

Canadian Collaboration Networks: A Comparative Analysis of the Natural Sciences, Social Sciences and the Humanities¹

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Abstract

A basic dichotomy is generally made between publication practices in the natural sciences and engineering (NSE) on the one hand and social sciences and humanities (SSH) on the other. However, while researchers in the NSE share some common practices with researchers in SSH, the spectrum of practices is broader in the latter. Drawing on data from the CD-ROM versions of the *Science Citation Index*, *Social Sciences Citation Index* and the *Arts & Humanities Citation Index* from 1980 to 2002, this paper compares collaboration patterns in the SSH to those in the NSE. We show that, contrary to a widely held belief, researchers in the social sciences and the humanities do not form a homogeneous category. In fact, collaborative activities of researchers in the social sciences are more comparable to those of researchers in the NSE than in the humanities. Also, we see that language and geographical proximity influences the choice of collaborators in the SSH, but also in the NSE. This empirical analysis, which sheds a new light on the collaborative activities of researchers in the NSE compared to those in the SSH, may have policy implications as granting councils in these fields have a tendency to imitate programs developed for the NSE, without always taking into account the specificity of the humanities.

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Introduction

A basic dichotomy is generally made between natural science and engineering (NSE) and social sciences and humanities (SSH). However, while researchers in the NSE share practices with researchers in SSH, the spectrum of practices is broader in the latter. In addition, while some studies have compared collaborative activities in the NSE and the social sciences (SS) (Glänzel 1995; Stefaniak 2001), none has analysed collaborative practices of scholars in the humanities. This paper analyses collaboration practices of researchers in the SSH compared with those in the NSE, using Canada as an example. The first section presents some methodological issues related to the application of bibliometric methods to literature in the SSH and the sources and methods used in this study. In the second section, we analyse the different collaborative practices of researchers in the SSH and the NSE by using the Canadian example.

Methods

The application of bibliometric methods to the analysis and evaluation of research practices in the NSE is well established. Their application to the analysis of the SSH is, however, more problematic. In this section, we review the shortcomings associated with bibliometric analyses in the SSH. The methods and sources used in this study will also be presented.

Bibliometrics in the SSH

Bibliometric methods are very useful for measuring the dissemination of knowledge in the natural sciences, but they are less effective in some applied fields, such as engineering (van Raan, 2003). Applied to the SSH, bibliometric methods poses three main problems.²

² For an exhaustive survey of the use of bibliometrics in the SSH, see Archambault and Vignola Gagné (2004).

First, knowledge dissemination media and, by extension, communication media in general are more varied in the SSH than in the NSE. A number of scholars have highlighted these fundamental differences between the scientific communication practices of scholars in the NSE and those in the SSH (Glänzel and Schoepflin, 1999; Hicks, 1999 and 2004; Moed, Luwel and Nederhof, 2002; van Raan, 2003). This is reflected in the greater role played by monographs, conference papers and proceedings, and non-scientific literature in the SSH. Depending on the discipline, articles may be a relatively minor publishing medium compared with others, such as books. Unfortunately, no database covers these other forms of publication as systematically and exhaustively as Thomson Scientific does for journal articles.

Second, SSH research subjects are sometimes more local in orientation and, as a result, the target readership is more often limited to a country or region (Glänzel, 1996; Hicks, 1999 and 2004; Ingwersen, 1997; Nederhof *et al.*, 1989; Nederhof and Zwaan, 1991; Webster, 1998; Winclawska, 1996). SSH scholars reportedly publish more often in their mother tongue and in journals with a more limited distribution (Gingras, 1984 and 2002; Line, 1999). These research and publication practices have important consequences on the coverage of SSH publications from countries in which the main language is not English.

Furthermore, according to Hicks (1999), a number of SSH disciplines have more paradigms competing with one another than do those in the NSE, and as a result SSH literature is more fragmented – a situation that hinders the formation of a solid “core” of scientific journals –, thereby making article-based bibliometric analysis more difficult to conduct successfully.

Therefore, one cannot mechanically rely on Thomson Scientific data to calculate publication rates or produce research impact indicators, nor to compare, rank or benchmark the research

performances of research institutions. However, these data can be used to map SSH scholars' collaborative activities by measuring joint publication of articles and highlighting differences among disciplines. The resulting collaboration rates must be interpreted as being the output of scholars who publish articles, not the output of all scholars in the SSH. In fields in which the article is not a major dissemination medium, our analysis will probably provide less insight into overall practices. However, it will still bring out the characteristics of an important subset of the SSH population of scholars: those who publish articles. Furthermore, in spite of its limitations, measuring collaboration on the basis of articles is probably the best approach currently available. According to Moody (2004), the collaboration rate for books is generally lower than that for articles. Therefore scholarly articles are a more informative medium for analysing collaboration not only in the natural sciences but also in the social sciences and humanities, although we must be careful not to generalize the results to all scholarly research output.

Building bibliometric statistics

The bibliometric data presented here comes from Thomson Scientific databases on CD-ROM: SCI, SSCI and AHCI. From these three data sources, a relational database has been created in which each piece of information was inserted into specific tables (articles, authors, addresses, journals, research fields, etc.) and fields (author's names, departments, institutions, cities, countries, etc.) For all Canadian addresses, a complete harmonization of institutions has been performed to regroup under one designation the multiple ways an institution could be written³. Also, each institution was classified into sectors such as universities, governments, hospitals, industries, etc. Although these three databases list several types of document, only articles, research notes and review articles are generally used for bibliometric studies because

³ McGill University, for instance, could be written as McGill-Univ, MacGill-Univ, McQuill-Univ, or as one of its affiliated colleges, Macdonald-Coll.

they are the usual vehicle for disseminating new knowledge. However, there are no clear standards on this subject (Moed, 1996): other types of document are deemed to be important in some disciplines but not in others.⁴

Table 1 gives the number and percentage share of the various document types in the social sciences, humanities and natural sciences. It shows that, while the three types generally used for bibliometric studies – articles, research notes and review articles – account for nearly 80% of NSE scholars' research output and 62% of those in the social sciences, they account for slightly less than 35% of documents listed in the humanities. Book reviews play an important role in knowledge dissemination in the social sciences (27%) and is central in the humanities (57%) reflecting the importance of books in these disciplines. Including this type of document for bibliometric statistics would no doubt have yielded increased coverage. Yet, as Table 1 shows, the mean number of addresses per book review is very low, suggesting that book reviews are very rarely co-authored. These results are reinforced by a recent study of referencing practices showing that scholars in humanities refer three times more often to books than to articles (Larivière *et al*, 2006).

Accordingly, while the types of document selected (articles, notes and review articles) represent a lower percentage of publications listed in the SSH database than in the NSE, they are most likely to be produced collaboratively, and since the purpose of our study is to measure the collaborative activities of SSH scholars, we have decided to use only these three types.

⁴ For example, meeting abstracts in engineering disciplines. See Godin (1998).

Table 1: Document types in all fields of the natural sciences, social sciences and humanities for the World Production — percentage share and mean number of addresses, 1980-2002

Document Type	Natural Sciences			Social Sciences			Humanities		
	No. of Documents	%	Mean No. of Addresses	No. of Documents	%	Mean No. of Addresses	No. of Documents	%	Mean No. of Addresses
Article	10,050,775	72.194%	1.80	908,483	58.640%	1.43	371,240	31.682%	1.06
Artistic Production	2	0.000%	1.50	83	0.005%	1.06	32,397	2.765%	1.03
Bibliography	950	0.007%	1.52	454	0.029%	1.41	1,911	0.163%	1.18
Biography	14,059	0.101%	1.25	4,713	0.304%	1.19	5,113	0.436%	1.09
Book Review	8,252	0.059%	1.07	421,800	27.226%	1.03	665,994	56.836%	1.01
Chronology	49	0.000%	1.29	39	0.003%	1.08	58	0.005%	1.02
Correction	14,034	0.101%	1.89	530	0.034%	1.48	130	0.011%	1.10
Criticism	4	0.000%	1.25	389	0.025%	1.02	19,702	1.681%	1.03
Discussion	20,922	0.150%	2.29	3,868	0.250%	2.08	3,027	0.258%	1.88
Editorial Content	256,537	1.843%	1.39	58,757	3.793%	1.23	20,682	1.765%	1.16
Letter	577,003	4.145%	1.39	34,109	2.202%	1.09	15,374	1.312%	1.03
Meeting Abstract	2,024,856	14.544%	1.51	49,184	3.175%	1.26	2,755	0.235%	1.09
News	2,767	0.020%	1.23	302	0.019%	1.13	365	0.031%	1.04
Note	611,672	4.394%	1.55	35,080	2.264%	1.30	17,190	1.467%	1.05
Other Reviews	3,002	0.022%	1.13	1,411	0.091%	1.08	2,085	0.178%	1.03
Reprint	2,663	0.019%	2.84	490	0.032%	1.31	163	0.014%	1.07
Review Article	334,260	2.401%	1.66	29,559	1.908%	1.37	13,593	1.160%	1.10
All types	13,921,807	100%	1.72	1,549,251	100%	1.30	1,171,779	100%	1.03

This paper uses the fields classification developed by CHI Research and used by the US National Science Foundation. The main advantage of this classification is that categories are mutually exclusive and therefore each journal appears in only one field. The advantage of this type of classification is that it bypasses problems associated with multiple counts. Unfortunately, a similar classification has not been developed for the humanities. Thus, it was necessary to classify those journals and to associate them to mutually exclusive fields and sub-fields.

Types of collaboration

We focus our analysis on the two most important form of collaboration: international and interinstitutional. We consider that a paper is the result of an international collaboration when it comprises at least two different institutional addresses from at least two countries. In the Canadian context, this means that articles with at least one Canadian address and one address from a foreign country are considered to be the result of international collaboration. The same

principle applies to calculating interinstitutional collaboration: articles with at least two addresses from different Canadian institutions will be counted as instances of interinstitutional collaboration. Interinstitutional collaborations are, thus, collaborations between two Canadian institutions. The counting of articles with more than one author serves to measure overall collaboration between scholars. Once an article is attributed to more than one author, it is considered to be the result of a collaboration.

Collaborative Practices

This section provides insight into SSH scholars' collaborative practices and illustrate differences in practices among SSH disciplines. First, we will analyse articles written by more than one author to determine overall collaboration practices by Canadian scholars. Second, we will examine international collaboration with a view to determining Canada's position in a global collaborative network. Third, we will look at the collaborative networks of Canadian institutions.

Multi-author articles

The proportion of articles written by more than one author reflects the overall level of collaboration by Canadian scholars. A paper must be signed by at least two authors to be considered the result of a collaborative activity. Figure 1 shows the evolution of the proportion of multi-author articles. It shows that almost all articles in the NSE are joint publications, which is hardly surprising, considering that research output in those disciplines is usually the result of a team effort. In 2002, more than 2 out of 3 Canadian papers in the social sciences had multiple authors, compared to 1 out of 2 papers at the world level. In the humanities, on the other hand, the vast majority of articles were written by just one scholar. Overall, the collaboration rate in the humanities stayed low at about 10%, but there was a

slight increase over the 23-year period. However, the increase was much lower than in the social sciences, where the rate of growth outstripped that observed in the NSE. While these figures indicate three distinct trends, they also suggest that the collaborative practices of scholars in the social sciences correspond more closely to those in the natural sciences than to those in the humanities.

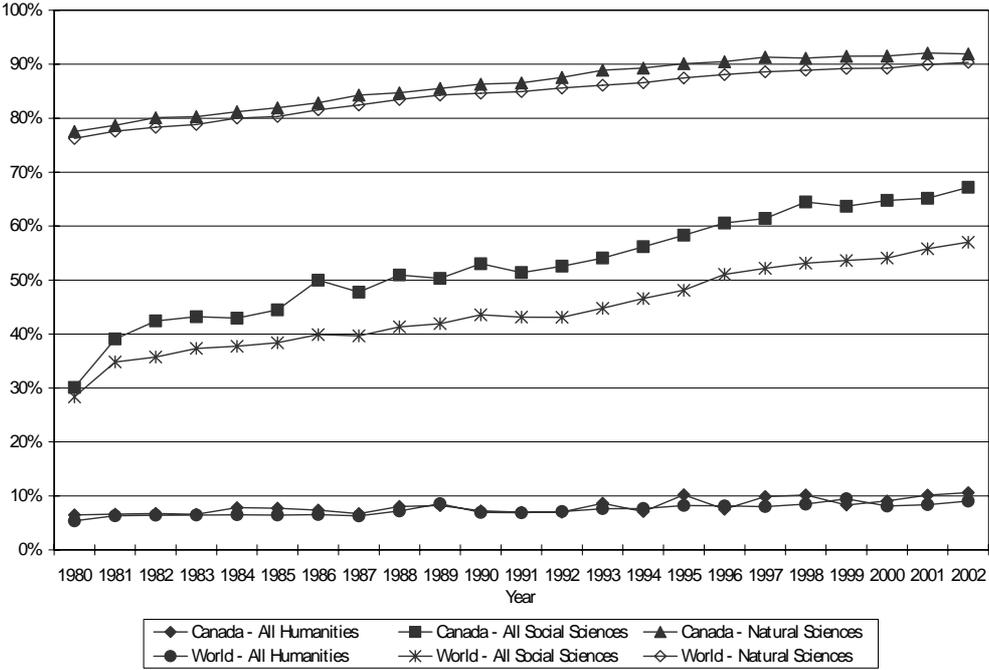


Figure 1: Proportion of multi-author articles in NSE, social sciences and humanities, Canada and the world, 1980-2002

Variations among disciplines are quite considerable (Table 2). In 1998-2002, most articles in psychology and economics and management were written by more than one author, compared with about 60% in other social sciences and education. Slightly more than 1 article out of 3 resulted from collaboration in law, compared with about 10% in history and the humanities. Multi-authorship is marginal in literature (4%), the only discipline where no growth is observed.

Table 2: Canadian multi-author articles, by discipline, 1980-2002

Field	1980-1985		1986-1991		1992-1997		1998-2002		Total	
	N. Papers	% Multi-Author								
Law	43	17.8%	68	27.2%	68	33.7%	56	39.7%	235	28.2%
Economics and Management	1,162	44.0%	1,742	50.0%	2,326	60.5%	2,005	67.2%	7,235	55.9%
Education	362	40.5%	462	45.3%	530	45.5%	422	58.9%	1,776	46.8%
History	159	10.6%	180	12.0%	216	13.4%	188	14.5%	743	12.6%
Other Humanities	290	7.6%	284	8.0%	335	9.5%	260	10.8%	1,169	8.8%
Literature	98	4.0%	80	3.4%	89	3.6%	72	4.3%	339	3.8%
Psychology	1,535	61.1%	2,506	70.5%	3,011	75.0%	2,682	82.2%	9,734	73.0%
Other Social Sciences	1,800	33.2%	2,993	42.4%	4,318	49.8%	4,199	57.6%	13,310	46.8%
Canada (Social Sciences and Humanities)	5,449	27.9%	8,315	36.5%	10,893	42.7%	9,884	50.0%	34,541	39.4%
Canada (Natural Sciences)	83,507	80.0%	110,581	85.1%	135,721	89.6%	116,349	91.6%	446,158	87.0%

International Collaboration

Our study shows that the contribution of international collaboration in the NSE and the social sciences grew steadily over the 23-year period, both for Canada and for the world (Figure 2). In 1980, only 15% of Canadian articles in the NSE and 11% in the social sciences involved international partners, but by 2002 the figures had risen to 42% and 25% respectively. The international collaborative activities of Canadian scholars were well above the world average in 2002, in both the NSE (20% for the world) and in the social sciences (10% for the world)⁵.

The practices of scholars in the humanities are different. The amount of international collaboration by Canadian scholars remained fairly stable during the period studied, which is hardly surprising since very few papers had more than one author. Worldwide, there was a modest increase, but international collaboration remained the exception rather than the rule.

⁵ One might note that the world's international collaboration rate is lower than the lowest international collaboration rate for a country (Japan). In 2002 (NSE), 116 459 articles out of 586 034 counted at least two address from at least two countries, for a world collaboration rate slightly below 20%. By comparison, Japan had 12 371 international collaborations out of 60 937 articles, for an international collaboration rate just above 20%. This distortion between the world's and countries international collaboration rates is caused by the fact that the international collaborations are not only bilateral collaborations between two countries, but multilateral collaborations. Thus, an article that is the result of international collaboration is counted for each country, but only account for one paper in the world's international collaboration rate. This distortion could probably be resolved by using fractional counting.

The proportion of output resulting from international collaboration varies from country to country (Table 3). However, while for most countries the international collaboration rate in the social sciences is almost comparable to that in the natural sciences, it is way below in the humanities, for which the percentages are stagnant and very low. Between 1998 and 2002, only two countries had an international collaboration rate above 15% in the humanities: China and Hong-Kong. Again, we can see that the social sciences have a different collaboration pattern than the humanities.

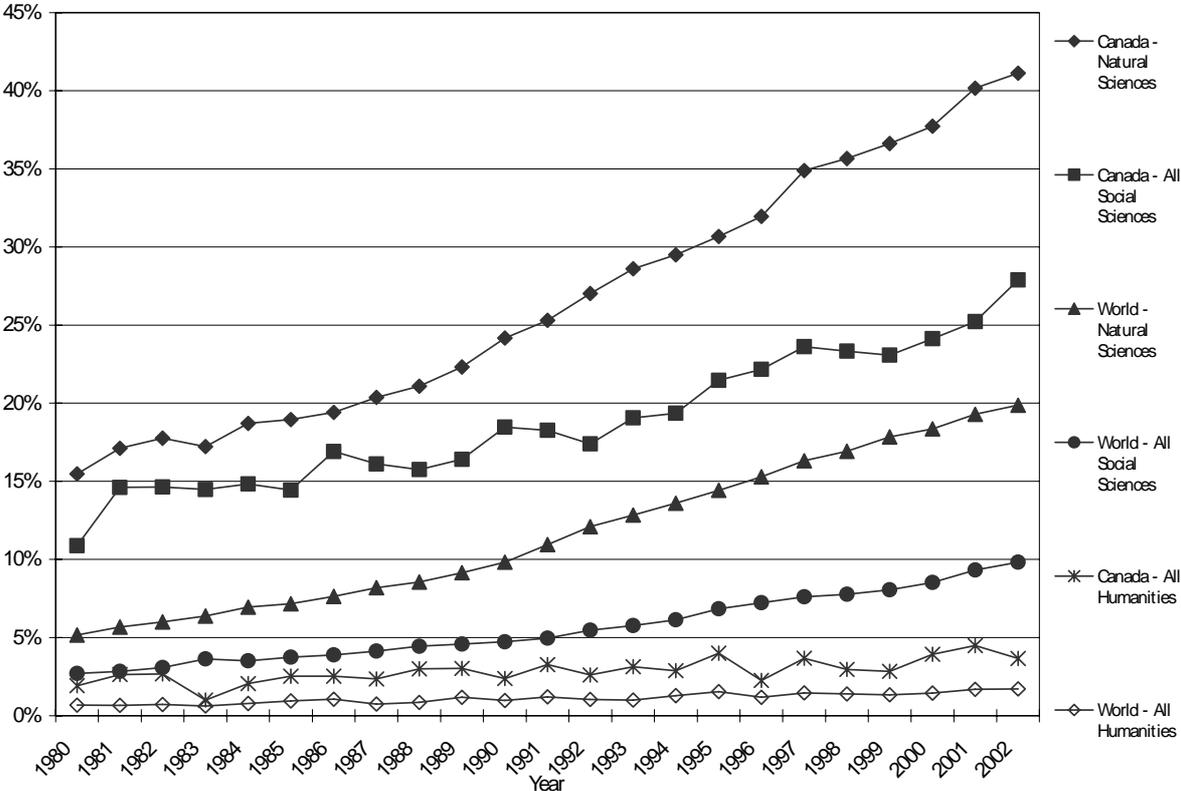


Figure 2: International collaboration trends in NSE, social sciences and humanities, Canada and the world, 1980-2002

Table 3: International collaboration rates of countries in humanities, social sciences and NSE, 1980-2002 (1000 or more publications in SSH as a whole)

Country	1980-1985			1986-1991			1992-1997			1998-2002		
	Hum.	SS	NSE									
Switzerland	4.6%	15.0%	28.0%	4.0%	20.1%	37.5%	4.5%	27.2%	46.8%	3.4%	34.6%	53.5%
Belgium	4.6%	19.0%	23.4%	4.0%	28.1%	33.9%	4.6%	36.6%	44.9%	6.3%	42.8%	53.4%
Norway	4.5%	12.8%	20.8%	7.3%	15.9%	27.8%	6.1%	20.0%	39.0%	2.5%	25.4%	47.5%
Sweden	5.0%	14.3%	19.9%	0.9%	17.2%	26.8%	5.1%	21.3%	38.0%	8.1%	22.9%	46.2%
Netherlands	5.5%	11.0%	18.4%	5.9%	15.8%	24.0%	6.5%	21.1%	34.6%	8.9%	28.1%	44.8%
Hong Kong	7.0%	16.2%	22.6%	1.3%	24.0%	22.8%	10.8%	38.2%	38.6%	15.0%	39.7%	43.1%
France	2.2%	11.1%	17.2%	2.0%	16.3%	25.0%	2.0%	24.0%	34.2%	2.1%	29.8%	42.0%
Israel	4.7%	23.5%	23.1%	5.9%	28.2%	30.2%	5.1%	28.7%	37.8%	4.1%	28.1%	41.9%
Germany	1.5%	5.8%	15.5%	2.2%	8.6%	23.1%	2.9%	12.7%	32.5%	4.0%	19.0%	40.7%
Italy	2.7%	11.6%	18.3%	4.3%	22.1%	25.9%	4.0%	30.3%	33.4%	4.8%	34.1%	39.0%
New Zealand	2.0%	14.5%	14.4%	3.1%	18.5%	21.8%	6.6%	25.6%	31.1%	6.7%	30.2%	38.5%
Canada	2.1%	14.4%	17.6%	2.7%	17.0%	22.2%	3.1%	20.6%	30.4%	3.6%	24.7%	38.3%
UK	2.2%	8.0%	14.2%	2.9%	10.2%	19.2%	3.4%	14.0%	28.2%	3.8%	18.2%	37.3%
Spain	0.5%	13.5%	13.1%	1.2%	21.5%	22.0%	2.0%	24.1%	30.4%	2.0%	24.8%	36.9%
Australia	2.3%	11.0%	13.5%	3.7%	13.4%	18.7%	4.5%	16.3%	26.5%	5.6%	20.3%	35.4%
China	1.9%	20.7%	19.0%	12.6%	30.7%	24.4%	13.9%	52.4%	28.1%	17.1%	42.6%	26.9%
Republic of Korea	0.0%	42.1%	32.7%	6.3%	56.0%	29.0%	14.0%	54.1%	27.5%	9.9%	45.4%	25.1%
U.S.	0.9%	3.6%	8.2%	1.2%	4.8%	11.8%	1.4%	7.0%	17.8%	1.6%	9.1%	24.1%
India	1.1%	11.4%	6.1%	3.0%	12.4%	10.1%	4.4%	16.6%	14.5%	5.8%	23.7%	20.1%
Japan	2.8%	12.8%	6.0%	6.2%	16.6%	9.1%	3.4%	21.7%	14.0%	8.5%	24.1%	18.6%

Zitt, Bassecouard and Okubo (2000), have shown that, for NSE, historical, linguistic and cultural ties have an impact on the choice of collaborators. The international networks of collaboration (Figure 3) created with UCINET (Borgatti, Everett, and Freeman, 2002) and NETDRAW (Borgatti, 2002) show this is also true in the social sciences, as illustrated by the high rates of collaboration between Austria and Germany, the Netherlands and Belgium, and New Zealand and Australia. This is also true for Canadian provinces: while the U.S. is the first partner of all provinces, the statistics show relatively stronger ties between the researchers from the French-speaking province of Quebec and scholars from France and Belgium (Larivière, Lebel and Lemelin, 2004).

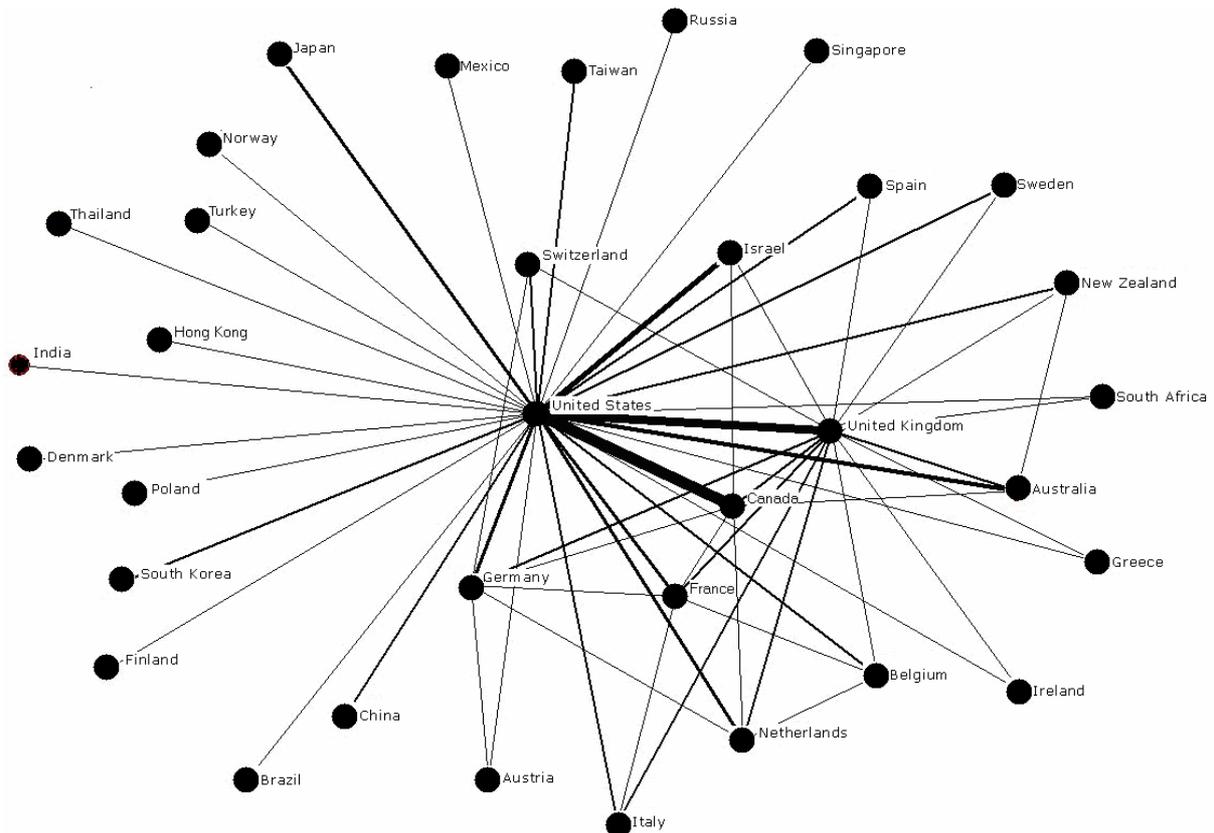


Figure 3: International Collaboration of Scholars in the Social Sciences, 1980-2002 (200 or more joint publications)

Interinstitutional collaboration

Figure 4 presents trends in interinstitutional collaboration of Canadian researchers. It shows the growing importance of this form of collaboration in the social sciences as well as in the NSE. While the interinstitutional collaboration rate was higher in the NSE than in the social sciences (26% compared with 22% in 2002), the gap narrowed between 1980 and 2002. By contrast, the rate for the humanities remained stable at 2–3%.

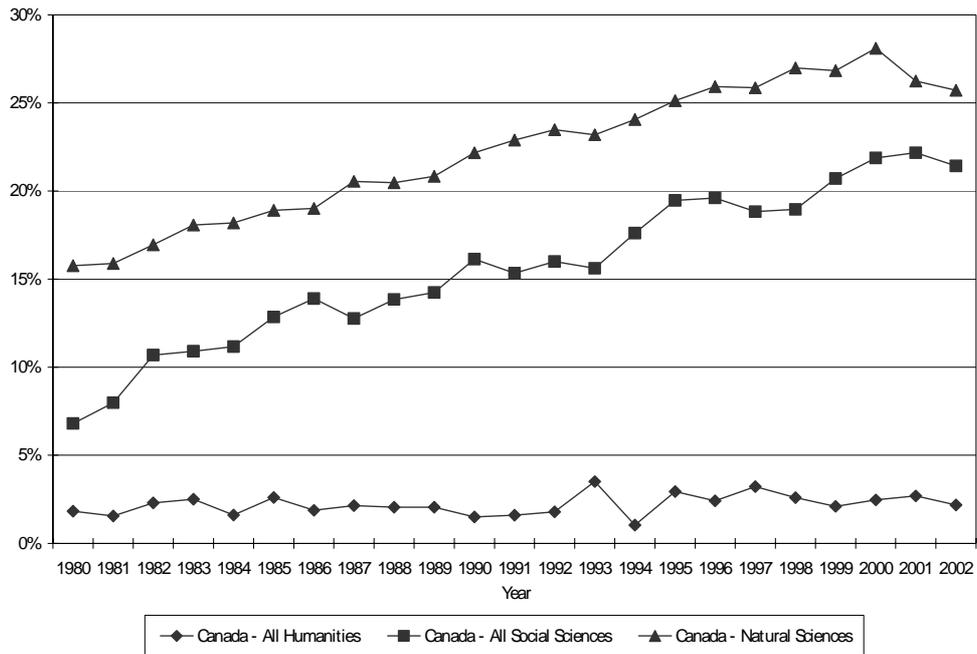


Figure 4: Trends in interinstitutional collaborative activities of Canadian scholars in NSE, social sciences and humanities, 1980-2002

Figures 5, 6 and 7 present the Canadian interinstitutional collaborative networks in the SS and in the NSE⁶. In the first two cases (Figures 5 and 6), the University of Toronto is the central node of the network. Freeman's centrality measure also shows that McGill University is much less central in SS than in NSE, whereas the University of British Columbia and the *Université de Montréal* are much more central nodes in SS than in NSE.

Note also that geographic proximity seems to be a decisive factor in choosing collaborators. The close ties between institutions in the West, between institutions in Quebec and between those in Ontario are evident, in both SS and NSE. This should come as no surprise: as noted above, geographic proximity and the use of a common language influence, at the macro level of countries, the choice of collaborators. Our data shows that this is also true between institutions in Canada, a country with two official languages. Comparing Figures 5 and 6 also suggests that francophone universities are much more integrated in the Canadian network in

⁶ Rates of interinstitutional collaboration in the humanities were too low to compile a network.

NSE than in SS. If one takes into account that nearly all Quebec papers in NSE are written in English and that objects under study in NSE tend to be universal (cells, electrons, etc.), this difference between the two network makes sense.

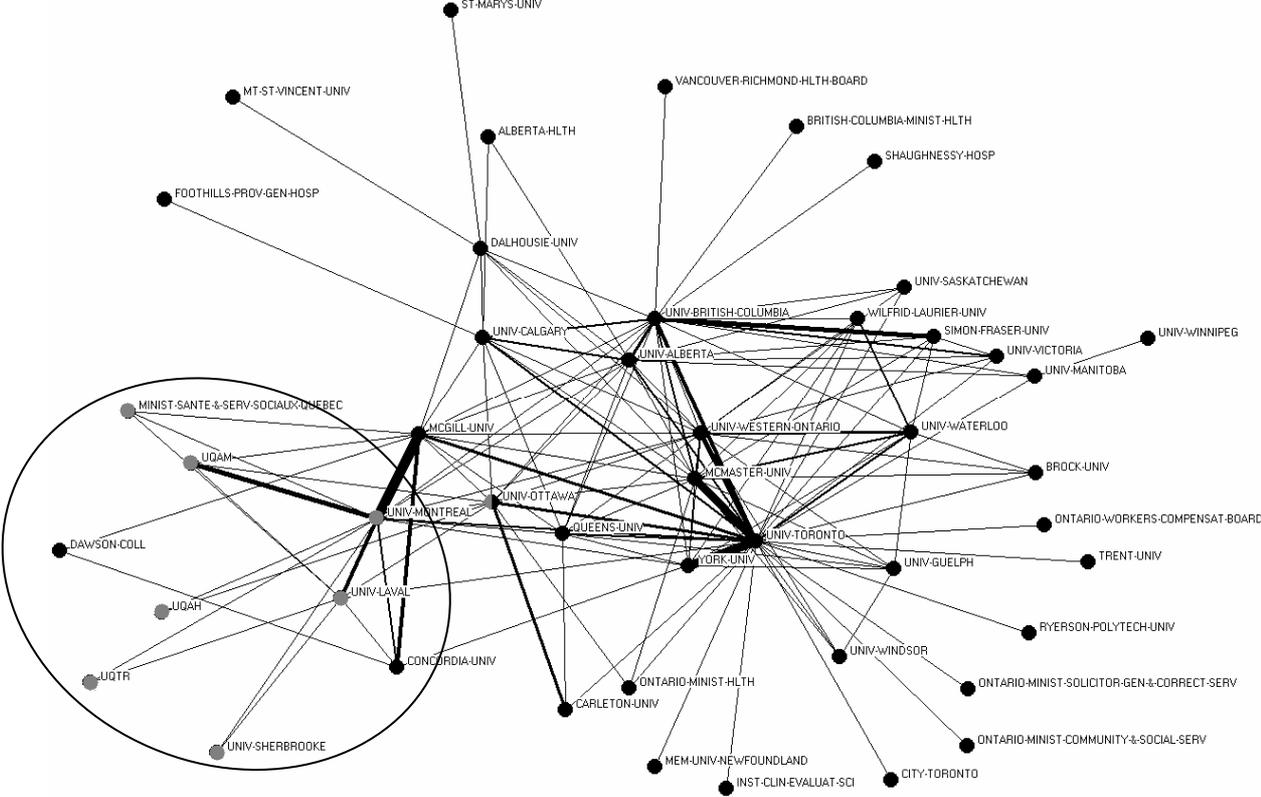


Figure 5: Interinstitutional collaborative activities of Canadian scholars in the social sciences, 1980-2002 (20 or more joint publications). Black nodes represent anglophone institutions; grey nodes represent francophone institutions.

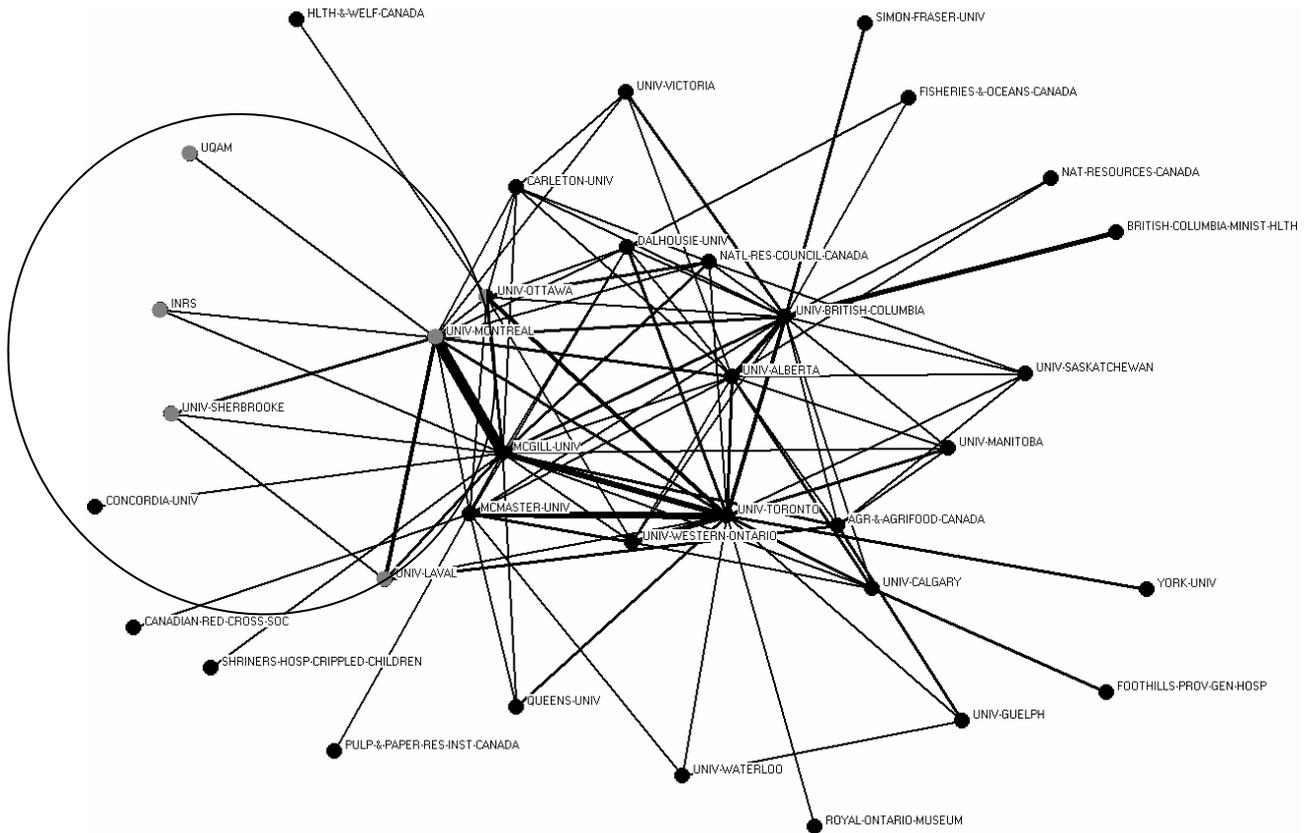


Figure 6: Interinstitutional collaborative activities of Canadian scholars in the NSE, 1980-2002 (250 or more joint publications). Black nodes represent anglophone institutions; grey nodes represent francophone institutions.

As Figure 7 shows, the collaborations in SS between Francophone and Anglophone institutions essentially vanishes when we look at the papers written in French only. This clearly confirms that even in SS, the language of collaboration with Anglophone institutions is essentially English. All these data show that, contrary to what Ajiferuke (2005) suggested, physical distance as well as language does play a structuring role in the choice of collaborators.

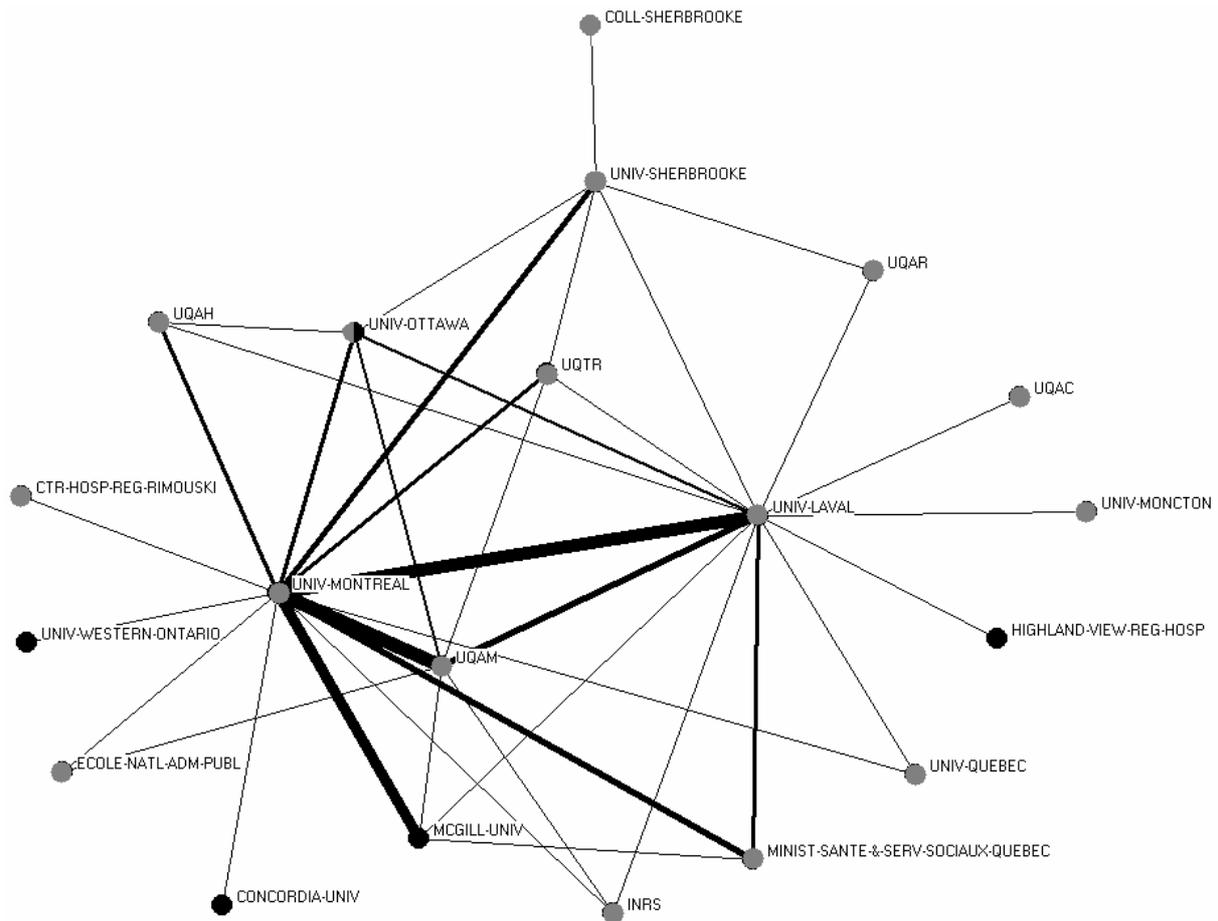


Figure 7: Interinstitutional collaborative activities of Canadian papers written in French in the social sciences, 1980–2002 (1 or more joint publications). Black nodes represent anglophone institutions; grey nodes represent francophone institutions.

Conclusion

The collaborative activities of Canadian scholars, as measured by the number of joint publications, are increasing in both the NSE and the SSH. There is also an upward trend in international collaboration. However, the rate of growth is not the same across all disciplines. While rates for all types of collaboration in the social sciences rose steadily since 1980, collaboration rates for the humanities remained unchanged in a number of cases. Overall, psychology and economics and administration were the disciplines with the strongest collaboration, followed by social sciences, education, and law. In the humanities, history was the discipline in which collaborative activities were most frequent, but the rate remains very low. In the humanities and literature, formal collaboration based on co-authorship is a

marginal phenomenon. Not surprisingly, the disciplines with the highest collaboration rates are, in general, the ones in which journal articles are the main medium of knowledge dissemination. Also, these findings tend to confirm those of Moody (2004), who showed that quantitative research was more likely to be performed in collaboration.

The most visible expression of scientific collaboration is obviously co-authorship. Almost all articles in the NSE are jointly published, compared with two thirds in the social sciences and about 10% in the humanities. The most common form of partnership leading to a joint publication is international collaboration, followed by interinstitutional collaboration within Canada. Expressed in another way, in a slim majority of cases, Canadian scholars work more often with collaborators in foreign institutions than with those in other Canadian institutions. In both NSE and SSH, geographic and linguistic proximity also has an influence on the choice of these interinstitutional collaborators. While this is hardly surprising for scholars in SSH, who tend to work on more local topics, this was less expected for researchers in NSE, whose research objects are more universal and whose audience is therefore more international.

Though the level of collaboration in the social sciences, and particularly in the humanities, is lower than in NSE, one should keep in mind that collaboration between scholars can also take other forms that cannot be measured by bibliometrics, such as participation in conferences and seminars, co-direction of theses and co-publishing of books or book chapters. More research in the sociology of science is required to gain insight into the different forms of research collaboration in the social sciences and humanities. This being said, bibliometric mapping of collaborative networks gives a very good idea of the overall trends in collaboration and highlight important differences between the humanities, the social sciences and NSE; social sciences being nearer to the NSE than to the humanities. Given the tendency

of granting councils in the SSH to imitate the programs developed for the NSE, these differences should be taken into account, particularly for the humanities.

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