Distributional Differences of the Impact Factor in the Sciences Versus the Social Sciences: An Analysis of the Probabilistic Structure of the 2005 Journal Citation Reports

Stephen J. Bensman
LSU Libraries, Louisiana State University, Baton Rouge, LA 70803-3300. E-mail: notsjb@lsu.edu

This paper examines the probability structure of the 2005 *Science Citation Index (SCI)* and *Social Sciences Citation Index (SSCI) Journal Citation Reports (JCR)* by analyzing the Impact Factor distributions of their journals. The distribution of the *SCI* journals corresponded with a distribution generally modeled by the negative binomial distribution, whereas the *SSCI* distribution fit the Poisson distribution modeling random, rare events. Both Impact Factor distributions were positively skewed—the *SCI* much more so than the *SSCI*—indicating excess variance. One of the causes of this excess variance was that the journals highest in the Impact Factor in both *JCR*s tended to class in subject categories well funded by the National Institutes of Health. The main reason for the *SCI* Impact Factor distribution being more skewed than the *SSCI* one was that review journals defining disciplinary paradigms play a much more important role in the sciences than in the social sciences.

Introduction

In this article, the distributional differences of the impact factor in the sciences versus the social sciences are analyzed. The impact factor is one the key measures of the *Science Citation Index* (*SCI*) and *Social Sciences Citation Index* (*SSCI*) *Journal Citation Reports* (*JCR*) produced annually by Thomson Scientific's Institute for Scientific Information (ISI). Briefly defined, the impact factor is an estimate of the current mean citation rate of the articles published in the journals covered by the citation indexes. Both the citation indexes and the *JCR*s were created by Eugene Garfield.

One of the main purposes of this article is to prepare the ground for further research. Due to differences between scientific and scholarly disciplines, it is generally recognized that citation analyses should be performed on sets of journals well-defined by subject. However, such disciplinary analyses can be greatly aided by global analyses of the *SCI* and *SSCI JCR*s for two basic reasons. First, mapping the overall impact factor probability structure of the *JCR*s would be helpful in determining the relative position of a given discipline in that structure. Here, it was found that the subject fields of the *JCR*s are probabilistically heterogeneous with the overall probabilistic structures of the *JCR*s heavily affected by the higher probabilities of the biomedical and behavioral sciences. Second, it was thought useful to establish whether there are any benchmark differences distinguishing the sciences from the social sciences in respect to the distribution of the impact factor. Such benchmark differences, if found, would be useful for analytical and classificatory purposes in analyses of the impact factor patterns in individual disciplines. As will be seen, on a global basis, the sciences and social sciences were found to have impact factor distributional patterns that differ markedly from each other due to the greater importance of review journals in the sciences than in the social sciences. An important function of review articles is to codify knowledge and define disciplinary paradigms. In general, the sciences are judged to have higher paradigm consensus than the social sciences, and therefore the relative impact factors of review journals can be considered a gauge for judging whether a discipline's journal literature is conforming to the science or the social science model. The behavioral sciences were utilized to investigate this, and the analysis found that certain *SSCI* subject categories in psychology appear to adhere to the science model of dominant review journals.

The frequency distributions of the impact factor are tested in this article against the theoretical discrete probability distributions that lie at the basis of modern inferential, parametric statistics. Bensman (2000) has provided an historical justification for the utilization of these distributions. Modern parametric statistics were primarily developed in Britain as part of the biometric revolution stemming from Darwin's theory of evolution, and two of the best codifications of these statistics are Elliott (1977) and Snedecor and Cochran

Received July 18, 2007; revised October 2, 2007; accepted December 3, 2007

 • Published online 16 April 2008 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/asi.20810

(1989). Parametric statistical techniques have been incorporated into the functions of such computer programs as Excel, SAS, and SPSS, but many of them are based upon the assumption of the normal distribution, which is virtually nonexistent in library and information science. The chi-squared index of dispersion test, which is utilized in this article, is one of the simplest and most efficient techniques for identifying the type of theoretical probability distribution best modeling the frequency distribution of the data, so that the proper mathematical transformations can be performed to make this data approximate the normal distribution required by parametric statistical techniques. Other theoretical distributions may be used to model citations and other bibliometric data, but the ones discussed in this article are those commonly used in inferential, parametric statistics.

Measures and Data

The *JCR*s are constructed from a database compiled from some 7,500 scholarly and technical journals covered by the ISI citation indexes. Each *JCR* contains citation data for one specific year, and the year of this data is termed "the *JCR* year," which is 2005 for this article. The online *JCR*s allow the creation of what is termed the "Journal Summary List," which gives the journal title plus five important measures by which the journals can be ranked. Of these five measures, three are of interest to this article: impact factor, total cites, and articles. The online *JCR* Help (Institute for Scientific Information, 2005) defines the impact factor in the following manner: "Average number of times articles from the journal published in the past two years have been cited in the *JCR* year." Total cites is defined as "the total number of times that a journal has been cited by all journals included in the database in the *JCR* year." This measure differs from the impact factor in two important respects: (a) it is a gross count of citations to the journal and not a mean of citations per article, and (b) it is not limited to citations of the 2-year backfile preceding the *JCR* year but counts citations to the entire backfile of the journal without temporal limit. The articles measure of the Journal Summary List is defined as the "total number of articles in the journal published in the *JCR* year." It is a measure of the current physical size of the journal.

A correct understanding of the *JCR* measures requires a thorough knowledge of the *JCR* concept of an "article." The online *JCR* Help has the following definition of article:

> An article is a significant item published in a journal covered by *Journal Citation Reports*. Editorials, letters, news items, and meeting abstracts are usually not counted as articles because they are not generally cited. The articles [measure] counts research articles, review articles, notes, and corrections/retractions . . .

The *JCR*, thus, divides articles into "citable" and "non-citable." It should also be noted that the *JCR* also counts research and review articles separately. The Online *JCR* Help sets the following criteria for defining a published item as a review article: (a) it cites more than 100 references, (b) it appears in a review publication or a review section of a journal, (c) the word *review* or *overview* appears in its title, and (d) the abstract states that it is a review or survey.

Of the two citation measures of interest in this article, the impact factor has been the one most widely utilized in the evaluation of journals, scientists, scientific programs, etc. This has caused it to be highly controversial, attracting the attention of the major academic (Monastersky, 2005), financial (Begley, 2006), and scientific (Adam, 2002) news media. Here, the impact factor has been described as error-ridden, manipulated, abused, and distorting the course of scientific research. The impact factor began to be developed in its present form by Garfield and Sher (1963), who rejected absolute citation counts like total cites as too influenced by journal size and "not much more sophisticated than ranking the importance of a journal by the quantity of articles published." They then stated: "The first step in obtaining a more meaningful measure of importance is to divide the number of times a journal is cited by the number of articles that journal has published" (p. 200). Bensman (2007a, pp. 118, 117–122) has shown that Garfield was heavily influenced in his development of the impact factor by the work of Martyn and Gilchrist (1968), who in a study of British scientific journals pioneered the technique of controlling for journal age—or temporal size—by restricting the citation counts to the 2-year backfile preceding the evaluation year and for journal physical size by dividing number of citations by the number of citable items. Garfield (1972a, 1972b, 1976b) ultimately came to incorporate both these techniques into his construction of the impact factor, and his reasons for this are still clearly visible in the following justification of the impact factor set forth in the online *JCR* Help:

> The impact factor mitigates the importance of absolute citation frequencies. It tends to discount the advantage of large journals over small journals because large journals produce a larger body of citable literature. For the same reason, it tends to discount the advantage of frequently issued journals over less frequently issued ones and of older journals over newer ones. Because the journal impact factor offsets the advantages size and age, it is a valuable tool for journal evaluation.

The online *JCR* Help specifies that "only original research and review articles are used in impact factor calculations." These types of articles comprise the denominator of the impact factor, and both types classify as citable. The division of published items into citable and noncitable comprises the Achilles' heel of the impact factor, and it appeared early in the measure's development. Thus, Martyn and Gilchrist (1968) stated: "What constitutes a citable item is a nice point, and we proceeded on an *ad hoc* basis, arguing that we were more interested for correction purposes in preserving the ratios between journal sizes than in achieving a pure and absolute accuracy based on a set of complex (but ultimately subjective) rules" (p. 5). Garfield (1972a, pp. 478–479, n. 28) himself initially thought that such a distinction could not be made. The type of discrepancies, which can arise, was

DOI: 10.1002/asi

graphically demonstrated by Joseph and Hoey (1999), editors of *CMAJ: Canadian Medical Association Journal*. Hand-counting what they considered citable items published by *CMAJ* in 1997, they arrived at 175 instead of the 303 reported by the *JCR*.

Garfield (1972a, 1972b, 1976a) utilized the impact factor in his early analyses of the structure of the scientific journal system, making a number of discoveries about this measure and the system that still hold basically true today. First, whereas large research journals dominate the upper stratum of total cites rankings, small review journals dominate impact factor rankings, indicating that review articles have a higher mean citation rate than research articles. Second, most scientific articles, including those in the most prestigious journals, have an extremely low mean citation rate. One indication of this was the small ratio of the number of references processed each year for the *SCI* to the number of different items cited by those references, which in the 1960s was consistently around 1.7 (Garfield, 1972a, pp. 474–475 and p. 478, n. 19). Garfield (1973, p. 5) was surprised by this finding and dubbed this ratio "Garfield's constant" (1976b). Basing himself on this ratio and binomial theory, Bensman (2007b, p. 27) estimated that Garfield's constant of 2.15 for 1993 equated to a probability of 0.0003 of a scientific article being cited that year. And, third, the distribution of scientific journals by the impact factor is highly and positively skewed with the vast bulk of the *SCI JCR* journals restricted to the extremely short range below Garfield's constant for the given year. Garfield (2000, p. 10; 2005, p. 5) pointed out that one consequence of this situation was that ISI decided to calculate the impact factor to three decimal places for the *JCR*s to avoid the inevitably numerous ties that would result in listing many journals alphabetically under this measure despite his own opinion that the measure is accurate only to one decimal place.

The purpose of this article is to determine whether there are any distributional differences of journals over the impact factor between the sciences and the social sciences by analyzing the probabilistic structures of the 2005 *SCI* and *SSCI JCR*s on this measure. For this purpose, all the titles of 2005 *SCI* and *SSCI JCR*s were downloaded into an Excel spreadsheet. Title changes were not taken into account. For the *SCI JCR* the initial title count was 6,088, but 42 did not have recorded impact factors and were eliminated. It was decided to eliminate the title *Lecture Notes in Computer Science* as anomalous and distortional. Its 18,886 2005 articles were three times higher than the title next highest on this count, and inspection of the title's Web site revealed these articles to be a peculiar documentary mix. Bibliographic analysis of title revealed that the Library of Congress did not consider the title a serial but a monographic series. These facts were reported to Thomson Scientific, which removed it from *JCR* coverage as "an ostrich egg in a hummingbird nest" together with its subseries *Lecture Notes in Artificial Intelligence* (Marie McVeigh, personal communications, May 1, 18, and 23, 2007). Of the 6,045 titles remaining, 201 did not have article data, and these titles were excluded from calculations involving article counts. These titles were classified in the *SCI JCR* into 171 subject categories.

In respect to the 2005 *SSCI JCR,* 1,747 titles were initially downloaded, of which 2 did not have impact factors and were eliminated. The title highest in article count in the 2005 *SSCI JCR* was also an anomalous one, being once again far above on this measure than the other titles. It was *Forbes*, a popular business magazine, whose articles are in no way comparable to those of *The American Economic Review*. It was not excluded, but its inclusion in the *JCR* demonstrates the difficulty of defining a citable source. There were 47 titles without article data, which were excluded from calculations involving article counts. The *SSCI JCR* titles were classified into 54 subject categories.

Probabilistic and Statistical Conceptualization of the Impact Factor

Statisticians classify variables and distributions as either continuous or discrete. In the former, the variable can assume any value, whereas in the latter, only limited gradations are possible. However, the distinction between continuous and discrete is somewhat ambiguous, and statisticians sometimes adopt a cavalier attitude toward it. Thus, Snedecor and Cochran (1989) write: "Actually, all quantitative data are discrete as recorded, since we round for simplicity, e.g., height to the nearest inch, temperature to nearest °F, age to the last birthday" (p. 17). The authoritative *Encyclopedia of Statistical Sciences* (Kotz & Johnson, 1982) states the matter thus:

> By far the most commonly used discrete distributions are those for which the x_j's are the nonnegative integers. They are used in models for "count data," which include variables representing the results of counts (of defective items, apples on a tree, etc.). However, it is not necessary that the variable takes only integer values (an observed proportion is a simple counterexample); it can even take an infinity of values in any finite interval and still have a discrete distribution. (p. 387)

From this perspective it can be seen that total cites and articles are classic discrete variables, but it is possible to classify the impact factor as a discrete variable, which rises in increments of a thousandth. Garfield himself rounded it to the nearest tenth in his utilization of the measure.

In his classic textbook, Fisher (1925) declared: "The normal distribution is the most important of the continuous distributions; but among the discontinuous distributions the Poisson Series of the first importance" (p. 57). Coleman (1964) made the Poisson distribution the centerpiece of his seminal work on the application of quantitative models in sociology because it arises from a process particularly suited for social phenomena and therefore "constitutes a rational model whose assumptions can mirror our assumptions about actual phenomena" (p. 291). The Poisson distribution arises from a process whereby events occur infrequently and randomly over time and space in such a way that for each division of time or space the probability of its containing events is proportional to the size of the division. Here, space will be defined in terms of articles and subject categories. In a landmark paper on deviations from the Poisson, the noted statistician "Student" (1919) defined the conditions necessary for this distribution. These conditions may be summarized as follows: (a) the probability of two occurrences in the same division must be, if not equal, then small; (b) there must be probabilistic homogeneity in the sense that each division must have the same probability of occurrence; and (c) there must be no contagion in the sense that the occurrence of an event in a division must not affect the probability of further occurrences. The Poisson distribution has one parameter, lambda (λ), which can be defined as average number of occurrences per division of time or space. Under the conditions of the Poisson, lambda equals both the arithmetic mean and variance of the distribution, and, in Excel notation, the Poisson distribution is, thus, characterized by the following identity:

$$\lambda = \text{AVERAGE} = \text{VAR}$$

This distribution is important as a model of true randomness.

The impact factor may be conceptualized in terms of the Poisson process. It is possible to define it as a function of a number of Poisson variables. The first variable is the number of items published by a given journal over a 2 *JCR*-year period and judged citable; the second is the number of citations to this 2-year backfile of the journal in the succeeding *JCR* year, and the impact factor itself may be defined as an estimate of the Poisson lambda or mean number citations per citable item of the journal during the impact factor's *JCR* year. The matter is further complicated by the *JCR*s being constructed on the basis of calendar year samples. It is possible to conceive of other 12-month sampling periods. The *JCR* counts thus may theoretically be considered only estimates of the true rates of occurrence accurate within certain confidence limits. Pearson and Hartley (1966, 80–83, 136–137, and 227) as well as Beyer (1968, pp. 238–239) contain tables and equations for calculating the confidence limits of observed Poisson variables. For example, the 95% confidence interval for an observed count of 50 citations ranges from 37 to 66 citations. Bensman (2007b, pp. 57–58) demonstrated the potential effects of Poisson confidence limits upon impact factor calculations with a sample of 120 chemistry journals.

This article will test the distributions of the journals in the 2005 *SCI* and *SSCI JCR*s by the impact factor against the Poisson. In his landmark paper on the Poisson, "Student" (1919) identified the two basic deviations from the Poisson. The first is the binomial, which is characterized by a variance that is significantly less than the mean. It occurs under the same conditions as the Poisson—probabilistic homogeneity and independence of events or absence of contagion—, but the probability of occurrence is higher. In addition, the binomial process differs from the Poisson process by being based not upon the occurrence of events over continuums of time and space but upon drawing samples of size *s* containing proportions of successes and failures from the population. Snedecor and Cochran (1989, pp. 117–119) show that the binomial tends to approximate the continuous normal distribution as sample size *s* increases, with the required *s* being smallest when the population proportion of successes or probability *p* equals 0.5. The other basic deviation from the Poisson identified by "Student" (1919) is the negative binomial distribution (NBD), which arises when the two basic conditions required for the Poisson—probabilistic homogeneity of the divisions and lack of contagion—are not met. One of its defining characteristics is that its variance is significantly greater than the mean. Two stochastic models lead to the NBD. The first is a compound Poisson model of probabilistic heterogeneity developed by Greenwood and Yule (1920) on the basis of industrial accidents among British female munitions workers during World War I. By this model, the events are occurring within divisions of time and space that have differing probabilities of occurrence. The other stochastic model leading to the NBD is a contagious one formulated by Eggenberger and Pólya (1984) in a 1923 paper analyzing the number of deaths from smallpox in Switzerland in the period 1877–1900. Feller (1943) proved that the Greenwood-Yule model of probabilistic heterogeneity and the Eggenberger-Pólya model of contagion both result in the NBD.

The test for the Poisson, which will be utilized in this article, is the chi-squared (χ^2) index of dispersion test originally created by Fisher (1925, pp. 60–64). Fisher's test was further developed by Cochran (1954, pp. 421–422), who placed it within the system of null and alternative hypothesis testing that is the standard method in statistics today. Elliott (1977, pp. 40–44) gives a full explanation of the test in its final form. It begins with the calculation of the variance-to-mean ratio or index of dispersion (I) thus in Excel notation:

$$\text{I} = \text{VAR/AVERAGE}$$

Since a defining characteristic of the Poisson is that the variance equals the mean, I is actually a comparison of sample variance to Poisson theoretical variance and should equal 1 or unity, if the data are following this distribution. The index of dispersion often departs from unity, and the significance of these departures is assessed through a chi-squared test, in which chi-squared is calculated in the following manner:

$$\text{X}^2 = \text{VAR} * (n-1)/\text{AVERAGE}$$

where n is the number of observations in the sample. For large samples ($n > 31$), the standard normal deviate (d)—zero mean and standard deviation of 1—can be calculated in the following manner:

$$\text{d} = \text{SQRT}(2 * \text{X}^2) - \text{SQRT}(2 * \text{v} - 1)$$

where v is degrees of freedom and equals $n - 1$. If d is less than the absolute value of 1.96, then the null hypothesis of the Poisson is accepted at the significance level of 0.05. However, if d is less than -1.96, the alternative of "a regular distribution" (VAR $<$ AVERAGE) is accepted, and,

DOI: 10.1002/asi

if d is greater than +1.96, the alternative hypothesis of a "contagious distribution" (VAR > AVERAGE) is accepted. According to Elliott (1977, pp. 46 and 50–51), the positive binomial distribution is the approximate mathematical model for a regular distribution, whereas the negative binomial distribution is the most useful mathematical model for the diverse patterns of contagious distributions. Thus, Elliott's two alternative hypotheses conform to the two deviations from the Poisson originally identified by "Student" (1919) in his landmark article.

Probabilistic Structures of the Impact Factor Distributions in the 2005 *SCI* and *SSCI JCRs*

The first step in the investigation of the probabilistic structures of the impact factor distributions in the 2005 *SCI* and *SSCI JCR*s was to estimate the overall probability of the impact factor for their respective journals. Snedecor and Cochran (1989, pp. 30–31) note that populations consisting of two classes (success-failure, yes-no, cite-no cite) are extremely common, and they define probability p as the proportion of successes in the population. They further state that if samples of a given size s are continually drawn from the population, the arithmetic mean will equal s times p. Probability p is one of the parameters of the binomial distribution, which is based upon the repeated drawing of samples of size s from a population. However, there is a major problem with citation counts in this. While it is possible to count the number of times an article has been cited, for example, it is not possible to count the number of times this article has not been cited. Grieg-Smith (1983, pp. 57–58) and Elliott (1977, p. 17) suggest handling this difficulty by a method, which will now be demonstrated with *SCI JCR* impact factor. One first hypothesizes or determines the maximum possible number of successes for any given member of the set. On the basis of the definition of Aristotle (1984) that "a probability is that which happens usually but not always" (p. 2236), the assumption will be made that the highest possible impact factor a 2005 *SCI JCR* title could achieve was that of the title actually highest on the measure that year. This title was *CA-A Cancer Journal for Clinicians* with an impact factor of 49.794, and its impact factor can now serve as a surrogate for the size s—49,794 thousandths in integer terms—of the binomial samples to be drawn from the journal population. According to this conceptualization, the *SCI JCR* titles each represent such a sample, and their number n—6,045—constitutes the number of these samples. Multiplying s by n yields the total impact factor possible—301,004.730, which is divided into the actual aggregate impact factor of all the 2005 *SCI JCR* titles—10,622.777—yielding 0.04 as an estimate of the impact factor probability p of the 2005 *SCI JCR*. This process was repeated for the 2005 *SSCI JCR*, which had 1,745 titles and where *Archives of General Psychiatry* was highest on the impact factor at 12.642. The impact factor p of the *SSCI JCR* was estimated to be 0.08 or about two times higher than that of the *SCI JCR*.

TABLE 1. Science Citation Index 2005 JCR frequency distribution of titles by impact factor over 20ths of the impact factor range.

20th intervals		No. titles	% titles
0.000	2.500	4957	82.00%
2.501	5.000	792	13.10%
5.001	7.500	131	2.17%
7.501	10.000	70	1.16%
10.001	12.500	31	0.51%
12.501	15.000	20	0.33%
15.001	17.500	13	0.22%
17.501	20.000	8	0.13%
20.001	22.500	2	0.03%
22.501	25.000	6	0.10%
25.001	27.500	2	0.03%
27.501	30.000	5	0.08%
30.001	32.500	4	0.07%
32.501	35.000	1	0.02%
35.001	37.500	0	0.00%
37.501	40.000	0	0.00%
40.001	42.500	0	0.00%
42.501	45.000	1	0.02%
45.001	47.500	1	0.02%
47.501	50.000	1	0.02%
Sum		6045	100.00%
Statistical measures			
Estimate of overall JCR probability			0.04
Normal symmetry tests			
Mean			1.757
Median			1.048
Mean-to-median ratio			1.68
Coefficient of skewness			6.91
Skewness standard normal deviation			0.03
Skewness in standard normal deviations			219.24
Poisson variance test			
Variance			7.098
variance-to-mean ratio			4.04
Chi-squared standard normal deviate for Variance-to-mean ratio			111.03

CA and *Archives of General Psychiatry* determine the impact factor range of their respective *JCR*s, and it is seen that the *SCI JCR* has a much longer range than the *SSCI JCR*—49.794 to 12.642. For comparative purposes, these impact factor ranges were divided into 20ths—or segments comprising 5% of the range—and the *JCR* titles were distributed across these segments. The results are shown in Tables 1–2 and graphed with histograms in Figures 1–2. Two types of statistical tests were conducted to explore the characteristics of the frequency distributions of the journals across the impact factor. These tests are summarized in the bottom part of Tables 1–2. The first type was tests of symmetry, and the standard of comparison was the normal distribution, which is perfectly symmetrical and all measures of central tendency—mean, median, and mode—equal each other. Of this type, one was to calculate the ratio of the mean *JCR* impact factor to the median *JCR* impact factor, which should equal one under conditions of the normal distribution. However, in both the *SCI* and *SSCI JCR*s the ratio was above one—1.68 for the *SCI JCR* and 1.41 for the *SSCI JCR*—indicating a

TABLE 2. Social Sciences Citation Index 2005 JCR frequency distribution of titles by impact factor over 20ths of the impact factor range.

20th intervals		No. titles	% titles
0.000	0.633	794	45.50%
0.634	1.266	536	30.72%
1.267	1.899	217	12.44%
1.900	2.532	86	4.93%
2.533	3.165	52	2.98%
3.166	3.798	24	1.38%
3.799	4.431	17	0.97%
4.432	5.064	7	0.40%
5.065	5.697	2	0.11%
5.698	6.330	1	0.06%
6.331	6.963	1	0.06%
6.964	7.596	1	0.06%
7.597	8.229	1	0.06%
8.230	8.862	1	0.06%
8.863	9.495	1	0.06%
9.496	10.128	3	0.17%
10.129	10.761	0	0.00%
10.762	11.394	0	0.00%
11.395	12.027	0	0.00%
12.028	12.660	1	0.06%
Sum		1745	100.00%
Statistical measures			
Estimate of overall JCR probability			0.08
Normal symmetry tests			
Mean			0.983
Median			0.697
Mean-to-median ratio			1.41
Coefficient of skewness			3.87
Skewness standard normal deviation			0.06
Skewness in standard normal deviations			65.96
Poisson variance test			
Variance			1.045
variance-to-mean ratio			1.06
Chi-squared standard normal deviate Variance-to-mean ratio			1.86

mean greater than the median, which is a sign of a positively skewed distribution. The coefficient of skewness was then calculated to compare how positively skewed were the *SCI* and *SSCI* impact factor distributions. According to Snedecor and Cochran (1989, pp. 78–79 and 487), if the sample comes from a normal population, the coefficient of skewness is normally distributed with a mean of zero and a standard deviation of SQRT(6/n). The test revealed that the *SCI JCR* impact factor distribution is much more positively skewed—coefficient of 6.91, which is 219.24 times greater than the standard normal deviation—than the *SSCI JCR* impact factor distribution—coefficient of 3.87, which is 65.96 times greater than the standard normal deviation.

However, of greatest interest and portent were the results of the chi-squared index of dispersion test of the impact factor distributions for the Poisson. For the *SCI JCR*, the variance-to-mean ratio was 4.04 with a standard normal deviate of 111.03, thereby rejecting the null hypothesis of the Poisson and indicating a distribution of the negative binomial type. The results of this test were much different in respect to the *SSCI JCR* impact factor distribution. Here, the variance-to-mean ratio was only 1.06 and the standard normal deviate was 1.86, which is too low to reject the null hypothesis of the Poisson though coming close to such a rejection. The highly skewed nature of the *SSCI JCR* impact factor distribution is compatible with the hypothesis of the Poisson, for Snedecor and Cochran (1989, p. 131) show that the Poisson can be markedly skewed in a positive manner. The conclusion to be drawn is that the distribution of journals over the impact factor is much more random in the *SSCI JCR* than in the *SCI JCR*.

Inspection of Tables 1-2 and Figures 1-2 reveals important differences in the distributions of journals by the impact factor between the *SCI* and *SSCI JCR*s. The vast bulk of the *SCI JCR* journals—82.00%—are highly concentrated in the bottom 20th of the impact factor range, whereas the vast bulk of the *SSCI* journals are more uniformly distributed across the three lowest 20ths of the impact factor

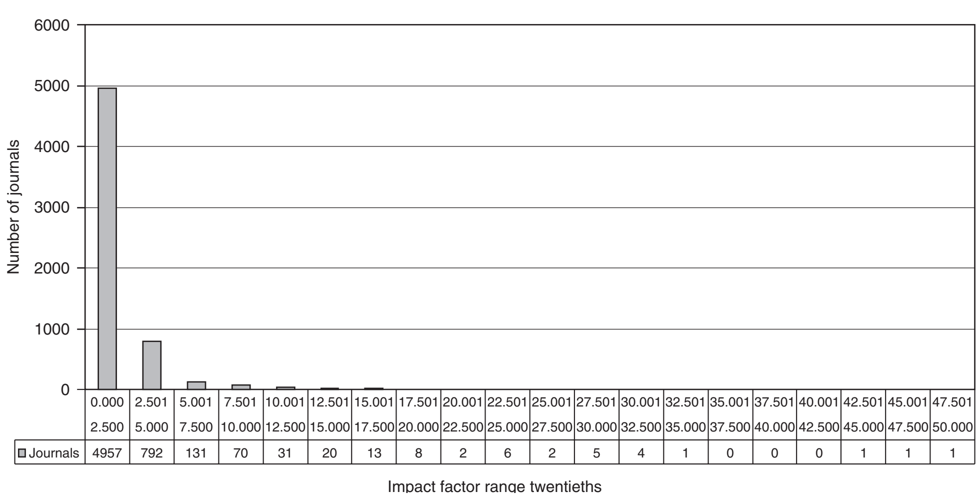

FIG. 1. Histogram of the distribution of the Science Citation Index 2005 JCR titles by impact factor over impact factor range 20ths.

DOI: 10.1002/asi

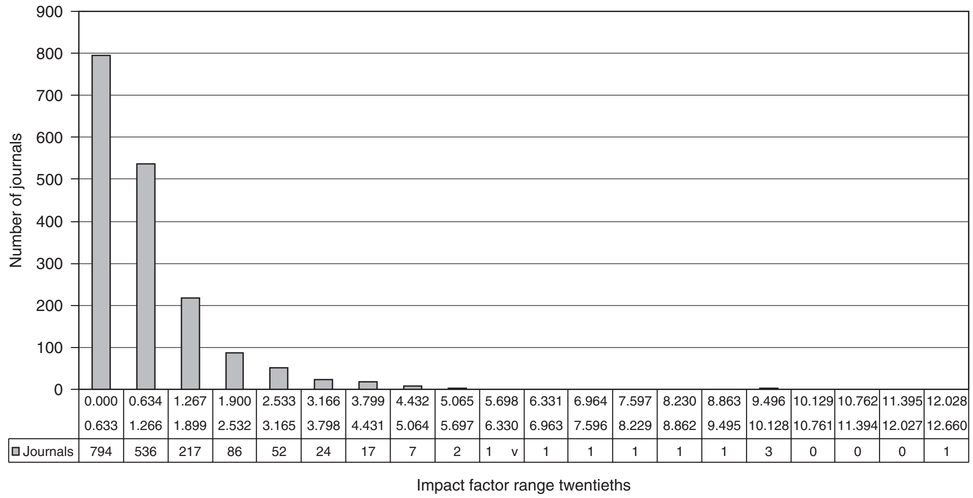

FIG. 2. Histogram of the distribution of the Social Science Citation Index 2005 journals titles by impact factor over impact factor range 20ths.

range—respectively, 45.50%, 30.72%, and 12.44% totaling 88.65%. This difference can be considered a function of the higher impact factor probability of the *SSCI JCR* titles over the *SCI JCR* titles. The almost total concentration of the *SCI JCR* titles in the bottom 20th of the impact factor range serves as corroboration of one of the key findings made by Garfield (1972a, 1972b, 1973, p. 5, 1976a) during his initial explorations of the citation structure of the scientific journal system with the impact factor, i.e., that most scientific articles, including those in the most prestigious journals, have an extremely low mean citation rate. Employment of the chi-squared index of dispersion test revealed that the journals in the bottom 20th of the *SCI JCR* impact factor range followed the binomial distribution, indicating the probabilistic homogeneity of these titles. It should be noted that, at this extremely low level of probability, the binomial and Poisson distributions tend to be equivalent. One consequence of this extreme compaction of so many titles into such a constricted range is an extraordinary number of titles tied with one or more other titles despite the calculation of the impact factor to three decimal places. All of these ties occurred in the bottom three 20ths of the *SCI JCR* impact range, and, in ascending order, the percentage of tied titles within these 20ths were the following: 86.02%, 33.21%, and 6.11%. Of the 6,045 *SCI JCR* titles, 4,535 or 75.02% were involved in ties. The *SSCI JCR* had a somewhat lower but still high rate of titles tied on the impact factor. These ties were also concentrated in the lower 20ths of the impact factor range but in a somewhat more dispersed form, being distributed across bottom six 20ths of the impact factor range. Of the 1,745 *SSCI JCR* titles, 1,051 or 60.23% were involved in ties, and, in ascending order, the percentage of tied titles in the bottom six 20ths of the impact factor range were as follows: 76.95%, 65.11%, 29.49 %, 17.44%, 19.23%, and 8.33%. These figures make doubtful the utilization of the impact factor for evaluative purposes at the lower end of this measure's range.

Sources of Variance

The journal impact factor distributions were positively skewed in both the *SCI* and *SSCI* 2005 *JCR*s, manifesting high levels of variance. Even though the null hypothesis of the Poisson was not rejected in favor of the alternative hypothesis of a NBD-type distribution, the standard normal deviate came close to such a rejection. This section will be dedicated to exploring the sources of the variance in the impact factor distributions by examining those journals located in the top fifteen 20ths or upper 75% of the impact factor range. There were 64 *SCI* journals and 60 *SSCI* journals in this part of the range. Table 3 reveals some important similarities and differences between the *SCI* and *SSCI* impact factor distributions by showing the proportions of the *JCR* aggregates of the three measures of interest in this article—impact factor, total cites, and 2005 articles—accounted for by these high-impact journals. First, the distributions are

TABLE 3. Science Citation Index and Social Sciences Citation Index 2005 JCRs: Comparison of the percent top impact factor (IF) titles to the percent JCR aggregate IF, total cites, and 2005 articles accounted for by the top IF titles.

	Impact factor[a]	Total cites[a]	2005 articles[a]
Science citation index 2005 JCR			
Top 64 IF titles % of JCR titles	1.06%	1.06%	1.10%
Top 64 IF titles % of JCR aggregate	12.33%	9.94%	1.09%
Ratio of % JCR aggregate to % JCR titles	11.6	9.4	1.0
Social sciences citation index 2005 JCR			
Top 60 IF titles % of *JCR* titles	3.44%	3.44%	3.53%
Top 60 IF titles % of *JCR* aggregate	16.61%	25.75%	7.30%
Ratio of % *JCR* aggregate to % JCR titles	4.8	7.5	2.1

[a]For the SCI JCR, there was a total of 6,045 titles in the impact factor/total citations set but only 5,844 titles in the 2005 articles set, whereas for the SSCI JCR there was a total of 1,745 titles in the impact factor/total cites set but only 1,698 titles in the 2005 articles set.

DOI: 10.1002/asi

similar in that these journals accounted for a higher proportion of the impact factor and total cites aggregates than their proportion of titles. Thus, the 64 *SCI* high-impact titles were 1.06% of the *JCR* titles but accounted for 12.33% of the aggregate *JCR* impact factor (a ratio of 11.6:1 ratio) and 9.94% of the aggregate *JCR* total cites (9.4:1), whereas the 60 *SSCI* high-impact titles represented 3.44% of the *JCR* titles but were responsible for 16.61% of the aggregate *JCR* impact factor (4.8:1) and 25.75% of the aggregate *JCR* total cites (7.5:1). However, in terms of 2005 articles, the 64 *SCI* high-impact titles were 1.10% of the *JCR* titles and contained 1.09% of the *JCR* aggregate 2005 articles (1:1), whereas the 60 *SSCI* high-impact titles represented 3.53% of the *JCR* titles but 7.30% of the *JCR* aggregate 2005 articles (2.1:1). The differing relative sizes between the *SCI* and *SSCI* high-impact titles is indicative of an important difference in their characteristics that will become clear later in this article.

Two facets of the high-impact journals will be analyzed. First, there will be analyzed their distribution over the *JCR* subject categories in which they were classified. Second, they will be analyzed in terms of their functional role, i.e., whether they are primarily research or review journals. Throughout the analysis, comparisons will be made in terms of medians and not arithmetic means. With skewed distributions such as the ones under discussion, the median is a better measure of central tendency, because it is less affected by extreme values than mean, a better estimate of the modal value, and therefore more representative of the population (Moroney, 1956, pp. 34–55). The case of Seglen (1992, 1997) against using the impact factor for evaluating journals and scientists is based upon this characteristic of the mean. In his view, the impact factor is an estimate of mean citation rate, and because all scientometric measures are highly skewed, it is therefore not representative of the citation rate of articles in either a journal or a scientist's oeuvre.

Variance and Subject Category

The journals of the *SCI* 2005 *JCR* are classed into 171 subject categories, whereas the journals of the *SSCI* 2005 *JCR* are classed into 54 subject categories. These categories are not crisp or mutually exclusive sets. Both the sciences and social sciences are highly interdisciplinary, and many journals are classed into two or more subject categories. The interdisciplinarity extends across *JCR* boundaries. For example, psychiatry is a subject category in both the 2005 *SCI* and *SSCI JCR*s, and we find it interesting that the title highest in impact factor in the *SSCI JCR*—*Archives of Psychiatry*—ranked 64th in impact factor in the *SCI JCR*. The *JCR*s provide a number of statistical measures for each subject category, including aggregate number of total cites, 2005 articles, and journals. There are two subject category measures for the impact factor: (a) the median impact factor of the journals in the category and (b) the aggregate impact factor, which the online *JCR* Help states "is calculated the same way as the impact factor for a journal, but it takes into account the number of citations to all journals in the category and the number of articles from all journals in the category." The distributional characteristics of the subject category measures were investigated. For the subject category measures most related to the variables under discussion in this article, the *SCI JCR* ranges and medians were as follows: median impact factor—range 0.318 to 2.667, median—1.030; total cites—range 684 to 2,207,432, median—103,862; and 2005 articles—range 330 to 47,485, median—5,570. The *SSCI JCR* had the equivalent ranges and medians: median impact factor—range 0.320 to 1.741, median—0.751; total cites—range 1,598 to 231,229, median—23,419.5; and 2005 articles—range—243 to 7,691, median—1,309. However, of most interest were the results of the chi-squared index of dispersion tests of the following subject category measures: median impact factor, Aggregate impact factor, total cites, 2005 articles, and number of journals. For the *SCI JCR* the test rejected the null hypothesis of the Poisson in favor of the alternative hypothesis of a NBD-type of distribution, indicating considerable probabilistic heterogeneity of the subject categories. The results were the same for the *SSCI JCR* subject category measures except in two cases—both the median impact factor and the aggregate impact factor resulted in acceptance of the alternative hypothesis of the positive binomial with its connotation of probabilistic homogeneity, corroborating the previous findings in respect to the distribution of journals by the impact factor in the social sciences.

Table 4 shows the distribution of the 64 high-impact *SCI* titles by *JCR* subject category. These 64 titles classed 84 times in 32 or 18.7% of the 171 subject categories. The reason for the excess of classifications over titles was that certain titles classed simultaneously in two more subject categories. Table 4 ranks the subject categories in descending order by the number of times the titles classed in them and, for analytical purposes, separates out from the full set of 32 subject categories a subset of eight categories, in which the titles classed four or more times. This subset is designated the "frequent subset." The high-impact full set and frequent subset are then compared to the *JCR* universe of 171 subject categories in terms of the median impact factor and total cites of the journals. For this comparison, median ranks and values are utilized.

The full set of 32 subject categories, into which the 64 high-impact *SCI* titles classed, tended to have higher median impact factors and total cites than the *JCR* universe of subject categories. In terms of ranks, the median of the median impact factor was 34.5 compared to 85.5 for the JCR universe (ratio 0.4 : 1), and the median total cites rank was 18.5 compared to *JCR* category median of 86 (0.2 : 1). Comparing values, the full category set had a median of 1.659 for median impact factor compared to a *JCR* category median of 1.030 (1.6 : 1) and a median of 452,324.5 total cites compared to a *JCR* median of 103.862.0 (4.4 : 1). These differences became exaggerated, when the full category set was restricted to the frequent subset. This subset comprised eight categories or 4.7% of the 171 *JCR* categories but accounted for 44 or 52.4% of the classifications of the high-impact titles. The frequent subset had a median rank of 7.5 in median impact factor compared to the *JCR* category median of

DOI: 10.1002/asi

TABLE 4. Science Citation Index 2005 JCR subject categories in which 64 titles highest in impact factor (IF) classed.

Category no.	Subject categories	No. high IF journals classed in category	Category median IF rank[a]	Category total cites rank	Category median IF	Category total cites
1	BIOCHEMISTRY & MOLECULAR BIOLOGY	8	8	1	2.323	2207432
2	CELL BIOLOGY	8	4	3	2.383	1029071
3	GENETICS & HEREDITY	6	2	11	2.626	593960
4	IMMUNOLOGY	5	10	8	2.301	688990
5	NEUROSCIENCES	5	7	4	2.362	1024673
6	MEDICINE, GENERAL & INTERNAL	4	95	7	0.971	695155
7	ONCOLOGY	4	5.5	6	2.371	726819
8	PHARMACOLOGY & PHARMACY	4	26	10	1.889	642819
9	CHEMISTRY, MULTIDISCIPLINARY	3	101	5	0.921	773231
10	CHEMISTRY, PHYSICAL	3	43	9	1.557	645427
11	DEVELOPMENTAL BIOLOGY	3	3	49	2.618	192042
12	MEDICINE, RESEARCH & EXPERIMENTAL	3	21	30	2.009	360056
13	MICROBIOLOGY	3	14	21	2.197	430214
14	PHYSIOLOGY	3	16	34	2.145	349492
15	ASTRONOMY & ASTROPHYSICS	2	50	17	1.446	463240
16	BIOTECHNOLOGY & APPLIED MICROBIOLOGY	2	37	27	1.634	383432
17	MULTIDISCIPLINARY SCIENCES	2	160	2	0.445	1159693
18	PHYSICS, CONDENSED MATTER	2	77	19	1.105	449411
19	BIOLOGY	1	72	56	1.179	176385
20	BIOPHYSICS	1	15	32	2.193	354827
21	CHEMISTRY, INORGANIC & NUCLEAR	1	48	41	1.500	250342
22	ECOLOGY	1	55	29	1.397	360523
23	ENDOCRINOLOGY & METABOLISM	1	11	18	2.290	455238
24	EVOLUTIONARY BIOLOGY	1	12	74	2.261	126068
25	MATERIALS SCIENCE, MULTIDISCIPLINARY	1	116	16	0.815	484920
26	PHYSICS, APPLIED	1	81	15	1.085	493141
27	PHYSICS, MULTIDISCIPLINARY	1	82	13	1.051	529006
28	PLANT SCIENCES	1	83	24	1.046	406231
29	POLYMER SCIENCE	1	99	38	0.926	267520
30	PSYCHIATRY	1	20	35	2.045	344332
31	SPECTROSCOPY	1	53	80	1.410	112605
32	TOXICOLOGY	1	32	60	1.684	163262

		Median IF ranks (a)	Total cites ranks	Median IF	Total cites
SCI JCR benchmarks					
Total no. *JCR* subject categories	171				
JCR subject category medians		85.5	86	1.030	103862.0
High IF journals full set					
No. categories in high IF category full set	32				
% Full set categories of total no. *SCI JCR* categories	18.7%				
No. times journals classed in full set	84				
Full set medians		34.5	18.5	1.659	452324.5
Ratio of full set medians to JCR category medians		0.4	0.2	1.6	4.4
High IF journals frequent subset					
No. categories in frequent subset	8				
% Frequent subset categories of total no. *SCI JCR* categories	4.7%				
No. times journals classed in frequent subset	44				
% Times journals classed in frequent subset	52.4%				
Frequent subset medians		7.5	6.5	2.343	710987.0
Ratio of frequent subset medians to *JCR* category medians		0.1	0.1	2.3	6.8

Categories are ranked in descending order by the number of times journals are classed in them. Those categories, in which journals are classified four times or more, are separated out for analytical purposes and designated the high IF journals frequent subset.

[a]Fourteen subject categories were involve in ties on median journal impact factor, causing the *JCR* category median rank on this measure of 85.5 and the oncology rank of 5.5.

DOI: 10.1002/asi

85.5 (0.1 : 1) and a median rank of 6.5 in total cites compared to the *JCR* category median of 86 (0.1 :1). In terms of values, the frequent subset had a median of 2.343 for the median impact factor, which was 2.3 times higher the *JCR* category median, and a median of 710,987.0 total cites, which was 6.8 times greater than the *JCR* category median.

Close examination of the eight frequent subject categories reveals them to be facets of what may be termed "biomedicine." There, thus, seems to be in operation in the probabilistic structure of the impact factor in the *SCI JCR* the same force that Graham and Diamond (1997, pp. 74–83 and 201–211) found in respect to the development of American research universities after World War II. Graham and Diamond called this force "the multiplier effect of medical schools," and they trace it to the meteoric rise of National Institutes of Health (NIH) research funding "provided by the perennial generosity of Congress toward the NIH" (p. 75). Graham and Diamond show how NIH funding profoundly changed the research structure of American universities. This hypothesis appears corroborated, when both the full set and the frequent subset are compared to the *JCR* category universe in terms of size. The *JCR* category medians for number of journals was 43 and for 2005 articles 5,570. The respective medians for the full set were 87.5 and 13,354 but for the frequent subset 138.5 and 19,958.5.

Table 5 summarizes the distribution of the 60 high-impact *SSCI* titles by *JCR* subject category. It is structured in the same way as Table 4 showing the distribution of the 64 high-impact *SCI* titles by *JCR* subject category. In reference to the full set of subject categories in which the high-impact *SSCI* titles classed, the social sciences exhibited the same interdisciplinary character as the sciences in that some of the 60 high-impact *SSCI* titles classed in two or more categories, resulting in the 60 titles classing 70 times in 21 of the 54 (38.9%) *JCR* subject categories. However, close inspection of these subject categories reveals a heavy concentration in the behavioral sciences with 9 of the 21 categories relating to psychiatry, psychology, and psychoanalysis. These categories fall within the purview of the National Institute of Mental Health, and some of this concentration is probably another manifestation of Graham and Diamond's medical multiplier effect. This effect also probably contributed to the appearance among the categories of Gerontology (National Institute on Aging), Health Policy & Services, Public, Environmental, & Occupational Health (National Institute of Environmental Health Sciences), and Substance Abuse (National Institute on Alcohol Abuse and Alcoholism, National Institute on Drug Abuse). Corroboration of this hypothesis is that one of the two high-impact Information Science & Library Science titles was the *Journal of the American Medical Informatics Association* (NIH Center for Information Technology). As a result, we do not find it surprising that the full set of 21 *JCR* subject categories in which the 60 high-impact *SSCI* titles classed had a greater probability of being cited than the other *JCR* subject categories. In terms of ranks, the median of the median impact factor was 12.0 compared to 27.75 for the *JCR* universe (ratio 0.4:1), and the median total cites rank was 11.0 compared to *JCR* category median of 27.5 (0.4:1). Comparing values, the full category set had a median of 0.906 for median impact factor compared to a *JCR* category median of 0.720 (1.3:1) and a median of 54,738.0 total cites compared to a *JCR* median of 23,419.5 (2.3:1). Once again, the probabilities of being cited dramatically rises, when the full set is restricted to the frequent subset of categories, in which the high-impact *SSCI* titles classed 4 or more times. The frequent subset comprised 6 or 11.1% of the 54 *JCR* categories but accounted for 45 or 64.3% of the 70 classifications of the high-impact *SSCI* journals. Five of the frequent categories were subclasses of the behavioral sciences. The frequent subset had a median rank of 6.0 for median impact factor compared to the *JCR* category median of 27.75 (0.2 : 1) and a median rank of 4.5 in total cites compared to the *JCR* category median of 27.5 (0.2 :1). In terms of values, the frequent subset had a median of 1.141 for the median impact factor, which was 1.6 times higher than the *JCR* category median, and a median of 125.972.0 total cites, which was 5.4 times greater than the *JCR* category median. The frequent subset of *JCR* categories also tended to be much larger than all the other *JCR* categories with a median of 80 journals per category compared to a *JCR* category median of 38 and a median of 3,703.5 articles in 2005 compared to a *JCR* category median of 1,309.

Variance and Journal Function

The two most important functions of scientific literature are to report original research and to review this research to assess its validity and form it into syntheses. Of these two functions, it was the review one that most affected Garfield's development of the citation indexing of science. Early in his career, Garfield was heavily influenced by the writings of J.D. Bernal and the proceedings of the 1948 Royal Society Scientific Information Conference at which Bernal played a significant role. In his seminal book, *The Social Function of Science,* Bernal (1940, pp. 297–298) advocated that in each branch of science the responsible bodies ensure that qualified authors periodically review the literature to summarize what they deem to be the chief discoveries and improvements in their fields. This proposal was endorsed by the Royal Society Scientific Information Conference, which adopted a recommendation recognizing the need for more "critical and constructive reviews" and stating that "senior scientists should regard the provision of reviews as an important ancillary to the pursuit of new knowledge" (Royal Society, 1948, p. 201). Garfield (1970, 1978) reports that one his early mentors, Chauncey Leake—a polymath, who served as president of the American Association for the Advancement of Science—admonished him to study review articles and try to understand why they were so important in science. In an oral history Garfield (1987, pp. 13–14) stated that he created the citation indexing of science by combining the structure of the review article with the method of the legal citator. Throughout his career, Garfield stressed the importance of the review articles, once comparing them to

DOI: 10.1002/asi

TABLE 5. Social Sciences Citation Index 2005 JCR subject categories in which 60 titles highest in impact factor (IF) classed .

Category no.	Subject categories	No. high IF journals classed in category	Category median IF rank[a]	Category total cites rank	Category median IF	Category total cites
1	PSYCHIATRY	12	3	1	1.326	231229
2	PSYCHOLOGY, MULTIDISCIPLINARY	10	33	5	0.650	122244
3	PSYCHOLOGY, CLINICAL	7	4	4	1.228	129700
4	PSYCHOLOGY, EXPERIMENTAL	7	2	3	1.500	130817
5	LAW	5	28.5	12	0.718	54316
6	PSYCHOLOGY, DEVELOPMENTAL	4	8	8	1.054	86738
7	BUSINESS	3	19	10	0.811	78427
8	ECONOMICS	3	37	2	0.609	161856
9	GERONTOLOGY	2	21	16	0.797	39052
10	HEALTH POLICY & SERVICES	2	11	14	0.985	42762
11	INFORMATION SCIENCE & LIBRARY SCIENCE	2	44	29	0.480	21758
12	MANAGEMENT	2	16	7	0.831	87417
13	PSYCHOLOGY, SOCIAL PUBLIC,	2	6	9	1.131	81007
14	ENVIRONMENTAL & OCCUPATIONAL HEALTH	2	9.5	6	1.000	89982
15	GEOGRAPHY	1	7	31	1.119	19760
16	POLITICAL SCIENCE	1	43	21	0.488	32586
17	PSYCHOLOGY, APPLIED	1	12	13	0.906	46754
18	PSYCHOLOGY, BIOLOGICAL	1	1	18	1.741	34130
19	PSYCHOLOGY, PSYCHOANALYSIS	1	23	49	0.778	6898
20	SOCIOLOGY	1	46	11	0.460	54738
21	SUBSTANCE ABUSE	1	5	27	1.137	23923
			Median IF ranks (a)	Total cites ranks	Median IF	Total cites
SSCI JCR benchmarks						
Total no. *JCR* subject categories		54				
JCR subject category medians			27.75	27.5	0.720	23419.5
High IF journals full set						
No. categories in high IF category full set		21				
% Full set categories of total no. *SSCI JCR* categories		38.9%				
No. times journals classed in full set		70				
Full set medians			12.0	11.0	0.906	54738.0
Ratio of full set medians to *JCR* category medians			0.4	0.4	1.3	2.3
High IF journals frequent subset						
No. categories in high subset		6				
% High subset categories of total no. *SSCI JCR* categories		11.1%				
No. times journals classed in high subset		45				
% Times journals classed in high subset		64.3%				
Frequent subset medians			6.0	4.5	1.141	125972.0
Ratio of frequent subset medians to *JCR* category medians			0.2	0.2	1.6	5.4

Note. Categories are ranked in descending order by the number of times journals are classed in them. Those categories, in which journals are classified four times or more, are separated out for analytical purposes and designated the high IF journals frequent subset.

[a]Four subject categories were involved in ties on median journal impact factor, causing the JCR median rank on this measure of 27.75 as well as the rank of 28.5 for law and 9.5 for public, environmental, and occupational health.

"an important opinion rendered by the chief justice of the Supreme Court" (Garfield 1987b, p. 5). The fact that Garfield found that review journals in the sciences generally have a higher impact factor or mean citation rate per article than other types of journals serves as validation of his view of the significance of the review article. From this perspective, the review article can be seen as theoretically related to the concept of the scientific "paradigm," which *The Oxford English Dictionary Online* (2007) defines in the following manner: "A conceptual or methodological model underlying the theories and practices of a science or discipline at a particular time; (hence) a generally accepted world view." Kuhn (1970) was the first to use the word in this sense in his landmark book, *The Structure of Scientific Revolutions*, in which he defined "paradigms" as "past scientific achievements. . .that some particular scientific community acknowledges for a time as supplying the foundation for its further practice" (p. 10). Therefore, the more important the role the review article plays in a given discipline, the more focused this discipline is upon the development of consensual paradigms.

Tables 6 and 7 summarize the findings on the categorization and statistical characteristics of the high-impact titles in terms of the review function versus the research function.

DOI: 10.1002/asi

TABLE 6. Science Citation Index 2005 JCR: Categorization and statistical characteristics of 64 titles highest on the impact factor in terms of review versus research functions.

Full set of 64 high-impact titles	
% 2005 articles designated review articles	24.25%
Median % review articles per title	74.83%
Median impact factor	16.614
Ratio of median impact factor to JCR median	15.85
Median total cites	12319.5
Ratio of median total cites to JCR median	13.80
Median 2005 articles	79.5
Ratio of median 2005 articles to JCR median	1.05
Subset of high-impact review titles	
Number review journals	36
% review journals	56.25%
% 2005 articles designated review articles	91.65%
Median % review articles per title	100.00%
Median impact factor	17.4165
Ratio of median impact factor to JCR median	16.62
Median total cites	7673.5
Ratio of median total cites to JCR median	8.59
Median 2005 articles	31.5
Ratio of median 2005 articles to JCR median	0.41
Subset of high-impact research titles	
Number research journals	28
% research journals	43.75%
% 2005 articles designated review articles	8.48%
Median % review articles per title	7.64%
Median impact factor	15.7755
Ratio of median impact factor to JCR median	15.05
Median total cites	31732
Ratio of median total cites to JCR median	35.53
median 2005 articles	183.5
Ratio of median 2005 articles to JCR median	2.41

Note. Titles were categorized as review journals if 50% or more of their articles were designated as review articles.

Table 6 does this for the 64 *SCI* high-impact titles, whereas Table 7 does this for the 60 *SSCI* high-impact titles; but both tables are structured in the same way. The first section of each table deals with the full set of high-impact titles, and the similarities and differences are revealing. It is immediately visible that the review function plays a much more important role in the higher impact of the *SCI* titles than of the *SSCI* ones. Thus, of the 2005 Articles published by these high-impact titles, 24.25% of the 64 *SCI* high-impact titles were designated review articles, whereas only 10.61% of the 60 *SSCI* high-impact titles received the same designation. This difference becomes even more stark in terms of median percent review articles per high-impact title—74.83% for the 64 *SCI* high-impact titles and 6.89% for the 60 *SSCI* high-impact titles. Given Garfield's findings on the generally higher impact factors of review journals, we were therefore not surprised to learn that the 64 *SCI* high-impact titles had a higher ratio of median impact factor to the *JCR* median (15.85 : 1) than did 60 *SSCI* high-impact titles (5.79 : 1). However, the 64 *SCI* high-impact titles and the 60 *SSCI* high-impact titles had similar ratios of total cites to the *JCR* median—13.80 : 1 for the *SCI* titles and 13.60 : 1 for the *SSCI* titles. Of great interest is the relative size of the high-impact titles to the other *JCR* titles. The ratios of median 2005 articles to the *JCR* median were 1.05 : 1 for the 64 *SCI* high-impact titles but 1.56 : 1 for the 60 *SSCI* high-impact titles. Because review journals are generally smaller than research journals, these differing ratios are indicative that the review function is playing a more important role in the higher impact of the *SCI* titles than of the *SSCI* titles.

The next section of Tables 6 and 7 summarizes the findings in respect to the subsets of review titles in the high-impact sets. To identify this subset, a journal was defined as a review journal, if 50% or more of its 2005 articles had been categorized as review articles. The results were again indicative that the review function was more influential in the higher impact of the *SCI* titles than of the *SSCI* titles. Of the 64 *SCI* high-impact titles, 36 or 56.25% were defined as review journals with 91.65% of their 2005 articles being review ones, whereas of the 60 SSCI high-impact titles, only 10 or 16.67% were categorized as review journals with 83.83% of their 2005 articles being designated as review ones. The *SCI* and *SSCI* review journals were similar in that both had higher median impact factors than the *JCR* medians (16.62 : 1 and 9.79 : 1) and higher median total cites than the

TABLE 7. Social Sciences Citation Index 2005 JCR: Categorization and statistical characteristics of 60 titles highest on the impact factor in terms of review versus research functions.

Full set of 60 high-impact titles	
% 2005 articles designated review articles	10.61%
Median % review articles per title	6.89%
Median impact factor	4.0375
Ratio of median impact factor to JCR median	5.79
Median total cites	4623
Ratio of median total cites to JCR median	13.60
Median 2005 articles	48.5
Ratio of median 2005 articles to JCR median	1.56
Subset of high-impact review titles	
Number review journals	10
% review journals	16.67%
% 2005 articles designated review articles	83.83%
Median % review articles per title	84.75%
Median impact factor	6.8265
Ratio of median impact factor to JCR median	9.79
Median total cites	3413
Ratio of median total cites to JCR median	10.04
Median 2005 articles	23.5
Ratio of median 2005 articles to JCR median	0.76
Subset of high-impact research titles	
Number research journals	50
% research journals	83.33%
% 2005 articles designated review articles	6.11%
Median % review articles per title	4.79%
Median impact factor	3.9535
Ratio of median impact factor to JCR median	5.67
Median total cites	5314.5
Ratio of median total cites to JCR median	15.63
Median 2005 articles	65
Ratio of median 2005 articles to JCR median	2.10

Note. Titles were categorized as review journals if 50% or more of their articles were designated as review articles.

DOI: 10.1002/asi

JCR medians (8.59 : 1 and 10.04 :1), but both had lower median 2005 articles than the *JCR* medians (0.41 : 1 and 0.76 : 1).

In the third and last section of Tables 6 and 7 the results of the analysis of the research journal subset are presented. Of the 64 *SCI* high-impact titles, 28 or 43.75% were research journals with only 8.48% of their 2005 articles designated review articles, whereas of the 60 *SSCI* titles, 50 or 83.33% were research journals with only 6.11% of their 2005 articles categorized as review ones. Like the high-impact review titles, the *SCI* and *SSCI* high-impact research journals statistically resembled each other. Both research subsets had higher ratios of median impact factors compared to the *JCR* median (15.05 : 1 for the *SCI* titles and 5.67 : 1 for the *SSCI* titles) and higher ratios of total cites to the *JCR* median (35.53 : 1 for the *SCI* titles and 15.63 : 1 for the *SSCI* titles). The main difference between the review subset and the research subset is that, in both the *SCI* and *SSCI* cases, the high-impact research titles tended to be larger than the other *JCR* titles. Thus, the *SCI* high-impact research journal subset had a median 2005 articles 2.41 times greater than the *JCR* median, and the *SSCI* high-impact research journal subset had a median 2005 articles 2.10 times greater than the *JCR* median. This is suggestive that whereas the higher impact of the high-impact review subsets was due to the importance of the review function, the higher impact of the high-impact research subsets was somehow related to journal size.

The Anomalous Position of the Behavioral Sciences

The behavioral sciences are covered in both the *SCI* and *SSCI JCR*s. In 2005, the *SCI JCR* had the following 2 of its 171 subject categories dedicated to the behavioral sciences (category journals number in parentheses): psychiatry (94) and psychology (60). On the other hand, the 2005 *SSCI JCR* devoted the following 11 of its 54 subject categories to the behavioral sciences (category journals number in parentheses): psychiatry (77); psychology, applied (49); psychology, biological (15); psychology, clinical (83); psychology, developmental (52); psychology, educational (38); psychology, experimental (68); psychology, mathematical (10); psychology, multidisciplinary (101); psychology, psychoanalysis (12); and psychology, social (46). The behavioral sciences thus lie directly athwart the borderline between the sciences and social sciences. It has been pointed out above (p. 19) that the title highest in impact factor in the *SSCI JCR*—*Archives of Psychiatry*—ranked 64th in impact factor in the *SCI JCR*.

This anomalous treatment of the behavioral sciences is not unique to the *JCR*s. Such treatment is also visible in the two standard library classification systems. For its part, the Dewey Decimal Classification (DDC) classes psychology together with philosophy in 100 and psychiatry in technology (600) as a subclass of medicine & health (610). Psychoanalysis is treated as a subclass of psychology. The Library of Congress Classification (LLC) treats the behavioral sciences in a similar way. Thus, the LLC places psychology in B together with philosophy and religion but psychiatry in R (medicine). However, in contrast to the DDC, the LLC makes psychoanalysis a subclass of psychiatry. The treatment of psychology by the DDC and LCC is reflective of the view of this discipline in the late 19th and early 20th centuries. According to Scott (1998, p. 63), in the DDC, whose first edition appeared in 1876, psychology was originally called "mental faculties," which was completely separate from physical considerations and consisted of what the mind does, such as think and feel. Therefore, its placement with philosophy appeared quite logical. The same type of thinking influenced the LLC whose schedules for psychology were first published in 1910 (Chan, 1999, p. 164).

The anomalous character of the behavioral sciences is also evident in the evolution of the classification of psychology in the major evaluations of the quality of research-doctorate programs in the United States. The first such evaluation was done by Cattell (1910), who, according to Reingold (1971) is noted for being the first person in the world to have the title "professor of psychology" (University of Pennsylvania, 1888) and developed the psychology program at Columbia University from 1891 to 1917. Cattell was heavily influenced by work of Auguste Comte on the hierarchy of sciences (Sokal, 1995, p. 70), and under this influence, he divided science into 12 basic disciplines, of which one—not surprisingly—was psychology. Such a treatment of psychology stands in sharp contrast to that of the contemporaneous library classification systems. Cattell's classification of psychology as a science was maintained by the 1964 evaluation of U.S. research-doctorate programs (Cartter, 1966), which placed it within the rubric "biological sciences." However, the 1969 rating of U.S. research-doctorate programs (Roose & Andersen, 1970) re-classed psychology from the "biological sciences" to the "social sciences." This classification of psychology was maintained by the 1981 assessment of U.S. research-doctorate programs (Jones, Lindzey, & Coggeshall, 1982), but the name of the subject category was changed to "social & behavioral sciences," indicating that there was something different about psychology from the other social sciences. The 1993 evaluation of U.S. research-doctorate programs (Goldberger, Maher, & Flattau, 1995) classified psychology within the same rubric, and this policy is being continued by the assessment under way today (National Academies U.S., 2006).

It is evident from the above that there have been difficulties in deciding whether to classify the behavioral sciences in the sciences or the social sciences. The two standard library classifications even treat psychology as being more related to the humanities. Due to the findings of this article, one possible classificatory consideration to be taken into account in dealing with the behavioral sciences is the pattern of the journal literature of a given discipline—particularly whether this discipline is adhering to the science model of dominant review journals playing a major role in the development of consensual paradigms. The 10 review journals among the 60 *SSCI JCR* titles highest in impact factor provide an opportunity to explore this possibility. Of these 10 review journals, 7 were also covered by the *SCI JCR*, and 8 classed in the behavioral sciences of which 6 were among

DOI: 10.1002/asi

those also covered by the *SCI JCR*. The distribution of these eight high-impact behavioral science review journals over *SSCI* subject categories was as follows: psychology, biological–1; psychology, clinical–2; psychology, developmental–1; psychology, experimental–1; and psychology, multidisciplinary–3. Of the two behavioral science review journals not also covered by the *SCI JCR*, one was in psychology, clinical, and the other was in psychology, developmental. From this, it can be deduced that at least certain fields in psychology are adhering to the science model of dominant review journals and that this adherence accounting for a good proportion of the variance and positive skew of the *SSCI JCR* impact factor distribution.

TABLE 8. *Science Citation Index 2005 JCR:* Pearson *r* correlation matrix for the impact factor, total cites, and 2005 articles.[a]

	Total cites	2005 articles
Impact factor	0.68	0.27
Total cites		0.70

Note. All correlations significant at the 0.01 level.
[a]The impact factor and total cites correlation is between 6,045 titles, but the 2005 articles correlations involve only 5,844 titles.

TABLE 9. *Social Sciences Citation Index 2005 JCR:* Pearson *r* correlation matrix for the impact factor, total cites, and 2005 articles.[a]

	Total cites	2005 articles
Impact factor	0.74	0.28
Total cites		0.56

Note. All correlations significant at the 0.01 level.
[a]The impact factor and total cites correlation is between 1,745 titles, but the 2005 articles correlations involve only 1,698 titles.

Relationship of the Impact Factor to Total Cites and 2005 Articles

The final step in the analysis was to investigate the relationship of the impact factor to total cites and 2005 articles. Both total cites and 2005 articles are measures of journal size. The number of 2005 articles can be considered a pure measure of the current physical size of a journal. However, for its part, the total cites measure represents a complex amalgam of current and past physical size, the past temporal size in terms of the age and concomitant length of the backfile, as well as the as the quality or prestige of the journal. This author (Bensman, 1996; Bensman, 2007b; Bensman, 2007c; Bensman and Wilder, 1998) has consistently found total cites to be a better surrogate than the impact factor for the library use and expert ratings of journals. He has also discovered total citations to the publications of the faculty of scientific research-doctorate programs to be more highly correlated with the peer ratings of these programs than mean citation rate per faculty member.

To investigate the relationship of the impact factor to total cites and 2005 articles, the Pearson product-moment correlation coefficient *r* was utilized. The Pearson *r* requires both variables to be normally distributed, and accordingly there were performed the transformations recommended by Elliott (1977, p. 33). Those variables, which tested to be of the negative binomial type—all the *SCI* measures as well as *SSCI* total cites and 2005 articles—were subjected to the natural logarithmic transformation. The *SSCI* impact factors had been found to follow the Poisson distribution, and therefore the square root transformation was employed. These transformations caused the distributions to approximate closely the normal distribution in terms of the mean-to-median ratio and variance. They also made the distributions much more symmetrical by considerably reducing the positive skewness, although some excess positive skewness remained. We find it interesting enough that in both *SCI* and *SSCI* cases, the impact factor distributions remained more positively skewed than the others despite the different transformations employed.

Tables 8 and 9 present the results of the Pearson *r* correlation analysis. In both *SCI* and *SSCI* cases, the impact factor has a low correlation with 2005 articles (0.27 for the *SCI* and 0.28 for the *SSCI*), whereas total cites has rather good correlations with 2005 articles (0.70 for the *SCI* and 0.56 for the *SSCI*). We do not find this surprising because the impact factor is a measure specifically designed to control for physical size, whereas total cites are partially a function of physical size. What we do find surprising and significant are the high correlations of the impact factor with total cites (0.68 for the *SCI* and 0.74 for *SSCI*). An analysis of the extreme outliers was undertaken to understand better what was happening. In both *SCI* and *SSCI* cases, the primary outliers were small review journals. Thus, of the 25 *SCI* extreme outliers, 13 were review journals, and of 13 *SSCI* extreme outliers, 6 were review journals. These results are in line with the finding by Bensman (2007b, pp. 49–55) with a set of 120 chemistry journals that the more carefully the set was defined in terms of function by restricting it to research journals through exclusion of the review journals, the more the impact factor and total cites approximated each other as measures of journal importance. The high Pearson correlations between the impact factor and total cites in the 2005 *JCR*s were corroborated with the Spearman rank-order correlation by Loet Leydesdorff (personal communication, June 2, 2007), who obtained coefficients of 0.71 for the *SCI* measures and 0.76 for the *SSCI* measures—both significant at 0.01 level.

The above findings indicate that when a journal set is clearly defined by research function by excluding small review journals, the older, larger, and more prestigious the journals, the higher their current mean citation rates tend to be. These findings confirm what Garfield found empirically. In a study of 1,000 papers most highly cited over the preceding decade, Garfield (1973) discovered not only that 200 journals accounted for all of them but also that merely 15 journals

DOI: 10.1002/asi

published a half of them. Garfield's list of these 15 titles revealed them to be large journals—such as the *Journal of Biological Chemistry* with 109—and he declared that not one of the 1,000 articles appeared in an "obscure" journal (p. 6). Garfield (1991, 1996) later found this dominant core of journals to be highly stable over time. These findings were corroborated by Cole (2000, pp. 116–118) in an analysis that demonstrated that highly cited articles concentrated in a small proportion of journals both in the sciences and social sciences. For his part, Bensman (2007b, pp. 62–68) proved with a sample of chemistry journals that journal rankings by both the impact factor and Total Cites were highly stable over the period 1993–2003, with the dominant journals on both measures tending to increase their dominance across time. The Spearman correlations between the 1993 and 2003 ranks were 0.91 for the impact factor and 0.90 for total cites, implying that the relative probabilities of journals being cited are rather stable in relationship to each other over time. From the statistical viewpoint, we find the high correlations between the impact factor and total cites quite surprising, given the random error particularly in determining the number of "citable" items for the divisor, sampling variance, compact interval distances, etc., entailed with the impact factor. This is particularly true in respect to the Spearman correlations where it would seem that the conversion of minute interval distances into unit ordinal ranks could compound the effects of random error and sampling variance. However, Siegel (1956, p. 210) points out that tied ranks tend to inflate the value of the Spearman rho, and it has been shown above that there were certainly many of these due to the compacting of so many titles within such constricted ranges. The high *SSCI* correlations throw doubt on drawing the conclusion that the *SSCI* impact factors were randomly distributed because they were tested to conform to the Poisson distribution. As a matter of fact, the test did come close to rejecting the null hypothesis of the Poisson in favor of the alternative hypothesis of a distribution of the negative binomial type. The high correlations are indicative of the operation of powerful causal factors, which can be stochastically explained by continued probabilistic heterogeneity reinforced by contagion or—in other words—the success-breeds-success mechanism of the Matthew Effect.

Conclusions

This article has examined the differences in the overall probabilistic structures of the 2005 *Science Citation Index* (*SCI*) and *Social Sciences Citation Index* (*SSCI*) *Journal Citation Reports* (*JCR*) as it pertains to the distribution of journals by the impact factor. To do this, it utilized the chi-squared index of dispersion test whose null hypothesis is the Poisson distribution, and alternate hypotheses are either the binomial distribution or one whose accepted model is the negative binomial distribution (NBD). The essence of this test is whether the variance of the data conforms to the theoretical variance expected under the conditions of the Poisson. Both the Poisson and the binomial distributions imply probabilistic homogeneity and independence of events in that the occurrence of an event does not affect the probability of its further occurrence. The latter condition is the stochastic process known in statistics as "contagion," and it is the model for cumulative advantage or a success-breeds-success mechanism known as the Matthew Effect. The Poisson arises from the binomial as the probability of occurrence becomes very small, and it is the model for random, rare events. In contrast, distributions of the NBD type arise when there is probabilistic heterogeneity and contagion is operative, and their primary characteristic is a variance far greater than the variance of either the Poisson or the binomial.

The chi-squared tests indicated that the distribution of journals by the impact factor conformed to a contagious distribution of the NBD type in the *SCI JCR* but to the Poisson in the *SSCI JCR*. However, the *SSCI* test came close to rejecting the Poisson in favor of a distribution of the NBD type—a standard normal deviate of 1.86 instead of the 1.96 or above required for rejection. Both the *SCI* and *SSCI* distributions were positively skewed—the *SCI* distribution much more so than the *SSCI* one. All these are signs of excessive variance. To discover the causes of this excessive variance, the journals highest in the impact factor and causing the bulk of the variance—64 *SCI* titles and 60 *SSCI* titles—were closely examined in respect to the subject categories in which they were classed and whether they were research or review journals. In respect to subject categories, both *SCI* and *SSCI* high-impact titles tended to class in fields where research is well-funded by the NIH. These fields tended to be bigger in numbers of journals and articles, causing both to have a higher probability of being cited. It thus seems that the probabilistic structures of both *JCR*s are heavily influenced by the biomedical multiplier effect that so influenced the development of American research universities after World War II due to ample NIH research funding. In respect to the research versus review function, it was found that review journals were much more predominant among the high-impact *SCI* journals than the *SSCI* ones. Review articles tend have much higher citation rates than research articles, and one reason for this is their role in defining the consensual paradigms that govern a given discipline. The review function appears to be much more important in the journal literature of the sciences than of the social sciences, and this accounts for the much higher variance and skewness of the *SCI* impact factor distribution in comparison to the *SSCI* one. It should be pointed out that the review function may be performed in the social sciences by the monograph instead of the review journal, and this may account for such journals as *Contemporary Sociology* and the *Journal of Economic Literature* where the book review is the predominant feature. There is evidence that the *Journal of Economic Literature* plays a role in paradigm development because it was among the 10 *SSCI* review journals highest on the impact factor.

In respect to the relationship of the impact factor to total cites and 2005 articles, the most important finding was that in both *SCI* and *SSCI JCR*s there were remarkably high

DOI: 10.1002/asi

correlations between the impact factor and total cites with small review journals being among the most important extreme outliers. This implies two things. First, the better defined a journal set is in terms of the research function, the more the impact factor approximates total cites as a measure of journal importance. Second, the bigger, older, and more prestigious the journal, the higher tends to be the current mean citation rate per article. The latter is symptomatic of the operation of contagion or the Matthew Effect, and it can be hypothesized as causal in the rank stability of the journals by these measures over time. Ironically, therefore, contrary to its stated purpose, the impact factor does not control for size but is itself a function of size.

It must be emphasized that this article is only an exploratory investigation. As a result, the article's findings cannot be taken as conclusive and must be validated by further research. First of all, the analysis was limited to one *JCR* year and therefore should be replicated with other *JCR* years to determine whether the same patterns repeat themselves. However, these global analyses can be considered merely preparatory and need to be validated by investigations of the impact factor probability structures of individual disciplines. In these disciplinary analyses, it is not expected that all *JCR* subject categories will manifest the same impact factor distributional characteristics as their parent *JCR*. Some *SCI* subject categories will probably resemble the *SSCI JCR* in this respect, while some *SSCI* subject categories should act more like the *SCI JCR*. For example, it was shown that certain *SSCI* subject categories of psychology appear to adhere to the *SCI* model of dominant review journals, thereby playing a role in increasing the variance and skew of the *SSCI* impact factor distribution. This is an area for further investigation, and the findings should be revealing about the different science and social science disciplines. As part of these disciplinary analyses, there should also be behavioral investigations to verify the reasons for the higher citation rate of review articles. Because the disciplinary studies will involve fewer titles, it may be possible to do what was not done in this analysis due to the massive number of titles: Analyze the *JCR* titles as bibliographic entities to determine what effect title changes, mergers, division in parts, etc., have upon the measures. The online *JCR* Help (Institute for Scientific Information, 2005) warns that in case of a title change the data is not combined "on the basis of *lineage* except where a title change has been so minor that it does not affect the title's position alphabetically." Therefore, the level of the bibliographic stability of titles has a great potential to affect their citation measures.

References

Adams, D. (2002). The counting house. Nature, 415 (6873), 726–729.

Aristotle. (1984). The complete works of Aristotle: The revised Oxford translation (Jonathan Barnes, Ed., Vols. 1–2). Bollingen series, 71(2). Princeton, NJ: Princeton University Press.

Begley, S. (2006, June 5). Science journals artfully try to boost their rankings. The Wall Street Journal, p. B1.

Bensman, S. J. (1996). The structure of the library market for scientific journals: The case of chemistry. Library Resources & Technical Services, 40 (2), 145–170.

Bensman, S.J. (2000). Probability distributions in library and information science: A historical and practitioner viewpoint. Journal of the American Society for Information Science, 51 (9), 816–833.

Bensman, S.J. (2007a). Garfield and the impact factor. Annual Review of Information Science and Technology, 41, 93–155.

Bensman, S.J. (2007b). Garfield and the impact factor: The creation, utilization, and validation of a citation measure: Part 2, The probabilistic, statistical, and sociological bases of the measure. Unpublished manuscript. Available at http://garfield.library.upenn.edu/bensman/bensmanegif22007.pdf

Bensman, S.J. (2007c). The impact factor, total citations, and better citation mouse traps: A commentary. Journal of the American Society for Information Science and Technology, 58 (12), 1904–1908.

Bensman, S.J., & Wilder, S. J. (1998). Scientific and technical serials holdings optimization in an inefficient market: A LSU serials redesign project exercise. Library Resources & Technical Services, 42 (3), 147–242.

Bernal, J.D. (1940). The social function of science (2nd corrected ed.) London: George Routledge.

Beyer, W.H. (1968). CRC handbook of tables for probability and statistics (2nd ed.). Cleveland, Ohio: Chemical Rubber Co.

Cartter, A.M. (1966). An assessment of quality in graduate education. Washington, DC: American Council on Education.

Cattell, J. M. (1910). A further statistical study of American men of science. Science, 32(828), 672–688.

Chan, L.M. (1999). A guide to the Library of Congress Classification (5th ed.). Library and information science text series. Englewood, CO: Libraries Unlimited.

Cochran, W.G. (1954). Some methods for strengthening the common X^2 tests. Biometrics, 10(4), 417–451.

Cole, S. (2000). The role of journals in the growth of scientific knowledge. In B. Cronin & H.B. Atkins (Eds.), The Web of knowledge: A festschrift in honor of Eugene Garfield (pp. 109–142). ASIS monograph series. Medford, NJ: Information Today.

Coleman, J.S. (1964). Introduction to mathematical sociology. New York: Free Press of Glencoe.

Eggenberger, F., & Pólya, G. (1984). _ber die Statistik verketteter Vorgänge. In G. Pólya [Probability; Combinatorics; Teaching and learning in mathematics]. (G.-C. Rota, Ed., pp. 94–104). Collected papers / George Pólya, Vol. 4. Mathematicians of our times, Vol. 22. Cambridge, MA: MIT Press.

Elliott, J.M. (1977). Some methods for the statistical analysis of samples of benthic invertebrates (2nd ed.). Freshwater Biological Association, 25.

Feller, W. (1943). On a general class of "contagious" distributions. Annals of Mathematical Statistics, 14(4), 389–400.

Fisher, R.A. (1925). Statistical methods for research workers. Biological monographs and manuals, 5. Edinburgh: Oliver and Boyd.

Garfield, E. (1970, April 22). Calling attention to Chauncey D. Leake—Renaissance scholar extraordinaire. Current Contents, 16, 5–6.

Garfield, E. (1972a). Citation analysis as a tool in journal evaluation. Science, 178 (4060), 471–479.

Garfield, E. (1972b, February 23). Citations-to divided by items-published gives journal impact factor; ISI lists the top fifty high-impact journals of science. Current Contents, 7, 5–8.

Garfield, E. (1973, Sept. 26). Which journals attract the most frequently cited articles? Here's a list of the top fifteen. Current Contents, 39, 5–6.

Garfield, E. (1976a). Significant journals of science. Nature, 264 (5587), 609–615

Garfield, E. (1976b, Feb. 9). Is the ratio between number of citations and publications cited a true constant? Current Contents, 6, 5–7.

Garfield, E. (1978, Feb. 13). To remember Chauncey D. Leake. Current Contents, 7, 5–15.

Garfield, E. (1987a). Oral history: Transcript of an interview conducted by Arnold Thackray and Jeffrey Sturchio at the Institute for Scientific Information, Philadelphia, PA, on 16 November 1987. Philadelphia: Beckman Center for the History of Chemistry.

DOI: 10.1002/asi

Garfield, E. (1987b, May 4). Reviewing review literature: Part 1, Definitions and uses of reviews. Current Contents, 18, 5–8.

Garfield, E. (1991, Sept. 2). In truth, the 'flood' of scientific literature is only a myth. The Scientist, 5(17), 11.

Garfield, E. (1996, Sept. 2). The significant scientific literature appears in a small core of journals. The Scientist, 10(17), 13.

Garfield, E. (2000). Interview with Eugene Garfield. Medical Writing, 8 (1). Retrieved July 20, 2005, from http://www.garfield.library.upenn.edu/papers/medicalwritingv8(1)1999.html.

Garfield, E. (2005). The agony and the ecstasy—The history and meaning of the journal impact factor: Paper presented at the International Conference on Peer Review and Biomedical Publication. Retrieved November 18, 2005, from http://garfield.library.upenn.edu/papers/jifchicago2005.pdf

Garfield, E., & Sher, I.H. (1963). New factors in the evaluation of scientific literature through citation indexing. American Documentation, 14(3), 195–201.

Goldberger, M.L., Maher, B. A., & Flattau, P. E. (Eds.). Research-doctorate programs in the United States: Continuity and change. Washington, DC: National Academy Press.

Graham, H.D., & Diamond, N. (1997). The rise of American research universities: Elites and challengers in the postwar era. Baltimore: Johns Hopkins University Press.

Greenwood, M., & Yule, G.Y. (1920). An inquiry into the nature of frequency distributions representative of multiple happenings with particular reference to the occurrence of multiple attacks of disease or of repeated accidents. Journal of the Royal Statistical Society, 83(2), 255–279.

Grieg-Smith, P. (1983). Quantitative plant ecology (3rd ed.). Studies in ecology, Vol. 9. Berkeley: University of California Press.

Institute for Scientific Information. (2005) Journal citations reports help. Philadelphia, PA.: Institute for Scientific Information. Available to subscribers at http://portal.isiknowledge.com/portal.cgi?DestApp=JCR&Func=Frame

Jones, L. V., Lindzey, G., & Coggeshall, P. E. (Eds.). (1982). An assessment of research-doctorate programs in the United States: Social & behavioral sciences. Washington, DC: National Academy Press.

Joseph, K.S., & Hoey, J. (1999). CMAJ's impact factor: Room for recalculation. Canadian Medical Association Journal, 161(8), 977–978.

Kotz S., & Johnson, N.L. (Eds.). (1982). Discrete distribution. Encyclopedia of statistical sciences (Vol. 2, pp. 387–388). New York: Wiley.

Kuhn, T.S. (1970). The structure of scientific revolutions (2nd ed., enlarged). Chicago: University of Chicago Press.

Martyn, J., & Gilchrist, A. (1968). An evaluation of British scientific journals. London: Aslib.

Monastersky, R. (2005, Oct. 14). The number that's devouring science. Chronicle of Higher Education, pp. A12–A7.

Moroney, M.J. (1956). Facts from figures (3rd ed.). Baltimore, MD: Penguin Books.

National Academies U.S. (2006). Taxonomy of fields. Retrieved November 29, 2007, from http://www7.nationalacademies.org/resdoc/Taxonomy_list.html

The Oxford English Dictionary Online. (2007). Oxford, England: Oxford University Press. Available at http://dictionary.oed.com/

Pearson, E.S., & Hartley, H.O. (Eds.). (1966). Biometrika tables for statisticians (3rd ed., Vol. 1.). Cambridge: University Press.

Reingold, N. (1971). Cattell, James McKeen. In C.C. Gillispie (Ed.), Dictionary of scientific biography (Vol. 3, pp. 130–131). New York: Charles Scribner's Sons.

Roose, K. D., & Andersen, C. J. (1970). A rating of graduate programs. Washington, DC: American Council on Education.

Royal Society. (1948). The Royal Society Scientific Information Conference, June 21– July 2, 1948, London:Author.

Scott, M.L. (1998). Dewey Decimal Classification, 21st ed.: A study manual and number building guide. Englewood, CO.: Libraries Unlimited.

Seglen, P.O. (1992). How representative is the journal impact factor. Research Evaluation, 2 (3), 143–149.

Seglen, P.O. (1997). Why the impact factor of journals should not be used for evaluating research. British Medical Journal, 314(7079), 497.

Siegel, S. (1956). Nonparametric statistics for the behavioral sciences. New York: McGraw-Hill.

Snedecor, G.W., & Cochran, W.G. (1989). Statistical methods (8th ed.). Ames: Iowa State University Press.

Sokal, M. M. (1995). Stargazing: James McKeen Cattell, American men of science, and the reward structure of the American scientific community, 1906–1944. In F. Kessel (Ed.), Psychology, science, and human affairs: Essays in honor of William Bevan (pp. 64–85). Boulder, CO: Westview Press.

"Student." (1919). An explanation of deviations from Poisson's Law in practice. Biometrika, 12, 211–215.

DOI: 10.1002/asi