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Source: *The Journal of Finance*, Vol. 45, No. 1 (Mar., 1990), pp. 301-309
Published by: Blackwell Publishing for the American Finance Association
Stable URL: http://www.jstor.org/stable/2328824
Accessed: 26/11/2009 07:15

THE JOURNAL OF FINANCE • VOL. XLV, NO. 1 • MARCH 1990

Patterns of Productivity in the Finance Literature: A Study of the Bibliometric Distributions

KEE H. CHUNG and RAYMOND A. K. COX*

ABSTRACT

This study finds a bibliometric regularity in the finance literature that the number of authors publishing n papers is about $1/n^c$ of those publishing one paper. We find that the finance literature conforms very well to the inverse square law ($c = 2$) if data are taken from a large collection of journals. When applied to individual finance journals, we find that values of c range from 1.95 to 3.26. We also find that top-rated journals have higher concentrations among their contributors. This implies that the phenomenon "success breeds success" is more common in higher quality publications.

IT IS FREQUENTLY OBSERVED in bibliometric matters and in various social phenomena that success breeds success. A frequently cited paper is more likely to be cited again than one little cited. An author of many papers is more likely to publish again than one who has published little. A journal which has been frequently consulted is more likely to be consulted again than one of previously infrequent use. This is analogous to the folk saying "the rich get richer and the poor get poorer".

Lotka's law of scientific productivity is an example of such empirical laws. Lotka (1926) proposes an inverse square law relating authors of scientific papers to the number of papers written by each author. Specifically, using data in the decennial index of *Chemical Abstracts* and in the name index of Auerbach's *Geschichtstafeln der Physik*, Lotka plots the number of authors against the number of contributions made by each author on a logarithmic scale. Lotka finds that the points are closely scattered around a straight line having a slope of approximately negative two. On the basis of this empirical observation Lotka concludes the following.

> In the cases examined, it is found that the number of persons making 2 contributions is about one-fourth of those making one; the number making 3 contributions is about one-ninth, etc.; the number making n contributions is about $1/n^2$ of those making one; and of all contributors, the proportion that make a single contribution, is about 60 percent.

Thus, Lotka's empirical finding can be summarized by the equation:

$$a_n = a_1/n^2, \; n = 1, 2, 3, \cdots, \tag{1}$$

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where

a_n = the number of authors publishing n papers and
a_1 = the number of authors publishing one paper.

Numerous studies have examined the institutional and individual sources of financial research. Henry and Burch (1974), Klemkosky and Tuttle (1977), Ederington (1979), Heck, Cooley, and Hubbard (1986), Niemi (1987), and Heck and Cooley (1988) have identified institutional contributions to finance journals. Klemkosky and Tuttle (1977), Schweser (1977), and Heck, Cooley, and Hubbard (1986) have documented the doctoral origins of the authors. Heck, Cooley, and Hubbard (1986) and Heck and Cooley (1988) have identified the individuals who conduct the research.

However, none of these studies has examined whether the pattern of productivity in the finance literature conforms to the well known empirical regularity, such as Lotka's Law, which has been observed in the literature of other academic disciplines.[1] The purpose of this paper is to examine whether there exist bibliometric regularities, such as Lotka's inverse square law and its variants, in the finance literature.

The paper is organized as follows. Section I presents a brief review of the theory of the bibliometric distributions developed since the publication of Lotka's study. Section II presents empirical findings on Lotka's Law in the finance literature. Section III presents empirical findings on the generalized Lotka's Law. Finally, Section IV is a conclusion.

I. A Brief Look at the Theory of the Bibliometric Distributions

Given the ubiquity of the bibliometric distributions and the quantity of literature discussing them, some studies have attempted to find why such distributions occur in the first place and their important analytical properties. Deterministic theorization of the bibliometric distributions has been presented by Mandelbrot (1954) and Bookstein (1977), and stochastic theorization has been offered by Simon (1955) and Price (1976), among others.

Using a model of word storage in the human mind and information theoretic considerations, Mandelbrot (1954) suggests that the number of publications of

[1] Since the publication of Lotka's paper, numerous authors have attempted to apply Lotka's Law to the literature of various disciplines. While in some studies Lotka's inverse square law holds (e.g., Murphy (1973) in humanities and Schorr (1975) in map librarianship), in others it does not. Voos (1974) finds that for the information science literature a new exponent of 3.5 gives the best fit with empirical data. Schorr (1974) finds that Lotka's inverse square law is not applicable to the literature of library science and proposes an inverse quadruple law whereby, for each 100 contributors of a single article, about six will contribute two papers, about one will contribute three papers, etc. Worthen (1978) reports that Lotka's Law does not fit the literature in medicine. Radhakrishnan and Kernizan (1979) find that Lotka's Law does not apply well to computer science literature. They find that an exponent of 3 gives the best fit. In a subsequent study, however, Subramanyam (1979) argues that the computer science literature does conform to Lotka's inverse square law if data are taken from a large collection of journals.

the rth ranking author, $f(r)$, is proportional to $1/(1 + \beta r)\tau$, where β and τ are constants. Bookstein (1977), taking a very different route, suggests that the number of authors publishing n papers is proportional to $1/n^c$, where c is a constant. It is interesting to note that, for $\tau = 1$ or $c = 2$, these distributions are simplified to Lotka's Law.[2] Thus, Lotka's Law is a special case of the forms derived by Mandelbrot and Bookstein on theoretical grounds.

Simon (1955) proposes a stochastic model which, among other things, implies that the number of authors with n publications is proportional to $1/[n(n + 1)(n + 2)\cdots(n + k - 1)]$ for some integer k or, more generally, to $\Gamma(n)/\Gamma(n + c)$, where c is a constant. Note that, if n is much larger than c, $\Gamma(n)/\Gamma(n + c) \approx 1/n^c$, which is the same result as Bookstein's.

Finally, Price (1976) suggests that the "cumulative advantage distribution" which can be derived from a modification of the Polya Urn model (see Feller (1968))[3] provides a sound conceptual basis for the statistical modeling of the situation in which "success breeds success". Price shows that such a stochastic law is governed by the beta function, which can be approximated by a skewed or hyperbolic distribution of the type that is widespread in bibliometric and diverse social science phenomena. In particular, this is shown to be an appropriate underlying probability theory for Lotka's Law of scientific productivity.

In sum, therefore, it seems that Lotka's Law and its variants have not only an empirical validity but also theoretical robustness since they can be derived from different sets of assumptions. The primary purpose of this paper is to examine whether Lotka's Law and its variants are also applicable to the finance literature. Specifically, we wish to test the following equation:

$$a_n = a_1/n^c, \; n = 1, 2, 3, \cdots, \tag{2}$$

where

a_n = the number of authors publishing n papers,
a_1 = the number of authors publishing one paper, and
c = a constant.

II. Empirical Evidence in the Finance Literature

A. Data Description

Data for the present study come from 15 journals which primarily publish financial research. Authorship for all articles and notes, excluding comments and

[2] See Bookstein (1977) for the proof.

[3] The Polya Urn model supposes that fate has in storage an urn containing red and black balls; at regular intervals a ball is drawn at random. At each drawing the number of balls of the color drawn is increased while that of the other color remains unchanged. Therefore, each occurrence of a red or of a black increases the probability of a further such occurrence; i.e., success (i.e., a red ball) is rewarded by an increased chance of further success, but failure (i.e., a black ball) is punished by an increased chance of further failure. The cumulative advantage distribution differs from the Polya Urn model in that success increases the chance of further success but failure has no subsequent effect in changing the probability of failure.

rejoinders, are compiled for each journal from the inaugural issue through the end of 1986.[4] Table I presents the proportion of authors by the number of publications.[5]

The table shows the difficulty of repeated publications in finance journals. Among 6,270 authors, most authors (62.2%) publish only once, and only 15.4% of authors publish more than three papers. A similar pattern is observed for individual journals. Percentages of authors with just one publication range from 64.3 for *Journal of Financial Economics* to 86.3 for *Journal of International Money and Finance.*

It is interesting to note that journals with higher citations,[6] which presumably have greater impact on the literature (i.e., *Journal of Finance*, *Journal of Financial Economics*, and *Journal of Financial and Quantitative Analysis*), have higher concentrations among their contributors. That is, percentages of authors with more than one publication in these three journals are 32.9, 35.7, and 31.3, respectively, whereas the average percentage of multiple publications for all other journals is 21.3. This indicates that the phenomenon "success breeds success" is more common in higher quality publications.

Finally, it is also interesting to note that the average percentage (76.7) of a single publication for individual journals is larger than that (62.2) for all fifteen journals as a whole, which indicates that authors tend to publish in more than one journal.

B. Tests and Findings

For the case of Lotka's Law (i.e., c = 2 in equation (2)), the theoretical frequency distribution can be found as follows. First note that

$$\sum_{i=1}^{\infty} a_i = a_1 \sum_{i=1}^{\infty} \frac{1}{i^2}. \tag{3}$$

However, we know that

$$\sum_{i=1}^{\infty} \frac{1}{i^2} = \frac{\pi^2}{6}. \tag{4}$$

[4] For an excellent documentation of authorship for all articles and notes published in fifteen journals from their inaugural issues through the end of 1986, see Heck (1988).

[5] In the case of multiple authorship, we use the "normal count"; i.e., each author of an article received full credit. We aggregate the data for $n > 5$ for succinctness and also for a statistical reason. The chi-square test, which we perform later, requires that the expected (i.e., theoretical) number of observations in each category should be at least five. Detailed data for each journal for the case $n > 5$ are available from the authors upon request.

[6] Mabry and Sharplin (1985) evaluate the relative impact of various finance and economics journals on four major finance journals (i.e., *Journal of Finance*, *Journal of Financial Economics*, *Journal of Financial and Quantitative Analysis*, and *Journal of Money, Credit and Banking*). Specifically, they compute the frequency with which all other journals are cited in these four journals. Their finding indicates that the *Journal of Finance*, *Journal of Financial Economics*, and *Journal of Financial and Quantitative Analysis* are the most influential journals of finance.

Table I

Frequency Distribution of Authors by Number of Publications for the Period between Inaugural Years and 1986

Lotka's Law states that the number of authors publishing n papers is $1/n^2$ of those publishing one paper.

Journal (Inaugural Year)	Number of Papers	Number of Authors	Frequency Distribution in Percent					
			1	2	3	4	5	>5
Financial Analysts Journal (1945)	2,554	1,883	73.9	14.2	5.4	2.5	1.2	2.8
Financial Management (1972)	511	604	74.8	16.1	4.1	2.0	1.5	1.5
Financial Review (1966)	278	369	79.7	14.6	3.8	1.1	0.5	0.3
Journal of Bank Research(1970)	392	426	81.5	10.8	3.5	1.9	0.9	1.4
Journal of Banking and Finance (1977)	298	364	79.9	14.3	4.7	1.1	0	0
Journal of Business Finance & Accounting (1974)	630	517	75.0	16.9	4.4	1.4	1.5	0.8
Journal of Finance (1946)	2,260	1,844	67.1	16.0	7.6	3.4	2.2	3.7
Journal of Financial Economics (1974)	332	297	64.3	17.2	7.4	4.4	2.7	4.0
Journal of Financial Education (1972)	292	297	79.8	13.8	3.7	1.4	1.0	0.3
Journal of Financial and Quantitative Analysis (1966)	942	905	68.7	17.2	7.8	2.2	1.8	2.3
Journal of Financial Research (1978)	223	306	79.0	13.1	4.9	2.0	1.0	0
Journal of Futures Market (1981)	248	302	79.1	16.2	3.0	0.7	0.3	0.7
Journal of International Money & Finance (1982)	141	161	86.3	11.2	2.5	0	0	0
Journal of Money, Credit and Banking (1969)	682	685	79.6	12.3	4.9	1.8	0.7	0.7
Journal of Portfolio Management (1974)	570	587	75.5	14.1	6.0	2.2	1.5	0.7
All Journals	10,353	6,270	62.2	15.3	7.1	4.0	2.9	8.5
Lotka's Law[a]			60.8	15.2	6.8	3.8	2.4	11.0

[a] This row gives the proportions of authors predicted by Lotka's Law.

Therefore, the proportion of all contributors publishing a single paper should be

$$a_1/\left(\sum_{i=1}^{\infty} \frac{1}{i^2}\right) = \frac{6}{\pi^2} = 0.6079. \tag{5}$$

Likewise, the proportions of authors publishing two, three, $\cdots$, and n papers should be

$$a_2/\left(\sum_{i=1}^{\infty} \frac{1}{i^2}\right) = \frac{6}{\pi^2}\frac{1}{2^2} = 0.152, \tag{6}$$

$$a_3/\left(\sum_{i=1}^{\infty} \frac{1}{i^2}\right) = \frac{6}{\pi^2}\frac{1}{3^2} = 0.0675, \tag{7}$$

and

$$a_n/\left(\sum_{i=1}^{\infty} \frac{1}{i^2}\right) = \frac{6}{\pi^2}\frac{1}{n^2}. \tag{8}$$

The last two rows in Table I compare the theoretical and actual frequency distributions of publication for all fifteen journals as a whole. Notice the remarkable predictive power of Lotka's Law. In particular, it is impressive to note that the actual proportion of all authors with a single publication (62.2%) is very close to the prediction made by Lotka's Law (60.8%). When we plot the proportions of authors with n publications against the number of publications made by each author (i.e., n) on a logarithmic scale, we find that the points are closely scattered around a straight line having a slope of approximately -2.

In order to test whether Lotka's Law applies to the observed data, we perform the chi-square goodness-of-fit test. The computed chi-square statistic is 10.1, whereas the critical value with $\propto = 5\%$ from the chi-square table is 11.1. Thus, we cannot reject the null hypothesis that Lotka's Law indeed describes the frequency distribution of the publications in the finance literature as a whole.

When applied to individual journals, the results are less impressive. Table II presents the results of the chi-square test for each journal. Among fifteen journals, only the *Journal of Financial Economics* conforms to Lotka's Law with a significance level of five percent.[7] This lower explanatory power of Lotka's Law for the individual journal than that for all journals is similar to the findings of Radhakrishnan and Kernizan (1979) and Subramanyam (1979). Radhakrishnan and Kernizan find that Lotka's Law, when applied to individual journal data, does not apply well to the computer science literature. Subramanyam, however, shows that the computer science literature does conform to Lotka's inverse square law if data are taken from a large collection of journals.

[7] We also perform the Kolmogorov-Smirnov goodness-of-fit test for each journal and for all journals as a whole. The maximum deviation, $D = \max\,[\text{abs}\{F_0(X) - S_N(X)\}]$, is computed, where abs is the absolute value sign, $F_0(X)$ is the theoretical cumulative frequency distribution function, and $S_N(X)$ is the observed cumulative distribution function of a sample of N observations. Test results indicate that publication patterns of the *Journal of Finance*, *Journal of Financial Economics*, *Financial Analyst Journal*, and all journals as a whole can be well explained by Lotka's Law.

Table II

Testing Lotka's and the Generalized Lotka's Laws for Individual Journals

Lotka's Law states that the number of authors publishing n papers is $1/n^2$ of those publishing one paper, and the Generalized Lotka's Law states that $a_n = a_1/n^c$, where a_n is the number of authors publishing n papers, a_1 is the number of authors publishing one paper, and c is a constant.

Journal	Chi-Square Statistics for Lotka's Law	Generalized Lotka's Law $\log(a_n/a_1) = -c\log(n) + e$: Fitted c	F-values	R^2
Financial Analysts Journal	79.49	2.47 (5)[a]	4255.74	1.00
Financial Management	33.46	2.51 (6)	1561.99	0.99
Financial Review	39.28	3.00 (13)	786.83	0.98
Journal of Bank Research	50.31	2.79 (11)	7315.31	1.00
Journal of Banking and Finance	40.11	2.84 (12)	329.09	0.97
Journal of Business Finance & Accounting	32.09	2.57 (7)	530.37	0.97
Journal of Finance	15.63	2.10 (2)	4627.45	1.00
Journal of Financial Economics	1.93*	1.95 (1)	32821.06	1.00
Journal of Financial Education	29.14	2.78 (10)	2570.35	0.99
Journal of Financial and Quantitative Analysis	20.46	2.26 (3)	567.39	0.98
Journal of Financial Research	24.29	2.65 (8)	5862.87	1.00
Journal of Futures Market	36.40	3.26 (15)	376.43	0.97
Journal of International Money & Finance	33.27	3.14 (14)	1258.43	1.00
Journal of Money, Credit and Banking	62.71	2.78 (9)	1311.90	0.99
Journal of Portfolio Management	27.82	2.44 (4)	3252.56	1.00

[a] The figures in parentheses are rankings of the author concentration.
* Chi-square value with $\alpha = 5\%$ is 11.1.

III. Empirical Evidence on the Generalized Lotka's Law

In this section we test the generalized Lotka's Law. Specifically, we compute the "best empirical value" of the constant c for each journal by fitting a line to the empirical frequency distribution given in Table I.[8] For this, note first from equation (2) that

$$a_n/a_1 = 1/n^c. \tag{9}$$

Taking the log of both sides of (9), we obtain

$$\log(a_n/a_1) = -c\log(n). \tag{10}$$

The constant c is obtained by estimating the regression equation forcing the intercept term to be zero.

The regression results are presented in Table II. The estimated exponents range from 1.95 for the *Journal of Financial Economics* to 3.26 for the *Journal of Futures Market*. For the majority of journals, the generalized Lotka's Law provides almost a perfect fit. The R-square values range from 0.97 to 1.00. Overall, the generalized version of Lotka's Law, i.e., $a_n = a_1/n^c$, is an excellent predictor of the pattern of productivity in the finance literature.

[8] The regression equations are estimated using categories 1 through 5. The sixth category is ignored since the number of observations in this category is generally very small.

Except for the *Journal of Financial Economics*, all other journals have exponents greater than two. It is interesting to note that the authors publishing in the *Journal of Finance*, *Journal of Financial Economics*, and *Journal of Financial and Quantitative Analysis* are the most concentrated (i.e., small c). As was pointed out earlier, this may be an indication that the phenomenon "success breeds success" is more common in higher caliber publications.[9] In fact, this result is in line with the previous finding that the *institutions* publishing in these top three journals are very much concentrated. Niemi (1987) reports that the twenty-eight leading research institutions have published approximately fifty percent of the total pages of these journals during 1975–1986. In an earlier paper, Klemkosky and Tuttle (1977) find that the top thirty-seven institutions have published 66.7 percent of the total pages in these journals.

On the other hand, the authors publishing in the *Financial Review*, *Journal of Futures Market*, and *Journal of International Money and Finance* are the least concentrated. This may reflect the youth of these journals; i.e., the *Journal of Futures Market* and *Journal of International Money and Finance* began publication only in 1981 and 1982, respectively. Because of such a short period of existence, not many authors have had the opportunity to have multiple publications in these journals.

IV. Conclusion

This study examines whether there exists any bibliometric regularity in the finance literature. Our empirical results strongly suggest that there exists one: the number of authors publishing n papers is about $1/n^c$ of those publishing one paper. We find that the value of the exponent (i.e., c) is equal to two if data are taken from a large collection of journals. For individual journals, we find that the best fitted values of the exponent range from 1.95 to 3.26. We also find that top-rated journals have higher concentrations among their contributors, implying that the phenomenon "success breeds success" is more common in higher quality publications.

[9] We also test the so-called Price Law, which states that the top $\sqrt{P}$ authors will produce at least half of the total papers published by the population of P authors. (See Price (1976), p. 299.) Our empirical results indicate that the top $\sqrt{P}$ authors, except for the case of the *Journal of Financial Economics*, vastly underpublished compared to the prediction made by the Price Law. For the *Journal of Financial Economics*, the top $\sqrt{P}$ authors published 104 papers, whereas the total number of papers is 332. For the *Journal of Finance* and *Journal of Financial and Quantitative Analysis*, the top $\sqrt{P}$ authors published 410 and 179 papers, respectively, whereas the total numbers of publications are 2,260 and 942, respectively. Therefore, although these journals exhibit relatively higher degrees of concentration of authorship than those of other finance journals, they are not commensurate with the expected result suggested by the Price Law.

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