

The Place of Serials in Referencing Practices: Comparing Natural Sciences and Engineering With Social Sciences and Humanities

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Journal articles constitute the core documents for the diffusion of knowledge in the natural sciences. It has been argued that the same is not true for the social sciences and humanities where knowledge is more often disseminated in monographs that are not indexed in the journal-based databases used for bibliometric analysis. Previous studies have made only partial assessments of the role played by both serials and other types of literature. The importance of journal literature in the various scientific fields has therefore not been systematically characterized. The authors address this issue by providing a systematic measurement of the role played by journal literature in the building of knowledge in both the natural sciences and engineering and the social sciences and humanities. Using citation data from the CD-ROM versions of the Science Citation Index (SCI), Social Science Citation Index (SSCI), and Arts and Humanities Citation Index (AHCI) databases from 1981 to 2000 (Thomson ISI, Philadelphia, PA), the authors quantify the share of citations to both serials and other types of literature. Variations in time and between fields are also analyzed. The results show that journal literature is increasingly important in the natural and social

sciences, but that its role in the humanities is stagnant and has even tended to diminish slightly in the 1990s. Journal literature accounts for less than 50% of the citations in several disciplines of the social sciences and humanities; hence, special care should be used when using bibliometric indicators that rely only on journal literature.

Introduction

Bibliometrics and other quantitative methods are being used increasingly in research evaluation because of the growing concern about accountability of public spending in science (King, 1987; Treasury Board of Canada Secretariat, 2001). While the validity and appropriateness of bibliometric methods are largely accepted in the natural sciences, the situation is more complex in the case of the social sciences and humanities.

Bibliometricians who evaluate research output in the natural sciences can rely on a well-defined set of core journals that contains the most-cited research and is covered comprehensively by both disciplinary and interdisciplinary databases. The same cannot be said about the social sciences and humanities.

Hicks (1999, 2004) recently summarized the difficulties surrounding the use of bibliometrics for the social sciences

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and humanities (SSH). Research in these domains is much more interdisciplinary than in the natural sciences and engineering (NSE). This situation often leaves researchers no choice but to use multidisciplinary databases, especially if citation analysis is to be performed. The combined use of Thomson ISI's (Philadelphia, PA) Social Sciences Citation Index (SSCI) and Arts and Humanities Citation Index (AHCI) can hardly be avoided given their extensive coverage. But their use is not without problems. Within the context of an analysis restricted to journal articles, the SSCI and AHCI fail to cover a good part of the literature published outside the United States and the United Kingdom, whether the language used is English or not. In fact, many authors consider these databases to be biased in favor of those two countries (Andersen, 2000; Glänzel, 1996; Nederhof & Noyons, 1992; Schoepflin, 1992; Webster, 1998). The adequacy of the SSCI and AHCI to evaluate SSH research is even more problematic when one considers the importance of books and other types of documents in the process of scholarly communication in these fields. For instance, Hicks (2004) convincingly argues that books not only form a sizeable part of publications in some disciplines of the social sciences and humanities but are also often cited, and this impact cannot be extrapolated from that of journal articles. Thus, the validity of evaluations using bibliometric methods and Thomson ISI's databases can only be properly assessed if the share of the various types of documents being used in scholarly communication is known. In this study we measure the importance of these different types of publications by looking at how often scientific journals are cited and, by extension, at how often other types of document are cited.

Non-Journal Publications in the Social Sciences and Humanities

Numerous studies have provided data on the relative proportion of journal and nonjournal forms of publishing. For instance, Nederhof, Zwaan, DeBruin, and Dekker (1989) measured the percentage of journal articles, report proceedings, and books (including edited books and book chapters) published by a sample of Dutch universities' departments.¹ They found that, for most of the departments, the results oscillated between 35% and 50% for articles and between 35% and 40% for books. Likewise, in their analysis of social science cocitation clusters, Small and Crane (1979) found that 39% of cited items in sociology were books, 24.5% in economics, compared to only 0.9% in high-energy physics. Based on these results, Hicks (1999) estimated that between 40% and 60% of the literature in the social sciences is composed of books.

In a survey of 618 social scientists, Andersen (2000) found that only a quarter of their publications were journal articles. Studying six economics research groups from 1980

to 1988, Nederhof and van Raan (1993) found that 37% of the groups' combined production was composed of journal articles. Within the framework of the Research Assessment Exercise (RAE) in the United Kingdom, Norris and Oppenheim (2003) evaluated the performance of 682 archaeologists. The authors found that 54% of the archaeologists' publications were monographs and 40% articles. In addition, Leydesdorff (2003) showed that whereas 79% of citations in articles covered by the Science Citation Index (SCI) were to other articles included in the database, this percentage was only 45% for the Social Sciences Citation Index (SSCI). Glänzel and Schoepflin (1999), using a method similar to the one used here, found that the percentage of references to serials in the SCI and SSCI varied between 35% in history, philosophy of science, and social sciences, and 94% in immunology.

In summary, all these studies claim that nonjournal literature is more important in scholarly communication in the social sciences and humanities than it is in the natural sciences and engineering. However, none provides comprehensive data as to the importance of this difference for all disciplines and its evolution over a long period. The results are mostly limited to either national or institutional levels or represent only a static view of publication practices. We address these issues by analyzing the number of references made to journal and nonjournal literature by journals covered in the SCI, SSCI, and AHCI databases from 1981 to 2000. The results provide important data for the evaluation of the role played by nonserial publications in various disciplines and their temporal evolution. Thus we contribute to assessing how journal-centric databases can be used to evaluate scientific outputs in SSH disciplines in which publications other than articles still play an important role.

Methods

The data used in this study are drawn from the CD-ROM version of the SCI, SSCI, and AHCI. For the natural sciences, journals were assigned fields and subfields using the classification system developed by CHI Research (Chicago, IL and Philadelphia, PA).² To avoid double-counting, CHI's system never places a journal in more than one field. The classification is divided into nine major fields, which are again broken down into more than one hundred specialties or subfields. However, CHI does not have a similar classification for the social sciences and the humanities. It was thus necessary to create a similar classification system for the SSH. ISI's classification of journals for the SSCI and AHCI was used as a starting point for creating eight SSH fields. Considering the fact that Thomson ISI assigns journals to more than one subfield, it was necessary to select the most relevant subfield for each journal to avoid double-counting references and articles when the data were aggregated by subfield.

¹These departments specialized in anthropology, experimental psychology, social history, Dutch literature, Dutch language, general literature, general linguistics, and public administration.

²CHI Research is a research firm specializing in quantitative science and technology research. For further information: <http://www.chiresearch.com>.

This paper uses Thomson ISI databases as a way of measuring referencing practices in different disciplines. It does not address other important issues such as the coverage of these databases by subfields. It concentrates on computing the proportion of serials and other types of documents cited over a period of 20 years. Cited literature can be considered relevant—cumulative knowledge (both positive and negative) that results from a process of “scientific selection.” Hence, this study measures the relative importance of journal literature in knowledge building in various NSE and SSH disciplines. In addition, one can hypothesize that referencing practices reflect publication practices and, therefore, that the proportion of serials in the references made by journal articles should largely reflect the relative production of articles by scholars. Accordingly, quantitatively evaluating the presence of non-serials provides a measure of both the importance of other types of document such as books, which, as we have seen, play an important role in SSH, and the evolution in time of the trend to produce journal articles rather than books.

Building the Indicator

The indicator needed to address our research question is similar to that used by Glänzel and Schoepflin (1999). In their study of how journal literature aged in the natural and social sciences, they describe a method to isolate citations made to serials (S) as opposed to citations made to nonserial literature (N). To be included in the S category, a reference needs to fulfill a list of criteria, the main one being the presence of volume and page numbers. References without a first page number needed to have a valid journal name and the string “in press” to be considered a serial. Manual and computerized procedures were used to extract references from serials that had no volume numbers but had valid first pages. All other references were categorized as nonserial literature.

Applying this method to a very large amount of data covering 20 years would have been impractical, especially when it came to manually classifying references. The main issue in building the indicator was to isolate references to journal articles from references to other types of scientific publication. This entailed using a purpose-built algorithm to parse the string of characters of the reference to separate the different types of information they contained. Using that algorithm, fields containing specific information such as the author’s name, title of the work cited, volume number, page number, and year of publication were created. Cases where the abovementioned variables were missing were labeled as null in the appropriate database field.

Observation of the data suggested that, for most fields, the presence of a volume number could be a sufficient criterion to distinguish journals from other types of literature. To validate our hypothesis, a random sample of 200 references (100 with a volume number and 100 without a volume number) was tested for each subfield. While some references were easy to authenticate as serials (J-MARKETING-RES,

AM-SOCIOLOGICAL-REV, etc.) or as nonserials (THESIS-UMINNESOTA, SCHELLENBERG-MEMOIRS, etc.), some other cases needed research on the Web because their titles did not contain any discriminating evidence.

Table 1 shows that both error rates vary considerably across fields. Indeed, for the social sciences fields in which articles are an important medium for the diffusion of scholarly communication (psychology, law, economics and management, education, and other social sciences), the error rate for references without a volume number were higher than for references with a volume number. This is hardly surprising; the probability that a serial is cited—as opposed to a nonserial—is greater in these fields. Also, we noticed that a large part of these errors are caused by nonacademic journals such as *Fortune*, *The Wall Street Journal*, or other newspapers that seldom have a volume number. Consequently, the share of serials could be slightly higher in these fields than the value obtained by our indicator.

On the opposite side, error rates for fields in the humanities (history, other humanities and literature) were higher for references with a volume number than for those without a volume number. Again, in these fields nonserial literature is much more important; thus, this comes as no surprise. A large part of these errors are caused by monograph series that have volume numbers, or by encyclopedias and dictionaries that have several volumes. On the whole, these error rates indicate that, for these fields, the share of serials in cited literature could be even lower than the value obtained by our method.

TABLE 1. Error rates for references with and without volume numbers, by field.

Field	Error rate volumes	Error rate No volume
Economics and Management	0%	11%
Education	2%	7%
History	11%	0%
Law	4%	18%
Literature	15%	1%
Other Humanities	18%	1%
Other Social Sciences	2%	7%
Psychology (SSH)	1%	4%
Average SSCI/AHCI	7%	6%
Biology	2%	3%
Biomedical Research	1%	13%
Chemistry ^a	1% (1%)	33% (9%)
Clinical Medicine	0%	12%
Earth and Space Science	8%	6%
Engineering	2%	0%
Mathematics	4%	5%
Physics	2%	4%
Psychology (NSE)	2%	5%
Average SCI	3% (3%)	9% (6%)

Note. The data are from the Science Citation Index (SCI), Social Sciences Citation Index (SSCI), and Arts and Humanities Citation Index (AHCI) databases, 1981–2000, Philadelphia, PA: Thomson ISI. Compiled with permission from Thomson ISI, by the Observatoire des Sciences et des Technologies, Université du Québec à Montréal, Montréal, Québec, Canada.

^aCorrected error rates are presented in parentheses.

In the natural sciences, our method proved to be somewhat problematic in the field of chemistry where the criteria of having a volume number proved to be insufficient to distinguish periodicals from nonperiodicals. However, by using the search strings *-J-*, J-*, *-J (for journal) or *lett* (for letter) in the journal field, it was possible to isolate a large part of these errors. The recalculated error rate that takes into account this more complex search is presented in parentheses in Table 1.

For other natural sciences fields, other types of error included book series that have volume numbers, especially in mathematics and engineering. In physics, preprints and e-prints stored in archives such as arXiv (www.arxiv.org), account for an important share of nonserial literature. In all cases, there is a high tendency to underestimate the share of serials in the natural sciences fields. For all fields, references to material “in press” created an error that tended to underestimate the number of citations to journal articles.

Taking into account that this study is performed at the macro level of analysis, this small potential measurement error does not adversely affect the global results in a significant manner. Because we aren’t analyzing the fine structure of the spectrum, these error rates do not affect global results.

Results

Figure 1 shows that the proportion of citations to journals in SSH journal literature is half of that observed in NSE. In particular, in 1981, the share of total citations to journal articles was slightly over 82% in NSE as opposed to 40% in SSH. Because the share of citations to periodicals grew faster in SSH than it did in SSE, this gap narrowed somewhat

in 2000 with 49% of citations in SSH being made to journal articles, compared to 87% in NSE. Though small, this growth indicates a general trend toward a greater use of journals as a diffusion mechanism in SSH as a whole, the slope of which varies, however, according to discipline, as we will now see.

Figure 2 reveals four groups in the NSE that exhibit different referencing practices: the health sciences, natural sciences, mathematics, and engineering. Clearly, scientists from the health sciences (biomedical research and clinical medicine) are those for whom journal articles are the most important source of scientific knowledge. In fact, this trend intensified fairly sharply during the last 20 years, increasing from more than 87% of references made to journal articles to over 93%. This trend reflects the accelerating pace of research in these fields. The second group comprises the natural scientists (physics, biology, earth and space, and chemistry) and the psychologists. Within this group, chemists are at the top end of the spectrum (growing from 82% of cited literature in 1981 to 87% in 2000) and psychologists at the bottom (from 74% in 1981 to 79% in 2000). The mathematicians act as a distinct group, with around 70% of their references being made to journal articles. Finally, the engineers are citing less journal literature than others but this share is rising—whereas 60% of the citations were to journal literature in 1981, this percentage grew to almost 68% in 2000.

As one can see here, citing practices vary greatly from one field to another and, as suggested, this must reflect the relative share of journal articles in the publication practices of these disciplines, engineers using more often than physicists, for example, conference proceedings as an outlet for their results. In addition, one can see that the calculated

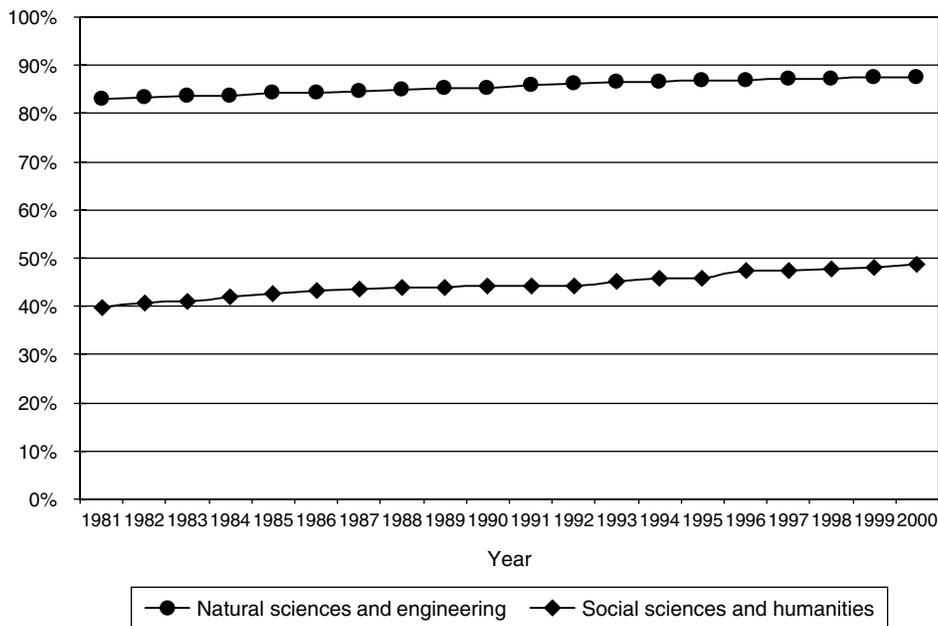


FIG. 1. Share of references made to journal articles for natural sciences and engineering (NSE) and natural sciences and engineering (NSE), 1981–2000. The data are from the Science Citation Index (SCI), Social Sciences Citation Index (SSCI), and Arts and Humanities Citation Index (AHCI) databases, 1981–2000, Philadelphia, PA: Thomson ISI. Compiled with permission from Thomson ISI, by the Observatoire des Sciences et des Technologies, Université du Québec à Montréal, Montréal, Québec, Canada.

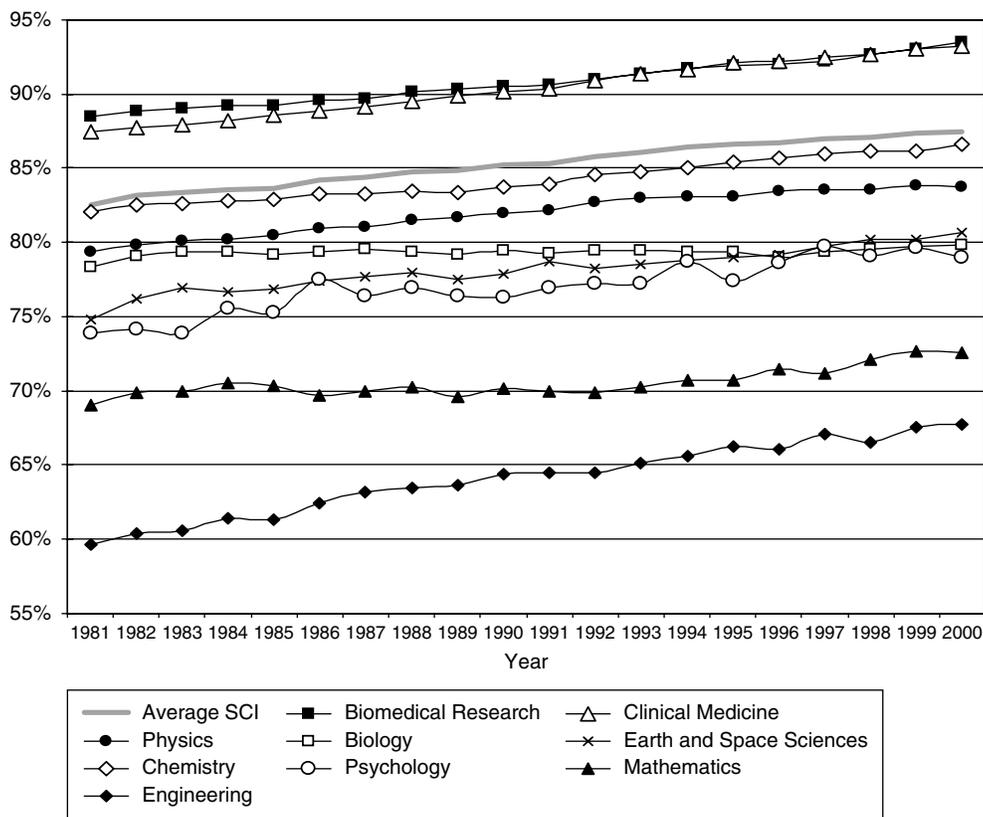


FIG. 2. Share of references made to journal articles for main fields in NSE, 1981–2000. The data are from the Science Citation Index (SCI), Social Sciences Citation Index (SSCI), and Arts and Humanities Citation Index (AHCI) databases, 1981–2000, Philadelphia, PA: Thomson ISI. Compiled with permission from Thomson ISI, by the Observatoire des Sciences et des Technologies, Université du Québec à Montréal, Montréal, Québec, Canada.

average does not represent a central trend within NSE, due in large part to the dispersion of referencing practices and the large proportion of health sciences papers in the SCI database.

In contrast to NSE where one could see some converging patterns in different fields' citing habits, SSH presents a much larger spectrum of behaviors (Figure 3). The proportion of the psychology literature that is indexed by Thomson ISI in SSCI follows a fairly similar pattern (albeit about 10% lower) than that which is indexed in SCI. As could be expected, the proportion of references to journal articles grew rapidly in economics and management. Although the overall trend is toward an increasing percentage of references being made to journal articles, there are some fields where the proportion of references to journals decreased in the 1990s (law, history, other humanities, literature and, to a lesser extent, education).

As one can see in Figure 3, in most SSH fields, less than one reference out of two is made to a journal article. This means that bibliometricians have to apply special care in the measurement of SSH scientific outputs when using journal-based bibliometric databases.

Given the low proportion of references made to journals in a discipline like history, one might see this as a sign that the references to nonserials are in fact references to primary

sources. We can consider these sources as being references that should not be taken into account in our study because they do not play the usual role of acknowledging previous research. In fact, it can be argued that these primary sources constitute the data on which the research is often based in SSH. For instance, for an historian working on the history of astronomy, citing a book by Kepler can be considered as primary as opposed to secondary source because the discussion on the contribution of Kepler is the object of the study. By contrast, scientists in NSE rarely cite ancient literature as primary sources, given the phenomena of obliteration by incorporation (Merton, 1968). Their primary sources are, generally, experimental data.

To ascertain that references made to primary sources were not responsible for the different proportion of references to journal articles in SSH specialties, a test was performed to characterize the age of the material being referred to. The hypothesis behind this is that if references were often made to older material in some specialties, these references would more likely be to primary rather than secondary sources. Table 2 shows that this effect does not influence the overall results of the study. As one can see, in NSE the difference between citation patterns when it comes to newer and older material is negligible. Similarly, for most SSH fields—and even for history—this difference is also not

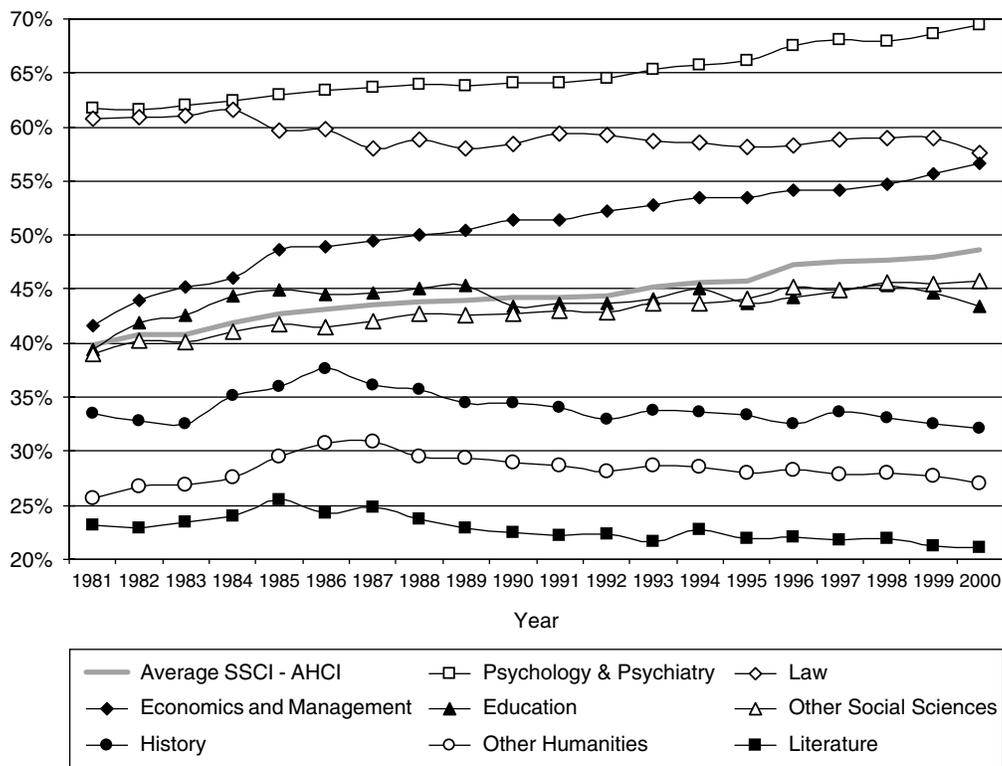


FIG. 3. Share of references made to journal articles for main fields in SSH, 1981–2000. The data are from the Science Citation Index (SCI), Social Sciences Citation Index (SSCI), and Arts and Humanities Citation Index (AHCI) databases, 1981–2000, Philadelphia, PA: Thomson ISI. Compiled with permission from Thomson ISI, by the Observatoire des Sciences et des Technologies, Université du Québec à Montréal, Montréal, Québec, Canada.

TABLE 2. Share of references made to journal articles for all fields, according to the publication year of the cited article, 1981–2000.

Field	All references	References made to material younger than 1900	References made to material younger than 1950	References made to material younger than 1970	Variation all/1970
Mathematics	70.8%	73.3%	73.1%	73.7%	4.1%
Physics	82.3%	84.8%	84.8%	85.4%	3.7%
Psychology	77.2%	77.8%	78.0%	78.3%	1.5%
Chemistry	84.6%	85.3%	85.2%	85.6%	1.2%
Engineering	64.8%	66.0%	65.9%	65.5%	1.2%
Biomedical Research	91.2%	91.5%	91.6%	91.8%	0.7%
Clinical Medicine	90.9%	91.3%	91.3%	91.4%	0.6%
Earth and Space Science	78.6%	78.9%	78.9%	79.0%	0.5%
Biology	79.4%	79.7%	79.5%	79.1%	-0.3%
<i>SCI</i>	85.7%	86.4%	86.5%	86.8%	1.3%
Literature ^a	23.0%	30.4%	30.0%	30.4%	32.5%
Other Humanities ^a	28.3%	35.4%	35.2%	35.8%	26.5%
Other Social Sciences	43.3%	44.3%	44.6%	45.3%	4.6%
Education	44.0%	44.6%	44.8%	45.7%	3.9%
Economics and Management	51.7%	52.3%	52.6%	53.2%	2.9%
Psychology and Psychiatry	65.5%	66.1%	66.4%	67.3%	2.8%
Law	59.1%	59.6%	59.8%	60.3%	2.0%
History	34.1%	36.0%	34.7%	34.8%	2.0%
<i>SSCI and AHCI</i>	44.7%	48.0%	48.5%	49.7%	11.0%

Note. The data are from the Science Citation Index (SCI), Social Sciences Citation Index (SSCI), and Arts and Humanities Citation Index (AHCI) databases, 1981–2000, Philadelphia, PA: Thomson ISI. Compiled with permission from Thompson ISI, by the Observatoire des Sciences et des Technologies, Université du Québec à Montréal, Montréal, Québec, Canada.

^aMany articles in both literature and other humanities do not systematically provide a year for the cited material, which partially accounts for this variation.

significant. In fact, the most notable difference can be found in literature and other humanities, where the effect of citations to older material is more tangible. However, even considering the relatively small variation in the citation patterns observed, it is still undisputable that journals play a more marginal role in SSH scholarly communication than they do in NSE.

One disadvantage of the method used in here is that it only measures references made in journals and therefore omits those made in other types of documents such as books. One could argue that citations made in books follow a substantially different pattern than those made in journals. However, as suggested by some, one can expect that if books follow a different pattern of referencing they would tend to cite books more often than journal literature would (Cronin, Snyder, & Atkins 1997; Line, 1981). Hence, this would tend to further increase—not decrease—the measured difference in referencing patterns between specialties, thus confirming our results.

Conclusion

Several studies have noted that journal articles were less important in the SSH than in the NSE (see e.g., Hicks, 1999, 2004), but the empirical evidence for this has, so far, been limited. For instance, Nederhof et al. (1989) have made partial measures in the case of a sample of departments at Dutch universities. Small and Crane (1979) have examined the use of books in the field of sociology while Norris and Oppenheim (2003) examined the production of archeologists and Andersen (2000) inquired about the media used in the social sciences in general.

The fact that journals are not as important in the SSH as in the NSE creates a particular problem in the field of bibliometrics and scientometrics where databases that index papers published in scholarly journals are the core sources of data. Currently, we do not have systematic data on the communication habits in the various disciplines and as such it is not possible to determine, aside from using anecdotal evidence, how useful and comprehensive are current databases in the evaluation of scientific output in various scientific fields. In the present article, we respond to this shortcoming by providing clear evidence of the relative importance of journals in the process of knowledge diffusion for all disciplines, as measured through references and their evolution over time.

Considered as a whole, there is a trend in SSH whereby journals play an increasingly important role in knowledge building as opposed to other means of scientific diffusion. However, for certain fields such as history, the humanities and literature, this trend is less clear: Over the last 10 years, the percentage of articles cited has even decreased slightly. Given that the proportion of references to journal articles is lower than 50% for many SSH fields, one should be careful in constructing performance measures on the sole basis of journal literature. Indeed, in cases where journal articles account for less than 50% of the references, the publication

pattern for documents other than journals could paint a completely different picture. For example, a department that specializes in economics could appear to be more productive than a department focusing on medieval history, but the opposite might be true when taking into account book publications. In other words, evaluations based only on measures obtained from journal databases are more likely to be less than adequate for disciplines in which less than 50% of references are made to journal articles than for those in which these references account for more than 50%.

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