Inter-University Collaboration in Canada

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Abstract
This study examines the extent of inter-institutional collaboration between scholars in the 48 major Canadian universities, and also determines the factors that influence such collaboration. Documents included in the *Science Citation Index Expanded* , *Social Science Citation Index*, and *Arts & Humanities Citation Index* of the online ISI's Web of Science database for the period 1990- October 31, 2003 were used as sources of data for the study. Making use of the author's affiliation field, we were able to determine the number of publications co-authored by scholars in each pair of universities. Multiple regression analysis was used to determine the influence of factors such as geographical distance, province, language, time zone, age, and peer group on collaboration. Only province and peer group were included in the final regression model.

Introduction

According to Katz and Martin (1997), "research collaboration could be defined as the working together of researchers to achieve the common goal of producing new scientific knowledge." Direct collaboration between two or more researchers is the fundamental unit of collaboration, and this could be categorized as intra-departmental collaboration, inter-departmental collaboration within an institution, inter-institutional collaboration within a country, and international collaboration (Qin, 1994; Katz & Martin, 1997). Though it is possible for two or more researchers to collaborate but publish their results separately or for two or more researchers to work separately on a problem but publish their results together in a joint paper, it is most common in bibliometric studies to equate co-authorship with collaboration (Subramanyam, 1983 ; Melin & Persson, 1996; Avkiran, 1997; Katz & Martin, 1997; Thorsteinsdóttir, 2000; Garg & Padhi, 2001; Persson, Glanzel & Danell, 2004).

Multiple-authored papers have generally been shown to have greater impact/influence than single-authored papers (Goffman & Warren, 1980; Lawani, 1986; Beaver, 2004) while a few studies have shown that the impact varies with the different types of collaboration ; internationally co-authored papers tend to get more cited than single-country papers (Narin & Whitlow, 1990; Katz & Hicks, 1997). In addition, collaboration, especially among researchers from different institutions, facilitates knowledge sharing, transfer of tacit knowledge, and cross-fertilization of ideas (Katz & Martin, 1997). Universities are a key sector in research production and many studies have investigated their collaboration patterns (Katz, 1994; Melin, 1996 ; Persson et al, 1997 ; Melin & Persson, 1998). In the case of Canadian universities, a couple of studies have focused on a single region in the country (Godin and Ippersiel, 1996 ; Thorsteinsdóttir, 2000). Also, Katz (1994) determined the effect of geographical proximity on intra-national university-university collaboration for three countries, including Canada. The study concluded that research cooperation decreased exponentially with the distance separating the collaborative partners. However, given that the data used in the study were from 1981 to 1990, it remains to be seen whether geographical distance still has an effect on research collaboration in the advent of the Internet and the growing ease of communication. Hence, the objectives of this study are to assess the extent of university-university collaboration for the whole of Canada, and to determine the factors influencing such collaboration using recent data (from 1990 till 2003).

Previous Studies

Qin (1994) investigated the research collaboration in the sciences using a sample of papers from *The Philosophical Transactions of Royal Society of London* from 1901-1991. She found out that, though within-departmental collaboration was the dominant form of collaboration, inter-institutional collaboration was becoming increasingly prevalent and the number of papers involving this type of collaboration was slightly more than those involving international collaboration but much more than

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inter-departmental collaboration within an institution. In their own study of research collaboration at Umeå University in Sweden in 1993, using the *Science Citation Index* as data source, Melin and Persson (1996) found that within-departmental collaboration, inter-institutional collaboration, and international collaboration were almost at the same level while inter-departmental collaboration was much less than any of the other three types. Persson and Melin with two other colleagues (1997) also studied the research collaboration at 22 Nordic Universities. The focus of the study was the comparison of National, Nordic, and Non-Nordic collaborations in the five countries (Denmark, Finland, Iceland, Norway, and Sweden) and across seven fields of study (Biology, Biomedicine, Chemistry, Clinical Medicine, Engineering, Geosciences, and Physics). In most cases, the percentage of Nordic collaboration was the least, but the relative positions of National and Non—Nordic collaborations varied across country and field of study. Merlin and Persson (1998) later added data for 8 universities in UK and three major technical colleges in Sweden to test relationships between institution size and collaboration types (external collaboration, internal collaboration, ratio of nationally and internationally co-authored articles, and ratio between mixed and internationally co-authorships). The correlation between institution size and each of external collaboration and internal collaboration was weak and positive while its correlation with each of the other two types of collaboration was weak and negative. However, none of the correlation coefficients was significant.

There have been a few studies looking at research collaboration in Canada. Godin and Ippersiel (1996) investigated the scientific collaboration between regions in Quebec Province of Canada from 1989 to 1992. The study divided the province into five regions (Montreal, Peripheral Montreal, Corridor, Quebec City, and Peripheral regions) and examined collaboration in universities, junior colleges, hospitals, government , and industry. Inter-regional co-authorships ranged from 5.6% to 34.7% with the bulk of the collaboration including Montreal, the metropolitan city of the province. Overall, inter-regional co-authorships accounted for 10.8% of publications by these regions which was less than 24.1% and 32.5% with the rest of Canada and foreign countries respectively.

Thorsteinsdóttir (2000) compared the external research collaboration of scientists in Iceland and Newfoundland, a province in Canada, from 1990-1994. Using the *Science Citation Index* , the study showed that, on the average, 46% and 57% of Newfoundland and Iceland papers respectively had outside research collaborator. However, both islands had similar collaboration patterns with their respective regions ; about 23% of Newfoundland papers were co-authored with scientists from other parts of Canada while 25% of Iceland papers were co-authored with scientists from other Nordic countries. Also, interviews with a sample of the scientists revealed that the main reason for their engagement in research collaboration was to combine complementary skills in tackling more complex problems.

In their attempt to construct a regression model to explain predisposition to collaborate, Foster and Meinhard (2002) interviewed 645 presidents or executive directors of nonprofit organizations in Canada. 21 independent variables on organizational characteristics, perceptions regarding environmental changes, and attitudes of the organization were identified for possible inclusion in the model but only six eventually qualified for inclusion. These were size of the organization, type of organization (feminist or not), perceived environmental impact, motivation for collaboration, competitive outlook, and obstacles to collaboration. It should be noted, though, that these variables accounted for only 18% of the variation in the extent of inter-organizational activities engaged by these organizations.

Methodology

There are 92 institutions that currently belong to the Association of Universities and Colleges of Canada (Association of Universities and Colleges, 2003). However, only 48 of these are considered major universities (Johnston, 2003) with the others being regarded as having a strictly religious or specialized mission (these include university colleges, open universities, colleges of art & design, agricultural colleges, military colleges, etc). So, only the 48 major universities are included in this study, and Maclean's Guide to Canadian Universities (Johnston, 2003) grouped them into three peer groups : Primarily Undergraduate (these universities are largely focused on undergraduate education,

with relatively few graduate programs) ; Comprehensive (these universities have a significant amount of research activity and a wide range of programs at the undergraduate and graduate levels, including professional degrees); and Medical-Doctoral (these universities offer a broad range of Ph.D. programs and research, as well as medical schools).

The online ISI's Web of Science database was used to collect collaborative data on these universities. The database includes *Science Citation Index Expanded* , *Social Science Citation Index*, and *Arts & Humanities Citation Index*. Data were collected at the end of October 2003 and contained articles published from 1990 till then. It should be noted that the Web of Science now contains data from 1981 but it was only recently that the pre-1990 data were added. To obtain the number of publications by a particular university during the time period of interest, we entered its name in the address field, and to obtain the number of co-authorships between two universities, we entered their names, joined together by the "AND" Boolean operator, in the address field. This is similar to the method adopted in previous bibliometric collaboration studies using *Science Citation Index* and/or *Social Science Citation Index* (Katz, 1994 ; Melin, 1996; Melin & Persson, 1998; Thorsteinsdóttir, 2000).

Previous studies have suggested that geography, language, and other socio-political factors could influence the level of research collaboration (Katz, 1994). Hence, we decided to collect data on the age, location, language, and peer group of the universities. Data on age, language, and peer grouping were collected from Maclean's Guide to Canadian Universities. The two official languages in Canada are English and French. Hence, the language of instruction in each of the 48 universities is either English or French except for the one that is officially bilingual. Canada is made up of ten provinces and three territories, and there are six time zones in the country. So, in terms of location, we considered the physical address, province and time zone in which the university is located. These data were collected from the website of each university.

We used a multiple regression analysis to determine the relationship between collaboration and the factors mentioned above. This is similar to the method used by Vaughan and Thelwall (2005) to determine whether the number of inlinks to a university website could be predicted or explained by faculty research profile, student quality, and the language of the university. In our regression model, the dependent variable is the number of co-authorships between a pair of universities. The independent variable age is represented by the absolute difference in the years of establishment of a pair of universities while the variable time zone also represents the absolute difference (given by the number of hours) in time zones for a pair of universities. For a pair of universities, we used their physical addresses to obtain their geographical distance using MapQuest (http://www.mapquest.com/directions/main.adp) , i.e., the physical address of one university is entered as the starting address and the one for the other university as the ending address. The other three variables, province, language, and peer group were introduced into the model as dummy variables. For each pair of universities, if they are both located in the same province, the province variable has a value of zero, otherwise it is one. The same applies for the language and peer group variables.

Results

The University of Toronto produced the highest number of publications during the time period, leading the next university by almost 30,000 publications (see Table 1). It is also interesting to note that the top 10 universities belong to the Medical Doctoral Group while the bottom ten belong to the Primarily Undergraduate group. Even though Maclean's Guide to Canadian Universities used factors such as research funding, diversity of offerings and the range of Ph.D. programs to define peer groupings, the number of publications seem to have validated these groupings (the Spearman's rank correlation between peer group and number of publications was 0.908).

In terms of collaboration between the universities, there are possible 1128 (i.e. 48*47/2) pairs but we have shown only the top 21 in Table 2. These are pairs with at least 500 co-authorships. The pair with the highest number of co-authorships is McGill University and Université de Montréal**.** Both universities are in the same province, the same town, and belong to the same peer group. However, the language of instruction at McGill is English while that at Université de Montréal is French. The

university that appeared most in the top 21 pairs is University of Toronto, and it is paired with five universities in its province (the other four in other provinces), eight universities belonging to its peer group (York University belongs to the Comprehensive group but is in the same town as University of Toronto), and nine universities using the same language of instruction.

Multiple regression analysis, using the stepwise method with a $p=.05$ criterion for variable entry or removal, was used in determining the relationship between co-authorships and the six independent variables (i.e. geographical distance, difference in time zone, difference in age, peer group, language, and province). Of the six variables, only peer group and province were included in the final regression model. The multiple correlation coefficient for the model is 0.298 , which is statistically significant at 0.01 level ($F=54.907$, $d.f. = 2,1125$). The corresponding coefficient of multiple determination is .089, i.e., about 9% of the variation in the number of co-authorships between two universities is being explained by the peer group and province factors. In order to explain more variation in co-authorships, and given the fact that the number of co-authorships between two universities cannot be greater than the number of publications for the university with the fewer publications, we decided to add the number of publications by the more productive university as well as the number of publications by the less productive university to the number of independent variables. We ran the multiple regression analysis again using the stepwise method, and the four independent variables included in the regression model are the number of publications for the less productive university, province, number of publications for the more productive university, and peer group. The multiple correlation coefficient for the new model is 0.728, which is statistically significant at 0.01 level ($F=317.113$, $d.f. = 4,1123$). The corresponding coefficient of multiple determination is .53, i.e., about 53% of the variation in the number of co-authorships between two universities is being explained by the four independent variables. The variance inflation factors (VIF) for the explanatory variables are 1.51, 1.004, 1.442, and 1.286 respectively. Given that these values are much less than 10, we can conclude that the explanatory variables are not highly correlated with each other, and hence, there is no multicollinearity problem.

Table 1. Number of publications by the universities (1990-2003).

University Name	**Peer Group**	**Number of Publications**
University of Toronto	Medical Doctoral	75068
Univ. of British Columbia	Medical Doctoral	45342
McGill University	Medical Doctoral	45048
University of Alberta	Medical Doctoral	36464
McMaster University	Medical Doctoral	26997
Université de Montréal	Medical Doctoral	26155
Univ. of Western Ontario	Medical Doctoral	24090
University of Calgary	Medical Doctoral	23689
University of Ottawa	Medical Doctoral	18398
Université Laval	Medical Doctoral	18227
Queen's University	Medical Doctoral	17207
University of Manitoba	Medical Doctoral	17035
University of Waterloo	Comprehensive	16684
University of Guelph	Comprehensive	15453
Dalhousie University	Medical Doctoral	14675
University of Saskatchewan	Medical Doctoral	14011
Université du Québec	Medical Doctoral	11747
York University	Comprehensive	10672
Simon Fraser University	Comprehensive	10037
University of Victoria	Comprehensive	9347
Carleton University	Comprehensive	7928
Memorial Univ. of Newfoundland	Comprehensive	7521
Concordia University	Comprehensive	6765
Université de Sherbrooke	Medical Doctoral	6613
Univ. of New Brunswick	Comprehensive	4495
University of Windsor	Comprehensive	4306
Brock University	Primarily Undergraduate	2408
University of Regina	Comprehensive	2373
Wilfrid Laurier University	Primarily Undergraduate	2029
Trent University	Primarily Undergraduate	2023
Laurentian University	Primarily Undergraduate	1813
University of Lethbridge	Primarily Undergraduate	1751
Lakehead University	Primarily Undergraduate	1631
University of Winnipeg	Primarily Undergraduate	1493
Univ. of Prince Edward Island	Primarily Undergraduate	1315
Saint Mary's University	Primarily Undergraduate	1302
St. Francis Xavier Univ.	Primarily Undergraduate	1258
Acadia University	Primarily Undergraduate	1066
Mount Allison University	Primarily Undergraduate	988
Université de Moncton	Primarily Undergraduate	914
Univ. of Northern British Columbia	Primarily Undergraduate	760
Bishops University	Primarily Undergraduate	556
Mount Saint Vincent Univ.	Primarily Undergraduate	495
Brandon University	Primarily Undergraduate	479
Univ. College of Cape Breton	Primarily Undergraduate	255
Ryerson University	Primarily Undergraduate	202
St. Thomas University	Primarily Undergraduate	170
Nipissing University	Primarily Undergraduate	96

Table 2. The top collaborating pairs of universities.

University Pair	Number of Co-authorships
McGill University - Université de Montréal	2824
University of Toronto - McMaster University	1736
University of Toronto - McGill University	1331
University of Toronto - Univ. of Western Ontario	1026
Univ. of British Columbia - University of Alberta	1014
University of Toronto - Univ. of British Columbia	981
Université Laval - Université du Québec	953
University of Alberta - University of Calgary	823
Université de Montréal - Université du Québec	810
University of Toronto - York University	795
University of Toronto - University of Alberta	754
Univ. of British Columbia - University of Victoria	676
University of Toronto - University of Ottawa	664
Univ. of British Columbia - St. Francis Xavier Univ.	655
Univ. of British Columbia - Université de Montréal	623
Univ. of British Columbia - McGill University	619
University of Toronto - Queen's University	615
McGill University - Université du Québec	604
Univ. of Western Ontario - McMaster University	596
University of Toronto - University of Calgary	561
Université de Montréal - Université Laval	556

Discussion and Conclusions

It was not surprising that geographical distance (or difference in time zones) did not influence the number of co-authorships between two Canadian universities in contrast to the findings of Katz (1994) as advance in technologies, such as the advent of the Internet, has made collaborations between two scholars in different geographical locations much easier. It was equally not surprising that language did not influence the number of co-authorships because it is only in one of the ten provinces (i.e. Quebec) that French is predominant, and only five of the 48 universities use French as their language of instruction. In addition, some scholars, especially those living in Quebec, are bilingual.

The two factors that seem to have influence on co-authorships are province and peer group. In Canada, provinces are responsible for university education, and universities in the same province may belong to an association (e.g. Council of Ontario Universities) which promote cooperation among them or have access to research funds which could only be used by researchers in that province only. Hence, in terms of policy, there isn't much that can be done to minimize the influence of province on collaboration between Canadian universities. While it is understandable that researchers, especially those in the Medical Doctoral peer group, may want to collaborate with those in similar universities due to comparable levels of intensity of research activities, it is desirable for them as leaders in research to mentor those in other peer groups. This could be achieved by involving them as co-investigators in research proposals submitted for funding to national research agencies, such as the Canadian Institutes of Health Research (CIHR), Natural Sciences and Engineering Research Council of Canada (NSERC), and Social Sciences and Humanities Research Council of Canada (SSHRC). Unfortunately, judging by the successful research applications to SSHRC in 2004 (see Table 3), there is a tendency for principal investigators of multi-university proposals to involve co-investigators from their own peer groups. To encourage more inter-peer group research collaboration, the national funding agencies should adopt evaluation schemes that would reward good inter-peer group research proposals.

Table 3. Inter-peer group collaboration in successful SSHRC grant applications for 2004 (rows represent the peer group of principal investigators and columns represent the peer groups of co-investigators).

Peer Group	Primarily Undergraduate	Comprehensive	Medical Doctoral
Primarily Undergraduate	13	7	7
Comprehensive	12	38	19
Medical Doctoral	15	22	220

References

Association of Universities and Colleges of Canada (2003). Directory of Canadian Universities. Retrieved October 7, 2003 from http://www.aucc.ca/can_uni/index_e.html.

Avkiran, N.K. (1997). Scientific collaboration in finance does not lead to better quality research. *Scientometrics*, 39(2), 173-184.

Beaver, D.D. (2004). Does collaborative research have greater epistemic authority? *Scientometrics*, 60(3), 399-408.

Foster, M.K. & Meinhard, A.G. (2002). A regression model explaining predisposition to collaborate. *Nonprofit and Voluntary Sector Quarterly*, 31(4), 549-564.

Garg, K.C. & Padhi, P. (2001). A study of collaboration in laser science and technology. *Scientometrics*, 51(2), 415-427.

Godin, B. & Ippersiel, M.P. (1996). Scientific collaboration at the regional level : The case of a small country. *Scientometrics*, 36(1), 59-68.

Goffman, W. & Warren, K.S. (1980). *Scientific information systems and the principle of selectivity*. New York : Praeger.

Johnston, A.D. (ed.). (2003). *The Maclean's Guide to Canadian Universities 2004*. Toronto: Rogers Publishing.

Katz, J.S. (1994). Geographical proximity and scientific collaboration. *Scientometrics*, 31(1), 31-43.

Katz, J.S. & Hicks, D. (1997). How much is a collaboration worth? A calibrated bibliometric model. *Scientometrics*, 40(3), 541-554.

Katz, J.S. & Martin, B.R. (1997). What is research collaboration? *Research Policy*, 26(1), 1-18.

Lawani, S.M. (1986). Some bibliometric correlates of quality in scientific research. *Scientometrics*, 9(1-2), 13-25.

Melin, G. (1996). The networking university : A study of a Swedish university using institutional co-authorships as an indicator. *Scientometrics*, 35(1), 15-31.

Melin, G. & Persson, O. (1996). Studying research collaboration using co-authorships. *Scientometrics*, 36(3), 363-377.

Melin, G. & Persson, O. (1998). Hotel cosmopolitan : A bibliometric study of collaboration at some European universities. *Journal of the American Society for Information Science*, 49(1), 43-48.

Narin, F. & Whitlow, E.S. (1990). *Measurement of Scientific Cooperation and Co-Authorship in CEC-related Areas of Science* (Report EUR 12900. Office for Official Publications of the European Communities, Luxembourg).

Persson, O., Glanzel, W. & Danell, R. (2004). Inflationary bibliometric values : The role of scientific collaboration and the need for relative indicators in evaluative studies. *Scientometrics*, 60(3), 421-432.

Persson, O., Melin, G., Danell, R. & Kaloudis, A. (1997). Research collaboration at Nordic universities. *Scientometrics*, 39(2), 209-223.

Qin, J. (1994). An investigation of research collaboration in the sciences through the Philosophical Transactions 1901-1991. *Scientometrics*, 29(2), 219-238.

Subramanyam, K. (1983). Bibliometriic studies of research collaboration : A review. *Journal of Information Science*, 6(1), 33-38.

Thorsteinsdóttir, O.H. (2000). External research collaboration in two small science systems. *Scientometrics*, 49(1), 145-160.

Vaughan, L. & Thelwall, M. (2005). A modeling approach to uncover hyperlink patterns : the case of Canadian universities. *Information Processing and Management*, 41(2), 347-359.