



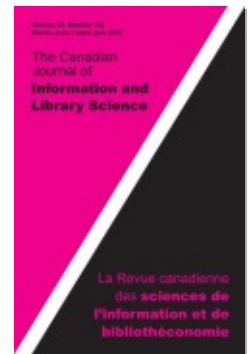
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An Analysis of Canadian Contributions to the Information
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An Analysis of Canadian Contributions to the Information Science Research Literature: 1989–2008

Une analyse des contributions canadiennes à la littérature de recherche en sciences de l'information : 1989–2008

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Abstract: A quantitative investigation of information science publications indexed in Web of Science by scholars affiliated with Canadian institutions was conducted for the period 1989 to 2008 as a follow-up to a 1991 study conducted by Chu and Wolfram. The findings reveal essentially linear growth in the number of contributions, as institutions housing library and information science programs contribute the most publications. The largest growth was observed in the area of information behaviour, where greater levels of author and inter-institutional co-authorship have been observed in recent years.

Keywords: scholarly communication, research productivity, research collaboration

Résumé : Une enquête quantitative portant sur les publications en sciences de l'information indexées dans Web of Science et dues à des chercheurs affiliés à des établissements canadiens a été menée pour la période 1989 à 2008 comme étude complémentaire à celle de 1991 réalisée par Chu et Wolfram. Les résultats révèlent une croissance essentiellement linéaire du nombre de contributions, le plus grand nombre de publications provenant des établissements ayant un département de bibliothéconomie et de sciences de l'information dans leurs murs. La plus forte croissance a été observée dans le domaine du comportement informationnel, avec un nombre plus élevé d'auteurs et de co-signatures interinstitutionnelles ces dernières années.

Mots-clés : communication scientifique, productivité dans la recherche, collaboration de recherche

Introduction and previous research

Information science (IS) has reached a level of maturity over the past two decades that has allowed for its investigation as a discipline from both historical and informetrics perspectives. The lack of consensus regarding the scope of the field (Schrader 1986; Hawkins 2001) has made the study of the discipline challeng-

ing. This lack of consensus has not deterred scholars from investigating the field, particularly through its literature, to identify key contributors, groups of scholars, topical areas of investigation, key publication sources, and the growth of the literature over time. The purpose of the present study is to examine the literature of information science while focusing on Canadian contributions to the research literature.

Most studies of the literature of information science have taken a quantitative or content-analysis approach. Among the earliest to undertake such a study, Small (1981) conducted a co-citation cluster analysis based on a subset of journals over a three-year period to better understand the relationship of information science to other social sciences. Järvelin and Vakkari (1993) outlined a content analysis of international literature in library and information science (LIS) and noted changes in the relative distribution in the topic coverage of the literature for three periods over 20 years. White and McCain (1998) conducted an author co-citation analysis of 120 IS authors identified through 8 IS and 4 library automation journals for the period 1972 to 1995. They visualized relationships among the identified authors over time and concluded, based on the analysis, that there had been a paradigm shift in information science in the 1980s, resulting in more emphasis on user studies thereafter. More recently, using the same list of journals, Zhao and Strotmann (2008) conducted a follow-up study for the period 1996 to 2005, which covered roughly the first decade of the World Wide Web. They concluded that the Web had a profound effect on information science due to the development of webometrics and search engine research. In a broader study that looked at library and information science, Åström (2007) examined co-citation patterns in articles from 21 LIS journals for the period 1990 to 2004. He also noted the rise in webometrics research during the period of his study, the stable structure of informetrics and information seeking and retrieval research, and the strong relationship between research topics and technological developments. All of these studies were focused on the discipline as a whole without geographic focus.

Canadian contributions to IS literature, which extend back approximately 50 years, merit investigation in their own right. To date, there have been few studies that have focused on information science within a Canadian context. Nilsen (2007) provided an historical investigation of the Canadian Association for Information Science (CAIS), the national society for information science in Canada, and called for further investigation of the field's development in Canada. From a more quantitative perspective, Wolfram and Chu (1989) and Chu and Wolfram (1991) examined the published research contributions made by Canadian-based researchers in the field up to 1988. Two decades have passed since their investigations and there have been many changes in the Canadian IS landscape. For instance, most Canadian schools of library and information science have seen substantial turnover in their faculty complement during this time as a result of retirements and program growth. New areas of study have emerged, prompted by technological developments such as the wider availability of the Internet. Changes have also taken place in the education of information

researchers, as new doctoral programs and a new generation of IS researchers have emerged.

In this study, the author conducts a follow-up investigation of Chu and Wolfram's (1991) earlier work into IS literature by Canadian-based researchers, which examined the period up to 1988. The present research focuses on the period 1989 to 2008. Note that the term "Canadian" is used for simplicity's sake. More accurately, this investigation focuses on researchers who are affiliated with Canadian institutions or organizations, although the authors themselves may not be Canadian. Similarly, this research does not consider the contributions made by Canadians who are not affiliated with a Canadian institution. However, some of these researchers, along with non-Canadians, may be included in the data set if they have published with colleagues at Canadian institutions.

Specific questions of interest guiding this research include:

- *How has the cumulative body of literature contributed by IS researchers at Canadian institutions grown during the study period?*

The contributions to the research literature of a discipline are cumulative, which can result in different patterns of growth. Given the growth of LIS school doctoral programs and increasing interest in IS topics by researchers in allied disciplines, the cumulative growth of the literature is hypothesized to be non-linear. (Note that the term "exponential growth" is sometimes used to describe more than linear growth. Such use assumes a specific type of mathematical model that may or may not be adequately represented by an exponential function.)

- *From which institutions have research contributions originated?*

The author hypothesizes that IS contributions continue to come primarily from institutions with LIS programs, but that growth (proportionate to LIS output) also comes from institutions supporting academic units in allied fields.

- *In which areas of information science have Canadian researchers contributed, and has the relative distribution of contributions to these areas changed over time?*

Areas of research contribution may wax and wane over time. Are trends apparent in the absolute contributions to these areas?

- *How have IS researchers at Canadian institutions engaged in collaborative research (as measured through co-authorship) with researchers at other institutions?*

Katz (1994) noted that research collaborations were strongly geographically based in Canada, Australia, and the United Kingdom, where intra-national collaborations between researchers at different institutions decreased exponentially with distance. His study was undertaken before the wider popularity of the Internet. Given the advances in telecommunications technologies to promote collaborations, is this the case for information science?

- *What are the demographic characteristics of the most prolific contributors to the research literature?*

Disciplines change over time as contributors enter and leave the field. Are there demographic concentrations or disparities evident in the list of the most prolific contributors?

Method

Studies of research literature have benefitted immensely from technical advances in bibliographic retrieval systems that have made it possible to analyse large collections of publications. Today's retrieval systems provide search and analysis features that were not present two decades ago. These features make it possible to conduct a more detailed examination of IS literature contributed by researchers affiliated with Canadian institutions.

A data set of IS literature by Canadian-based researchers was identified by searching Thomson Reuters's Web of Science (WoS). Retrieved records were limited to articles and conference proceedings that were from the time frame 1989 to 2008 and that had at least one author with a Canadian address. The retrieval parameters included 17 publication sources associated with information science that were included in WoS (see appendix). The author recognizes that the list of publications included can be debated. There are no universally agreed-upon parameters for what constitutes an IS publication source. The list used for this study includes seven of the eight IS journals identified by White and McCain (1998) and Zhao and Strotmann (2008) but excludes the *Annual Review of Information Science and Technology*, which contains review articles, not original research. The present investigation also does not include the four library automation journals they examined. The list of sources does include high-profile research journals in the field and more specialized journals that focus on sub-areas of the field (e.g., information retrieval, information organization, information policy, bibliometrics/informetrics), but not journals that focus on areas more tangential to IS research, such as education. The long-recognized phenomenon of the scattering of research literature across many sources (Bradford, 1934) makes the identification of all possible sources difficult. To retrieve documents from beyond the periodicals identified above, a topic search for the phrase "information science" with the same time frame and format limiters as above was Boolean ORed with the results of the periodical retrieval set. Note that in WoS, the topic "information science" addresses the subject area of "information science and library science." Other terminology, such as "information studies," proved to be too broad. A search for that term retrieved tens of thousands of records, most of which were irrelevant.

The "Analyze Records" feature of WoS was used to produce frequency distributions of retrieved records based on authorship, publication source, institutional affiliation, and year of publication. Full author and institution counts were used for multi-author publications (i.e., publication credit was not divided fractionally among authors or institutions). The full records of each publication from WoS were also downloaded to allow additional manual processing of data. Manual processing was done to identify multi-author publications and to classify the publications into subject categories. Institutional affiliations in multi-author publications were then reviewed to identify patterns of inter-institutional collaboration; these patterns were determined through the use of both descriptive data and multi-dimensional scaling. Total citation and adjusted citation counts (total

citations minus self-citations) for the top 20 contributing authors over all of each author's indexed publications in WoS were collected for the study time period. Authors also received full citation counts for collaborative works.

For subject classification, the author began with the five categories used by Wolfram and Chu (1989). Four of the five categories were adopted with some label changes to reflect more recent terminology (Information Behaviour, Information Organization, Information Retrieval, Scholarly Communication and Informetrics). Information Policy, which was not identified in the Wolfram and Chu study, was added as a more recent area of interest to the field. The fifth category used by Wolfram and Chu, representing a catch-all for information processes and social issues, was subdivided into four additional categories based on a finer analysis of the publications that fell into this category. The additional categories were Education, Professional Issues, Research Methods, and Other.

Results

Growth

The WoS search yielded 739 records of authors that had a Canadian affiliation in the 20-year period. Figure 1 summarizes the cumulative growth of the identified publications for the period 1989 to 2008. According to visual inspection, the growth appears to be linear, indicating a steady stream of contributions with

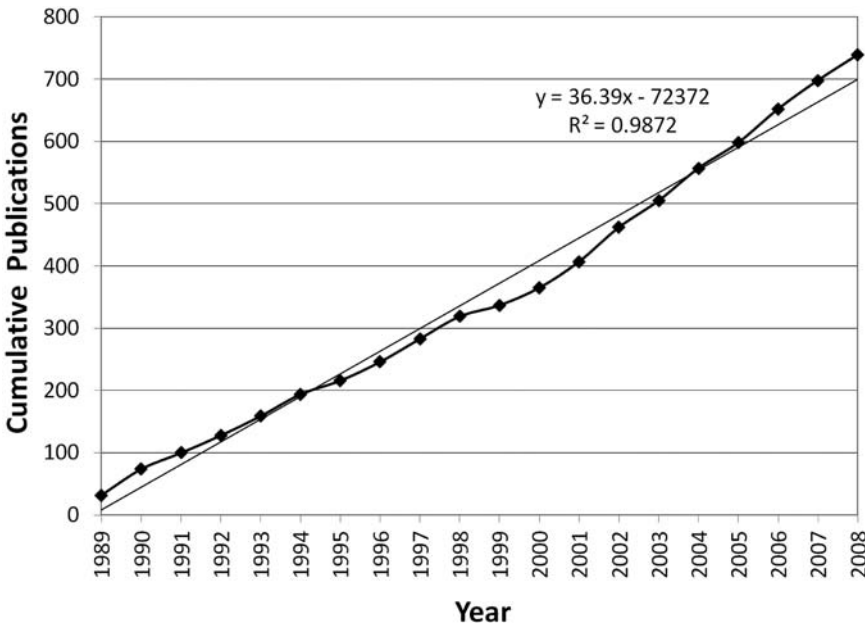


Figure 1: Growth of publications in information science by researchers in Canada.

no increasing annual growth. The goodness-of-fit for a linear model is quite high ($R\text{-squared} = 0.9872$). A second-order polynomial (i.e., non-linear) function provided the best fit based on the calculated goodness-of-fit ($R\text{-squared} = 0.998$), but it was only marginally better. In the interests of parsimony, the linear model was adopted.

Publication outlets

The identified publication outlets, which featured Canadian contributions during the time frame of the study, consisted of 47 journals and conference proceedings. Each of the 17 specifically identified journals included in the investigation contributed at least two publications with Canadian ties. The topic search for the phrase “information science” retrieved publications from 30 additional sources in LIS and allied disciplines, but most of these sources contributed only one or two publications. The most popular journals for research have been the *Canadian Journal of Information and Library Science* (previously the *Canadian Journal of Information Science*), the *Journal of the American Society for Information Science and Technology* (previously the *Journal of the American Society for Information Science*), and *Information Processing & Management*. In these three journals 48% of the search results were published (Table 1). Note that the proceedings of the annual CAIS meetings, which represent a prominent venue for Canadian researchers to present their IS research, are not currently indexed by WoS.

Areas of research

Each publication was categorized by year. Publications were classified into only one of the nine categories (whichever was deemed to be the dominant theme by the study author), but some publications could also fall into other areas.

Table 1: Most Frequent Publication Outlets

Source	Publications	Percentage of Total
Canadian Journal of Information (and Library Science)	150	20.3
Journal of the American Society for Information Science (and Technology)	131	17.7
Proceedings of the ASIST Annual Meeting	91	12.3
Information Processing & Management	74	10.0
Library & Information Science Research	59	8.0
Scientometrics	44	6.0
Information Society	29	3.9
Journal of Information Science	23	3.1
Library Quarterly	23	3.1
Knowledge Organization	22	3.0

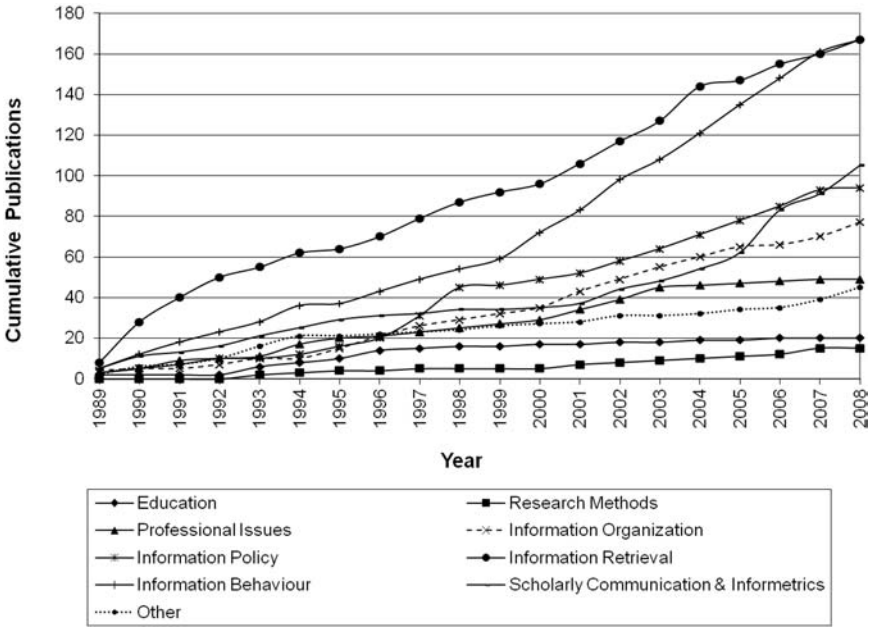


Figure 2: Absolute publication growth in subject categories.

Most articles' appropriate categories were clearly identifiable (e.g., "A Proposed Method of Measuring the Utility of Individual Information Retrieval Tools" was clearly in the Information Retrieval category), but others' were not. For example, "Frontiers in Conceptual Navigation" could fall into more than one category. The appearance of this publication in the journal *Knowledge Organization* qualified it for the Information Organization category. Similarly, "Gender Differences in Collaborative Web Searching Behavior: An Elementary School Study" has aspects of the Information Retrieval and Information Behaviour categories, but it was placed into the latter category because of its emphasis on user behaviour.

The frequency distribution of publications revealed absolute growth in all areas (Figure 2). Relative growth, that is, growth of publications in a given category in comparison to the total number of publications for the year, varied. Given a small increase in the number of publications in some categories annually, wide swings in other categories were apparent. Of note, Information Behaviour showed the steadiest relative growth over the 20-year period. Information Retrieval design and evaluation studies showed a relative decline after an increase in the early 1990s, although there has still been absolute cumulative growth for the category. Wolfram and Chu's (1989) study revealed that Information Retrieval was the most popular category for the time frame they studied, while the category in that study that most closely corresponded to Information

Behaviour (Human Factors) had more modest numbers. Järvelin and Vakkari (1993) in their analysis of international LIS articles also noted that research articles addressing information seeking were far fewer than those dealing with information storage and retrieval for their study period of 1965 to 1985. By the end of the time frame for the current investigation, the cumulative contributions to Information Retrieval and Information Behaviour were roughly equal. The Scholarly Communication and Informetrics category has shown relative growth and decline at different times. It was the smallest category in Wolfram and Chu’s study and was a relatively small category in Järvelin and Vakkari’s investigation. The popularity of webometrics as a sub-area within informetrics in more recent years was observed to be a contributing factor, as could be seen in the publication titles grouped into this category. The other categories also showed periods of relative growth and decline over the 20-year period of the study.

Institutional affiliations and collaborations

A breakdown of the institutional affiliations of the authors reveals that among the top eight contributing Canadian institutions are the seven universities with graduate programs in library and information science (or their equivalent). The eighth university is the University of Waterloo (Table 2). It is notable that researchers from the University of Western Ontario and the University of Toronto contributed more than 40% of the publication count. Both universities have large faculty numbers overall and have traditionally employed the largest numbers of full-time faculty members in library and information science among Canadian LIS schools.

The various faculties at LIS schools in Canada have exhibited stable faculty numbers or slight increases in growth according to the listings of full-time

Table 2: Top Ten Institutional Contributors

Institution Name	Publications	Percentage of Total
University of Western Ontario	180	24.4
University of Toronto	139	18.8
McGill University	70	9.5
University of Alberta	53	7.2
Université de Montréal	52	7.0
Dalhousie University	47	6.4
University of Waterloo	23	3.1
University of British Columbia	20	2.7
Concordia University	15	2.0
Université du Québec (all campuses)	13	1.8

faculty members appearing in the Association for Library and Information Science Education directories for 1989 and 2008. There has been considerable turnover in the faculty composition over the time frame of the study, as only one to four full-time faculty members have remained within each program between the first and last years of the investigation. Departmental affiliations for the more than 750 identified authors are not consistently included in the WoS records, thereby making it difficult to accurately estimate the average number of contributions per capita from each contributing department or school of each institution.

Of note among the top 30 contributing institutions are six non-Canadian universities (University of Illinois, Wolverhampton University, University of California at Los Angeles, Indiana University, University of Wisconsin (all campuses), and City University London). The presence of these institutions stems from multiple collaborations between these institutions and Canadian counterparts.

Levels of collaboration on publications have increased considerably. The average number of co-authors per publication has increased from 1.5 authors in 1989 to 2.5 in 2008. Of the 739 publications, 404 represent collaborative (multiple author) efforts. However, only 190 of the publications (26% of all publications) represent inter-institutional collaborations. The percentage of inter-institutional collaborations has not been uniform over time. A sharp increase in inter-institutional collaborations occurred over the last half of the study period. Between 1989 and 1997 an average of 7% of publications involved more than one institution. For the period 1998 to 2008, this average increased to 40% (Figure 3).

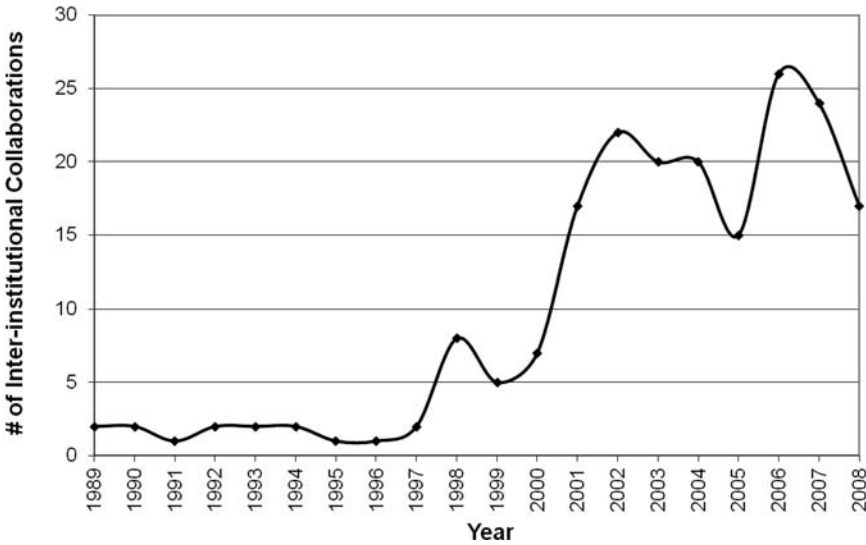


Figure 3: Number of inter-institutional collaborations by year.

The highest number of inter-institutional collaborations was claimed by faculty members at the University of Western Ontario (who collaborated with faculty members of 11 other institutions), followed by the University of Toronto (8), McGill University (5) and Dalhousie University (5). Most collaborations for the Canadian institutions in the field were with other Canadian institutions. For most institutions, there was either no international collaboration or just one international collaboration, though there were exceptions. Researchers at l'Université de Montréal collaborated with two international institutions. University of Toronto researchers collaborated with three international institutions. Researchers at the University of Western Ontario engaged in the most international collaborative efforts by linking with researchers from six institutions located either in the United States or the United Kingdom.

The author was interested in the related theme of determining patterns that may exist in inter-institutional collaboration relationships and frequency as measured through co-authorship. Katz (1994) noted that geography played a strong role in determining inter-institutional collaborations. In the Internet Age, when distance is less of a barrier, common research interests, faculty–student connections, and social networks are possible factors that contribute to collaborations. A multidimensional scaling (MDS) analysis was conducted on the most collaborative Canadian institutions using the PROXSCAL algorithm in SPSS for co-occurrence data (Leydesdorff & Vaughan, 2006). MDS allows one to visualize relationships among objects of interest based on a map of their calculated proximities. The more closely related the objects are, the more closely they are presented in the resulting map. The analysis resulted in an acceptable Stress-I goodness-of-fit value of 0.0582 (Figure 4). Groups of institutions within close geographic proximity that are reflected in the MDS map include the University of Toronto, McMaster University, and the University of Waterloo; and McGill University and l'Université de Québec (at least the Montreal campus). Conversely, there is a large distance between McGill University and l'Université de Montréal, as well as between York University and the University of Toronto. The close proximities on the map between geographically distant institutions such as the University of British Columbia or University of Alberta and several universities in central and eastern Canada point to other influencing factors for these collaborations. Common areas of research interest between investigators at different institutions or earlier collaborative relationships—as students/advisors or institutional colleagues, for example—could contribute to the closer proximities exhibited between some geographically distant institutions.

Authors

Specific individuals are not listed for their contributions to the IS literature. Unlike a list of institutions, which represent groups of researchers, a list of the top individual contributors can create controversy simply by who is and isn't included on the list. A few consolidated observations regarding the top 20 contributors, however, merit mention:

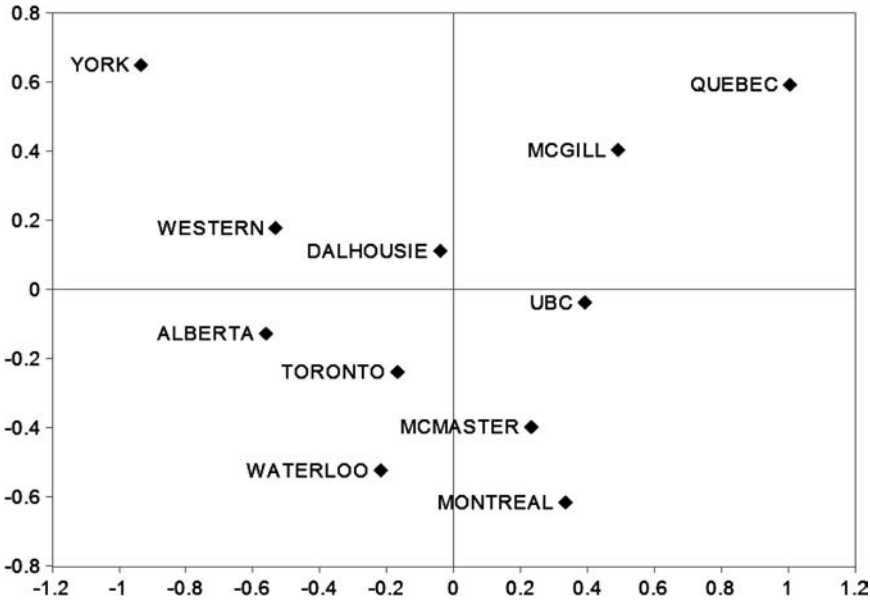


Figure 4: MDS plot of inter-institutional collaboration frequency.

- The top contributors each contributed at least nine publications returned by the search criteria.
- There is geographic representation from across the country (western, central, and eastern regions of Canada).
- Twelve of the top 20 (and 4 of the top 10) most prolific contributors are female.
- Eight of the top 20 contributors were already contributors to the research literature before the study period began.
- Three of the most prolific contributors on the list have since retired or passed on.
- At least four researchers on the list have had multiple institutional affiliations over the study period. Note that this does not affect the calculated institutional contributions because these were determined through WoS and according to institutional affiliations at the time of publication.
- Two of the five most prolific contributors hold or have held lengthy, full-time administrative positions for much of the time frame of the study.
- Adjusted citation counts and self-citation rates (number of self-citations divided by total citations) varied considerably among the top contributors. A significant correlation was observed between the numbers of publications and adjusted citation counts (Pearson's $r = 0.718$, $df = 18$, $p < .01$), which one would expect given that more publications present more opportunities to attract citations. The correlation between the numbers of citations received

and the self-citation rate was much lower and not significant (Pearson's $r = 0.265$, $df = 18$, $p > .05$), indicating that for most authors, citation counts were not unduly influenced by self-citations.

The influence of researchers after they have ceased contributing may still be quite strong. One instance, in particular, warrants mention. Jean Tague-Sutcliffe, a former dean of the University of Western Ontario's School of Library and Information Science (now the Faculty of Information and Media Studies) who passed away in 1996, continues to attract regular citations. Her research has generated the third-highest adjusted citation count for the study time frame, and most of the citations to her work have appeared since her passing.

Discussion

The continued linear growth observed in the number of publications was unexpected. With an increase in the number of and size of doctoral programs within Canadian LIS schools, one would anticipate steeper, non-linear growth, particularly in more recent years. With a higher average number of authors per publication, it is possible that research efforts simply are becoming more collaborative with greater doctoral student involvement. The linear result could also be a product of the data collection method because researchers at LIS schools may be publishing in allied areas that are not captured by the data collection method or are not indexed by WoS. This would include, for instance, monographs and book chapters. Curry (2000), in her study of Canadian LIS programs, noted that between 1990 and 2000, five of the seven LIS schools had changed, modified, or were contemplating changing their administrative unit affiliations. Such changes have the potential to influence the research agendas of faculty members within those schools. As systems-based information retrieval research has evolved from a sub-specialty within computer science and information science to become a more prominent area of investigation by industry (e.g., search engines), it has become increasingly difficult to determine the contributions to the area made by IS researchers (Meadows, 2008). The findings regarding the growth of the Information Behaviour category echo the observation made by Meadows in his study of information science in the United Kingdom.

The findings about individual authors reveal that there has been continuity in the field in Canada. As one would expect, those with the longest careers have had more opportunity to contribute to the research record. This is reflected in the rankings. Forty percent of the most prolific contributors were already contributing to the research literature before the current study period. Only 3 of the top 20 were no longer active academics by the end of the study period. It was also encouraging to see that approximately one quarter of those in the top 20 appear to be relatively recent contributors who began publishing during the second half of the study time frame.

The sizeable growth in collaborations exhibited over the past decade may have been influenced by several factors. Although more than half of the identified publications involved collaborative efforts, only one quarter were inter-institutional. No strong geographic influence on inter-institutional collaborations was observed. Growing numbers of doctoral students over the study period are likely to collaborate with faculty members and then continue collaborative relationships after graduation. The rise of the Internet over the study period has made inter-institutional collaborations more feasible. Incentives provided by national funding agencies such as the Social Sciences and Humanities Research Council, the Natural Sciences and Engineering Research Council of Canada, and the Canadian Institutes of Health Research may also encourage collaborative research projects within Canada, but they may not facilitate international collaborations. Possible changes in funding policies and their effect on IS research projects warrant further investigation.

Clearly, there are limitations presented by the methodology used. First, the method only captures sources that are indexed by WoS and are within the specified parameters. Monographs, book chapters, and proceedings of some relevant meetings in information science (e.g., CAIS conference proceedings for those years in which full proceedings were published) are not included. Second, there is no agreed-upon definition of what constitutes IS research or what an IS publication outlet is, once one moves beyond a handful of journals. Researchers with interests in information science may also publish in other areas that are not reflected in the data set, thereby undercounting their contributions to the knowledge base. For Canadian researchers who publish in other languages—most notably French, but possibly other languages—these contributions also may not be indexed by WoS. Furthermore, contributions made to allied areas, such as archival studies or knowledge management, are not captured by the methodology unless the publications are identified or indexed specifically as information science. Finally, co-authorship on publications serves only as a proxy for identifying collaborations. Collaborations may exist without a published record.

Conclusion

An analysis of research literature contributions can be revealing about shifts and trends within a discipline. The literature represents a record of the research landscape, contributors, and areas of study. The findings of the present study reveal an active IS research scene in Canada with steady growth, shifting areas of contribution over the study period, and an increase in collaborative research and inter-institutional collaboration, particularly since 2000. Institutions with LIS programs continue to be the primary contributors to the research literature, although contributions to the literature may also come from other units on the same campus. Future research could examine how the changing funding landscape for research in Canada has influenced the way in which IS research is carried out, both in terms of the research topics undertaken and the resulting collaborations.

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Appendix: Periodicals Used

Note: Parenthetical material indicates additions made to journals' names during the study period.

ASLIB Proceedings

Canadian Journal of Information (and Library) Science

Information Processing & Management

Information Research

Information Retrieval

Information Society

Journal of the American Society for Information Science (and Technology)

Journal of Documentation

Journal of Information Science

Journal of Informetrics

Knowledge Organization

Library & Information Science Research

Library Quarterly

Libri

Online (Information) Review

Proceedings of the ASIS(T) Annual Meeting

Scientometrics