authors in a number of fields who publish their research during a fixed, relatively short period of nine years. It would be very interesting to follow the publication dynamics of authors in different fields over their entire research career.

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[13] As emphasized by Wagner-Döbler (1995), and Wagner-Döbler & Berg (1995), rather than a study of the varying intensity with which scientists contribute in their respective fields, what we have accomplished with our cross-section of authors of different ages is a bibliometric description, a "snapshot" of the state of the different fields with regard to the structure of scientific participation.

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APPENDIX

Table A. The assignment of distinct articles by Thomson Reuters to one or several fields, and the construction of the extended count

Number of fields	Number of articles	%	Extended count
1	5,474,693	70.90	5,474,693
2	1,913,108	24.78	3,826,216
3	285,893	3.70	857,679
4	41,433	0.54	165,732
5	4,449	0.06	22,245
6	1,556	0.02	9,336
Total	7,721,132	100.0	10,355,901

Table B. Percentage of researchers who have their *ouvre* in a single field, in %. Authors of articles assigned by Thomson Reuters to a single field, and authors in the extended count

	% Researchers who have their *oeuvre* in one field	
	Articles assigned to one field	**Extended count**
AGRICULTURE AND FOOD SCIENCE	58.9	22.6
ASTRONOMY AND ASTROPHYSICS	65.2	32.4
BASIC LIFE SCIENCES	55.0	26.1
BASIC MEDICAL SCIENCES	41.8	10.3
BIOLOGICAL SCIENCES	61.4	22.6
BIOMEDICAL SCIENCES	53.5	22.5
CHEMISTRY & CHEMICAL ENGINEERING	72.7	30.4
CIVIL ENGINEERING AND CONSTRUCTION	70.1	7.7
CLINICAL MEDICINE	77.2	52.7
COMPUTER SCIENCES	76.7	33.5
EARTH SCIENCES & TECHNOLOGY	72.5	35.2
ECONOMICS AND BUSINESS	79.9	37.9
EDUCATIONAL SCIENCES	76.6	25.1
ELECTRICAL ENG. & TELECOMMUNICATION	72.3	19.8
ENERGY SCIENCE & TECHNOLOGY	64.3	8.5
ENVIRONMENTAL SCS. & TECHNOLOGY	60.7	23.3
GENERAL AND INDUSTRIAL ENGINEERING	56.5	2.8
HEALTH SCIENCES	58.3	23.5
INFORMATION & COMMUNICATION SCIENCES	73.3	29.9
INSTRUMENTS & INSTRUMENTATION	32.8	3.4
LAW & CRIMINOLOGY	76.1	44.3
MANAGEMENT & PLANNING	64.1	17.1
MATHEMATICS	71.4	33.0
MECHANICAL ENGINEERING & AEROSPACE	66.8	20.2
MULTIDISCIPLINARY JOURNALS	27.1	23.9
PHYSICS & MATERIALS SCIENCE	77.4	39.8
PSYCHOLOGY	61.0	30.0
SOCIAL & BEHAVIORAL SCIENCES	52.3	12.6
SOCIOLOGY & ANTHROPOLOGY	64.0	16.4
STATISTICAL SCIENCES	55.5	12.2
Total	66.3	30.9
Average	0.63	0.24
Std. Deviation	0.13	0.12
Coefficient of variation	0.20	0.50

Table C. Mean and maximum number of authors per article per field

	Mean (1)	Max (2)
AGRICULTURE & FOOD SCIENCE	3.5	3,072
ASTRONOMY & ASTROPHYSICS	5.3	147
BASIC LIFE SCIENCES	4.5	2,458
BASIC MEDICAL SCIENCES	4.8	3,042
BIOLOGICAL SCIENCES	3.1	1,012
BIOMEDICAL SCIENCES	4.5	854
CHEMISTRY & CHEMICAL ENG.	3.7	2,494
CIVIL ENG. & CONSTRUCTION	2.6	3,202
CLINICAL MEDICINE	4.6	815
COMPUTER SCIENCES	2.5	815
EARTH SCIENCES & TECHNOLOGY	3.1	223
ECONOMICS & BUSINESS	1.8	231
EDUCATIONAL SCIENCES	2.1	357
ELECTRICAL ENG. & TELECOMM.	3.0	370
ENERGY SCIENCE & TECHNOLOGY	3.8	150
ENVIRONMENTAL SCS. & TECH.	3.1	207
GENERAL & IND. ENGINEERING	2.5	131
HEALTH SCIENCES	3.4	69
INFORMATION & COMM. SCIENCES	1.8	174
INSTRUMENTS & INSTRUMENTATION	4.3	126
LAW AND CRIMINOLOGY	1.7	76
MANAGEMENT & PLANNING	1.8	58
MATHEMATICS	1.8	111
MECHANICAL ENG. & AEROSPACE	2.6	122
MULTIDISCIPLINARY JOURNALS	4.6	97
PHYSICS & MATERIALS SCIENCE	4.3	36
PSYCHOLOGY	2.7	51
SOCIAL & BEHAVIORAL SCIENCES	1.9	49
SOCIOLOGY & ANTHROPOLOGY	1.9	51
STATISTICAL SCIENCES	2.1	162
Average	3.1	–
Standard deviation	1.1	
Coefficient of variation	0.35	

Table D. The skewness of productivity (number of publications per person) according to the CSS approach. Average, standard deviation, and coefficient of variation over 30 fields of the percentages of individuals, and the percentages of articles by category. Total population

	Percentage of Individuals in Category:			Percentage of Articles in Category:		
	1	2	3	1	2	3
AGRICULTURE & FOOD SC.	81.4	13.6	4.9	41.3	24.8	33.9
ASTRONOMY & ASTROPHYSICS	82.0	12.9	5.1	20.8	27.5	51.7
BASIC LIFE SCIENCES	77.0	16.6	6.5	34.3	26.5	39.2
BASIC MEDICAL SCIENCES	83.1	12.4	4.6	47.3	23.6	29.1
BIOLOGICAL SCIENCES	80.1	14.5	5.5	39.6	25.8	34.6
BIOMEDICAL SCIENCES	77.8	15.6	6.6	34.2	24.9	40.9
CHEMISTRY & CHEMICAL ENG.	83.6	11.9	4.4	35.9	24.2	39.9
CIVIL ENG. & CONSTRUCTION	73.4	20.4	6.1	40.3	28.1	31.6
CLINICAL MEDICINE	83.7	11.7	4.5	34.1	24.4	41.5
COMPUTER SCIENCES	81.8	12.7	5.5	43.6	22.7	33.6
EARTH SCS. & TECHNOLOGY	76.4	16.6	7.0	30.5	25.8	43.6
ECONOMICS & BUSINESS	78.9	14.5	6.6	40.7	25.7	33.6
EDUCATIONAL SCIENCES	77.5	16.2	6.4	48.8	23.1	28.1
ELECTR. ENG. & TELECOM.	81.4	13.6	5.0	40.7	24.5	34.8
ENERGY SC. & TECHNOLOGY	80.4	13.5	6.1	41.2	23.3	35.4
ENVIRONMENTAL SCS. & TECH.	80.2	14.5	5.4	39.7	25.8	34.5
GENERAL & INDUSTRIAL ENG.	75.3	17.2	7.5	44.6	23.3	32.1
HEALTH SCIENCES	84.0	11.1	5.0	46.5	21.0	32.5
INFORMATION & COMM. SCS.	77.5	16.0	6.5	48.8	23.0	28.2
INSTR. & INSTRUMENTATION	81.5	13.6	4.8	41.0	24.4	34.6
LAW AND CRIMINOLOGY	77.6	15.4	7.0	47.1	21.3	31.6
MANAGEMENT & PLANNING	73.6	17.9	8.6	43.2	24.0	32.8
MATHEMATICS	74.2	17.3	8.5	29.9	25.4	44.7
MECH. ENG. & AEROSPACE	82.6	12.2	5.2	45.1	22.6	32.3
MULTIDISCIPLINARY JOURNALS	73.7	19.7	6.6	46.0	27.9	26.1
PHYSICS & MATERIALS SCIENCE	84.7	11.6	3.7	27.1	25.2	47.7
PSYCHOLOGY	80.5	13.8	5.7	38.5	24.1	37.4
SOCIAL & BEHAVIORAL SCS.	77.7	16.3	5.9	51.2	24.3	24.5
SOCIOLOGY & ANTHR.	75.3	17.7	7.0	47.1	25.2	27.7
STATISTICAL SCIENCES	81.3	12.7	6.0	42.3	22.4	35.2
Average	79.3	14.8	5.9	40.4	24.5	35.1
Standard Deviation	3.4	2.4	1.2	7.0	1.8	6.3
Coefficient of Variation	0.04	0.17	0.19	0.17	0.07	0.18

Category 1 = individuals with low productivity, smaller than or equal to μ_1
Category 2 = individuals with a fair productivity, between μ_1 and μ_2
Category 3 = individuals with a remarkable or outstanding productivity, above μ_2

where: μ_1 = mean of the productivity distribution;
μ_2 = mean productivity of individuals with productivity above μ_1.

Table E. Distribution of the number of publications per person for authors with above average productivity. Number of authors, first and second mean (namely μ_2 and μ_3), and skewness index.

	Number of Authors (1)	% (2)	First mean μ_2 (3)	Second mean μ_3 (4)	Skewness index (5)
AGRICULTURE & FOOD SC.	91,920	2.8	7.3	15.8	0.58
ASTRONOMY & ASTROPHYSICS	23,158	0.7	36.1	82.7	0.66
BASIC LIFE SCIENCES	435,390	13.2	7.5	15.9	0.63
BASIC MEDICAL SCIENCES	68,827	2.1	6.4	13.0	0.77
BIOLOGICAL SCIENCES	156,580	4.8	7.1	14.9	0.58
BIOMEDICAL SCIENCES	427,560	13.0	7.9	16.3	0.66
CHEMISTRY & CHEMICAL ENG.	271,829	8.3	11.8	27.0	0.69
CIVIL ENG. & CONSTRUCTION	33,448	1.0	4.1	9.4	0.54
CLINICAL MEDICINE	529,675	16.1	12.6	28.6	0.74
COMPUTER SCIENCES	75,717	2.3	6.8	13.3	0.81
EARTH SCS. & TECHNOLOGY	91,723	2.8	8.6	18.1	0.73
ECONOMICS & BUSINESS	25,911	0.8	6.4	11.5	0.47
EDUCATIONAL SCIENCES	26,261	0.8	3.6	7.0	1.00
ELECTR. ENG. & TELECOM.	93,917	2.9	7.4	16.2	0.60
ENERGY SC. & TECHNOLOGY	60,589	1.8	6.8	13.3	0.53
ENVIRONMENTAL SCS. & TECH.	122,762	3.7	7.2	15.1	0.58
GENERAL & INDUSTRIAL ENG.	37,099	1.1	3.8	7.3	1.00
HEALTH SCIENCES	65,626	2.0	6.9	13.6	0.54
INFORMATION & COMM. SCS.	9,815	0.3	3.6	6.9	1.00
INSTR. & INSTRUMENTATION	41,899	1.3	7.4	16.6	0.60
LAW AND CRIMINOLOGY	11,984	0.4	3.9	7.5	1.00
MANAGEMENT & PLANNING	19,047	0.6	3.7	6.5	0.41
MATHEMATICS	52,892	1.6	8.0	15.5	0.69
MECH. ENG. & AEROSPACE	51,799	1.6	6.7	13.3	0.80
MULTIDISCIPLINARY JOURNALS	98,931	3.0	3.3	6.3	0.97
PHYSICS & MATERIALS SCIENCE	256,345	7.8	20.4	55.2	0.76
PSYCHOLOGY	49,450	1.5	7.6	15.9	0.64
SOCIAL & BEHAVIORAL SCS.	16,607	0.5	3.3	6.3	1.00
SOCIOLOGY & ANTHR.	22,225	0.7	3.4	6.4	1.00
STATISTICAL SCIENCES	22,313	0.7	6.9	13.0	0.54
	3,291,299				
Average	109,710.0	3.3	7.9	17.0	0.72
Standard Deviation	136,570.5	4.1	6.3	15.6	0.18
Coefficient of Variation	1.2	1.2	0.80	0.92	0.25

Table F. The skewness of productivity (number of publications per person) according to the CSS approach. Average, standard deviation, and coefficient of variation over 30 Fields of the percentages of individuals, and the percentages of articles by category. Authors with above the mean productivity

	Percentage of Individuals in Category:			Percentage of Articles in Category:		
	1	2	3	1	2	3
AGRICULTURE & FOOD SC.	73.5	17.9	8.6	42.3	25.8	31.9
ASTRONOMY & ASTROPHYSICS	71.6	19.4	9.0	34.8	28.8	36.5
BASIC LIFE SCIENCES	71.8	19.1	9.1	40.4	26.6	33.0
BASIC MEDICAL SCIENCES	73.0	19.5	7.5	44.7	27.7	27.6
BIOLOGICAL SCIENCES	72.6	17.9	9.4	42.7	25.7	31.7
BIOMEDICAL SCIENCES	70.1	21.0	9.0	37.8	28.8	33.4
CHEMISTRY & CHEMICAL ENG.	72.8	19.3	7.9	37.7	28.1	34.2
CIVIL ENG. & CONSTRUCTION	76.9	16.1	7.0	47.1	24.9	28.0
CLINICAL MEDICINE	72.2	19.2	8.5	37.0	28.0	35.0
COMPUTER SCIENCES	69.6	20.9	9.5	40.3	28.0	31.7
EARTH SCS. & TECHNOLOGY	70.2	20.4	9.4	37.2	29.3	33.5
ECONOMICS & BUSINESS	68.7	20.8	10.5	43.3	27.8	28.9
EDUCATIONAL SCIENCES	71.8	21.0	7.1	45.1	28.8	26.1
ELECTR. ENG. & TELECOM.	73.3	18.8	7.9	41.3	27.4	31.3
ENERGY SC. & TECHNOLOGY	68.9	21.7	9.4	39.7	28.9	31.4
ENVIRONMENTAL SCS. & TECH.	73.0	18.8	8.2	42.8	27.5	29.6
GENERAL & INDUSTRIAL ENG.	69.8	21.7	8.5	42.0	28.3	29.7
HEALTH SCIENCES	69.0	21.3	9.7	39.2	28.0	32.8
INFORMATION & COMM. SCS.	71.2	19.2	9.6	44.9	24.9	30.2
INSTR. & INSTRUMENTATION	73.8	16.5	9.7	41.4	23.7	34.9
LAW AND CRIMINOLOGY	68.9	22.0	9.1	40.2	28.1	31.7
MANAGEMENT & PLANNING	67.6	21.7	10.7	42.2	27.8	30.0
MATHEMATICS	67.2	22.6	10.2	36.3	29.9	33.8
MECH. ENG. & AEROSPACE	70.4	20.6	9.1	41.1	27.8	31.1
MULTIDISCIPLINARY JOURNALS	74.9	18.0	7.1	51.7	25.3	23.0
PHYSICS & MATERIALS SCIENCE	75.8	17.5	6.6	34.6	27.6	37.8
PSYCHOLOGY	70.8	19.5	9.7	39.2	26.9	33.9
SOCIAL & BEHAVIORAL SCS.	73.4	18.8	7.8	49.8	26.1	24.1
SOCIOLOGY & ANTHR.	71.8	19.8	8.5	47.6	27.1	25.3
STATISTICAL SCIENCES	67.8	22.5	9.7	38.9	30.0	31.2
Average	71.4	19.8	8.8	41.4	27.4	31.1
Standard Deviation	2.4	1.7	1.1	4.1	1.5	3.5
Coefficient of Variation	0.03	0.09	0.12	0.10	0.06	0.11

Category 1 = individuals with a fair productivity, between μ_1 and μ_2
Category 2 = individuals with a remarkable productivity, between μ_2 and μ_3
Category 3 = individuals with an outstanding productivity, above μ_3

where: μ_1 = mean of the productivity distribution;
μ_2 = mean productivity of individuals with productivity above μ_1;
μ_3 = mean productivity of individuals with productivity above μ_2

Table G. The skewness of productivity (mean citation per article per person) according to the CSS approach. Average, standard deviation, and coefficient of variation over 30 Fields of the percentages of individuals, and the percentages of articles by category. Total population

	Percentage of Individuals in Category:			Percentage of Articles in Category:		
	1	2	3	1	2	3
AGRICULTURE & FOOD SC.	67.4	22.5	10.0	23.5	33.5	43.0
ASTRONOMY & ASTROPHYSICS	73.1	20.9	6.0	25.5	33.3	41.2
BASIC LIFE SCIENCES	71.5	20.8	7.7	25.7	32.1	42.2
BASIC MEDICAL SCIENCES	68.7	21.8	9.5	24.7	33.0	42.3
BIOLOGICAL SCIENCES	71.8	20.5	7.7	25.3	32.7	42.0
BIOMEDICAL SCIENCES	70.0	21.5	8.5	25.5	33.1	41.4
CHEMISTRY & CHEMICAL ENG.	71.1	20.9	8.0	24.5	33.1	42.4
CIVIL ENG. & CONSTRUCTION	69.9	20.5	9.7	21.8	32.7	45.5
CLINICAL MEDICINE	74.0	20.0	5.9	25.6	32.7	41.7
COMPUTER SCIENCES	73.2	19.5	7.3	18.0	33.4	48.6
EARTH SCS. & TECHNOLOGY	69.1	22.0	8.9	23.8	34.3	41.9
ECONOMICS & BUSINESS	71.7	19.9	8.4	22.6	32.8	44.6
EDUCATIONAL SCIENCES	71.9	19.9	8.3	23.0	33.0	44.1
ELECTR. ENG. & TELECOM.	72.5	19.9	7.6	21.4	33.2	45.5
ENERGY SC. & TECHNOLOGY	72.6	19.4	8.1	22.6	32.5	44.9
ENVIRONMENTAL SCS. & TECH.	69.6	21.3	9.1	24.8	33.5	41.7
GENERAL & INDUSTRIAL ENG.	69.4	21.4	9.2	21.8	33.9	44.3
HEALTH SCIENCES	68.0	22.2	9.8	23.4	33.9	42.7
INFORMATION & COMM. SCS.	71.3	20.3	8.4	21.4	32.9	45.7
INSTR. & INSTRUMENTATION	70.6	20.8	8.6	19.8	32.7	47.5
LAW AND CRIMINOLOGY	69.2	21.6	9.1	20.5	34.9	44.6
MANAGEMENT & PLANNING	70.8	20.2	9.0	21.9	32.6	45.5
MATHEMATICS	73.8	18.8	7.4	21.1	32.7	46.3
MECH. ENG. & AEROSPACE	70.1	21.5	8.4	21.5	34.9	43.6
MULTIDISCIPLINARY JOURNALS	75.8	17.6	6.6	19.9	31.3	48.8
PHYSICS & MATERIALS SCIENCE	73.6	19.4	7.0	22.3	32.7	45.0
PSYCHOLOGY	68.9	21.7	9.4	23.7	33.6	42.7
SOCIAL & BEHAVIORAL SCS.	69.8	20.8	9.3	23.1	33.1	43.8
SOCIOLOGY & ANTHR.	67.6	23.0	9.5	21.7	35.1	43.2
STATISTICAL SCIENCES	73.5	19.8	6.8	22.6	33.6	43.7
Average	71.0	20.7	8.3	22.8	33.2	44.0
Standard Deviation	2.1	1.2	1.1	1.9	0.8	2.0
Coefficient of Variation	0.03	0.06	0.13	0.09	0.02	0.05

Category 1 = individuals with low productivity, smaller than or equal to m_1
Category 2 = individuals with a fair productivity, between m_1 and m_2
Category 3 = individuals with a remarkable or outstanding productivity, above m_2

where: m_1 = mean of the productivity distribution;
m_2 = mean productivity of individuals with productivity above m_1.

Table H. Distribution of mean citation per article per person for authors with above average productivity. Number of authors, first and second mean (namely m_2 and m_3), and skewness index.

	Number of authors (1)	% (2)	First mean m_2 (3)	Second mean m_3 (4)	Skewness index (5)
AGRICULTURE & FOOD SC.	161,463	3.3	18.6	33.9	0.59
ASTRONOMY & ASTROPHYSICS	34,668	0.7	29.3	72.8	0.72
BASIC LIFE SCIENCES	538,677	11.1	39.0	82.2	0.66
BASIC MEDICAL SCIENCES	127,433	2.6	20.8	38.4	0.61
BIOLOGICAL SCIENCES	221,554	4.6	24.4	50.2	0.66
BIOMEDICAL SCIENCES	578,264	11.9	29.2	57.3	0.65
CHEMISTRY & CHEMICAL ENG.	479,962	9.9	25.1	50.9	0.65
CIVIL ENG. & CONSTRUCTION	37,900	0.8	14.4	26.2	0.55
CLINICAL MEDICINE	846,112	17.4	38.2	93.8	0.74
COMPUTER SCIENCES	111,769	2.3	11.3	24.6	0.70
EARTH SCS. & TECHNOLOGY	120,210	2.5	18.2	34.7	0.63
ECONOMICS & BUSINESS	34,742	0.7	17.4	33.6	0.63
EDUCATIONAL SCIENCES	32,779	0.7	14.3	27.9	0.62
ELECTR. ENG. & TELECOM.	138,853	2.9	12.6	26.2	0.70
ENERGY SC. & TECHNOLOGY	84,927	1.7	17.5	34.5	0.63
ENVIRONMENTAL SCS. & TECH.	188,231	3.9	20.3	37.5	0.58
GENERAL & INDUSTRIAL ENG.	45,926	0.9	11.4	21.5	0.64
HEALTH SCIENCES	131,002	2.7	18.4	33.4	0.56
INFORMATION & COMM. SCS.	12,539	0.3	15.6	31.0	0.59
INSTR. & INSTRUMENTATION	66,619	1.4	13.6	27.6	0.65
LAW AND CRIMINOLOGY	16,469	0.3	12.1	22.9	0.55
MANAGEMENT & PLANNING	21,064	0.4	17.8	33.8	0.57
MATHEMATICS	53,750	1.1	9.7	20.2	0.67
MECH. ENG. & AEROSPACE	88,833	1.8	12.0	23.8	0.61
MULTIDISCIPLINARY JOURNALS	91,198	1.9	162.7	362.0	0.68
PHYSICS & MATERIALS SCIENCE	440,974	9.1	21.5	47.1	0.66
PSYCHOLOGY	78,723	1.6	21.2	39.4	0.60
SOCIAL & BEHAVIORAL SCS.	22,485	0.5	18.7	34.4	0.55
SOCIOLOGY & ANTHR.	29,235	0.6	14.0	26.5	0.62
STATISTICAL SCIENCES	31,669	0.7	15.1	33.5	0.65
	4,868,030	100.0			
Average	162,268	3.3	23.8	49.4	0.63
Standard Deviation	204,500	4.2	27.2	61.6	0.05
Coefficient of Variation	1.3	1.3	1.14	1.25	0.08

Table I. The skewness of productivity (mean citation per article per person) according to the CSS approach. Average, standard deviation, and coefficient of variation over 30 Fields of the percentages of individuals, and the percentages of articles by category. Authors with above average productivity

	Percentage of Individuals in Category:			**Percentage of Articles in Category:**		
	1	**2**	**3**	**1**	**2**	**3**
AGRICULTURE & FOOD SC.	69.2	21.1	9.7	43.8	27.4	28.8
ASTRONOMY & ASTROPHYSICS	77.7	17.2	5.1	44.7	25.2	30.1
BASIC LIFE SCIENCES	73.1	19.8	7.1	43.3	27.3	29.5
BASIC MEDICAL SCIENCES	69.6	21.5	8.9	43.8	28.2	28.0
BIOLOGICAL SCIENCES	72.6	20.1	7.2	43.8	27.6	28.6
BIOMEDICAL SCIENCES	71.7	20.1	8.2	44.4	27.2	28.4
CHEMISTRY & CHEMICAL ENG.	72.3	19.8	7.9	43.8	27.2	29.0
CIVIL ENG. & CONSTRUCTION	67.9	21.9	10.2	41.8	28.8	29.4
CLINICAL MEDICINE	77.2	17.8	5.0	43.9	26.0	30.1
COMPUTER SCIENCES	72.7	19.6	7.6	40.8	27.9	31.3
EARTH SCS. & TECHNOLOGY	71.2	20.5	8.3	45.0	27.3	27.7
ECONOMICS & BUSINESS	70.2	20.6	9.1	42.4	27.8	29.8
EDUCATIONAL SCIENCES	70.7	20.3	9.1	42.8	27.4	29.8
ELECTR. ENG. & TELECOM.	72.3	20.3	7.4	42.2	28.2	29.6
ENERGY SC. & TECHNOLOGY	70.5	20.7	8.8	42.0	28.3	29.8
ENVIRONMENTAL SCS. & TECH.	70.0	21.0	9.0	44.5	27.7	27.8
GENERAL & INDUSTRIAL ENG.	69.9	20.9	9.3	43.3	27.7	28.9
HEALTH SCIENCES	69.3	21.5	9.2	44.2	28.1	27.7
INFORMATION & COMM. SCS.	70.7	20.8	8.4	41.9	28.6	29.5
INSTR. & INSTRUMENTATION	70.8	20.4	8.8	40.7	28.0	31.3
LAW AND CRIMINOLOGY	70.4	20.5	9.2	43.9	27.6	28.6
MANAGEMENT & PLANNING	69.3	21.2	9.5	41.7	28.2	30.0
MATHEMATICS	71.8	20.4	7.8	41.4	28.1	30.5
MECH. ENG. & AEROSPACE	72.0	19.5	8.5	44.5	26.8	28.7
MULTIDISCIPLINARY JOURNALS	72.6	19.0	8.3	39.1	26.9	33.9
PHYSICS & MATERIALS SCIENCE	73.5	19.5	7.0	42.1	27.7	30.2
PSYCHOLOGY	69.9	21.0	9.1	44.0	28.0	28.0
SOCIAL & BEHAVIORAL SCS.	69.1	21.6	9.3	43.0	28.3	28.7
SOCIOLOGY & ANTHR.	70.8	20.8	8.4	44.9	28.1	27.1
STATISTICAL SCIENCES	74.5	19.2	6.3	43.5	27.5	29.1
Average	71.5	20.3	8.3	43.0	27.6	29.3
Standard Deviation	2.2	1.0	1.2	1.4	0.7	1.4
Coefficient of Variation	0.03	0.05	0.15	0.03	0.03	0.05

Category 1 = individuals with a fair productivity, between m_1 and m_2
Category 2 = individuals with a remarkable productivity, between m_2 and m_3
Category 3 = individuals with an outstanding productivity, above m_3

where: m_1 = mean of the productivity distribution;
m_2 = mean productivity of individuals with productivity above m_1;
m_3 = mean productivity of individuals with productivity above m_2.

Table J. The skewness of productivity (number of publications per person) according to the CSS approach. Average, standard deviation, and coefficient of variation over 30 fields of the percentages of individuals, and the percentages of articles by category. Total population. Fractional case

	Percentage of Individuals in Category:			Percentage of Articles in Category:		
	1	2	3	1	2	3
AGRICULTURE & FOOD SC.	79.2	15.3	5.4	32.2	26.6	41.2
ASTRONOMY & ASTROPHYSICS	80.1	13.6	6.3	16.8	27.9	55.4
BASIC LIFE SCIENCES	78.5	15.6	5.9	30.3	27.5	42.2
BASIC MEDICAL SCIENCES	76.5	17.5	6.0	34.0	28.2	37.8
BIOLOGICAL SCIENCES	78.5	15.6	5.9	28.4	26.9	44.6
BIOMEDICAL SCIENCES	77.2	16.7	6.2	28.9	27.6	43.6
CHEMISTRY & CHEMICAL ENG.	82.5	13.1	4.4	28.9	25.8	45.3
CIVIL ENG. & CONSTRUCTION	75.6	17.9	6.5	33.6	26.8	39.6
CLINICAL MEDICINE	80.4	14.4	5.2	28.9	25.6	45.4
COMPUTER SCIENCES	79.5	14.8	5.7	33.7	26.5	39.9
EARTH SCS. & TECHNOLOGY	79.9	14.2	6.0	27.6	26.7	45.7
ECONOMICS & BUSINESS	73.3	18.3	8.4	28.1	28.4	43.5
EDUCATIONAL SCIENCES	70.9	22.7	6.4	29.5	35.7	34.8
ELECTR. ENG. & TELECOM.	78.0	16.6	5.4	29.7	27.2	43.1
ENERGY SC. & TECHNOLOGY	73.9	19.4	6.7	28.1	29.2	42.7
ENVIRONMENTAL SCS. & TECH.	76.0	17.4	6.6	29.1	27.9	43.0
GENERAL & INDUSTRIAL ENG.	77.8	16.0	6.2	40.2	25.6	34.2
HEALTH SCIENCES	77.5	16.7	5.8	32.5	28.8	38.7
INFORMATION & COMM. SCS.	78.3	15.7	6.1	37.9	29.0	33.0
INSTR. & INSTRUMENTATION	74.7	17.8	7.5	33.5	27.7	38.8
LAW AND CRIMINOLOGY	70.7	22.4	6.8	29.8	36.9	33.3
MANAGEMENT & PLANNING	63.7	21.1	15.2	26.5	24.7	48.8
MATHEMATICS	79.2	14.5	6.4	25.2	28.3	46.4
MECH. ENG. & AEROSPACE	76.2	17.7	6.1	29.3	27.5	43.2
MULTIDISCIPLINARY JOURNALS	68.8	22.8	8.4	32.6	31.9	35.5
PHYSICS & MATERIALS SCIENCE	82.0	13.1	4.9	25.0	25.9	49.1
PSYCHOLOGY	79.8	14.5	5.7	31.0	26.2	42.8
SOCIAL & BEHAVIORAL SCS.	71.4	18.3	10.4	30.7	27.2	42.1
SOCIOLOGY & ANTHR.	68.5	24.2	7.3	26.2	38.0	35.8
STATISTICAL SCIENCES	79.9	14.1	6.0	30.3	25.7	44.0
Average	76.3	17.1	6.7	30.0	28.3	41.8
Standard Deviation	4.4	3.0	2.0	4.2	3.2	5.1
Coefficient of Variation	0.06	0.18	0.30	0.14	0.11	0.12

Category 1 = individuals with low productivity, smaller than or equal to μ_1

Category 2 = individuals with a fair productivity, between μ_1 and μ_2

Category 3 = individuals with a remarkable or outstanding productivity, above μ_2

where: μ_1 = mean of the productivity distribution;

μ_2 = mean productivity of individuals with productivity above μ_1.

Table K. The skewness of productivity (number of publications per person) according to the CSS approach. Average, standard deviation, and coefficient of variation over 30 fields of the percentages of individuals, and the percentages of articles by category. Authors with above the mean productivity. Fractional case.

	Percentage of Individuals in Category:			**Percentage of Articles in Category:**		
	1	**2**	**3**	**1**	**2**	**3**
AGRICULTURE & FOOD SC.	73.8	18.3	7.9	39.3	26.9	33.9
ASTRONOMY & ASTROPHYSICS	68.5	20.8	10.6	33.5	30.0	36.5
BASIC LIFE SCIENCES	72.6	19.1	8.3	39.5	27.4	33.1
BASIC MEDICAL SCIENCES	74.4	18.3	7.3	42.7	26.4	30.9
BIOLOGICAL SCIENCES	72.6	18.9	8.5	37.7	27.7	34.6
BIOMEDICAL SCIENCES	73.0	18.8	8.2	38.7	27.4	33.9
CHEMISTRY & CHEMICAL ENG.	75.1	17.7	7.2	36.3	27.2	36.4
CIVIL ENG. & CONSTRUCTION	73.4	19.0	7.6	40.3	27.1	32.6
CLINICAL MEDICINE	73.5	18.5	8.1	36.1	27.8	36.1
COMPUTER SCIENCES	72.3	18.9	8.8	39.9	27.1	33.0
EARTH SCS. & TECHNOLOGY	70.3	19.9	9.8	36.8	28.5	34.6
ECONOMICS & BUSINESS	68.5	20.8	10.7	39.4	28.3	32.2
EDUCATIONAL SCIENCES	78.0	15.2	6.7	50.6	23.5	25.9
ELECTR. ENG. & TELECOM.	75.3	17.6	7.1	38.7	26.6	34.6
ENERGY SC. & TECHNOLOGY	74.3	18.3	7.4	40.6	26.9	32.5
ENVIRONMENTAL SCS. & TECH.	72.5	18.9	8.7	39.4	27.1	33.5
GENERAL & INDUSTRIAL ENG.	72.2	19.7	8.2	42.8	27.1	30.1
HEALTH SCIENCES	74.3	17.8	7.9	42.6	26.0	31.4
INFORMATION & COMM. SCS.	72.1	19.8	8.1	46.8	26.3	26.9
INSTR. & INSTRUMENTATION	70.3	20.6	9.1	41.7	26.9	31.4
LAW AND CRIMINOLOGY	76.7	15.6	7.7	52.6	21.2	26.2
MANAGEMENT & PLANNING	58.1	28.6	13.3	33.6	32.0	34.4
MATHEMATICS	69.3	20.8	9.9	37.9	29.2	32.9
MECH. ENG. & AEROSPACE	74.3	18.1	7.6	38.9	27.0	34.2
MULTIDISCIPLINARY JOURNALS	73.1	19.3	7.6	47.3	27.0	25.7
PHYSICS & MATERIALS SCIENCE	73.0	18.6	8.4	34.5	28.2	37.3
PSYCHOLOGY	71.8	19.3	8.9	37.9	27.6	34.4
SOCIAL & BEHAVIORAL SCS.	63.8	25.8	10.4	39.3	31.4	29.3
SOCIOLOGY & ANTHR.	76.8	16.0	7.2	51.5	24.0	24.5
STATISTICAL SCIENCES	70.0	20.1	9.9	36.8	28.1	35.1
Average	72.1	19.3	8.6	40.5	27.3	32.3
Standard Deviation	3.9	2.6	1.4	4.9	2.1	3.5
Coefficient of Variation	0.05	0.13	0.16	0.12	0.08	0.11

Category 1 = individuals with a fair productivity, between m_1 and m_2
Category 2 = individuals with a remarkable productivity, between m_2 and m_3
Category 3 = individuals with an outstanding productivity, above m_3

where: m_1 = mean of the productivity distribution;
m_2 = mean productivity of individuals with productivity above m_1;
m_3 = mean productivity of individuals with productivity above m_2

Table L. The skewness of productivity (mean citation per article per person) according to the CSS approach. Average, standard deviation, and coefficient of variation over 30 fields of the percentages of individuals, and the percentages of articles by category. Total population. Fractional case.

	Percentage of Individuals in Category: 1	2	3	Percentage of Articles in Category: 1	2	3
AGRICULTURE & FOOD SC.	67.7	22.2	10.0	25.9	40.1	34.0
ASTRONOMY & ASTROPHYSICS	73.3	20.6	6.1	22.3	52.8	24.9
BASIC LIFE SCIENCES	71.8	20.7	7.5	27.6	41.2	31.1
BASIC MEDICAL SCIENCES	68.8	22.1	9.2	23.3	36.6	40.0
BIOLOGICAL SCIENCES	72.2	20.2	7.6	32.4	39.4	28.1
BIOMEDICAL SCIENCES	70.2	21.4	8.4	25.7	41.5	32.8
CHEMISTRY & CHEMICAL ENG.	71.3	20.7	8.0	24.3	42.4	33.2
CIVIL ENG. & CONSTRUCTION	69.8	20.5	9.7	28.7	36.3	35.0
CLINICAL MEDICINE	74.4	19.7	5.9	30.7	48.1	21.2
COMPUTER SCIENCES	73.6	19.3	7.1	24.7	38.3	37.0
EARTH SCS. & TECHNOLOGY	69.3	21.8	8.8	21.0	45.6	33.4
ECONOMICS & BUSINESS	71.9	19.8	8.3	22.3	36.6	41.0
EDUCATIONAL SCIENCES	72.0	19.8	8.2	23.6	38.2	38.1
ELECTR. ENG. & TELECOM.	72.7	19.7	7.6	22.4	41.3	36.3
ENERGY SC. & TECHNOLOGY	73.0	19.2	7.9	25.3	38.2	36.5
ENVIRONMENTAL SCS. & TECH.	69.8	21.1	9.1	22.7	42.6	34.7
GENERAL & INDUSTRIAL ENG.	69.7	21.1	9.2	23.2	39.7	37.1
HEALTH SCIENCES	68.2	22.0	9.8	25.3	42.5	32.2
INFORMATION & COMM. SCS.	71.4	20.2	8.3	25.4	39.8	34.8
INSTR. & INSTRUMENTATION	71.3	20.5	8.2	22.5	37.7	39.8
LAW AND CRIMINOLOGY	69.3	21.7	9.1	23.1	42.0	34.9
MANAGEMENT & PLANNING	71.0	20.1	8.9	20.4	35.2	44.4
MATHEMATICS	74.1	18.6	7.4	27.7	43.3	29.0
MECH. ENG. & AEROSPACE	70.2	21.4	8.4	25.1	42.9	31.9
MULTIDISCIPLINARY JOURNALS	75.8	17.7	6.5	27.0	40.9	32.1
PHYSICS & MATERIALS SCIENCE	74.0	19.2	6.8	25.9	44.8	29.3
PSYCHOLOGY	69.2	21.5	9.3	23.2	44.3	32.6
SOCIAL & BEHAVIORAL SCS.	70.0	20.6	9.4	26.8	36.8	36.4
SOCIOLOGY & ANTHR.	67.8	22.6	9.6	22.6	36.3	41.1
STATISTICAL SCIENCES	73.7	19.6	6.8	26.7	40.5	32.9
Average	71.2	20.5	8.2	24.9	40.9	34.2
Standard Deviation	2.1	1.2	1.1	2.7	3.8	4.9
Coefficient of Variation	0.03	0.06	0.14	0.11	0.09	0.14

Category 1 = individuals with low productivity, smaller than or equal to m_1
Category 2 = individuals with a fair productivity, between m_1 and m_2
Category 3 = individuals with a remarkable or outstanding productivity, above m_2

where: m_1 = mean of the productivity distribution;
m_2 = mean productivity of individuals with productivity above m_1.

Table M. The skewness of productivity (mean citation per article per person) according to the CSS approach. Average, standard deviation, and coefficient of variation over 30 Fields of the percentages of individuals, and the percentages of articles by category. Authors with above average productivity. Fractional case.

	Percentage of Individuals in Category:			Percentage of Articles in Category:		
	1	2	3	1	2	3
AGRICULTURE & FOOD SC.	68.9	21.7	9.4	54.1	26.3	19.6
ASTRONOMY & ASTROPHYSICS	77.2	17.4	5.4	67.9	27.0	5.0
BASIC LIFE SCIENCES	73.5	19.5	7.1	57.0	26.8	16.2
BASIC MEDICAL SCIENCES	70.7	20.6	8.7	47.8	28.8	23.5
BIOLOGICAL SCIENCES	72.7	20.1	7.2	58.4	24.5	17.1
BIOMEDICAL SCIENCES	71.9	20.0	8.1	55.8	27.6	16.6
CHEMISTRY & CHEMICAL ENG.	72.1	19.9	8.0	56.1	26.9	17.0
CIVIL ENG. & CONSTRUCTION	68.0	21.9	10.1	50.9	25.7	23.4
CLINICAL MEDICINE	76.9	18.1	5.0	69.4	22.8	7.8
COMPUTER SCIENCES	73.1	19.3	7.6	50.9	27.3	21.9
EARTH SCS. & TECHNOLOGY	71.2	20.6	8.2	57.8	28.8	13.4
ECONOMICS & BUSINESS	70.4	20.4	9.2	47.2	29.9	22.9
EDUCATIONAL SCIENCES	70.7	20.8	8.6	50.1	29.3	20.6
ELECTR. ENG. & TELECOM.	72.1	20.4	7.5	53.2	26.8	20.0
ENERGY SC. & TECHNOLOGY	70.8	20.5	8.6	51.1	28.7	20.1
ENVIRONMENTAL SCS. & TECH.	69.9	21.0	9.1	55.1	28.1	16.8
GENERAL & INDUSTRIAL ENG.	69.7	21.0	9.3	51.7	27.0	21.3
HEALTH SCIENCES	69.3	21.4	9.2	56.9	26.1	17.0
INFORMATION & COMM. SCS.	70.8	20.8	8.4	53.3	26.7	20.0
INSTR. & INSTRUMENTATION	71.3	20.3	8.4	48.6	31.1	20.3
LAW AND CRIMINOLOGY	70.4	20.5	9.1	54.6	28.3	17.1
MANAGEMENT & PLANNING	69.4	21.2	9.5	44.2	30.6	25.3
MATHEMATICS	71.6	20.4	7.9	59.9	25.0	15.1
MECH. ENG. & AEROSPACE	71.9	19.7	8.5	57.3	26.2	16.5
MULTIDISCIPLINARY JOURNALS	73.3	18.8	7.9	56.0	26.5	17.5
PHYSICS & MATERIALS SCIENCE	73.7	19.4	6.9	60.4	26.1	13.4
PSYCHOLOGY	69.9	21.0	9.2	57.6	27.2	15.2
SOCIAL & BEHAVIORAL SCS.	68.7	21.8	9.4	50.3	27.2	22.5
SOCIOLOGY & ANTHR.	70.3	21.1	8.6	46.9	29.8	23.3
STATISTICAL SCIENCES	74.4	19.3	6.4	55.2	25.3	19.5
Average	71.5	20.3	8.2	54.5	27.3	18.2
Standard Deviation	2.2	1.0	1.2	5.6	1.8	4.5
Coefficient of Variation	0.03	0.05	0.15	0.10	0.07	0.25

Category 1 = individuals with a fair productivity, between m_1 and m_2
Category 2 = individuals with a remarkable productivity, between m_2 and m_3
Category 3 = individuals with an outstanding productivity, above m_3

where: m_1 = mean of the productivity distribution;
m_2 = mean productivity of individuals with productivity above m_1;
m_3 = mean productivity of individuals with productivity above m_2.

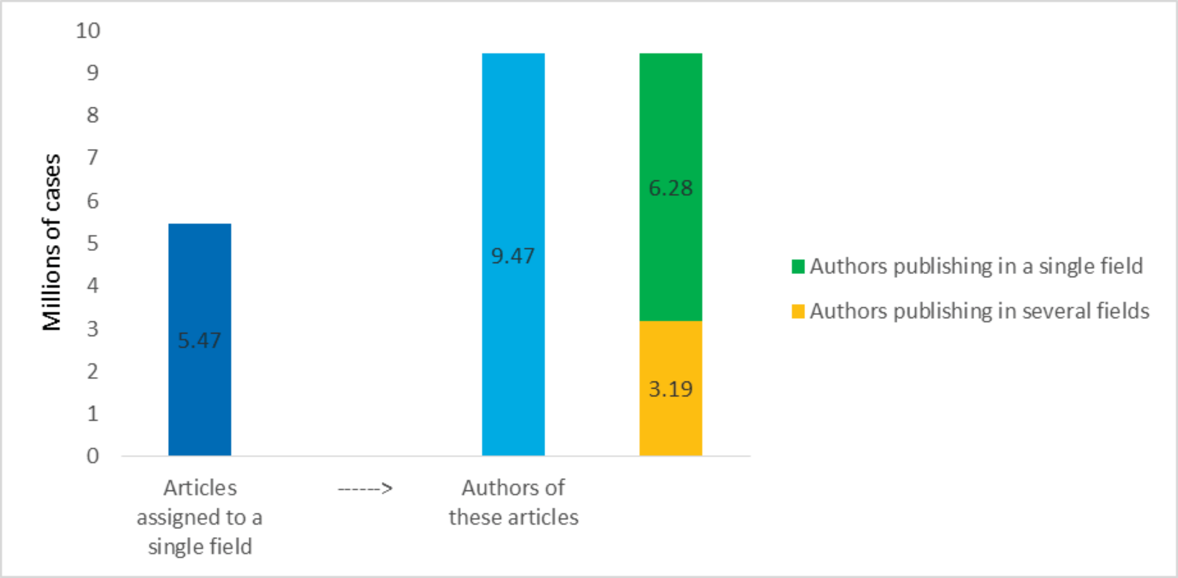

Figure 1.A. Authors (of articles assigned to a single field) who have their *oeuvre* in one or more fields

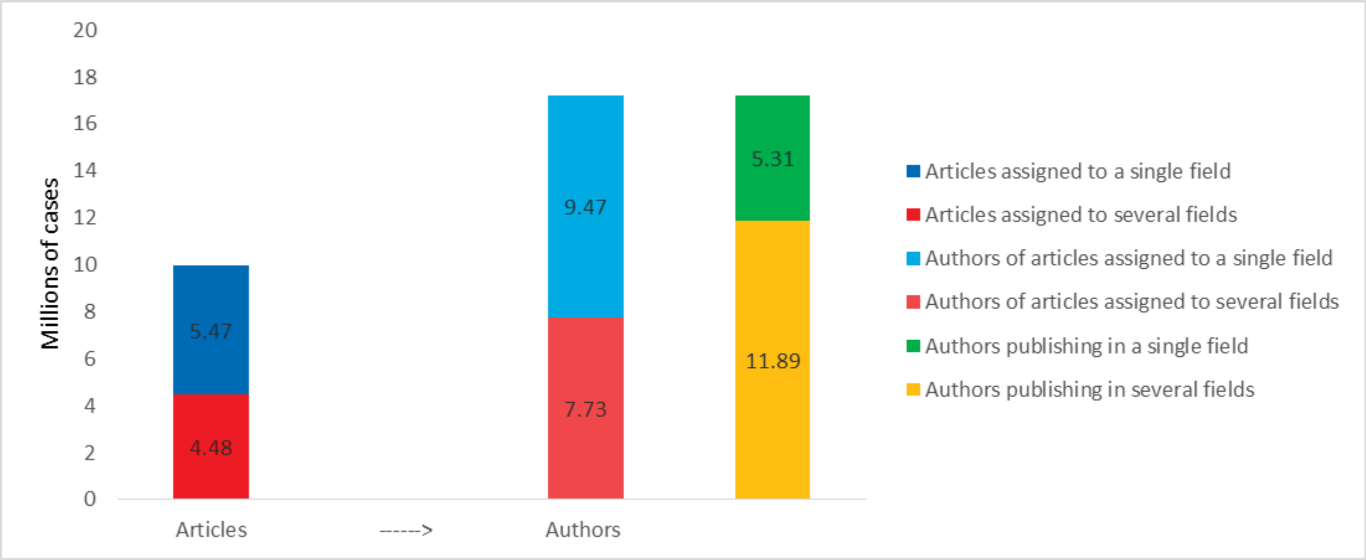

Figure 1.B. Authors (and articles in the extended count) who have their *oeuvre* in one or more fields

Table 1. Number of publications, and number of authors by scientific field

	N_f (1)	% (2)	I_f (3)	% (4)	M_f (5)	% (6)
AGRICULTURE & FOOD SCIENCE	255,252	2.46	495,525	2.88	1,136,124	2.36
ASTRONOMY & ASTROPHYSICS	128,823	1.24	128,908	0.75	1,054,833	2.19
BASIC LIFE SCIENCES	909,320	8.78	1,889,540	10.99	4,985,250	10.34
BASIC MEDICAL SCIENCES	150,859	1.46	406,529	2.36	830,230	1.72
BIOLOGICAL SCIENCES	465,373	4.49	785,341	4.57	1,851,376	3.84
BIOMEDICAL SCIENCES	914,794	8.83	1,925,259	11.19	5,104,175	10.59
CHEMISTRY & CHEMICAL ENG.	1,136,042	10.97	1,662,043	9.66	4,996,227	10.37
CIVIL ENG. & CONSTRUCTION	74,855	0.72	125,858	0.73	229,423	0.48
CLINICAL MEDICINE	1,758,929	16.98	3,258,493	18.95	10,119,951	21.00
COMPUTER SCIENCES	312,308	3.02	416,676	2.42	910,380	1.89
EARTH SCIENCES & TECHNOLOGY	293,657	2.84	388,739	2.26	1,131,675	2.35
ECONOMICS & BUSINESS	132,336	1.28	122,889	0.71	277,878	0.58
EDUCATIONAL SCIENCES	67,880	0.66	116,491	0.68	185,008	0.38
ELECTRICAL ENG. & TELECOMM.	329,914	3.19	504,441	2.93	1,170,563	2.43
ENERGY SC. & TECHNOLOGY	150,402	1.45	309,527	1.80	705,484	1.46
ENVIRONMENTAL SCS. & TECH.	394,191	3.81	619,686	3.60	1,457,305	3.02
GENERAL & INDUSTRIAL ENG.	86,279	0.83	150,233	0.87	253,651	0.53
HEALTH SCIENCES	211,818	2.05	409,315	2.38	848,596	1.76
INFORMATION & COMM. SCS.	30,679	0.30	43,614	0.25	69,200	0.14
INSTS. & INSTRUMENTATION	89,607	0.87	226,792	1.32	525,785	1.09
LAW AND CRIMINOLOGY	38,454	0.37	53,544	0.31	88,208	0.18
MANAGEMENT & PLANNING	56,627	0.55	72,120	0.42	122,934	0.26
MATHEMATICS	284,399	2.75	205,178	1.19	601,657	1.25
MECHANICAL ENG. & AEROSPACE	207,306	2.00	297,584	1.73	632,474	1.31
MULTIDISCIPLINARY JOURNALS	92,165	0.89	376,086	2.19	602,553	1.25
PHYSICS & MATERIALS SCIENCE	1,384,180	13.37	1,671,513	9.72	7,173,348	14.88
PSYCHOLOGY	186,238	1.80	253,346	1.47	613,258	1.27
SOCIAL & BEHAVIORAL SCIENCES	42,675	0.41	74,552	0.43	113,238	0.23
SOCIOLOGY & ANTHROPOLOGY	59,125	0.57	90,123	0.52	144,116	0.30
STATISTICAL SCIENCES	111,414	1.08	119,488	0.69	265,934	0.55
TOTAL	10,355,901	100.00	17,199,433	100.00	48,200,834	100.00
AVERAGE	345,197		573,314		1,606,694	
COEFFICIENT OF VARIATION	1.3		1.3		1.5	

N_f = Number of publications in field *f* in the extended count according to the multiplicative approach, where each publication is counted as many times as the number of fields to which it is assigned in the Web of Science

I_f = Number of authors in field *f*

M_f = Number of publications in field *f* in the double extended count according to the multiplicative approach, where each publication in the extended count is counted as many times as the number of its authors

Table 2. Characteristics of productivity distributions when individual productivity is defined as the number of articles per person. Total population in all fields

FIELDS	Mean (1)	% with a single publication (2)	Maximum (3)	Coefficient of Variation (4)
AGRICULTURE & FOOD SCIENCE	2.29	68.2	247	1.81
ASTRONOMY & ASTROPHYSICS	8.18	51.6	418	2.72
BASIC LIFE SCIENCES	2.64	63.4	419	1.84
BASIC MEDICAL SCIENCES	2.04	69.6	337	1.66
BIOLOGICAL SCIENCES	2.36	66.7	216	1.68
BIOMEDICAL SCIENCES	2.65	64.8	386	1.90
CHEMISTRY & CHEMICAL ENG.	3.01	65.5	687	2.48
CIVIL ENG. & CONSTRUCTION	1.82	73.4	120	1.47
CLINICAL MEDICINE	3.11	66.8	623	2.47
COMPUTER SCIENCES	2.18	68.3	216	1.65
EARTH SCIENCES & TECH.	2.91	63.9	286	1.88
ECONOMICS & BUSINESS	2.26	65.8	84	1.38
EDUCATIONAL SCIENCES	1.59	77.5	142	1.30
ELECTRICAL ENG. & TELECOM.	2.32	68.3	232	1.91
ENERGY SCIENCE & TECH.	2.28	66.9	182	1.66
ENVIRONMENTAL SCS. & TECH.	2.35	67.1	274	1.74
GENERAL & INDUSTRIAL ENG.	1.69	75.3	98	1.34
HEALTH SCIENCES	2.07	71.5	183	1.73
INFORMATION & COMM. SCS.	1.59	77.5	107	1.28
INSTS. & INSTRUMENTATION	2.32	68.0	101	1.72
LAW AND CRIMINOLOGY	1.65	77.6	97	1.41
MANAGEMENT & PLANNING	1.70	73.6	64	1.12
MATHEMATICS	2.93	60.8	336	1.83
MECH. ENG. & AEROSPACE	2.13	69.3	215	1.66
MULTIDISCIPLINARY JOURNALS	1.60	73.7	99	1.06
PHYSICS & MATERIALS SCIENCE	4.29	65.1	1,547	3.64
PSYCHOLOGY	2.42	67.7	224	1.83
SOCIAL & BEHAVIORAL SCS.	1.52	77.7	39	1.02
SOCIOLOGY & ANTHROPOLOGY	1.60	75.3	53	1.06
STATISTICAL SCIENCES	2.23	68.4	224	1.64
Average	2.46	69.0	275.20	1.73
		0.08		
Coefficient of Variation	0.50	68.2	1.04	0.31

Table 3. The skewness of two types of productivity distributions according to the CSS approach. Average, standard deviation, and coefficient of variation over 30 fields of the percentages of individuals, and the percentages of articles (or citations) by category

Individual productivity = number of articles per person

	Percentage of people in category: 1	2	3	Percentage of articles in category: 1	2	3
I. Total population						
Average (Std. dev.)	79.3 (3.4)	14.8 (2.4)	5.9 (1.2)	40.4 (7.0)	24.5 (1.8)	35.1 (6.3)
Coeff. of variation	0.04	0.17	0.19	0.17	0.07	0.18
II. Successful authors with above average productivity						
Average (Std. dev.)	71.4 (2.4)	19.8 (1.7)	8.8 (1.1)	41.4 (7.0)	27.4 (1.5)	31.1 (3.5)
Coeff. of variation	0.03	0.09	0.12	0.10	0.06	0.11

Individual productivity = mean citation per article per person

	Percentage of people in category: 1	2	3	Percentage of total mean citations in category: 1	2	3
III. Total population						
Average (Std. dev.)	71.0 (2.1)	20.7 (1.2)	8.3 (1.1)	22.8 (1.9)	33.2 (0.8)	44.0 (2.0)
Coeff. of variation	0.03	0.06	0.13	0.09	0.02	0.05

IV. Successful authors with above average productivity				Percentage of total mean citations in category: 1	2	3
Average (Std. dev.)	71.0 (2.2)	20.3 (1.0)	8.3 (1.2)	43.0 (1.4)	27.6 (0.7)	29.3 (1.4)
Coeff. of variation	0.03	0.06	0.13	0.03	0.03	0.05

	Percentage of citations in category: 1	2	3
V. Total population			
Average (Std. dev.)	22.6 (3.1)	40.2 (3.7)	37.2 (4.6)
Coeff. of variation	0.14	0.09	0.12
VI. Total population			
Average (Std. dev.)	52.0 (5.0)	27.7 (1.8)	20.3 (3.7)
Coeff. of variation	0.10	0.06	0.18

Total population, Row I (same interpretation for Row III substituting m_1 and m_2 for μ_1 and μ_2)
Category 1 = people with a low productivity, below μ_1 (mean productivity)
Category 2 = people with a fair productivity, above μ_1 and below μ_2 (mean productivity of people with productivity above μ_1)
Category 3 = people with a remarkable or outstanding productivity, above μ_2

Successful population, Row II (same interpretation for Row IV substituting m_3 for μ_3)
Category 1 = people with a fair productivity, between μ_1 and μ_2
Category 2 = people with a remarkable productivity, between μ_2 and μ_3
Category 3 = people with outstanding productivity, above μ_3

Previous results for citation distributions in a comparable case:

VII. Articles published in 1998-2002 in 219 sub-fields with a fixed, five-year citation window. Table 1, in Albarrán *et al.* (2011):

Percentage of articles in category: 1	2	3	Percentage of citations in category: 1	2	3
68.6 (3.7)	-	10.0 (1.7)	29.1 (1.6)	-	44.9 (4.6)
0.05		0.17	0.05		0.10

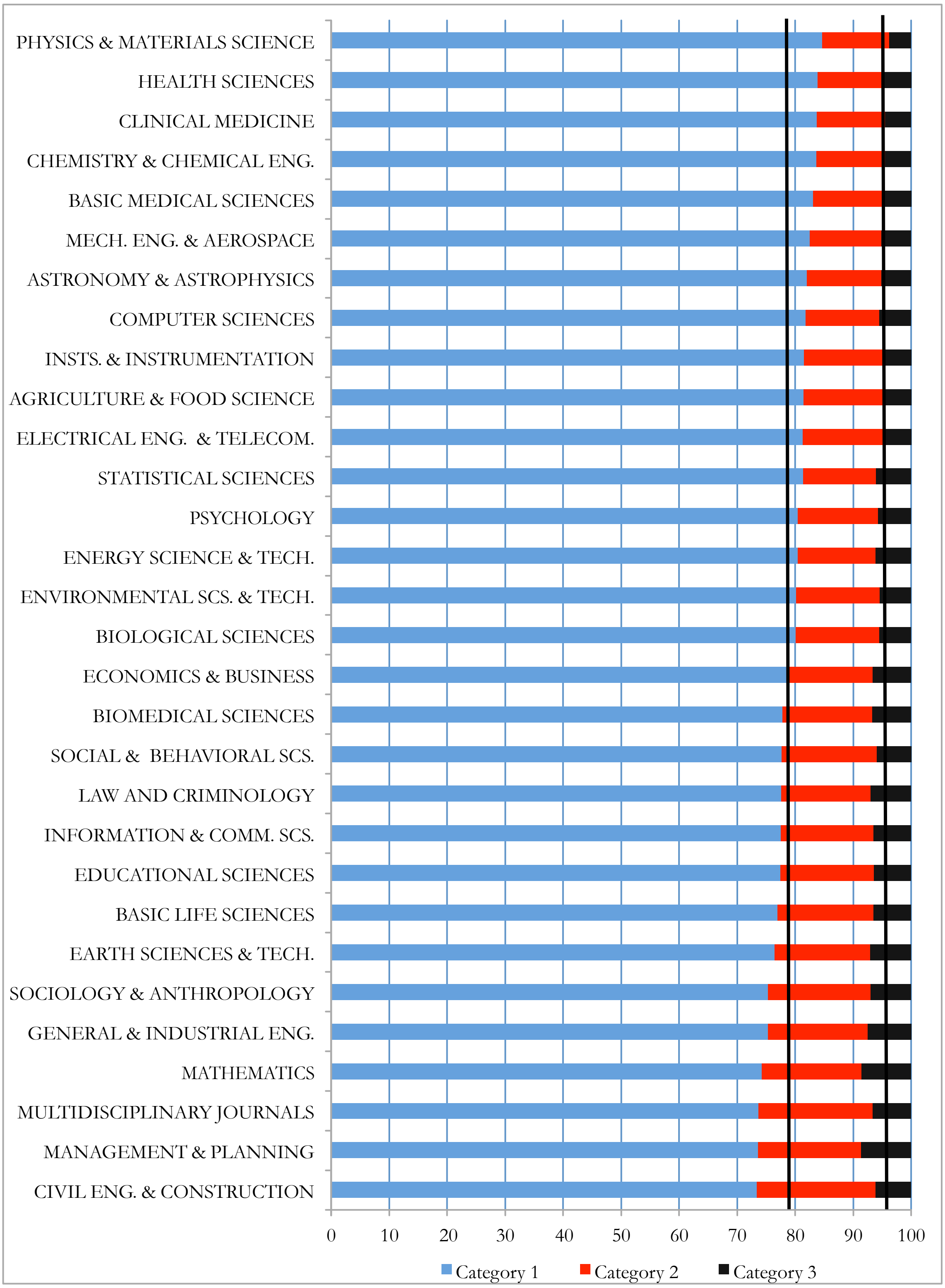

Figure 2. Partition of productivity distributions into three categories according to the CSS technique. Productivity = number of articles per person. Population as a whole

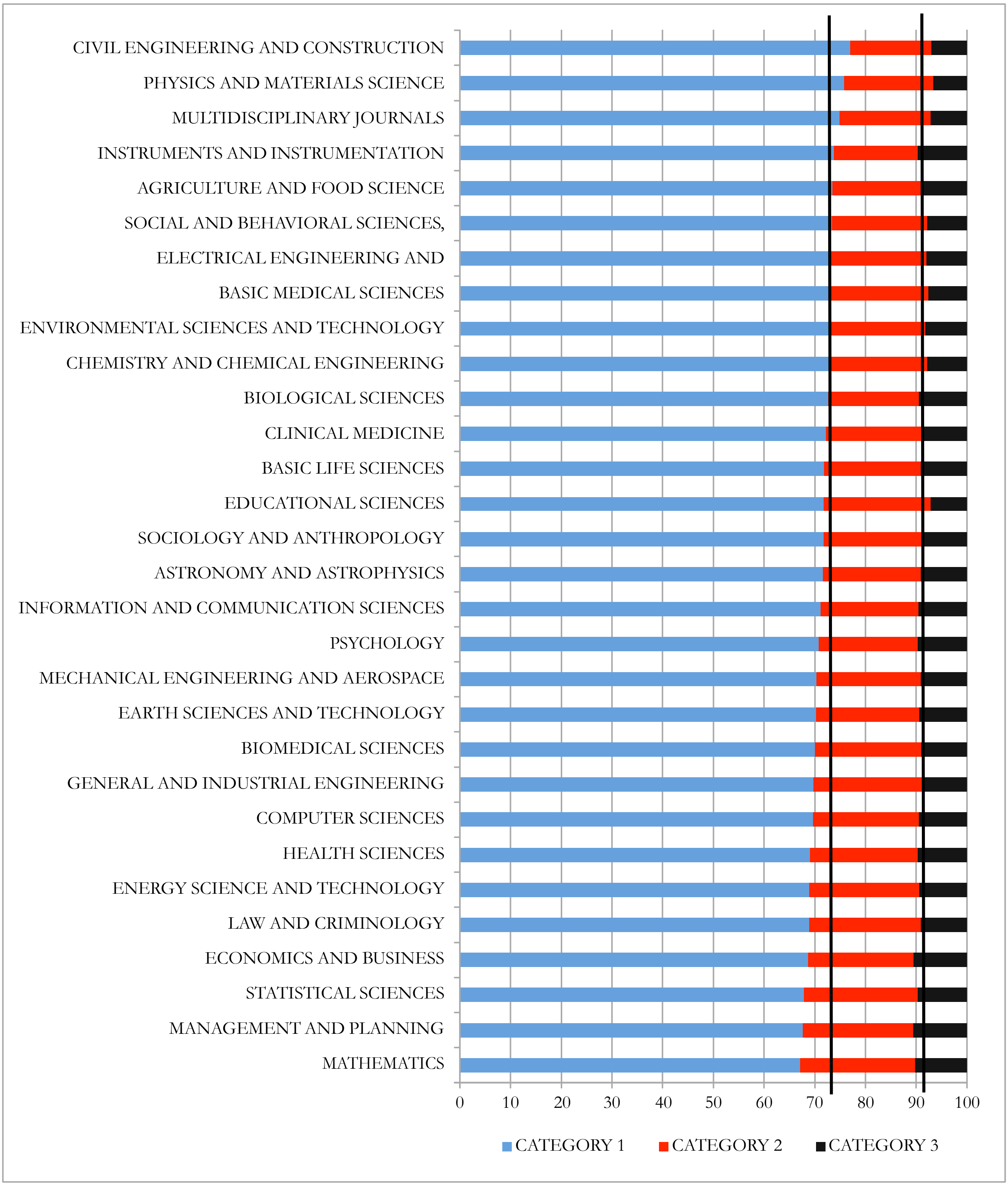

Figure 3. Partition of productivity distributions into three categories according to the CSS technique. Productivity = number of articles per person. Successful authors with above average productivity

Table 4. Characteristics of productivity distributions when individual productivity is defined as the mean citation per article per person. Total population in all fields

	Mean (1)	% uncited articles (2)	Maximum (3)	Coefficient of Variation (4)	Skewness index (5)
AGRICULTURE & FOOD SCIENCE	7.9	12.2	778	1.52	0.60
ASTRONOMY & ASTROPHYSICS	10.6	11.4	2,323	3.18	0.65
BASIC LIFE SCIENCES	15.0	6.7	5,037	2.27	0.63
BASIC MEDICAL SCIENCES	8.7	11.0	1,078	1.70	0.54
BIOLOGICAL SCIENCES	9.2	11.9	5,668	2.73	0.61
BIOMEDICAL SCIENCES	11.8	8.5	2,368	1.82	0.62
CHEMISTRY & CHEMICAL ENG.	9.6	11.6	3,647	2.11	0.59
CIVIL ENG. & CONSTRUCTION	5.5	20.4	260	1.61	0.54
CLINICAL MEDICINE	13.3	9.2	5,545	2.90	0.67
COMPUTER SCIENCES	3.7	32.3	625	2.44	0.79
EARTH SCIENCES & TECHNOLOGY	7.4	14.6	1,780	1.97	0.57
ECONOMICS & BUSINESS	6.3	18.5	1,065	1.92	0.62
EDUCATIONAL SCIENCES	5.2	21.4	777	1.87	0.72
ELECTRICAL ENG. & TELECOM.	4.4	25.0	943	2.35	0.62
ENERGY SCIENCE & TECHNOLOGY	6.2	18.8	557	1.93	0.60
ENVIRONMENTAL SCS. & TECH.	8.2	12.5	2,378	1.69	0.62
GENERAL & INDUSTRIAL ENG.	4.5	22.7	274	1.67	0.66
HEALTH SCIENCES	7.7	13.6	1,524	1.61	0.60
INFORMATION & COMM. SCIENCES	5.7	20.7	630	2.04	0.65
INSTR. & INSTRUMENTATION	5.0	21.5	1,791	2.32	0.69
LAW AND CRIMINOLOGY	4.7	23.4	176	1.68	0.67
MANAGEMENT & PLANNING	6.7	18.6	647	1.82	0.65
MATHEMATICS	3.2	29.6	1,057	2.49	0.77
MECHANICAL ENG. & AEROSPACE	4.6	22.8	545	1.91	0.66
MULTIDISCIPLINARY JOURNALS	49.3	6.3	8,483	2.38	0.79
PHYSICS & MATERIALS SCIENCE	7.3	19.1	3,022	2.89	0.68
PSYCHOLOGY	8.6	12.8	1,049	1.62	0.60
SOCIAL & BEHAVIORAL SCIENCES	7.3	16.0	540	1.66	0.55
SOCIOLOGY & ANTHROPOLOGY	5.8	17.7	724	1.81	0.59
STATISTICAL SCIENCES	5.2	22.4	3,268	4.43	0.71
TOTAL					
--					
Average	8.6	17.1	1,952	2.14	0.64
Coefficient of Variation	0.95	0.38	1.01	0.29	0.10

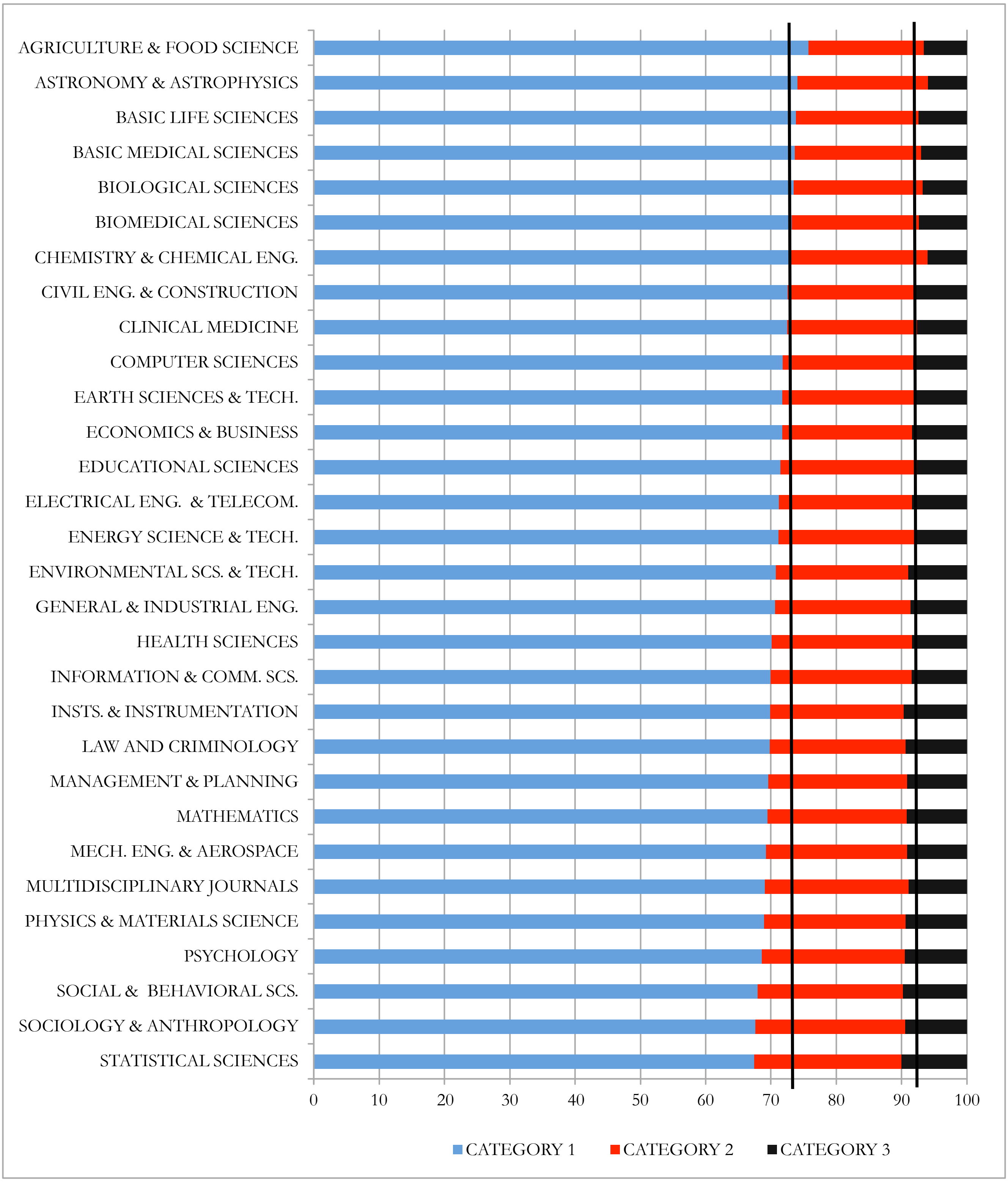

Figure 4. Partition of productivity distributions into three categories according to the CSS technique. Productivity = mean citation per article per person. Population as a whole

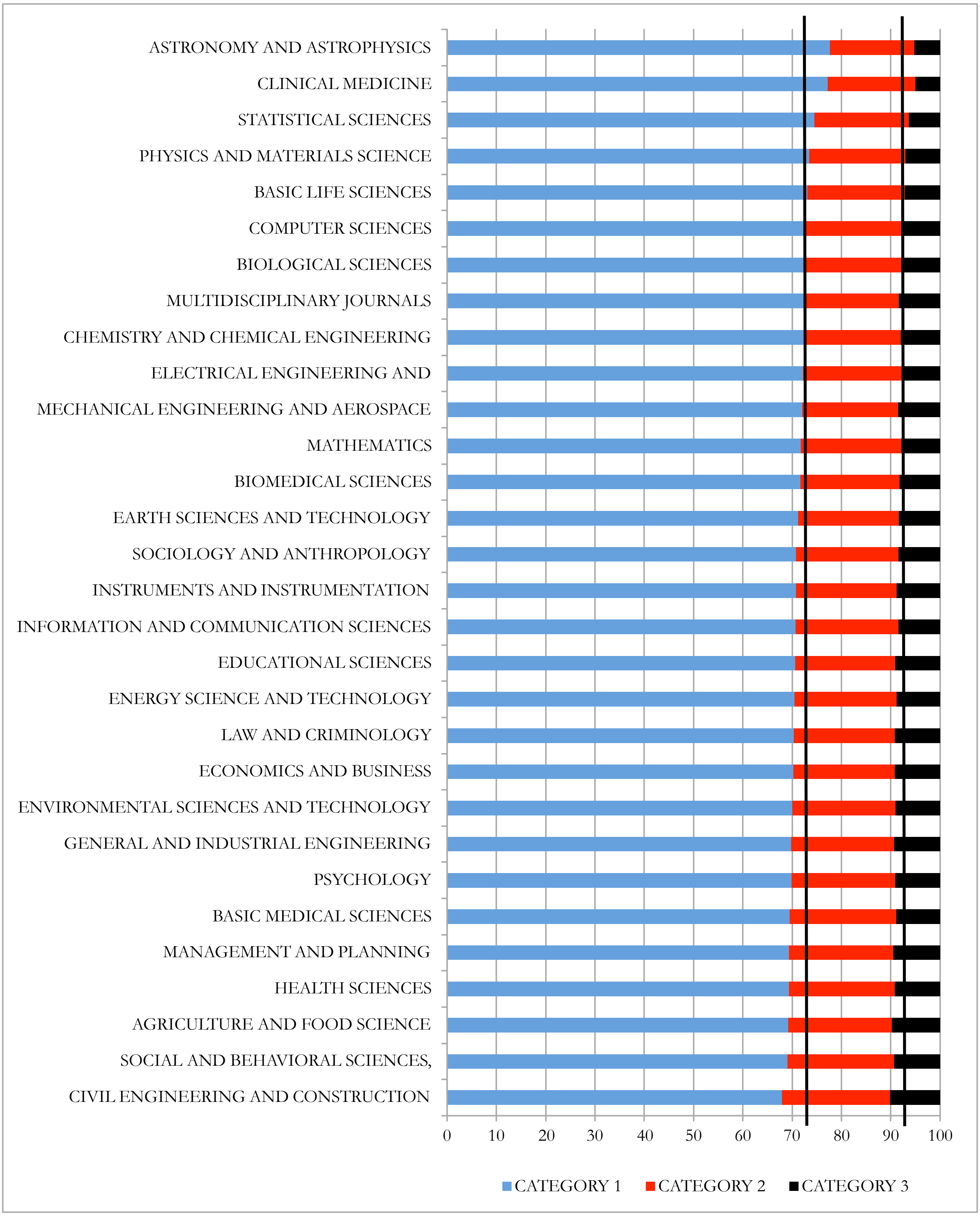

Figure 5. Partition of productivity distributions into three categories according to the CSS technique. Productivity = mean citation per article per person. Successful authors with above average productivity

Table 5. Comparison of individual productivities across fields. Mean field productivity ratios taking Chemistry & Chemical Engineering as the reference field for the two productivity measures (number of articles per person, and mean citation per article per person)

	Number of articles per person			Mean citation per article per person		
	μ_1	μ_2	μ_3	m_1	m_2	m_3
AGRICULTURE & FOOD SCIENCE	7.6	6.2	5.8	8.3	7.4	6.7
ASTRONOMY & ASTROPHYSICS	27.2	30.6	30.6	11.1	11.7	14.3
BASIC LIFE SCIENCES	8.8	6.4	5.9	15.6	15.6	16.2
BASIC MEDICAL SCIENCES	6.8	5.4	4.8	9.0	8.3	7.5
BIOLOGICAL SCIENCES	7.8	6.1	5.5	9.6	9.8	9.9
BIOMEDICAL SCIENCES	8.8	6.7	6.0	12.3	11.6	11.3
CHEMISTRY & CHEMICAL ENG.	10.0	10.0	10.0	10.0	10.0	10.0
CIVIL ENG. & CONSTRUCTION	6.1	3.5	3.5	5.8	5.8	5.1
CLINICAL MEDICINE	10.3	10.7	10.6	13.9	15.2	18.4
COMPUTER SCIENCES	7.3	5.7	4.9	3.9	4.5	4.8
EARTH SCIENCES & TECH.	9.7	7.3	6.7	7.7	7.3	6.8
ECONOMICS & BUSINESS	7.5	5.4	4.3	6.6	6.9	6.6
EDUCATIONAL SCIENCES	5.3	3.1	2.6	5.5	5.7	5.5
ELECTRICAL ENG. & TELECOM.	7.7	6.3	6.0	4.6	5.0	5.1
ENERGY SCIENCE & TECH.	7.6	5.8	4.9	6.5	7.0	6.8
ENVIRONMENTAL SCS. & TECH.	7.8	6.1	5.6	8.6	8.1	7.4
GENERAL & INDUSTRIAL ENG.	5.6	3.2	2.7	4.7	4.6	4.2
HEALTH SCIENCES	6.9	5.9	5.0	8.0	7.3	6.6
INFORMATION & COMM. SCS.	5.3	3.1	2.6	6.0	6.2	6.1
INSTR. & INSTRUMENTATION	7.7	6.3	6.1	5.2	5.4	5.4
LAW AND CRIMINOLOGY	5.5	3.3	2.8	4.9	4.8	4.5
MANAGEMENT & PLANNING	5.7	3.1	2.4	7.0	7.1	6.7
MATHEMATICS	9.8	6.8	5.7	3.4	3.9	4.0
MECHANICAL ENG. & AEROSPACE	7.1	5.7	4.9	4.8	4.8	4.7
MULTIDISCIPLINARY JOURNALS	5.3	2.8	2.3	51.4	64.9	71.2
PHYSICS & MATERIALS SCIENCE	14.3	17.3	20.4	7.6	8.6	9.3
PSYCHOLOGY	8.1	6.5	5.9	9.0	8.5	7.7
SOCIAL & BEHAVIORAL SCS.	5.1	2.8	2.3	7.7	7.5	6.8
SOCIOLOGY & ANTHROPOLOGY	5.3	2.9	2.4	6.1	5.6	5.2
STATISTICAL SCIENCES	7.4	5.8	4.8	5.4	6.0	6.6

μ_1 = Mean of the distribution where productivity is measured as the number of articles per person

μ_2 = Mean productivity for individuals whose productivity is above μ_1

μ_3 = Mean productivity for individuals whose productivity is above μ_2

m_1 = Mean of the productivity distribution where productivity is measured as the mean citation per article per person

m_2 = Mean productivity for individuals whose productivity is above m_1

m_3 = Mean productivity for individuals whose productivity is above m_2

Table 6. The skewness of two types of productivity distributions according to the CSS approach. Average, standard deviation, and coefficient of variation over 30 fields of the percentages of individuals, and the percentages of articles (or citations) by category. Fractional case.

	Individual productivity = number of articles per person					
	Percentage of people in category:			Percentage of articles in category:		
	1	2	3	1	2	3
I. Total population						
Average (Std. dev.)	76.3 (4.4)	17.1 (3.0)	6.7 (2.0)	30.0 (4.2)	28.3 (1.8)	41.8 (5.1)
Coeff. of variation	0.06	0.18	0.30	0.14	0.11	0.12
II. Successful authors with above average productivity						
Average (Std. dev.)	72.1 (3.9)	19.3 (2.6)	8.6 (1.4)	40.5 (4.9)	27.3 (2.1)	32.3 (3.5)
Coeff. of variation	0.06	0.13	0.16	0.12	0.08	0.11

	Individual productivity = mean citation per article per person					
	Percentage of people in category:			Percentage of citations in category:		
	1	2	3	1	2	3
III. Total population						
Average (Std. dev.)	71.2 (2.1)	20.5 (1.2)	8.2 (1.1)	24.9 (2.7)	40.9 (3.8)	34.2 (4.9)
Coeff. of variation	0.03	0.06	0.14	0.11	0.09	0.14
IV. Successful authors with above average productivity						
Average (Std. dev.)	71.5 (2.2)	20.3 (1.0)	8.2 (1.2)	54.5 (5.6)	27.3 (1.8)	18.2 (4.5)
Coeff. of variation	0.03	0.05	0.15	0.10	0.07	0.25

Total population, Row I (same interpretation for Row III substituting m_1 and m_2 for μ_1 and μ_2)
Category 1 = people with a low productivity, below μ_1 (mean productivity)
Category 2 = people with a fair productivity, above μ_1 and below μ_2 (mean productivity of people with productivity above μ_1)
Category 3 = people with a remarkable or outstanding productivity, above μ_2

Successful population, Row II (same interpretation for Row IV substituting m_3 for μ_3)
Category 1 = people with a fair productivity, between μ_1 and μ_2
Category 2 = people with a remarkable productivity, between μ_2 and μ_3
Category 3 = people with outstanding productivity, above μ_3

Table 7. Comparison of individual productivities across fields. Mean field productivity ratios taking Chemistry & Chemical Engineering as the reference field for the two productivity measures (number of articles per person, and mean citation per article per person). Fractional case.

	Number of articles per person			Mean citation per article per person		
	μ_1	μ_2	μ_3	m_1	m_2	m_3
AGRICULTURE & FOOD SCIENCE	7.2	5.8	5.2	8.3	7.5	6.7
ASTRONOMY & ASTROPHYSICS	16.4	16.9	14.0	10.6	11.2	13.4
BASIC LIFE SCIENCES	7.0	5.5	4.8	15.4	15.3	16.0
BASIC MEDICAL SCIENCES	4.2	2.9	2.5	9.1	8.4	7.8
BIOLOGICAL SCIENCES	8.3	6.8	6.1	9.5	9.7	9.9
BIOMEDICAL SCIENCES	6.6	5.0	4.5	12.2	11.6	11.3
CHEMISTRY & CHEMICAL ENG.	10.0	10.0	10.0	10.0	10.0	10.0
CIVIL ENG. & CONSTRUCTION	6.5	4.3	3.8	5.8	5.7	5.1
CLINICAL MEDICINE	9.1	8.1	7.6	13.6	14.9	18.0
COMPUTER SCIENCES	10.8	8.6	7.3	3.8	4.5	4.9
EARTH SCIENCES & TECH.	11.8	10.4	8.7	7.6	7.2	6.8
ECONOMICS & BUSINESS	16.9	11.2	8.4	6.6	6.9	6.6
EDUCATIONAL SCIENCES	8.2	4.9	4.3	5.5	5.7	5.5
ELECTRICAL ENG. & TELECOM.	8.5	6.7	6.5	4.6	5.0	5.1
ENERGY SCIENCE & TECH.	4.9	3.3	3.0	6.4	6.9	6.8
ENVIRONMENTAL SCS. & TECH.	8.8	6.4	5.5	8.5	8.1	7.4
GENERAL & INDUSTRIAL ENG.	5.4	3.6	2.9	4.7	4.6	4.2
HEALTH SCIENCES	7.2	5.3	4.6	8.0	7.3	6.6
INFORMATION & COMM. SCS.	10.0	7.1	5.3	5.9	6.2	6.1
INSTR. & INSTRUMENTATION	3.6	2.3	1.8	5.1	5.4	5.4
LAW AND CRIMINOLOGY	11.8	6.9	5.5	4.9	4.8	4.5
MANAGEMENT & PLANNING	9.8	4.9	3.0	6.9	7.1	6.7
MATHEMATICS	22.2	19.6	15.6	3.4	3.9	4.0
MECHANICAL ENG. & AEROSPACE	9.1	6.7	6.2	4.8	4.8	4.7
MULTIDISCIPLINARY JOURNALS	4.9	2.6	2.0	49.7	62.5	69.9
PHYSICS & MATERIALS SCIENCE	13.1	13.4	12.7	7.5	8.5	9.3
PSYCHOLOGY	11.3	9.5	8.2	9.0	8.4	7.8
SOCIAL & BEHAVIORAL SCS.	7.0	4.2	2.7	7.7	7.5	6.8
SOCIOLOGY & ANTHROPOLOGY	8.6	5.0	4.1	6.1	5.6	5.2
STATISTICAL SCIENCES	11.3	9.6	7.9	5.4	6.0	6.6

μ_1 = Mean of the distribution where productivity is measured as the number of articles per person

μ_2 = Mean productivity for individuals whose productivity is above μ_1

μ_3 = Mean productivity for individuals whose productivity is above μ_2

m_1 = Mean of the productivity distribution where productivity is measured as the mean citation per article per person

m_2 = Mean productivity for individuals whose productivity is above m_1

m_3 = Mean productivity for individuals whose productivity is above m_2