A Bibliometric Chronicling of Library and Information Science's First Hundred Years

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This paper presents a condensed history of Library and Information Science (LIS) over the course of more than a century using a variety of bibliometric measures. It examines in detail the variable rate of knowledge production in the field, shifts in subject coverage, the dominance of particular publication genres at different times, prevailing modes of production, interactions with other disciplines, and, more generally, observes how the field has evolved. It shows that, despite a striking growth in the number of journals, papers, and contributing authors, a decrease was observed in the field's market-share of all social science and humanities research. Collaborative authorship is now the norm, a pattern seen across the social sciences. The idea of boundary crossing was also examined: in 2010, nearly 60% of authors who published in LIS also published in another discipline. This high degree of permeability in LIS was also demonstrated through reference and citation practices: LIS scholars now cite and receive citations from other fields more than from LIS itself. Two major structural shifts are revealed in the data: in 1960, LIS changed from a professional field focused on librarianship to an academic field focused on information and use; and in 1990, LIS began to receive a growing number of citations from outside the field, notably from Computer Science and Management, and saw a dramatic increase in the number of authors contributing to the literature of the field.

Introduction

Our aim in writing this paper is to present an encapsulated history of the Library and Information Science (LIS) field[2] using a variety of standard bibliometric techniques. From very modest beginnings, the field has grown to the point where in North American universities alone there are 58 accredited programs with roughly 1,000 full-time faculty members. Internationally, there is considerable research activity spanning a diverse range of subfields (human information behavior, knowledge representation, information retrieval, bibliometrics, etc.) and a growing number of scholarly journals, newsletters, and conferences dedicated to reporting the results of both academic and practitioner research. Furthermore, there exists a miscellany of encyclopedias, textbooks, and histories chronicling, delineating, and describing the field (e.g., Bates & Maack, 2010; Farkas-Conn, 1990; Vakkari & Cronin, 1992).

In 1926, the University of Chicago established the Graduate Library School with a $1 million grant from the Carnegie Foundation (Richardson, 1982). Until its closure in 1989, the school remained an important center of teaching and scholarship in LIS (Richardson, 1992) and was the original home of *The Library Quarterly* (LQ), which has been published continuously by the University of Chicago Press since 1931. Chicago alumni may wish to lay claim to the title of the nation's most intellectually venerable LIS program, but others will claim bragging rights as far as longevity is concerned. The University of Illinois has been offering LIS courses and programs since 1897 when Katharine Sharp

[2]For simplicity's sake, we use the terms field and discipline interchangeably in the text, while cognizant of the fact that much more has been, and could be, said on the relative appropriateness of each term vis-à-vis LIS.

moved to Urbana Champaign from the Armour Institute in Chicago (Grotzinger, 1992). Sharp's mentor was Melvil Dewey, who, in 1887, established the Columbia College School of Library Economy in New York City, which relocated for some years to Albany where it became the New York State Library School before rejoining Columbia in 1926 (Wiegand, 1996). The Columbia University School of Library Service, as it was subsequently known, was eliminated in 1992, 3 years after the Chicago school suffered the same fate.

LIS programs may be fewer in number, generally smaller in size, and arguably less tightly integrated into the folds of the academy than some other social sciences and humanities departments, but there nonetheless exists a fairly established population of schools/departments that have developed an identifiable institutional character and share a distinct academic/professional ethos (see Sugimoto, Russell, & Grant, 2009). As is the case for their peers in other academic fields, scholars in LIS are expected to undertake research and publish the results of their endeavors. Over the decades, over the course of a century in fact, a considerable body of recorded knowledge has been produced by both LIS faculty and research-inclined practitioners. LQ was followed by other important journals, including *American Documentation* in 1950 (now *Journal of the American Society for Information Science & Technology*) and the *Journal of Documentation* in 1945 (launched by Aslib in the U.K. and presently appearing under the Emerald imprint). In recent years new journal titles have appeared with regularity. However, none has been around as long as *Library Journal* (LJ) which was founded in 1876 by Melvil Dewey and continues to this day. Indeed, for several decades LJ was the only serial of note in the LIS domain, though even then it was more a magazine than a scholarly journal.

The aggregate literature of a field mirrors the intellectual concerns and fashions that are constitutive of the field. Over time, the literature builds upon itself and solidifies in the manner of geological strata; at different times different topics, methods, or ideologies will be in vogue and visible; some of these eventually acquire canonical or paradigmatic status; others will have limited influence, crumble, and fade from view. Using 110 years of bibliometric data, we examine in detail the variable rate of knowledge production in the field, shifts in subject coverage, the dominance of particular publication genres (journal articles, conference proceedings, etc.) at different times, prevailing modes of production (single versus multiple authorship), interactions with other disciplines, and, more generally, observe how the field has evolved.

Literature Review

The LIS research community has, unsurprisingly, given its longstanding association with bibliometrics, produced numerous studies, synchronic and diachronic, analyzing the structure of the field and quantitatively describing networks of intellectual influence at multiple levels of aggregation,

using various units of analysis. Borgman (1990) once noted that bibliometric studies can be classed according to which element of the scholarly communication system they study (that is, the units of analysis under consideration). She identified three main types of units: *producers* (the author of a document or aggregates of authors, such as institutions and countries), *artifacts* (the documents used in communicating scholarship and their aggregates [e.g., journals]), and *concepts* (the topics under examination). Her three-fold classification is used here to structure our review of the literature. The aim of this review is not to comprehensively describe all bibliometric studies of LIS; rather, the objective is to identify salient findings about LIS derived from previous bibliometric analyses and to identify gaps in our knowledge of the field.

Producers

Research on highly prolific or highly cited authors typically uses author names as concept markers for their works (e.g., Howard White for bibliometrics or Nicholas Belkin for information retrieval), delineating the scholarly landscape by clustering these authors according to similarities (topics, citations, etc.). Such analyses provide an indication of the canonical authors and subdomains of the field; these analyses indicate the bodies of literature with which doctoral students and neophytes in the field should become acquainted (e.g., Åström, 2010; Budd, 2000; Cronin & Meho, 2007; Levitt & Thelwall, 2009; Moya-Anegon, Herrero-Solana, & Jimenez-Contreras, 2006; White, 2001). Occasionally, canonical authors include "outsiders" (e.g., Foucault's high ranking in Åström's [2010] analysis; see also Cronin & Meho's study of French theorists [2009]), demonstrating interdisciplinary influences on the field. Common subfields identified through author analysis include bibliometrics (and related areas), information retrieval (hard/soft, user/system), information seeking, and communication studies (Åström, 2010; White & McCain, 1998; Moya-Anegon et al., 2006).

Studies of author aggregates provide basic descriptions of authorial practice within the field: authors are predominately male and tend to cite male authors (Siddiqui, 1997; Hakanson, 2005); the majority of articles in the field are single-authored (Levitt & Thelwall, 2009), although the number of authors per paper is increasing (Koehler et al., 2000); and authors tend to be academic researchers from the U.S. (Sin, 2011; Erfanmanesh, Didegah, & Omidvar, 2010). Institutional rankings show a stable group of universities with elite status in the field, many of which are U.S. institutions ranked in the top 10 by *U.S. News and World Report* (e.g., Bates, 1998; Budd, 2000; Pettigrew & Nicholls, 1994). The fairly static nature of this core group should not come as a surprise: Siddiqui (1997) found that 50% of LIS publications originated from 13 LIS programs in the U.S. These institutions also tend to form dense collaboration networks: geography and language significantly influencing collaboration patterns (Sugimoto & Cronin, 2012; Yan & Sugimoto, 2011).

There have been numerous context-specific studies focusing on the "state of LIS" in particular countries such as Slovakia (Steinerova, 2003), Botswana (Moahi, 2008), Great Britain (McDonald & Feather, 1995), Poland (Sapa, 2007) Spain (Anegon, Contrearas, & Corrochano, 1998; Cano, 1999), Taiwan (Huang & Lin, 2011), and China (Hu, Hu, Gao, & Zhang, 2011) as well as larger geographic regions (e.g., Asia [Mukherjee, 2010], sub-Saharan African [Onyancha, 2009], and Eastern Europe [Uzun, 2002]). These studies contribute to our holistic understanding of the field. We know that the journals and topics that dominate the scholarly landscape of one country may not exercise the same influence elsewhere: geography, language, and political systems shape what is published and read; additionally, variations in authorship, referencing styles, and topics of interest vary appreciably depending on the country and language in which the article is published (Huang & Lin, 2011; Sapa, 2007; Schlögl & Stock, 2008; Hu et al., 2011).

Bibliometric studies are so numerous in LIS that scholars have even analyzed the best data sources and methods for conducting such analyses (Meho & Spurgin, 2005). However, there are limitations with much of the research in this area. Many studies simply use LIS as a test-bed to demonstrate a new or modified bibliometric technique (e.g., Ajiferuke & Wolfram, 2010; Waltman, Yan, & van Eck, 2011) and lack interpretative depth. Some may be limited to a small sample of journals or cover a short time period. Others focus on only one type of producer (e.g., LIS deans and directors [Cronin & Crawford, 1999], those who publish in open access journals [Mukherjee, 2009], public librarians [VanFleet, 1993]). To identify overarching trends, one must patch together numerous studies, which often vary greatly in terms of the unit of analysis employed and the time span covered.

Artifacts

Journals are perhaps the most popular unit of analysis. More than a decade ago, Nisonger (1999) identified 178 articles ranking LIS journals. Such studies continue to be popular, particularly as a method for identifying the core journals in the field. Some journals feature consistently in such studies: Nisonger's (1999) meta-analysis identified JASIST as the preeminent journal in the field. Other core journals have that have been identified include: *Information Processing & Management, Journal of Documentation, Journal of Information Science, Scientometrics, Library & Information Science Research, Library Quarterly, College & Research Libraries, Journal of Academic Librarianship, Reference & User Services Quarterly*, RQ, *Library Trends*, and *MIS Quarterly* (e.g., Åström, 2007, 2010; Nisonger & Davis, 2005; Sin, 2011; Zhao, 2010; Schlögl & Stock, 2004; Minguillo, 2010). These and other journals have also been the focus of single-journal investigations, examining topic selection, authorship patterns, and referencing behavior: *Journal of Education for Library and Information Science*

(Coleman, 2007), *Journal of Information Science* (Bonnevie, 2003), *Libri* (Wormell, 2000), *Journal of Librarianship and Information Science* (Furner, 2009), *Journal of Documentation* (Nebelong-Bonnevie & Frandsen, 2006), *Malaysian Journal of Library & Information Science* (Bakri & Willett, 2008, 2009), *Scientometrics* (Peritz & Bar-Ilan, 2002), and JASIST (e.g., Tsay, 2008; Harter & Hooten, 1992; Lipetz, 1999). Such studies provide information about the shifting presence of authors and topics in different journals; however, as Harter and Hooten (1992, p. 591) noted, there "is some danger in extrapolating the results from a sample of articles from a single journal to an entire field."

Analyses of LIS journals typically utilize Journal Citation Report (JCR) categories to delineate the field. Journals within the JCR category Library Science and Information Science tend to cluster into three or four major subfields: management information systems, information science, library science, and scientometrics (Ni & Ding, 2010; Ni & Sugimoto, 2011; Moya-Anegon et al., 2006; Milojević, Sugimoto, Yan, & Ding, 2011). The distinctness of the MIS cluster has led many to remove these journals from subsequent analyses, arguing that they should not be included in the same JCR class. With these journals removed from the frame, the remaining journals have been grouped under three rubrics: library science, information science, and scientometrics (e.g., Waltman et al., 2011; Milojević et al., 2011).

Other artifacts that have been analyzed include highly cited articles (Blessinger & Hrycaj, 2010), conference proceedings (e.g., Smeaton, Keogh, Gurrin, McDonald, & Kodring, 2003), websites (Vaughan & Thelwall, 2003; Arakaki & Willett, 2009), and theses (Sugimoto, 2011; Sugimoto, Li, Russell, Finlay, & Ding, 2011a; Sugimoto, Ni, Russell, & Bychowski, 2011b; Keat & Kiran, 2008; Gao, Yu, & Luo, 2009; Buttlar, 1999). Acknowledgments have also received attention, with studies noting an increase in the frequency of LIS articles containing acknowledgments to colleagues, trusted assessors, technicians, and funding agencies (Cronin, 2001; Cronin & Shaw, 1999; Harter & Hooten, 1992; Zhao, 2010). As with producer studies, numerous artifact studies have made use of LIS journals, but more by way of illustrating a new method or application (e.g., Via & Schmidle, 2007; Waltman et al., 2011; Kim, 1992) than discussing the evolution of the field.

Journals and other artifacts are also used as proxies for disciplines in an effort to explore interdisciplinary connections. Import/export studies of LIS journal articles have identified five main disciplines with which the field is trading intellectually: Computer Science, Business/Management, Health/Medical Sciences, Engineering, and Communication (e.g., Erfanmanesh et al., 2010; Odell & Gabbard, 2008; Cronin & Meho, 2007; Huang & Chang, 2012; Chang & Huang, 2011). Analyses of theses have revealed similar disciplinary associations with Business/Management, Computer Science, Education, Communication/Journalism, and Psychology (Prebor, 2010; Sugimoto et al., 2011b).

Concepts

To capture the conceptual and professional evolution of the field, topic modeling and word analyses have been employed.[3] Using keywords, title words, and full articles, scholars have illustrated the three-pillared nature of the field: library science, information retrieval, and bibliometrics (e.g., Åström, 2002; Milojević et al., 2011; Janssens, Leta, Glänzel, & De Moor, 2006). To these three has also been added two other emergent and increasingly dominant areas: web studies (van den Besselaar & Heimeriks, 2006; Janssens et al., 2006) and information-seeking behavior (Milojević et al., 2011). Subdomains have also been the focus of word analysis; for example, analyses of the information retrieval literature (e.g., Ding, Chowdhury, & Foo, 2001; Sugimoto & McCain, 2010; Smeaton et al., 2003). Journals are not the only source of topic analysis: the method has also been applied to dissertations in order to examine shifts in the field since 1930 (Sugimoto et al., 2011). A limitation of such studies has been the timeframe used (ranging from 2 to 20 years) and the number of artifacts examined (a single conference proceeding to a dozen journals). While these and similar studies have provided valuable state-of-the-art descriptions, what is lacking is a comprehensive account of how the field has evolved, based on an analysis of key concepts.

Methods

Data

The data presented in this paper are sourced from Thomson Reuters' Web of Science (WoS), which includes the Century of Science and the Century of Social Science for the period 1900–1944, as well as the Science Citation Index Expanded (SCIE), the Social Sciences Citation Index (SSCI), and the Arts and Humanities Citation Index (AHCI) for the period 1945–2010. The version of the WoS used here has been built using the source data in text format provided by Thomson Reuters. The source data were transformed into a relational database stored on a Microsoft SQL-Server, in which any variable can be linked to any other.

For the purposes of this paper, LIS literature is defined as all papers published in journals having the classification "Information Science & Library Science" in the field and subfield classification created by CHI Research (now *The Patent Board*[4]) and used by the US National Science Foundation (NSF) in the *Science and Engineering Indicators Series*.[5] The main advantage of this classification scheme over that provided by Thomson Reuters is that i) it has a two-level classification (discipline and specialty), which allows the use of two different levels of aggregation, and ii) it categorizes each journal into only one discipline and specialty, which prevents double counts of papers when data are presented by discipline. However, as with all classification systems, perfection remains elusive.[6] For example, *Law Library Journal* is categorized as Law and *Library Computing* as Computers; both are thus excluded from our sample. In sum, we analyzed 160 journals, resulting in a total of approximately 96,000 papers for the years 1900–2010. It must also be said that the trends observed are a function of Thomson Reuters' indexing policies: coverage changes over time and journals may no longer be indexed even though they continue to be published.

Our analysis begins with a detailed historical profile of scholarly production in the LIS field, covering the following: the number and growth of journals; the number and type of publications produced by scholars and researchers; rates of coauthorship and average number of authors per paper; number of unique authors and their productivity; percentage, immediacy, and intensity of citations to the literature; average age of the cited literature over time; and types of materials cited over time. Where possible, we compare indicators of scholarly activity in LIS with trends generally in the social sciences and humanities. We supplement these basic bibliometric data with a lexical analysis of the field: we examine the frequency of use and dominance of keywords in the scholarly and professional literature of the field, identify growth terms, along with terms in decline and terms that remain stable, on the not unreasonable assumption that the constitutive features and prevailing concerns of a field are revealed in the titles of journal articles, conferences papers, and theses.

In a recent article, Milojević et al. (2011) reviewed the literature on the function of title words in scholarly journal articles. Title words, as do keywords, index terms, and descriptors, perform a signaling function; they alert the reader of an academic text to its content and, in some cases at least, to the orientation or disposition of a particular study. We concur with Milojević et al. (2011, p. 1934) that "the analysis of words derived from document titles thus appears to be a promising approach to trace processes of discourse formation and cognitive structure of fields or disciplines." We looked at the frequency with which a selection of axial terms from the lexicon of library and information science were used over time. Our sample was purposive in nature. We first looked at the top 1,500 words appearing in titles over the 1900–2010 period, and then selected terms (some of which were truncated for reasons of inclusivity) based on our knowledge of the field and its history in order to observe their emergence, growth, and decline. Great care was taken in ensuring that we did not only keep terms currently in use, but also terms that were important in the past. These terms,

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[3]It should be noted that a number of content analyses have also been performed on the LIS literature to investigate issues such as the use of theory or methods (e.g., Pettigrew & McKechnie, 2001; Enger, Quirk, & Stewart, 1989, Fidel, 2008, Hider & Pymm, 2008; Järvelin & Vakkari, 1990, 1993; Kumpulainen, 1991). However, as these involve a different approach to analysis, they will not be discussed in tandem with the bibliometric analyses of the field.

[4]http://www.patentboard.com/

[5]http://www.nsf.gov/statistics/seind06/c5/c5s3.htm#sb1

[6]For instance, one limitation of our analysis is that journals keep the same classification throughout the period.

which we have labeled growth words, stable or declining words, and short-lived words, are surrogates for domains of activity and intellectual inquiry that have, or have had, significance in the field. It goes without saying that many of these words are paired in the titles of journal articles (e.g., "information seeking," "citation analysis") and we have thus used phrases rather than unigrams as appropriate.

For comparative purposes, we analyzed all-field data to show the relative growth or decline of our focal terms within both the LIS literature and the wider scholarly literature. This allows us to see whether, and to what extent, lexical trends in LIS are reflected in, or reflective of, trends in the literature more generally. Stated otherwise, we want to know whether the lexical leading edge is found in LIS and whether the relative intensity with which certain terms feature in the titles of LIS papers matches the intensity of their use across other literatures. We do, of course, acknowledge the limitations of this approach. Take, for example, the case of a term such as "citation": in LIS this is typically associated with bibliometric and scientometric approaches; however, within the literature of criminal justice, for example, "citation" could carry quite a different connotation. The same can be said for a term such as "behavior," which covers an enormity of human, mechanical, organizational, and social activity, such that to claim ownership rights would be extremely naive. Nonetheless, these terms are fundamentally important within LIS and exploring their waxing and waning over the last century provides us with an indication of how both the discourse and substance of the field have changed.

Disciplines do not evolve in vacuo. They share topics, tools, and methods with other disciplines which, in turn, influence their development. Such interdependencies have evolved over the course of the last century, across many scientific disciplines. As shown by Gingras and Larivière (2010), interdisciplinarity decreased between 1945 and 1975—a period in which the creation of knowledge grew exponentially—and, since then, it has been increasing steadily. In order to examine the reciprocal relationships between LIS and other disciplines, we analyze both the references cited as well as the references received by LIS papers. This established procedure (Porter & Chubin, 1985; Rinia et al., 2001; Tomov & Mutafov, 1996) provides an indication of the importation of knowledge from other disciplines (references made) and the exportation of knowledge to other disciplines (citations received). This is displayed as a ratio of LIS to other disciplines. In addition, we analyze the percentage of references within LIS papers to papers outside the discipline and the volume of citations received by LIS from other disciplines.

Another method of studying interdisciplinarity is to look at the various literatures in which authors publish (Rinia, van Leeuwen, & van Raan, 2002). Here we analyze the proportion of authors, for LIS and comparable disciplines, who, for a given year, have published in more than one discipline. The comparable disciplines we have chosen are of a similar size because the likelihood of publishing in several disciplines is a function (among other things) of the size of these disci-plines: from a strict probabilistic point of view, the smaller the size the main discipline of a researcher is, the more likely he or she is to publish outside. In terms of number of papers, the disciplines that were of a size similar to LIS were Political Science and Public Administration, Anthropology and Archaeology, Area Studies, Sociology, Philosophy, and Language and Linguistics. Of course, authors publishing in two disciplines are de facto counted twice. This does not influence the comparison, as the goal here is to measure whether LIS has more—or fewer—monodisciplinary authors than other comparable disciplines.

Results

We present here the findings of our century-long analysis of the library and information science field, focusing on i) journals and authors, ii) terms and topics (growing, stable or in decline, short-lived), and iii) trends in interdisciplinarity.

Journals and Authors

From an *N* of one (*Library Journal*) at the beginning of the 20th century, the number of LIS journals (based on the sampling frame described above) has risen to 70 (Figure 1a). The fluctuations in the plot between 1980 and the present can be explained in terms of journals either ceasing publication or not being indexed. The general trend for all disciplines combined has been consistent growth in the number of scholarly journals being published, estimated by Mabe (2003, pp. 196–197) to be 3.25% for the 20th century. At present, LIS accounts for roughly 1.5% of all WoS-indexed journals classified as Social Sciences & Humanities (SSH), down from a peak of just over 4% in 1960 (Figure 1a). This indicates that the overall rate of new journal creation has been somewhat faster in other SSH disciplines, be it in existing or newly created SSH fields. Figure 1b shows the number of papers published in LIS journals over the course of the last century and up to the present, from less than 40 to roughly 2,500 papers per annum. The downturn in the paper production rate in the first part of the 21st century mimics the dip in the number of LIS journal titles recorded for those years. From roughly 1940 to 1960, LIS papers accounted for almost 4% of all SHH papers, but the field's market-share has since dropped to just over 1.5%.

Sole authorship was the norm in LIS for the first half of the 20th century, as can be seen from Figure 2a. This shows the growth in the average number of authors per paper: rising from a base of one to 2.4 in 2010. Today, roughly two-thirds of LIS papers are coauthored, up from 5% in 1960. In this regard, LIS is not dramatically different from many other fields; see, for instance, Cronin, Shaw, and LaBarre's (2003, 2004) 100-year of scholarly publication patterns in philosophy, psychology, and chemistry; Hart (2000) for a survey of authors' motivations for collaborating in the practitioner literature of LIS; and Sin (2011) for an analysis of national and international coauthorship trends in the scholarly literature of LIS.
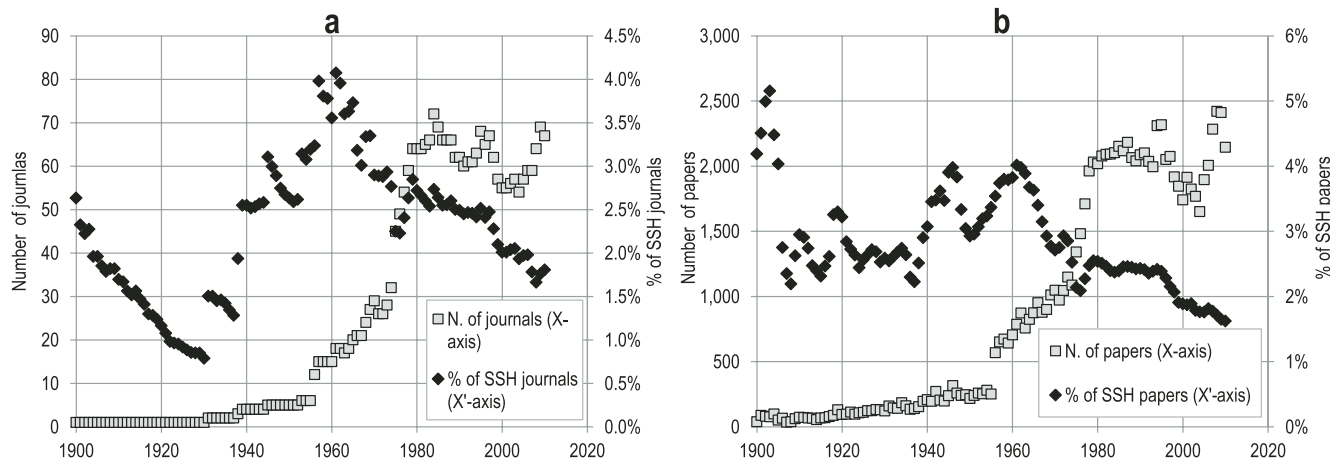
FIG. 1. (a) Number and percentage of LIS journals among all SSH journals and (b) number and percentage of LIS papers among all SSH papers, 1900–2010.
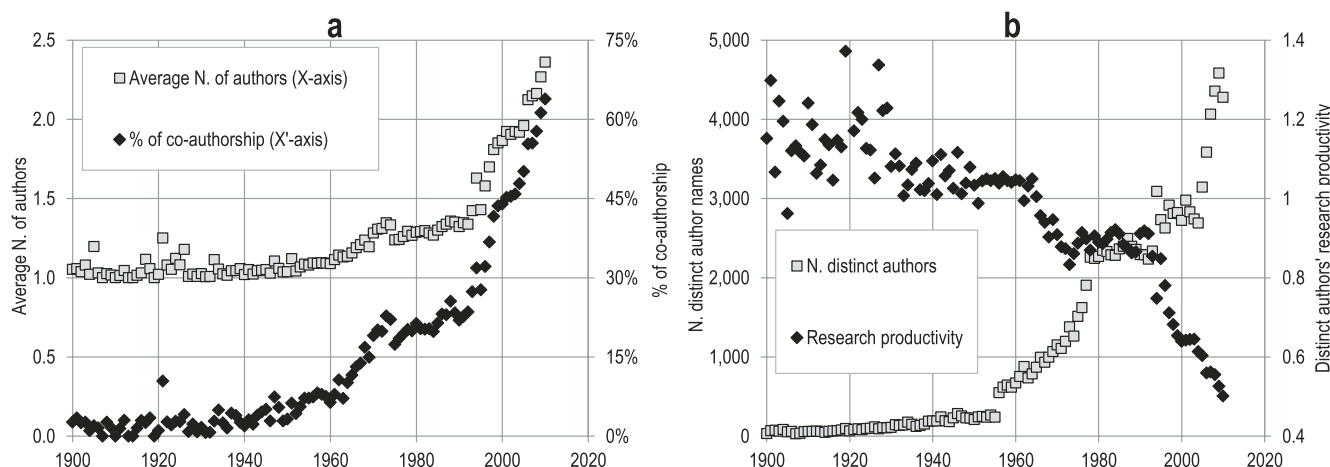

FIG. 2. (a) Percentage of papers with more than one author and average number of authors per paper, and (b) number of distinct authors and their research productivity, 1900–2010.

The number of unique authors publishing in the LIS literature has increased over the course of the last century as the field has matured and expanded, with notable growth from the 1960s onwards (Figure 2b). Most striking is the spike in the first decade of the 21st century. At present there are roughly 4,500 distinct author names[7] publishing in the field. Counterintuitively perhaps, the trend line for per capita research productivity has gone in the opposite direction (Figure 2b). While there are more authors contributing to the literature than ever before, the average annual output measured in terms of the number of published LIS papers per author has dropped to a low of roughly 0.5 (Figure 2b).

This would seem to suggest that the author pool includes many transient authors, who also publish in other fields, or are occasional authors. We return to the issue of transient authors later in the paper.

The percentage of LIS papers cited at least once, including self-citations, has risen over the decades (Figure 3a), from 15–25% between 1930 and 1960 to about 70% in 2004. The drop observed in 2005 and thereafter simply reflects the shorter citation window of these more recent papers. This trend is similar to that observed for all social sciences aggregated (Larivière, Gingras, & Archambault, 2009). The rate at which papers published in 1990 are cited following publication year is shown in the inset in Figure 3a. Forty percent are cited at least once within 3 years of publication and 50% after 5 years. The figure rises slowly thereafter; 55% of papers receive at least one citation 20 years after their publication. The average number of citations per paper shows steady long-term growth, as can be seen from Figure 3b.

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[7]No disambiguation was performed here. Hence, these numbers may include cases where several distinct researchers have the same surname and initial(s), as well as other cases of individual researchers who appear under more than one surname-initial(s) combination. While the first case underestimates the number of authors, the second case overestimates it.
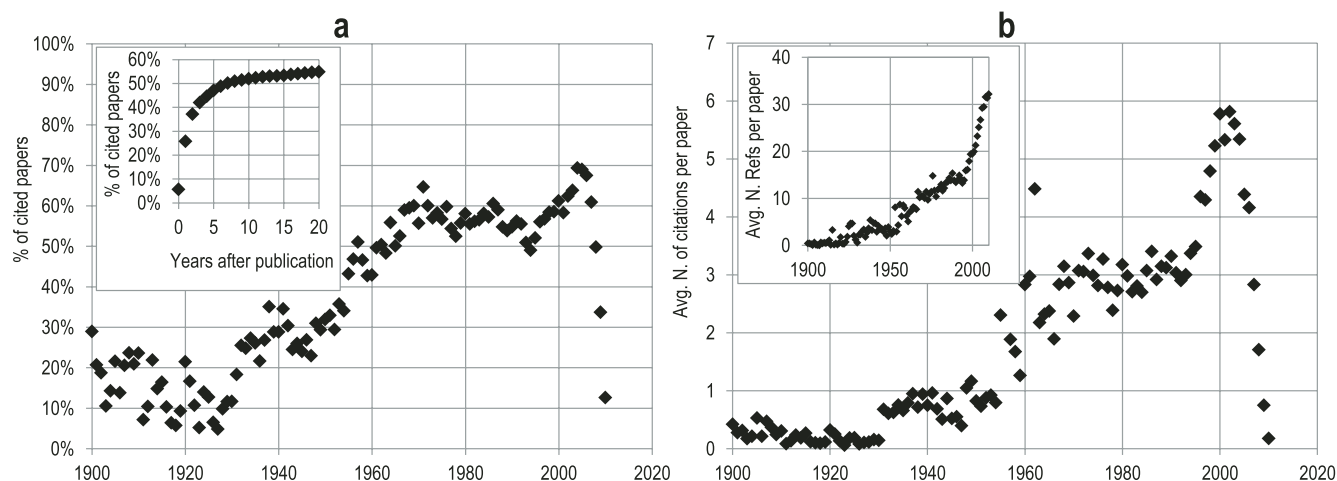
FIG. 3. (a) Percentage of cited papers and (b) average number of citations per paper, 1900–2010. Inset: Percentage of cited papers by year following publication, 1990.
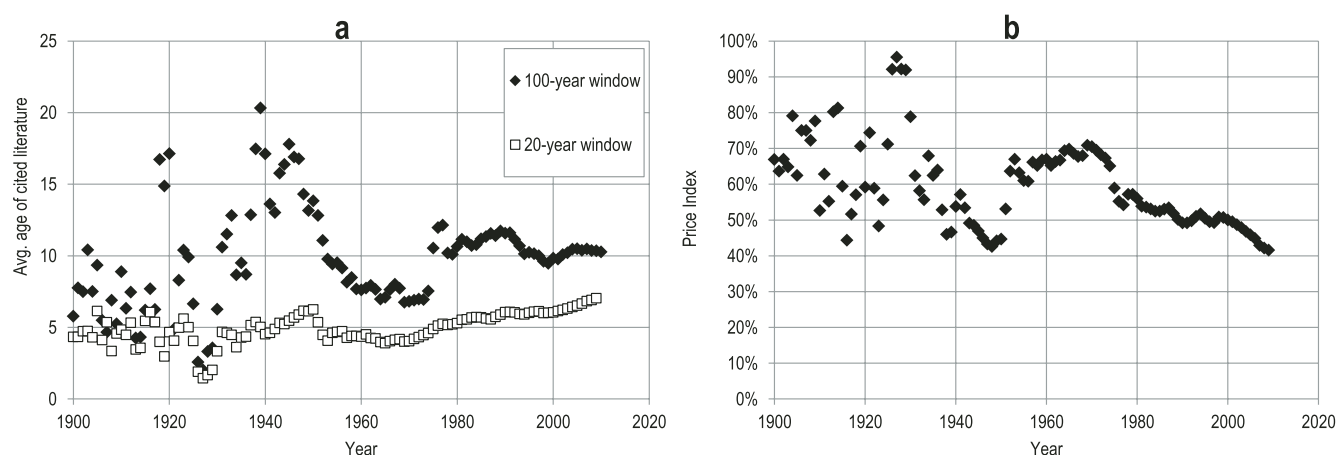

FIG. 4. (a) Average age of cited literature (100- and 20-year citation windows) and (b) Price Index (100-year citation window), 1900–2010. Three-year moving averages.

There is a noticeable surge in the last decade of the 20th century, with the average number of citations per LIS paper peaking at six. Unsurprisingly, the evolution of the number of references follows a similar pattern (inset of Figure 3b): it has increased significantly from an average of less than 0.5 in the 1900–1910 era to more than 32 in 2010. Although this increase was linear during most of the 20th century, it became exponential after the mid-1990s.

Figure 4a,b shows the aging characteristics of literature cited by LIS papers. Contrary to the prevailing notion that papers obsolesce faster currently, the literature cited by LIS papers is, on average, increasingly old. This phenomenon is not, however, peculiar to LIS: it has also been observed in both the sciences and social sciences in general, and is a consequence of the end of the exponential growth of papers as well as of the easier (digital) access to older documents (Larivière, Archambault, & Gingras, 2008). More specifically, two of the three indicators presented in Figure 4 point

in this direction: the average age using a 20-year window as well as the Price Index (the percentage of cited references that are 5 years or younger [Price, 1986]). The trend for the average age of cited literature using a 100-year window is more complex: it increased between 1970 and 1990, decreased until the late 1990s, and then increased slightly again until about 2005. The dip in the 1990s is likely due to the change in the variety of disciplines cited in the LIS literature at that time. As Cronin and Meho (2008, p. 563) have noted, the field "is less introverted than before, drawing more heavily on the literature of such disciplines as computer science and engineering on the one hand and business and management on the other." We return to this issue later.

The distribution of references to different publication genres is shown in Figure 5a,b. Theses have typically accounted for approximately 1% of citations to the LIS literature—compared with 0.7 in 2004 for all SSH disciplines combined (Larivière, Zuccala, & Archambault,
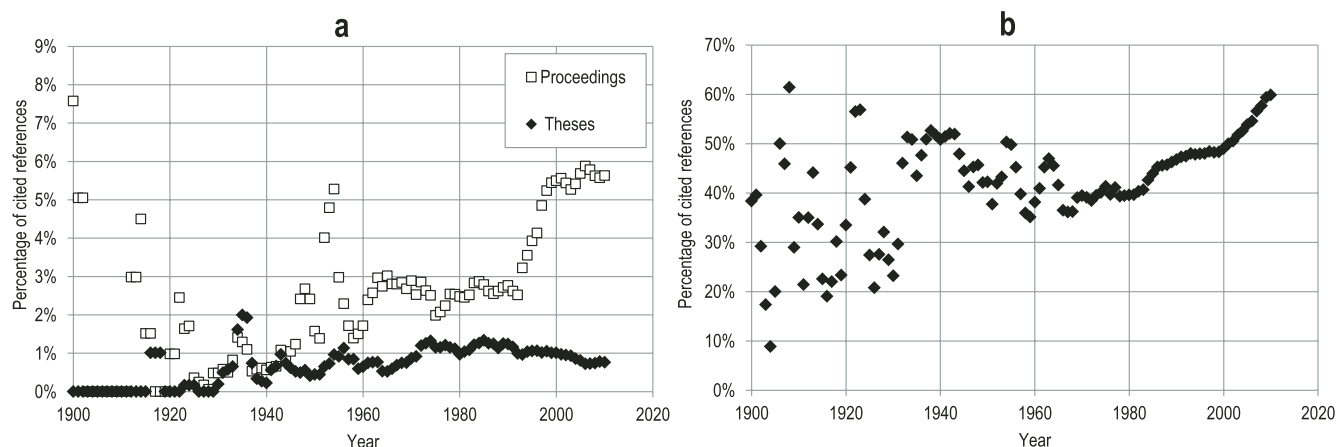
FIG. 5. (a) Percentage of references made to theses and conference proceedings and (b) percentage of references made to serials, 1900–2010. Three-year moving averages.

2008)—while the relative importance of conference proceedings has grown such that they accounted for 5–6% of all citations to the literature by the beginning of the 21st century. This is greater than the SSH average of 2.5% observed by Lisée, Larivière, and Archambault (2008). The high proportion of conference proceedings cited by LIS papers is likely a reflection of the field's important ties with computer science, a discipline in which conference papers are central to the diffusion of new knowledge (Butler & Visser, 2006; Glänzel, Schlemmer, Schubert, & Thijs, 2006). The great majority of citations—now running at 60%—is to the journal literature, with the remainder going to books or gray literature (research reports, preprints, etc.).

Terms and Topics

As fields evolve—theoretically, methodologically, structurally—so, too, does language, both the technical jargon associated with a specific area of scientific or scholarly inquiry and everyday terminology. Topical shifts occur in most fields, with greater or lesser frequency and intensity, as paradigms, worldviews, and ideologies compete for hegemony. In the process, language renews itself and neologisms slip into contemporary usage. Terms such as webometrics, blogs, and wikis would not have been found in the pages of this journal even a decade or two ago, yet today are commonplace. Similarly, the use of some terms decreases as they are obliterated by incorporation, rather like citations to well-established concepts or canonized individuals (Merton, 1968). Over the course of a century it is thus probable that the research literature of LIS will have experienced shifts in subject emphasis, as the field renews itself, embraces new technologies, broadens its conceptual horizons, and interacts with near neighbors. We would also expect to observe changes in the language used in the writing of academic texts. Of course, some foci (and the related nomenclature) will remain invariant; staples include information retrieval (even if now a much more sophisticated area of research

activity) and bibliometrics (along with its younger cousins, informetrics and scientometrics). Much, however, is new, or at least much is described using terms that are new—terms that would surely perplex the field's pioneers. We next present the data on each of our key terms, focusing on the proportion of these terms in the titles of LIS journal articles. It should be noted that we are highlighting proportionality rather than absolute values. We are not concerned whether the total number of papers with these terms has increased or decreased, but rather the proportion of titles containing these terms in any given time period. This provides an indication of the market-share held by these terms over time. Additionally, we provide a few contextualizing remarks. Many possible interpretations exist, and we readily concede that our potted histories are as personal as they are minimalist.

Growth Words

Words that have a positive trend line in the LIS literature over the 20th century or during the most recent years are listed here as growth terms. These include: *information, technology, citation, analysis, bibliometric**,[8] *impact, journal, scholarly, access, user, use, search, management, knowledge, theory, model, research, data, behavior/ behavior, information seek*, health, clinical, literacy, network, social network**, and *academic lib**. They are shown in Figure 6 and are briefly described below.

Information shows an overall upward trend: rare and sporadic in the early literature, it now occurs in nearly 10% of all titles. However, the plot has not been linear. There was a spike about 1970, with nearly 20% of titles containing the term, followed by a drop around 1980. The spike corresponds loosely to the advent of the information/computer age. *Technology* was used sporadically in the 1940s and

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[8]Truncation of a term indicates a search whereby all possible endings for this term were considered. For example, librar* would include librarian, library, libraries, librarians, etc.
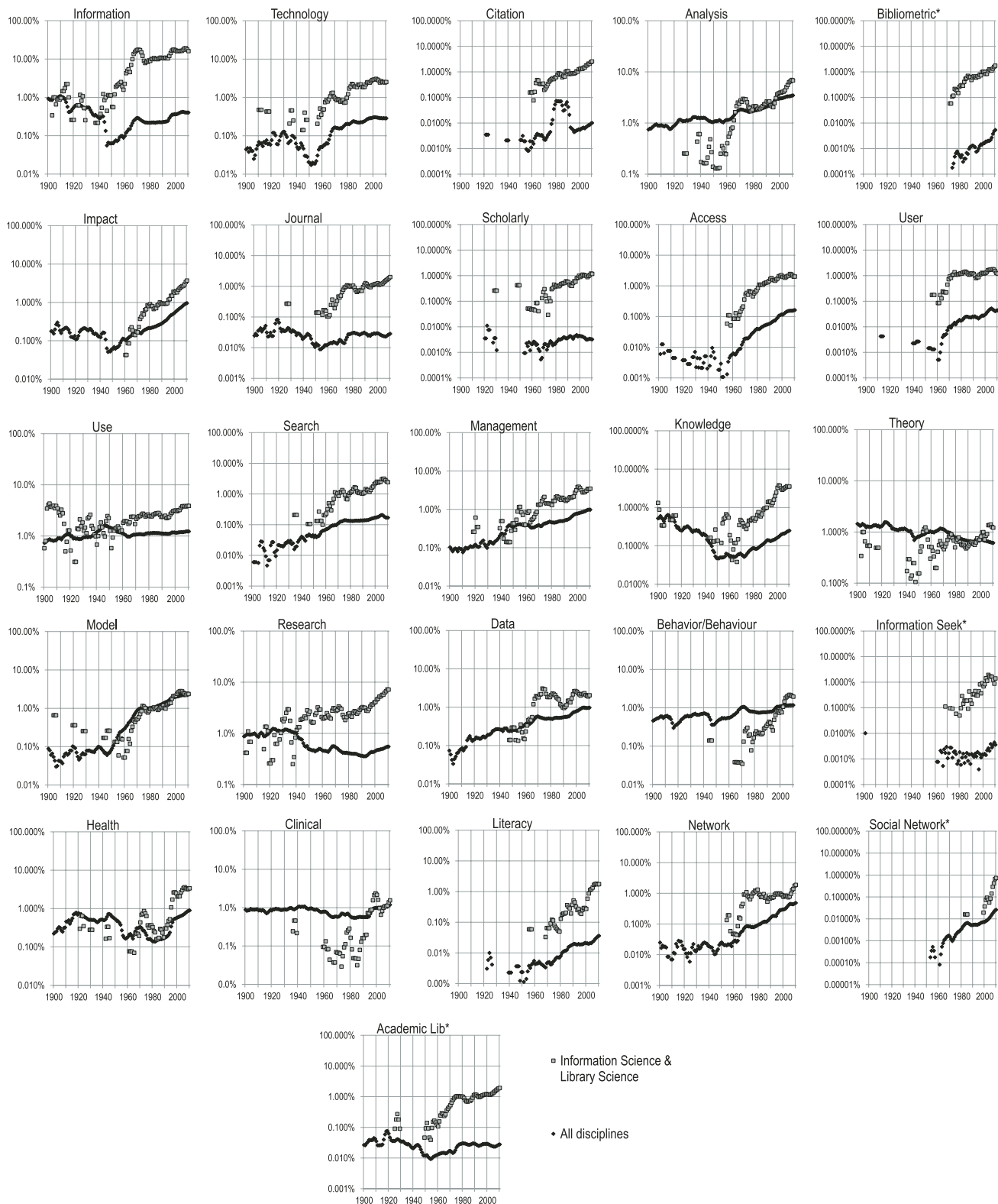
FIG. 6.   Percentage of LIS papers and of papers in all disciplines excluding LIS containing a particular word in their titles, for *growth words*, 1990–2010. Three-year moving averages.

1950s, but came to prominence around 1960 (2% of all titles used the term) with advances in computing and information technology. It then declined until 1980 before resurging. It is again found in approximately 2% of article titles.

The growth of literature on *citation* began in 1960, following the introduction of ISI's (now Thomson Reuters) citation indexes, the brainchild of Eugene Garfield. The use of this term in titles has grown from less than 1% prior to 1960 to nearly 2% today. *Analysis* has gone from less than 1% to more than 4%. This may reflect the growing empiricism of the field generally or could be, in part, an artifact of the rise in research on citation analysis and evaluative bibliometrics. The term *bibliometric** was coined in the English language literature in the 1960s by Pritchard (1969), and entered the professional discourse of the field later than citation indexing/analysis. It now appears in roughly 1% of article titles. *Impact* has seen perhaps the most striking growth, emerging in the 1960s and now appearing in roughly 2.5% of all titles, likely reflecting the surge of interest in scientific indicators, impact factors, and productivity rankings.

The use of the term *journal* has followed a similar pattern, appearing in the 1960s and rising to more than 1% currently with the growth of interest in the scholarly communication process, the costing and pricing of scholarly journals, and the emergence of open access publishing. Although *scholarly* had some brief mentions in the 1940s, it was not until the 1970s that the term began to appear consistently in the literature. It now occurs in 1% of all titles.

Access became vogue around 1960 and the number of mentions has risen from less than 1% then to 2% today. This may correspond with the rise of the personal computer and the ability of users to search for and access information on their own, rather than via an intermediary. Unsurprisingly in the light of the foregoing, *user* also makes its appearance in the literature around 1960. While rising quickly to about 1%, it has not featured prominently since then. For the past three decades, *use* has been seen in 2–3% of all titles. This is in line with Prebor's (2010) assessment that LIS differentiates itself from other fields by a focus on the use and users of various types of information.

Search also emerged around 1960 in the early days of mechanized information retrieval research, notably the Cranfield experiments, and the development of SMART at Cornell University. It has exhibited a fairly consistent increase, now appearing in almost 2% of titles. With the launch of Google and other search services, the term *retrieval* seems to have ceded ground to the popular generic term, *search* (see the results on *retrieval* below).

The first use of the term *management* in the title of an LIS article occurred around 1920. However, it was not until the 1950s that it began to appear with frequency. *Management* has been used in 2–3% of titles in the last decade, reflecting growing interest in library management and later the emergence of information management, information resources management, and knowledge management as areas of academic and professional interest. *Knowledge*, surprisingly, did not show up until the late 1950s. It now appears in about

3% of article titles, due, it seems reasonable to suggest, to the growth of interest in topics such as knowledge representation, knowledge-based economies, knowledge workers, and knowledge management.

Theory entered the literature around 1950, steadily increased since the end of the 1980s, and is now in more than 1% of titles. As the LIS field has become more academic in character, there has been a growing emphasis on theories and theory-building. The term *model* came to the fore around 1960 and appeared in more than 2% of titles by 2000. This was likely connected to the growth of interest in modeling human information behavior and developing models of information seeking and information use.

Research exhibits erratic growth, from 1% to 4%. The most consistent increase has occurred in the last 20 years, likely signifying growing interest in empirical investigations in the field. *Data* is almost nonexistent before 1960, rising to nearly 4% by the late 1970s. This spike was followed by relative stability; it appears in about 2% of titles over the course of the last 30 years. This may reflect the growing empiricism of the field and, perhaps, the concern for data qua data (data curation, data citation, etc.).

The terms *behavior* and *behaviour* (searched together) had a few isolated uses in titles in the 1940s and again in the 1960s, but did not see consistent use until the 1970s. Uses of *behavior/behaviour* in titles increased steadily, peaking around 2% in 2007. It has remained around 2% since 2007. The term is likely associated with the area of information-seeking behavior (noted as an emergent area in Milojević et al., 2011). This is evidenced by the nearly identical pattern for *information seek** in the literature.

Health currently appears in almost 3% of titles, an indication of the LIS field's strong interest in health/medical librarianship, health informatics, and cognate areas. With the related term *clinical* we note sporadic occurrences in the 1960s and 1980s, growing to 2% in 2000. It is now hovering around 1%, perhaps having been subsumed in some instances under the broader term *health*.

The term "information literacy" was coined by Zurkowski in 1974 as part of a report to the National Commission on Libraries and Information Science (Badke, 2010). A few years later, *literacy* enters the discourse of the field and now appears in 1% of all LIS journal article titles, an indication, perhaps, of the importance of policy statements on literacy in general, and information literacy in particular, produced by bodies such as the American Library Association.

Network appeared around 1970. It hovers around 1%. *Social netw** appeared once in 1984 in the LIS literature and not again until 2000. Since then, it has grown more than two orders of magnitude and is now found in the titles of more than 1% of papers. Finally, *academic lib** was seen sporadically in the 1940s and then appeared in 2% of titles in the 1960s and early 1970s. It has remained around 2% for the last few decades.

Globally, the trends observed for LIS are quite similar to those observed for all other disciplines taken altogether. Terms that increase in LIS typically also increase in other

disciplines as well—although this increase is generally smaller outside LIS. Of course, the fact that we choose LIS-related terms influences the frequency of the use of the term: except for *model* and *clinical*, all terms are used, in 2010, more often in LIS than outside. However, for some words—such as *analysis, impact, use, management, knowledge, theory, research, data, behavior/behaviour*, and *health*—their proportional use in the field was greater than outside the field only in the second half of the 20th century.

Stable and Declining Words

A number of words that were prominent in the early 20th century in the LIS literature are now in decline. These include: *librar*, librarian, book, university, public, children, archiv*, catalog*, subject head*, index*, classification*, and *retrieval*. They appear in Figure 8 and are described below. Other terms have remained fairly stable across the last century: *document** and *policy* are such cases. These are depicted in Figure 7 and described below.

The term *librar** was found in nearly 70% of all titles in the early part of the century but the corresponding figure today is 16%, the most dramatic decline of all (although this still represents a large proportion of the overall literature). However, this is not necessarily an indication that the absolute amount of library literature has declined, but rather that the proportion of such literature has declined as information science journals were founded (Donohue & Karioth, 1966). *Librarian* has also decreased, from 7% in the first part of the century to less than 1% today. The most precipitous decline happened between 1960 and 1980, when many information-related terms entered the literature. *Book** has suffered a similar fate: from nearly 20% in the 1900s to 1% today.

In 1940 the term *university* appeared in almost 10% of titles. That number declined to less than 1% in the 1980s, which may be explained (and offset) by the rise in the use of the term *academic lib**, but has since risen to nearly 2%.

Literature on public libraries appears to be in relative decline. The term *public* appeared in nearly 30% of all titles in the 1900s. It now appears in roughly 2%. A focus on *children* is evident in the early parts of the century, with the word occurring in 14% of titles. That figure dropped to around 5% in the 1920–1940s and then to less than 1% around 1960. While there has been a slight increase (in the 1970s for example) it has never risen above 1%. This likely reflects the relative decline in research and scholarship dealing with children's literature and related areas. It may also have something to do with the fact that fewer faculty members in LIS programs now have backgrounds in education and pedagogy.

The literature on archives has also declined, relatively speaking. Searching on *archiv** we found that the term peaked at 7% in 1949 and is now around 1%. However, in absolute numbers, *archive** has not varied much—on average, 30 papers per year contain the term in the title—a figure that has not varied much over time. This may suggest

that the subfield is not actually in decline; rather, it is not growing at the same rate as other subfields.

Catalog* peaked at 4% in 1960. It has now declined to less than 1%. However, the decline corresponds to the rise of other related terms (e.g., *citation, access, user, data*). The term *subject head** has also declined significantly, from a high of roughly 5% in 1905 to less than half a percent today. *Indexing* has experienced an overall decline—emerging in the 1940s and rising to nearly 4% by 1960 and then declining to less than 1% by 2010. *Classification* has fluctuated, peaking in the mid-1970s at 5% and declining to less than 1%.

Retrieval has had a rather dramatic history in LIS titles. It emerged in the late 1950s and quickly rose to more than 5% in 1970. It then dipped to less than 1% by 1980. It saw an increase to 2% around 2000 and since dropped back to 1%. As suggested above, this may be a result of authors favoring newer terms, such as *search*, for similar studies.

Document* has a strong presence, accounting for approximately 5% of the literature across the century. This reflects interest in documentation—there are several journals in the field devoted to this area (e.g., *Journal of Documentation*) and also the document-based analysis present in a number of study types (e.g., information retrieval, citation analysis, etc.). *Policy* emerged around 1950, likely corresponding with the creation of the National Science Foundation. It has remained under 1% since that time, showing no growth.

It is worth noting here that the trend for LIS papers does not always follow that observed in other disciplines—especially with regard to traditional LIS topics. Certain terms that are declining proportionally in LIS are beginning to see increased traction in other fields. For example, while the relative importance of *archiv*, catalog*, subject head** and, to a lesser extent, *classification*, are decreasing in LIS literature, their use is increasing outside LIS. Certain fields are adopting, and in the process redefining, core constructs from LIS.

Short-Lived Words

LIS routinely adopts new technologies, which typically obsolesce faster than concepts or objects of study. This is reflected in the literature of the field (Figure 8). For example, CD-ROMs were invented in the 1980s and are first mentioned in the literature around the mid-1980s. By the 1990s the word occurred in more than 2% of titles. It then declined almost as quickly as it emerged, both inside and outside LIS. Other terms with similar leptokurtic distributions include *electronic, database*, internet, computer, automat*, web*, and *digital*.

Electronic appeared around 1960 with the advent of first-generation online databases, databanks, and prototypical electronic libraries. It peaked at around 3.5% in the late 1990s. It now is at 2%. The use of the term remained stable outside LIS, mainly because of its use in engineering. Literature on *databases* emerged around 1980 and the word appeared in more than 2% of all titles; the figure is now less than 1%. *Computer* emerged in the late 1950s, rose to 4% in
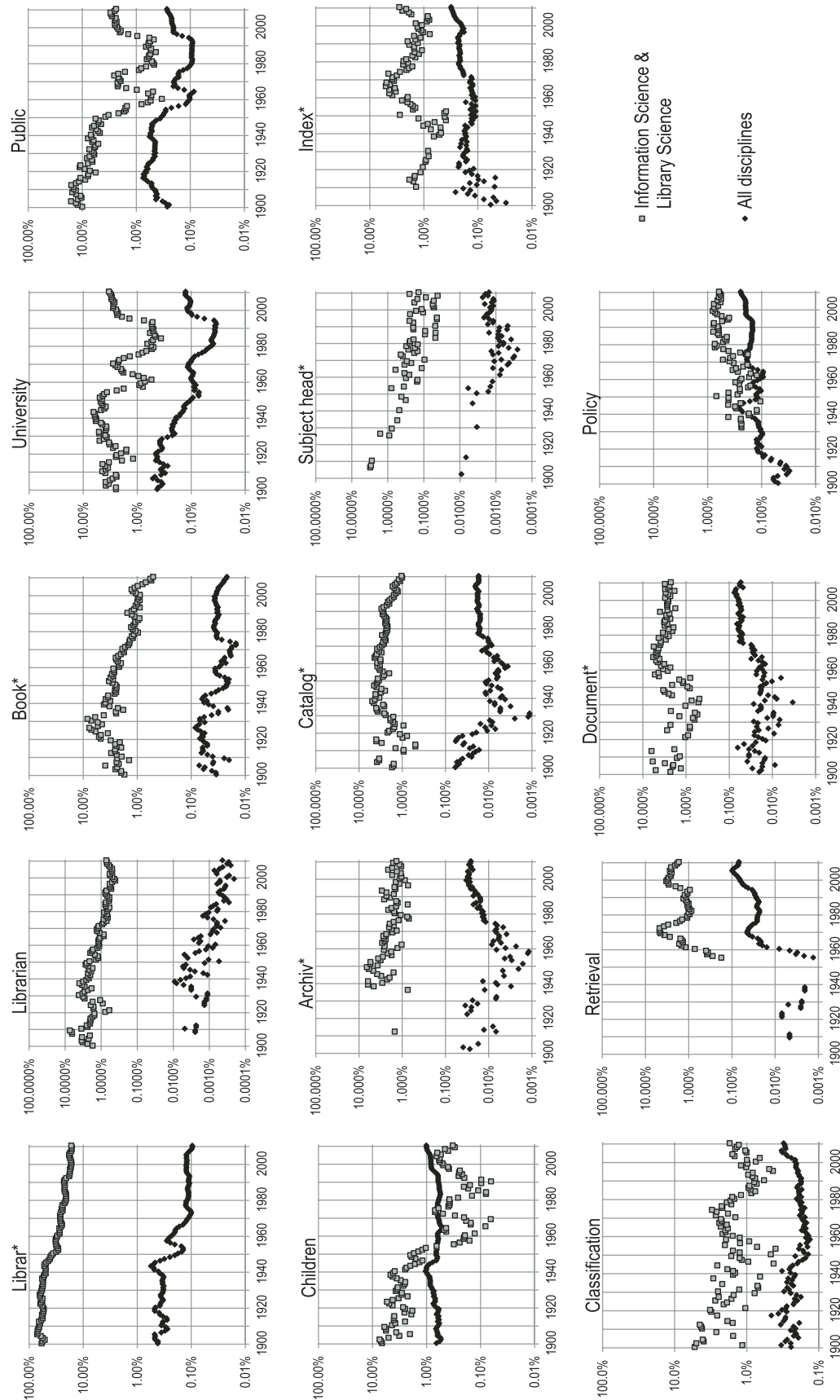
FIG. 7. Percentage of LIS papers and of papers in all disciplines (excluding LIS) containing a particular word in their titles, for *stable words* or *words in decline*, 1990–2010. Three-year moving averages.
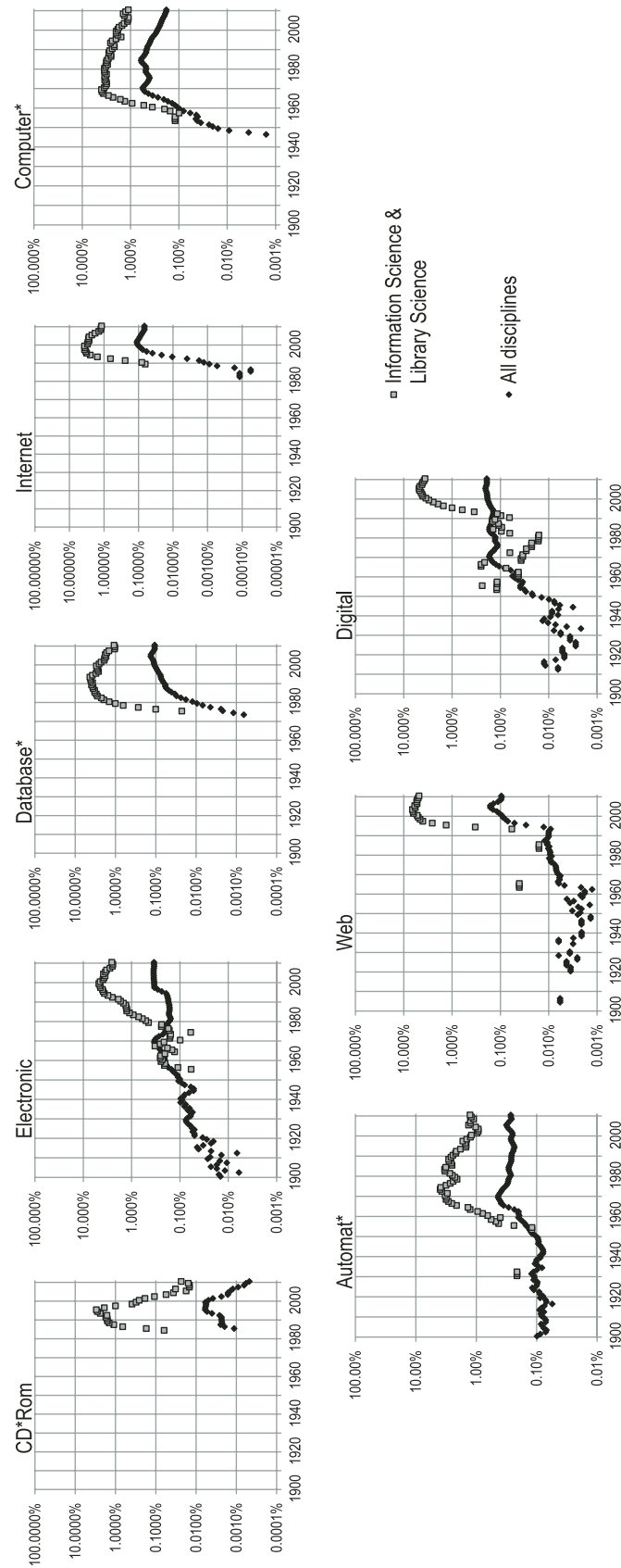
FIG. 8. Percentage of LIS papers and of papers in all disciplines (excluding LIS) containing a particular word in their titles, for *short-lived words*, 1990–2010. Three-year moving averages.
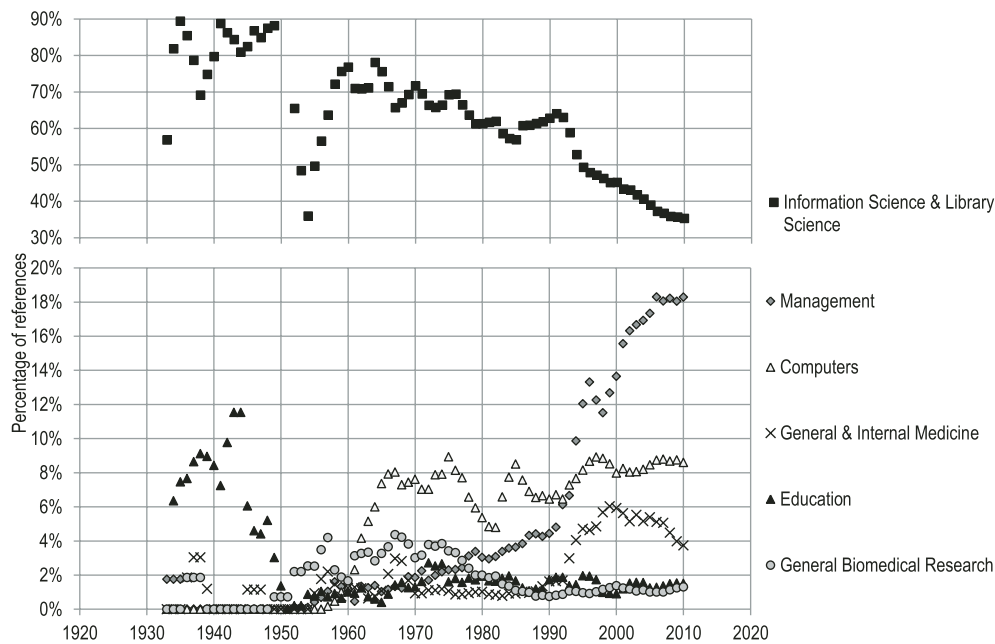
FIG. 9.   Interdisciplinarity of references made by LIS papers, 1933–2010. Three-year moving averages.

the 1970s, and has since decreased to less than 1%. *Automated* shares a similar history: it appeared in the 1960s and rose to 4% in the mid-1970s, reflecting a growing concern for library automation. The term, somewhat passé in the LIS literature, is now found in less than 1% of article titles.

Web emerged in the mid-1990s and within a few years was found in 4% of titles. Between 2000 and 2010, however, it dipped to under 3% (time has yet to tell whether this will stabilize or continue to decline). This is likely a case of obliteration by incorporation: the web remains a tool as well as an object of study that is highly relevant to LIS and to other disciplines; its small drop is probably due to the triviality of mentioning that one uses it. *Digital* exhibits an essentially similar pattern. Although there were sporadic uses of this term in the 1960s, it was not until the 1990s, with numerous digital library initiatives around the globe, that the term caught hold and rose to more than 4%. It then dropped to 2% over the next couple years. *Internet* similarly emerged in 1990s, rose to 3% by 2000, and then declined to 1%.

The literature of LIS changes with the introduction of new technologies. LIS is neither a technological leader nor laggard in this regard: it is not a bellwether, but nor should it be considered a late adopter.

Interdisciplinarity

To what degree is LIS a self-reliant field and to what extent does it source ideas and stimulation from other disciplines? Here we provide a diachronic analysis of the extent to which LIS is a net exporter or importer of ideas and knowledge, highlighting the fields with which it has established intellectual trading links over time. As shown in Figure 9, the degree to which the LIS literature cites itself

has declined steadily since the early 1960s. Currently, about 36% of the all references made to source items—references to books or other nonindexed items are not included here—in any given LIS paper are references to an LIS source, down from 80% in the 1960s. This can be explained, in large part, by the increase in the number of references made by LIS researchers to articles in management journals—up from 2% in 1970 to more than 18% in 2010. The other main discipline cited by LIS is Computers, fluctuating between 4 and 8% during the 1960 to 1995 period. It has stabilized at around 8% since then. General & Internal Medicine also accounts for a significant proportion of the LIS literature, although its share of reference has decreased from 6% to 4% since 2000. General Biomedical Research—a category that includes interdisciplinary journals such as *Science, Nature* and *PNAS*, accounts for less than 1% of the references and has been relatively stable since the beginning of the 1980s. Although the numbers are smaller at the beginning of the period—and, hence, more easily affected by small variations—the figure also shows the declining importance of Education: Education references cited by LIS papers steeply declined during the 1940s and now account for about 1% of the references.

Figure 10 presents the citations received by LIS papers. The increase in interdisciplinary citations starts later than for interdisciplinary references (1990s rather than the 1960s). The increase in interdisciplinarity has been quite steep: the percentage of citations received coming from other fields has increased from 20% to 60% in 15 years. The majority of citations now received by LIS come from other disciplines. Management and Computers account for a large proportion of the citations received, representing in 2010 10% and 8% of the citations, respectively. General & Internal Medicine
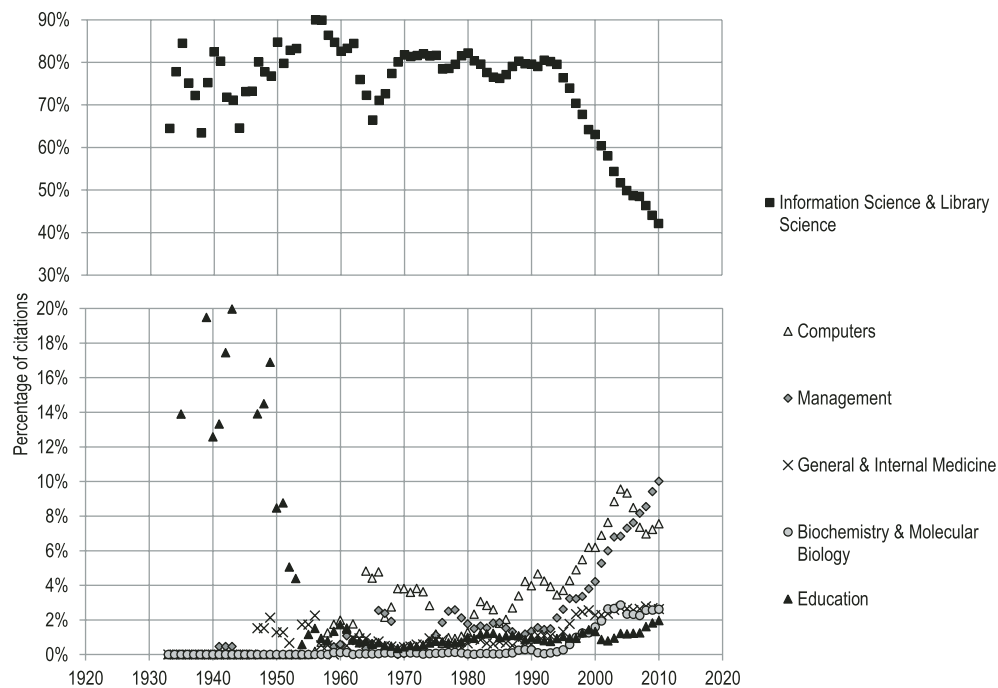
FIG. 10.   Interdisciplinarity of citations received by LIS papers, 1933–2010. Three-year moving averages.

and Biochemistry & Molecular Biology have also been increasingly citing LIS papers since the mid-1990s, while Education journals' share of citations decreased between 1933 and 1955, and remained lower than 2% since then—although it has recently picked up again.

As one might expect, the import/export ratio of LIS varies according to the partner discipline. Figure 11 presents this ratio for the main disciplines that cite and are cited by LIS papers. Although LIS's import dependency has been steadily decreasing since the mid-1990s—from 3.5 to about 1.3 in 2010 (inset)—it still has a negative balance of trade with most fields. The fields with which LIS has a positive balance of trade are from the natural, mostly medical sciences. Several of the fields with which LIS has a negative balance of trade are from the social sciences and the humanities: this may be a reflection of the "sociological turn in information science" (Cronin, 2008), in which the methods and concept of social sciences are increasingly being used in the LIS field, without reciprocation.

Another method of studying interdisciplinarity is to look at the various disciplines in which authors publish. Figure 12 reveals the interdisciplinarity of LIS and other disciplines' authors, defined as the percentage who, for a given year, have published in more than one field. The greater this percentage is, the more we can say that authors from a given field are "interdisciplinary." LIS authors—and comparable disciplines' authors—are defined here as authors who have published at least one paper in one LIS journal for the specific year studied. Given that our goal here is not to obtain exact percentages but to compare the values obtained for LIS with those of other disciplines, no disambiguation was performed.

All things being equal, authors from LIS and other fields should, roughly, be equally affected by homonyms and, hence, the comparison remains valid. The figure shows that, although LIS authors were the least interdisciplinary at the beginning of the period, their interdisciplinarity has considerably increased during the 1990s to the extent that by 2010 LIS is among the fields for which interdisciplinarity is the highest.

Discussion and Conclusion

We have presented here a condensed history of a field. Using a variety of bibliometric measures we have depicted the growth of LIS as a site of knowledge production and consumption in the academy over the course of more than a century. Our study not only provides field-specific indicators of scholarly productivity and impact but also includes aggregate data on scholarly publication, authorship, and citation trends in the social sciences and humanities in general. This allows us to see whether, how, and to what extent trends in LIS differ from those observable in other disciplines and fields.

The growth of the field was demonstrated in all aspects of production: there has been striking growth in the number of journals, number of papers produced, and number of contributing authors. Despite this growth, a decrease was observed in the field's market-share of all social science and humanities research. This is likely due to the exponential growth of journals in the late 20th century, reflecting the creation and growing specialization of knowledge domains and the development of new disciplines and fields. However,
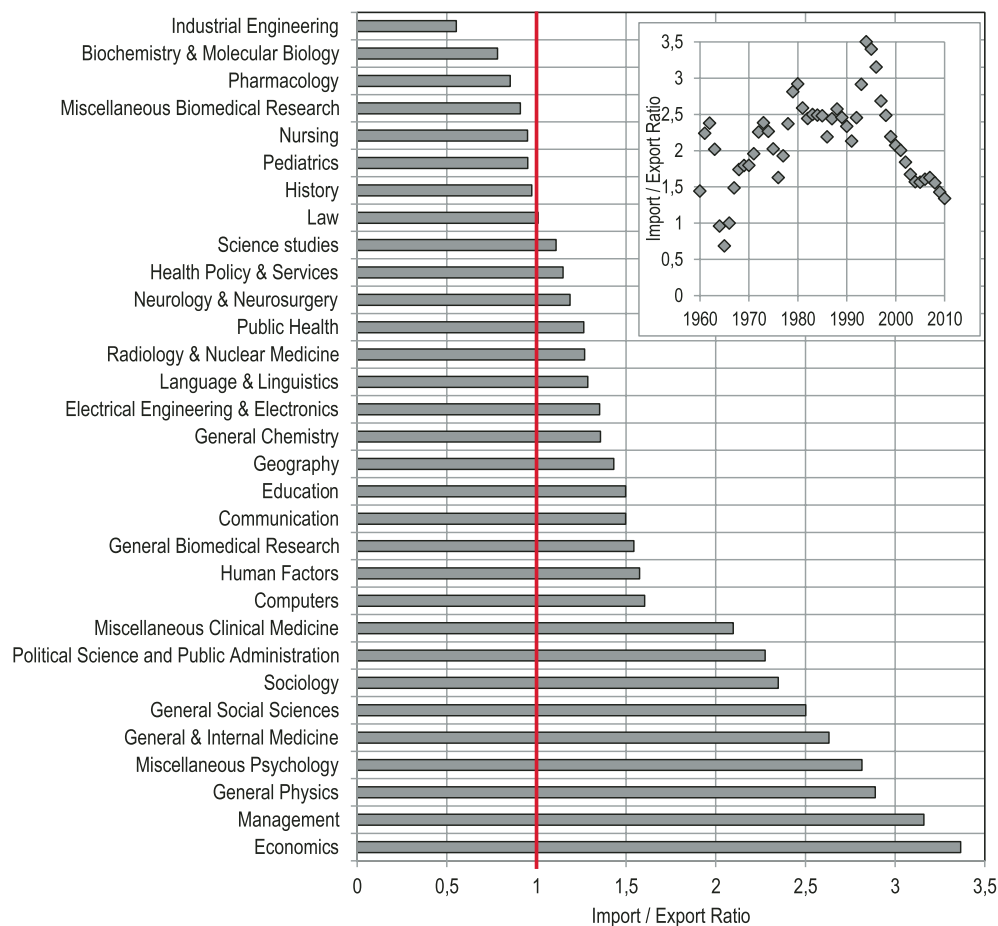
FIG. 11. Import/export ratio of LIS with top fields (more than 700 references/citations), 1991–2010. Inset: Evolution of the import/export ratio, 1960–2010.
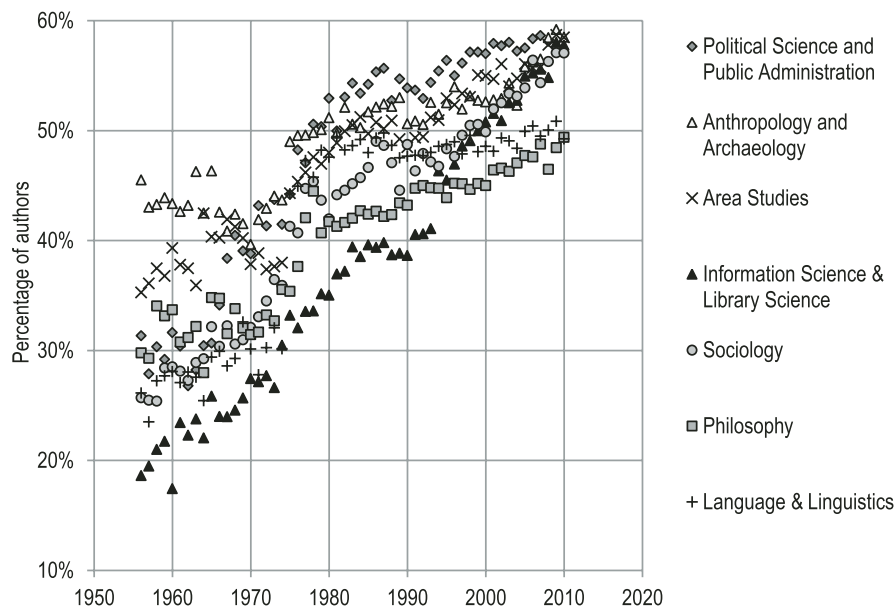

FIG. 12. Percentage of authors also publishing in another field, for LIS and SSH disciplines with a comparable number of papers, 1956–2010. Three-year moving averages.

the market-share of papers is greater than that of journals, which suggests that LIS journals tend to carry more papers per annum than other social science journals. Also of note is the exponential increase in papers and journals between 1960 and 1980. This time period corresponds to a shift in the topical and interdisciplinary landscape of the field—a move from terms relating to librarianship and corresponding institutions (e.g., libraries, universities, and archives), to information and associated practices (e.g., use, behavior, access). Changes in the field's focal concerns can be seen by analyzing the growth and decline of key words. The only words of the dozens we examined that have been ever-present and inclining since the beginning of the century are *information, research*, and *use. Document** has remained present and stable across the century. The remaining growth words are those that are new to the field, largely those that emerged around 1960.

Authorship patterns began to change in the same time period—a slight increase in the number of authors per paper is seen starting in the 1960s, with exponential growth beginning around 1990. Collaborative authorship is now the norm, a pattern visible across the social sciences. However, although the average number of authors per paper has increased, the average number of papers per author has decreased. This suggests a change in mode of production and the criteria deemed necessary for authorship: while the historical criterion for authorship was the writing of a text, other contributions are now recognized (Biagioli, 2003; Birnholtz, 2006; Pontille, 2004). Hence, the increase is likely due to a growth in the number of doctoral students, technicians, and other transient authors given credit on academic papers. It may also be an artifact of the growing interdisciplinarity of the field.

The growth and interdisciplinarity of the field have been accompanied by a growth in visibility. LIS papers are cited as much as the average social science paper (Wallace, Larivière, & Gingras, 2009) and are attracting citations faster than they used to. However, despite the faster harvesting of citations, the average age of references is greater—demonstrating the maturation of the field and the canonization of early literature. While trivial work is presumably forgotten and the best is obliterated through incorporation, there remains a corpus of older work that LIS continues to cite, even as it produces more that is cited faster. This is not unprecedented: as shown by Egghe (2010) and Larivière et al. (2008), the increasing age of cited literature often accompanies the end of the exponential growth of a body of literature.

The idea of boundary crossing was also examined. In the most recent year, nearly 60% of authors who published in LIS also published in a journal of another discipline. As noted elsewhere, there is a shift in the composition of LIS faculty (Sugimoto et al., 2011b; Wiggins & Sawyer, 2012). Faculty members are drawn from a variety of fields and may continue to publish in the disciplines of their academic training. Such fluidity threatens rigid conceptions of disciplinarity: What does it mean to be a part of a discipline? What criteria are necessary for consideration as a member of a discipline? Scholars' disciplinary identity may be operationalized by a number of criteria (place of academic training, current affiliation, venues in which they disseminate their work), all of which may yield different results. In examining other similarly sized disciplines, the same trend can be observed. The permeability of contemporary disciplines begs the question of the use and place of traditional notions of disciplines in an age of liquid disciplinarity.

The high degree of permeability in LIS was also demonstrated through reference and citation practices: whereas once an insular field in terms of citations and references LIS scholars now cite and receive citations from other fields more than from LIS itself. Two major structural shifts emerge from the data: in 1960, the field's character altered. As demonstrated by the world analysis, LIS changed from a professional field focused on librarianship to an academic field focused on information and use. This resulted in a sea change in the referencing patterns of the field, particularly with regard to the importation of knowledge from Computer Science. The second major shift occurred in 1990, when LIS began to receive a growing number of citations—which significantly contributed to the increase of the average impact of LIS papers—from outside the field, notably from Computer Science and Management. In addition, there was a dramatic increase in the number of authors contributing to the literature of the field. These trends reflect the advent of the Internet, World Wide Web, and the information economy. It is not surprising to see that LIS is tightly coupled in terms of citations and references with these two disciplines: the vast quantity of information produced needs to be managed, and its production, storage, and dissemination is done with computers. These disciplines interact reciprocally with LIS: exchanging knowledge bidirectionally. LIS has come of age and is now attracting attention from its academic near neighbors.

Acknowledgment

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