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Bibliometric Analysis of the Impact of Funding on Scientific Development of Researchers

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***Abstract*—**Every year, a considerable amount of money is being invested on research, mainly in the form of funding allocated to universities and research institutes. To better distribute the available funds and to set the most proper R&D investment strategies for the future, evaluation of the productivity of the funded researchers and the impact of such funding is crucial. In this paper, using the data on 15 years of journal publications of the NSERC (Natural Sciences and Engineering research Council of Canada) funded researchers and by means of bibliometric analysis, the scientific development of the funded researchers and their scientific collaboration patterns will be investigated in the period of 1996-2010. According to the results it seems that there is a positive relation between the average level of funding and quantity and quality of the scientific output. In addition, whenever funding allocated to the researchers has increased, the number of co-authors per paper has also augmented. Hence, the increase in the level of funding may enable researchers to get involved in larger projects and/or scientific teams and increase their scientific output respectively.

***Keywords*—**Bibliometrics, Collaboration, Funding, Productivity.

I. Introduction

SCIENTIFIC activities and size and quality of the R&D sector play a key role in determining the world-wide position of a country. Many articles has acknowledged funding as the main determinant of research productivity (*e.g.* [1]-[3]) and the level of research funding has been indicated as the most crucial factor for improving the research productivity. Although the approach towards the allocation of the research funding varies across the countries and different procedures are being followed worldwide for this purpose, governments are annually investing considerable amounts of money on R&D in a hope for a higher scientific development of the funded researchers.

It is easy to judge the productivity and the impact of the research of the Nobel laureates or star (highly productive) scientists. However, for the rest of scientists one should have quantitative indicators in order to analyze and compare the scientific productivity of the researchers [4]. Publications are usually considered as the main output of the scientific activities (*e.g.* [5], [6]). They are also viewed as the principal measure of academic recognition in most of the western countries [7]. It is claimed that a limited number of journal papers are currently publishing the main output of the scientific research [6]. In addition, a small number of scientists are publishing most of the scientific papers and the weights of publications are not divided evenly [8]. This is known as the Lotka's law in the literature [9], introduced by Lotka in 1926.

Governments have funded researches for more than sixty years [10] and have employed various tools and techniques, both quantitative and qualitative, to measure their scientific performance [11]. Having such a history, the impact of funding on the scientific output has been investigated in the literature from various perspectives. A few studies assessed the impact of funding on the productivity of the medical schools or programs (*e.g.* [3], [12] and [13]). A number of studies focused on the effect of contractual funding on the quantity and quality of the scientific publications (*e.g.* [14], [15]). Using statistical analysis, various studies investigated the impact of federal funding (*e.g.* [16], [17]), industry finding (*e.g.* [18]), or private funding (*e.g.* [19]) on scientific productivity and research performance. In addition, a few studies focused on the scientific productivity at the countries level and assessed the impact of national investments (*e.g.* [20], [21]).

Evaluating the impact of funding has also attracted the attention of the Canadian researchers. In Canada, scientific articles have been recognized as the main output of researchers and universities [22] and bibliometrics has been mostly used for scientific evaluation purposes [23]. In a report to the Program Evaluation Committee of NSERC discussed the feasibility of bibliometric evaluation of the funded research. Godin [22] in a bibliometric evaluation studied the impact of NSERC funding on the productivity and papers' quality of the supported researchers for the period of 1990-1999. He used Science Citation Index (SCI) database and analyzed the number of papers written by funded researchers over a 10-year time period to find NSERC proportion amount of contribution to the scientific development of Canada. In a series of studies, Campbell and his colleagues performed bibliometric evaluations on the impact of funding on scientific performance [24]-[26]. In two recent studies, [27], [19] used regression analysis to study the impact of public and private funding on the scientific production of the Canadian academics working in biotechnology and nanotechnology fields respectively.

Despite using different methodologies to assess the impact of funding (*e.g.* bibliometrics, statistical analysis), most of the studies in the literature have found a positive relation between funding and the rate of the publications regardless of intensity

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of the relation (*e.g.* [2], [22], [16] and [28]). However, there also exist some studies that found no significant relation (*e.g.* [19][1], [15]) or even a negative impact (*e.g.* [17]).

This paper extends the previous research in two ways. First, we will use a larger and more recent data set spanning from 1996 to 2010 that will be defined in detail in the section "Data and Methodology". Second, apart from analyzing the productivity and quality of the work of the NSERC funded researchers, we will assess the impact of funding on scientific collaboration. In addition, we will assess the impact of funding on scientific activities of the researchers of top selected Canadian universities. The rest of the paper is organized as follows: Section "Data and Methodology" describes methodology and data that will be used in this study. The empirical results and interpretations are provided in section "Results". Section "Conclusion" presents the findings of this research and the limitations of this study and some directions for the future work are discussed in the last section "Limitations and Future Work".

II. Data and Methodology

NSERC was selected as the funding organization to focus on in this paper since it is the main federal funding organization in Canada. Almost all the Canadian researchers in natural sciences and engineering receive a research grant from NSERC [22]. We first collected the funding data from NSERC for the period of 1996 to 2010 that contained information like name of the grantee, his/her affiliation, year, and amount of the award. This led to 47,789 distinct Canadian researchers who received funding from NSERC during the aforementioned period. Then, we searched over SCOPUS[2] to gather the articles of the NSERC funded researchers for the mentioned period. For this purpose, we searched for all the articles that had acknowledged NSERC funding support within the body of the article. This was a crucial step in fetching the accurate data. All the related information such as article co-authors, co-author affiliations, article title, abstract *etc.* was then extracted. The articles dataset totally contained 130,510 articles and 177,449 authors that acknowledged the NSERC support in the respective article. For evaluating the quality of the papers, SCImago [30] was selected for collecting the impact factor information of the journals in which the articles were published in and the result was integrated into another dataset. SCImago was chosen for two main reasons. First, it provides the journal impact factors for each of the single years of our examined time interval. This enables us to perform a more precise analysis since we are considering the impact factor of the journal in the year that an article was published not its impact in the current year. Secondly, SCImago is powered by SCOPUS that makes it more compatible with our articles database.

Having all the required data collected, we search for relationships between the amounts of funding that NSERC has allocated to researchers and their scientific productivity in terms of the number of publications and quality of the papers. In addition, the impact of funding on the collaboration pattern of the researchers is analyzed. Bibliometric analysis is used for this purpose to assess the scientific productivity and collaboration patterns of the funded researchers.

[1] They found no impact of private funding but positive impact of public funding.

[2] SCOPUS is a commercial database of scientific articles that has been launched by Elsevier in 2004. It is now one of the main competitors of Thomson Reuter's Web of Science.

III. Results

The results of this research are presented in two sections. In the first section, the impact of funding is evaluated for different Canadian provinces and the productivity and collaboration of their researcher are compared. In the second section, we focus on top seven selected Canadian universities and analyze the funding impact on their scientific activities.

A. Canada-Wide Analysis

For the Canada-wide analysis, we considered NSERC funded researchers from all the ten Canadian provinces. We excluded Canadian territories (namely Yukon, Nunavut, and Northwest Territories) from our analyses since the calculated indicators were too small for the mentioned territories in comparison with the ones for provinces. In addition, we also excluded the student funding programs.

As it can be seen in Fig. 1, Canadian provinces can be divided into two groups based on their total share from NSERC funding. The first group contains Ontario, Quebec, British Columbia, and Alberta that have received considerably higher share of NSERC funding from the provinces of the second group. Saskatchewan, Nova Scotia, Manitoba, New Brunswick, Newfoundland & Labrador, and Prince Edward provinces belong to the second group that have received comparable but much lower total share of funding from the provinces in the first group. We will use the terms "first group" and "second group" in the rest of the paper for pointing to the aforementioned provinces.

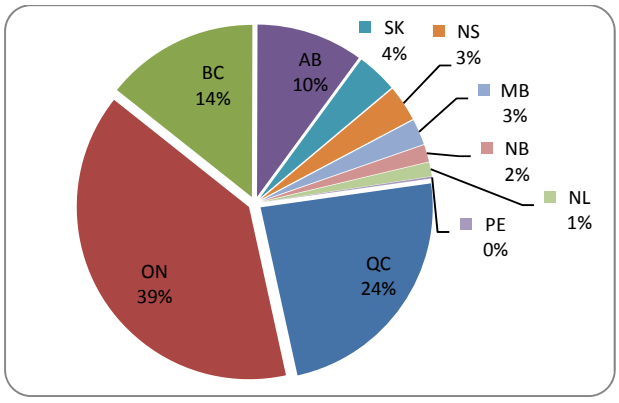


Fig. 1 Total funding share of Canadian provinces, 1996-2010

Although there are considerable differences in the total amount of NSERC funding allocated to the Canadian provinces, the average amount of funding dedicated to the researchers are quite comparable. According to Fig. 2 (a), the average total amount of funding per researchers in the

examined provinces was in the range of 8-13 percent. More interestingly, this share is the same for all the members of our first group under study by having the level of 11 percent. Moreover, although Ontario had the highest level of total funding with a considerable difference, Saskatchewan is the highest if we consider the average share.

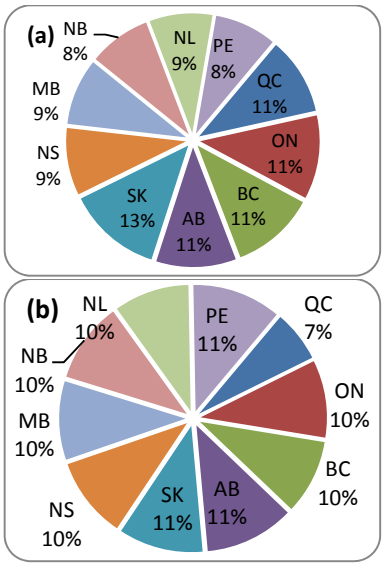


Fig. 2 (a) Average share of total funding per researchers in Canadian provinces, 1996-2010, (b) Average share of total number of articles per researchers in Canadian provinces, 1996-2010

Fig. 2 (b) shows the average provincial share of total number of articles for the NSERC funded researchers. Almost all the Canadian provinces have the same share of the total number of articles except the researchers from Quebec. More interesting, when we compare the results from Figs. 2 (a), and (b), it can be seen that although Quebecers have a considerable share of the total funding the average number of articles that they have produced is the lowest. This is a preliminary finding and we will further investigate other important factors, like the quality of the papers.

Apart from the total amount of articles and funding allocated, it could be informative if we consider the trends of the mentioned factors during the examined time interval. According to Fig. 3, funding has had an increasing trend during almost all the years where it reached to its maximum in 2010 for all the four provinces. However, Ontario has received significantly more money than other provinces in our first group and is also producing more articles respectively. More interestingly, the trend of articles can be divided into three different periods. From 1996 to 2002 and from 2007 to 2010 the number of articles has remained almost constant for all the four provinces under study. The constant trend in the number of articles in the mentioned periods is quite interesting since it is not in line with the increasing amount of funding in the respective time intervals. Moreover, from 2002 to 2007 we see a drastic increase in the number of articles in all the provinces. There is a possibility that researchers focused more on other factors (*e.g.* quality of the papers) rather than the quantity of the articles during the constant periods.

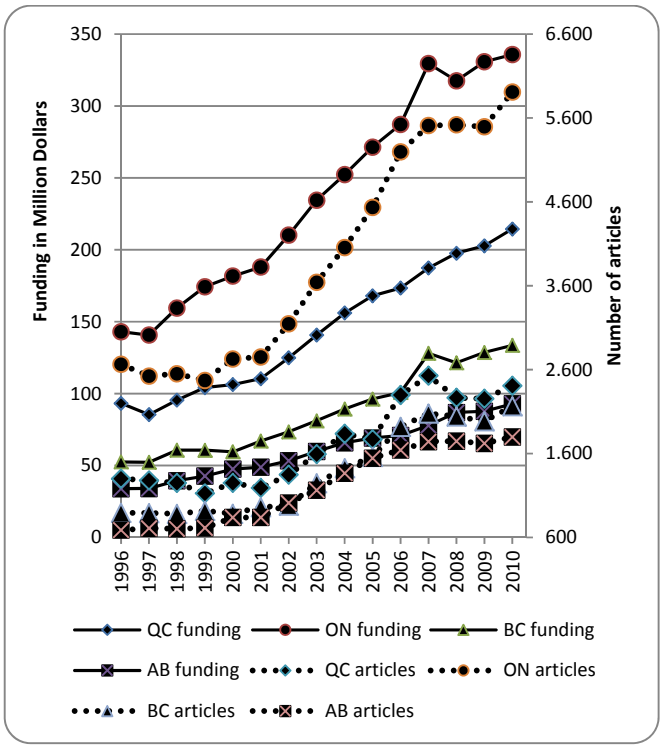


Fig. 3 Publication rate and funding in the first group of the Canadian provinces, 1996-2010

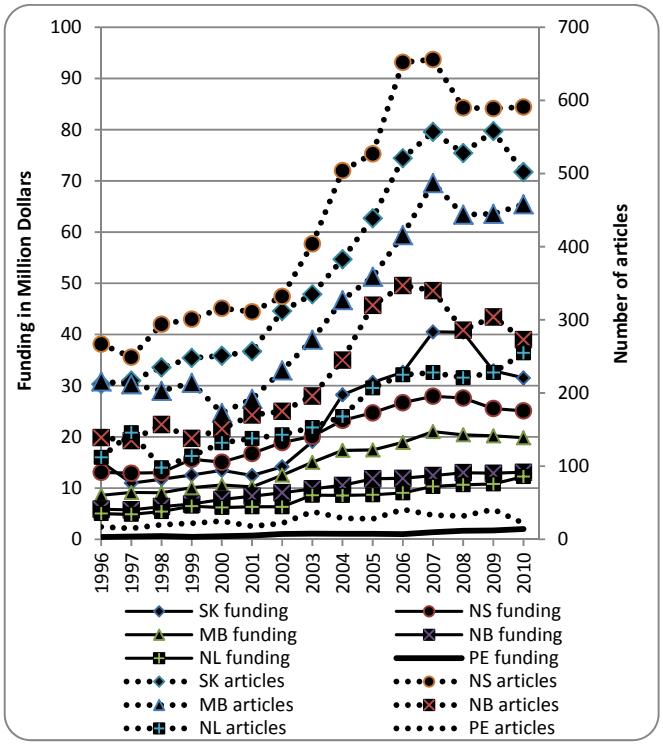
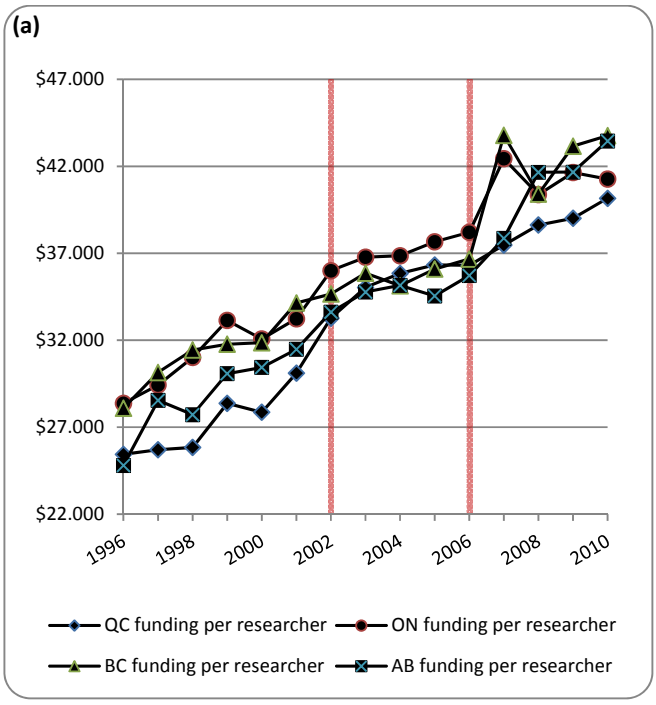


Fig. 4 Publication rate and funding in the second group of the Canadian provinces, 1996-2010

The trend of number of articles in the second group of

provinces (Fig. 4) is following the same trend as the first group except for the Prince Edward province where the amount of funding and number of articles is much less than the others that makes its trend looks more constant during the whole time interval. In addition, the amount of funding for the provinces of the second group has not always been increased specially for Saskatchewan and Nova Scotia where we see a considerable drop in the amount of funding after 2007. This may acknowledge the higher attention of NSERC to the first group of provinces which is quite reasonable since most of the high ranked universities and research institutes are located in the first group of provinces. We will take the number of researchers into account in order to investigate the average productivity of the researchers in the Canadian provinces.

As it can be seen in Fig. 5 (a), apart from the period of 2002 to 2006 where the average amount of funding per researcher is almost constant for all the four provinces, in the other parts of the time interval we see an increasing trend. However, researchers from Quebec are receiving lower amount of money almost during the whole period. This difference is bolder during the first and last three years of the time interval. Fig. 2 (b) shows the same indicator for the provinces in our second group. Here, we see some fluctuations in the average amount of funding till 2002 where after that the funding trend is augmenting. This increase is more notable for the researchers of Saskatchewan where after 2002 their trend completely disports from the others. More interestingly, after 2003 the average amount of funding for the researchers of Saskatchewan becomes considerably higher even than the researchers from our first group. To investigate the output and productivity of the Canadian researchers we do the same analysis for the average number of articles.



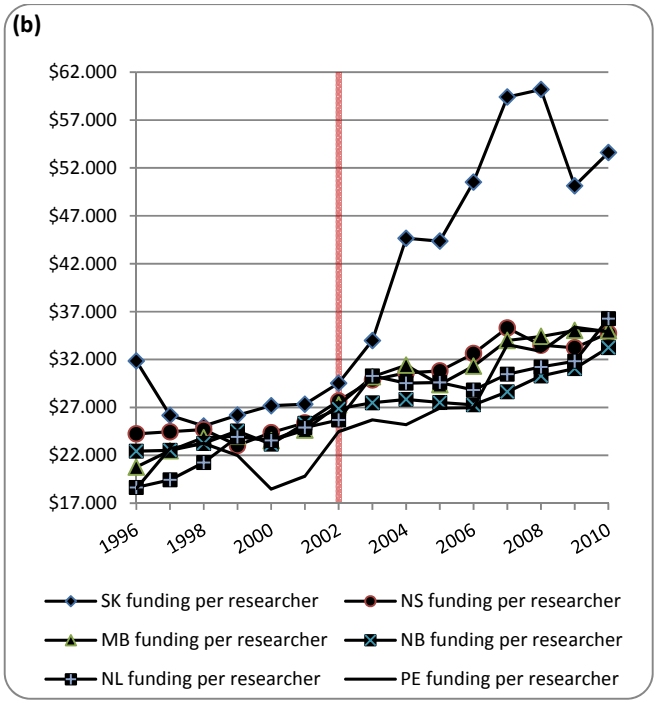


Fig. 5 (a) Funding per researchers in the first group of provinces, 1996-2010, (b) Funding per researchers in the second group of provinces, 1996-2010

Figs. 6 (a) and (b) show the trends of number of articles produced per researcher during the examined time interval. Nothing can be said about the researchers of Prince Edward province since their trend is very sinusoidal with considerable differences between maximums and minimums. This was quite predictable since the total amount of funding allocated to the researchers of Prince Edward and also the number of researchers there is much lower than the other provinces. Excluding Prince Edward from Fig. 6 (b), we can divide the trends in both figures into three different periods. From 1996 to 2001 and 2006 till 2010, although there exist some fluctuations in the number of articles, the trend is almost constant. However, from 2001 till 2006 a drastic increase is seen in the number of articles per researchers. Comparing these results from the results of Fig. 5, it can be said that one of the reasons of such an increase in the number of articles could be the constant raise of average funding between 1996 and 2002.

More interestingly, it seems that the constant average funding allocated to each researcher during 2002 to 2006 has been reflected in the steady trend of the number of articles from 2006 to 2010. Of course it was not the only reason and other factors like the collaboration among researchers could also affect the trends of productivity. The other point that can be observed is that the productivity of the researchers from the provinces of our second group is quite comparable with the ones in the first group. This is also interesting since the average funding allocated to the provinces in our first group is quite more than the ones in the second group. Hence, it seems that no matter what the level of funding was whenever it has

been increased it motivated the researchers to produce more articles. The only exception is the researchers from Quebec that are showing a very low productivity calculated by the average number of articles per researchers. One of the reasons for such a low productivity could be the language factor in a way that there is a possibility that the works of French speaking researchers were less counted in our analysis since SCOPUS is English-biased and may be non-English articles are underrepresented. As the next step, we take the quality of the papers into the account in order to see whether there are also some interrelations between funding, number of articles, and the quality of the papers.

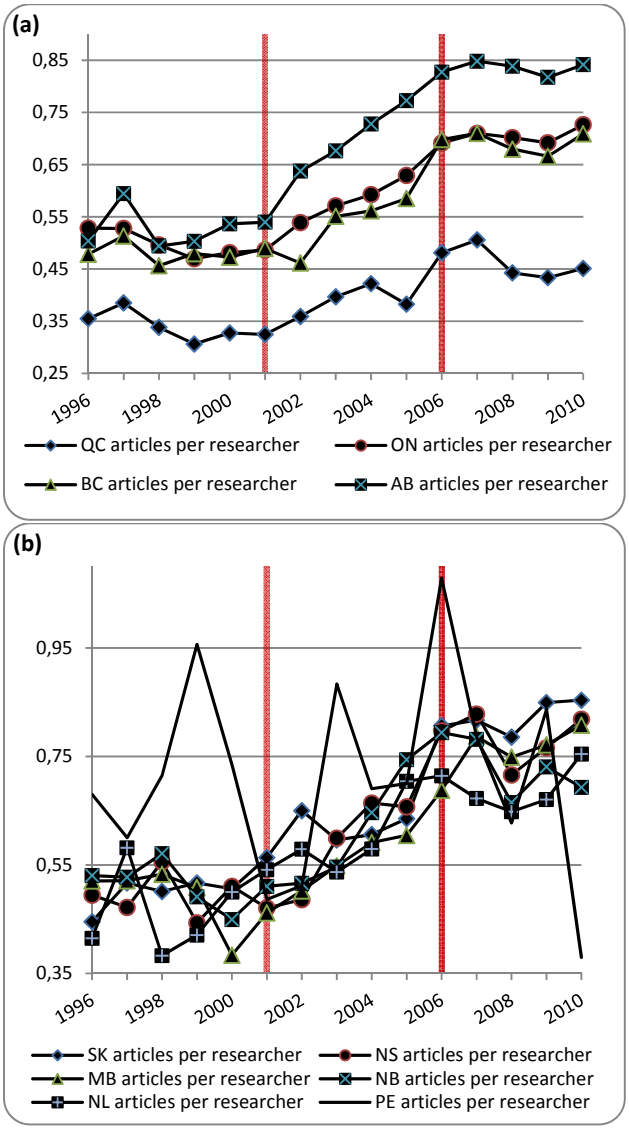
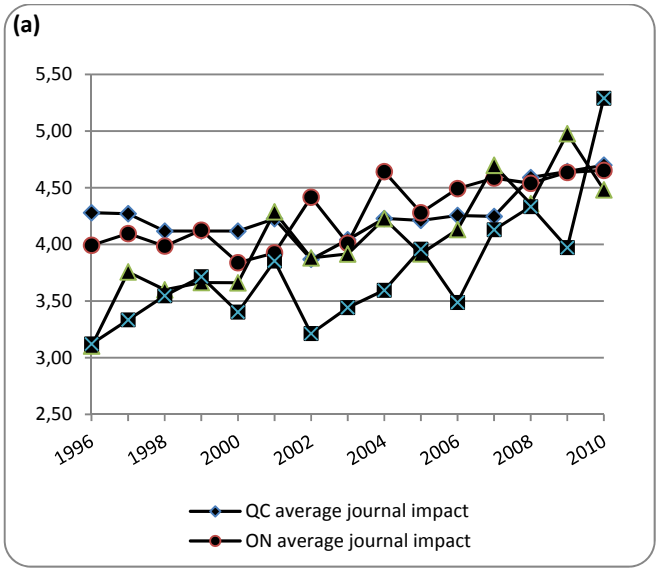


Fig. 6 (a) Articles produced per researchers in the first group of provinces, 1996-2010, (b) Articles produced per researchers in the second group of provinces, 1996-2010

Figs. 7 (a) and (b) depict the trend of the quality of the papers published during the examined period calculated by the average journal impact factor over the number of articles. As it can be seen, the quality of the papers published by the researchers in our first group of study follows an increasing trend where for the researchers of the second group of provinces the trend is almost steady during the whole period. Predictably, researchers from the provinces in the first group on average publish in higher quality journals from their counterparts in the second group. This was expected since the quality of the universities and research institutes of the provinces in the first group is on average higher than the ones in the second group[3]. In addition, as it was observed in Figs. 5 (a) and (b) the average level of funding available to the researchers in the first group is also higher. This may enable them to improve the quality of their work through different ways like supplying more modern equipment, employing more skillful experts in their research teams, forming larger research teams, *etc*.

According to Fig. 7 (a), although researchers from Alberta have shown a considerable progress in the quality of their work recently, papers of the researchers from Quebec and Ontario have had the highest quality. Apart from the language factor that was already discussed, the high quality articles can also justify our findings from Fig. 6 where the researchers from Quebec had the lowest average productivity. In other words, it seems that researchers in Quebec focus more on the quality of their work rather than the quantity, by publishing in higher quality journals. Moreover, from Figs. 5 (b) and 7 (b), it can be said that although the average funding allocated to the researchers of Saskatchewan has increased after 2002, the quality of their work has remained almost constant. Comparing this with our findings from Fig. 6 (b), it seems that Saskatchewan researchers have more focused on increasing the number of articles, paying less attention to their quality.



[3] Based on the number of high ranked universities.

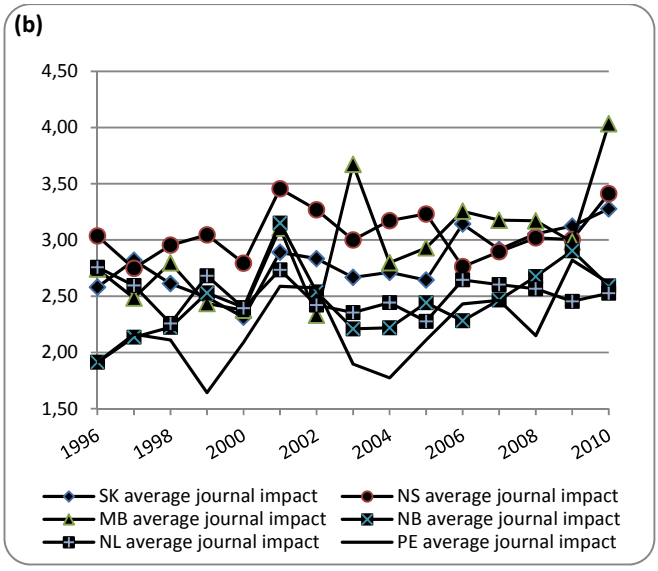


Fig. 7 (a) Average journal impact factor in the first group of provinces, 1996-2010, (b) Average journal impact factor in the second group of provinces, 1996-2010

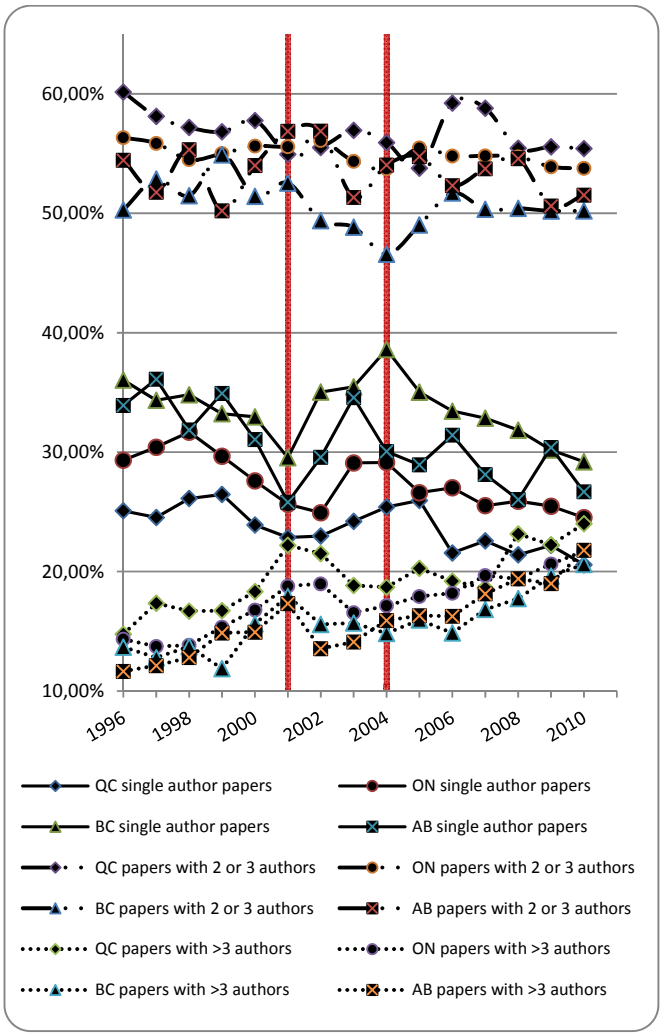


Fig. 8 Co-authorship patterns of the researchers in the first group of provinces, 1996-2010

Apart from the direct impact of funding on scientific production, funding can also influence scientific output indirectly (e.g. through affecting scientific collaboration that may results in higher or lower scientific output). Fig. 8 depicts the scientific collaboration pattern of the researchers in the first group of provinces, measured by the number of authors in articles. As it can be seen, the trend for the articles with two or three authors is almost constant for all the provinces in the first group during the whole time interval. Interestingly, it seems that researchers tended gradually to get involved in bigger research teams since the trend of number of articles with more than three authors is increasing and at the same time, the trend for the single authored articles is declining.

According to Fig. 8, we can also divide the trends into three different periods. From 1996 to 2001, and from 2004 to 2010, the tendency of the researchers for larger teams is being increased almost uniformly where from 2001 to 2004 researchers tended more to write the paper individually. Comparing these results with our findings from Fig. 5 (a), it can be said that the steady trend of funding during the period of 2002 to 2006 for the researchers of the provinces in the first group could be one the reasons that forced researchers to do their work more individually. In other words, whenever there was no increase in the level of funding researchers were forced to squeeze the size of their research teams in order to cut the expenses of their research. Of course other factors could have also played a role (*e.g.* researchers from different disciplines may followed different collaboration patterns), but in general this could be one of the reasons that NSERC funded researchers tended to publish more single authored articles from 2001 to 2004.

Fig. 9 shows the results of the same analysis for the researchers in the second group of provinces. Again, an almost constant trend is seen for the number of articles with two or three authors during the whole time interval. However, the increase in the number of papers with more than three authors is not drastic except for the researchers from Saskatchewan and Manitoba. According to Fig. 9, although there were some fluctuations in the number of single authored articles from 1996 to 2004, the overall slope was almost constant. However, after 2004 researchers tended to involve more members to their teams as the number of single authored articles is decreasing. This is also in line our findings from Fig. 5 (b) since it was after 2002 when the level of funding started to increase constantly for the researchers in the second group of provinces. Hence, it seems that there is a positive relation between the average level of funding and the team size of the researchers. We continue the analysis by focusing on the top seven selected Canadian universities in the next section.

B. Top Canadian Universities

In the second phase of the analysis, we focused on the top Canadian universities based on their rankings in 2013 [31] and investigated the impact of funding on their researchers' scientific development. As it was expected, our first group of provinces has the highest share of high ranked universities. Namely, Ontario, Quebec, British Columbia, and Alberta have

the highest share of top universities respectively. To do the analysis, we chose the top university form each of the provinces presented in the list of top twenty Canadian universities. Concordia University was also added to the list[4].

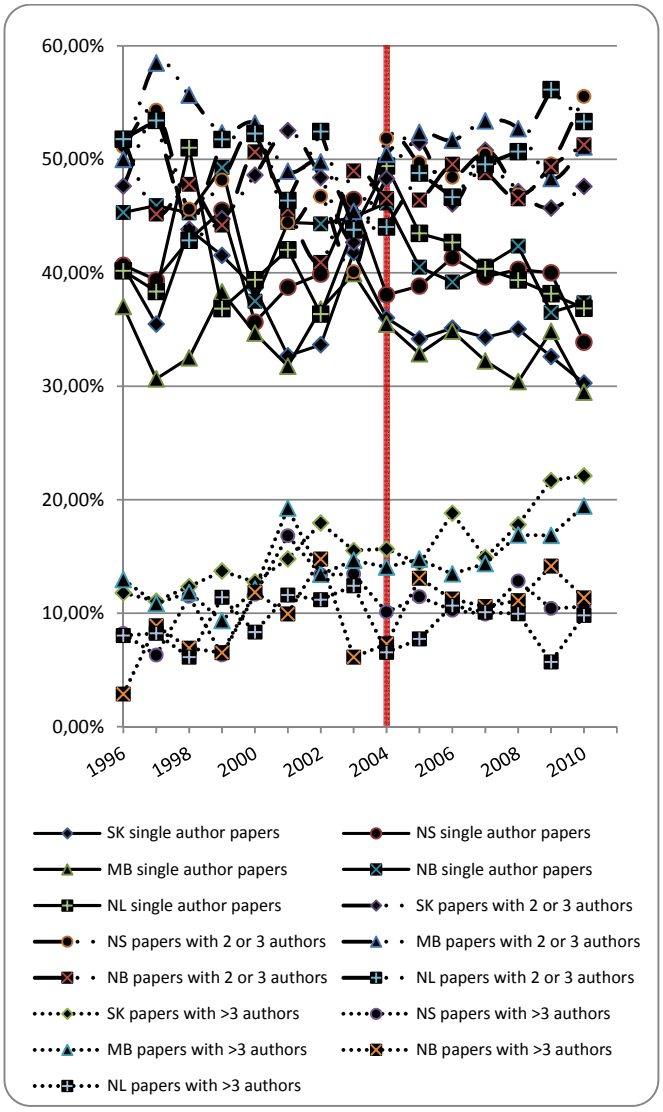


Fig. 9 Co-authorship patterns of the researchers in the second group of provinces, 1996-2010

According to Figs. 10 (a) and (b), it seems that there is a positive relation between the amount of funding allocated to the universities and the number of articles that they have produced. Moreover, as expected the productivity of the universities and their funding share seem to be highly related to the university's ranking. To have a better picture of the relation, we take the number of researchers into the account. As it can be seen in Figs. 11 (a) and (b), although there are some considerable differences in the average share of funding for the selected universities, the average productivity of them is quite comparable. In other words, despite having different share of funding the level of productivity for the selected universities is almost the same. In addition, apart from the University of Saskatchewan that has the highest share of funding and the lowest share of output, and Concordia University that has the lowest share of funding and high share of output, it seems that there is a positive direct relation between funding and productivity. To investigate the possible relation more, we analyze the trend of funding and number of articles per researchers during the examined period.

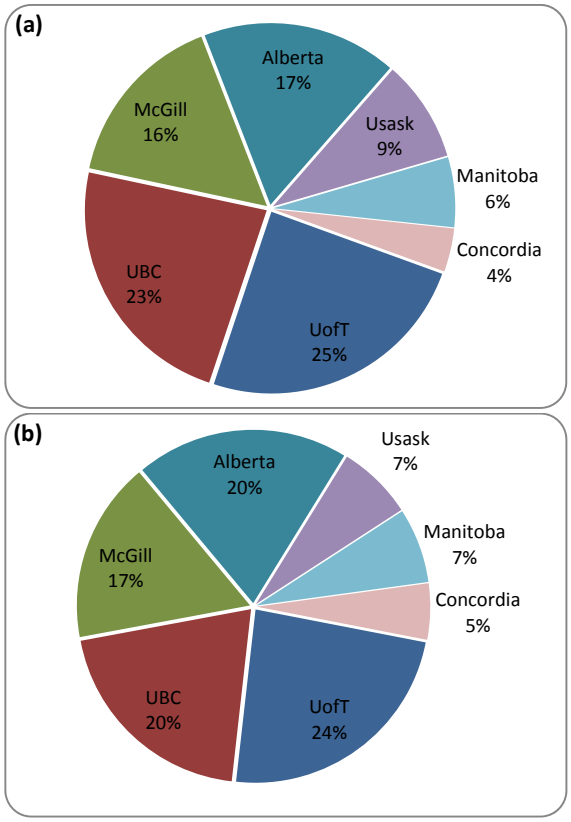
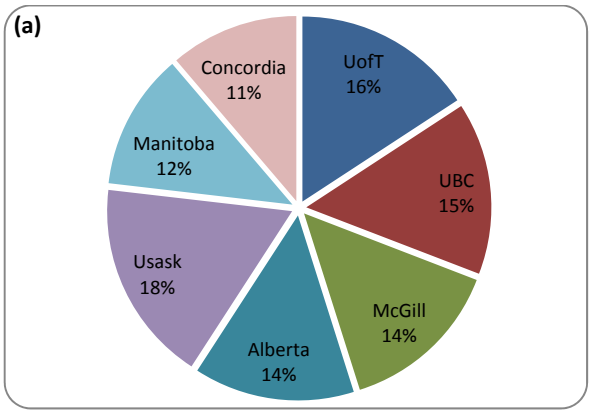


Fig. 10 (a) Total funding share of top selected Canadian universities, 1996-2010, (b) Total number of articles share of top selected Canadian universities, 1996-2010



[4] Concordia University ranked 19th in the list.

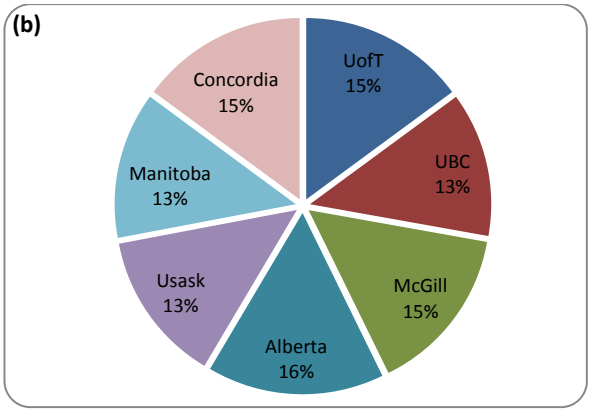


Fig. 11 (a) Total average funding share per researcher in top selected Canadian universities, (b) Total average articles share per researcher in top selected Canadian universities

As it can be seen in Fig. 12, a drastic jump is observed for the University of Saskatchewan after 2004 making its researchers the highest NSERC funding receivers among the selected universities. This is in line with our previous findings from Fig. 5 (b). Interestingly, the average funding per researcher for the selected universities has been always increasing without any steady period. Comparing this result with the findings from Fig. 5 (a), it can be said that although provinces experienced some steady funding periods, the funding allocated to the top universities has not been decreased by NSERC. Hence during the low budget periods, may be NSERC decreased the funding of the less productive research institutes and universities and tried to constantly increase the budget of the high ranked universities in an attempt to increase the scientific development. In addition, the top four high ranked Canadian universities namely, University of Toronto, University of British Columbia, McGill University, and University of Alberta have been receiving an almost equal average funding per researcher.

The trend of the average number of articles per researcher in the selected universities during the examined time interval is depicted in Fig. 13. This figure is completely in line with Figs. 6 (a) and (b) where a drastic increase was observed in the number of articles per researchers from 2002 to 2006. Hence, the selected universities completely reflect the productivity of their provinces. In other words, whenever the selected universities show high productivity the scientific output of their respective province goes higher, and vice versa. In addition, University of British Columbia and McGill University show lower productivity in comparison with the other universities who are performing at almost the same level. This becomes more interesting when we compare the results with our findings from Fig. 12. Concordia University that has the lowest average share of funding per researcher is producing considerably high rate of scientific papers. In other words, the researchers from Concordia University and University of Manitoba seem to be the most efficient scientists.

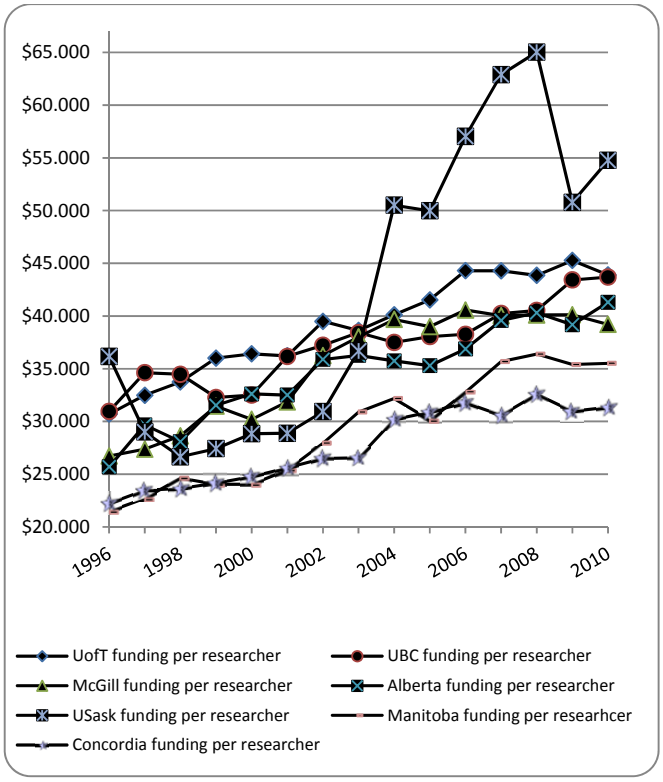


Fig. 12 Average funding per researcher in the top selected Canadian universities, 1996-2010

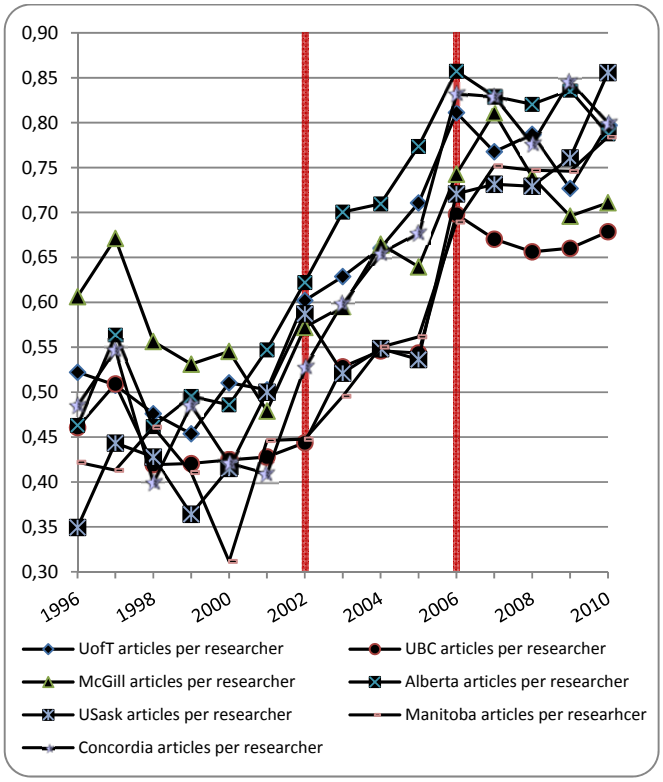


Fig. 13 Average number of articles per researcher in the top selected Canadian universities, 1996-2010

Of course to have a more precise picture of productivity and efficiency, one should also take the quality of the researchers' work into the account. According to Fig. 14, researchers from the University of Toronto are on average publishing in higher quality journals. This difference became bolder after 2002. From 2002 to 2006, an almost decreasing trend is observed in quality of the papers for all the universities except University of Toronto, and University of Manitoba. Comparing this result with our findings from Fig. 13, interestingly it is seen that during the mentioned period researchers tended to produce more articles. In addition, as discussed earlier a steady NSERC average funding trend is seen from 2002 to 2006 for the Canadian provinces. Hence, it seems that researchers focused more on increasing the number of articles by publishing in lower quality journals during the aforesaid time interval may be in an aim to at least secure their level of funding. After 2006, although they almost maintained the same level of articles production, the quality of the journals was augmented. In addition, although researchers form Concordia University and University of Manitoba were more efficient in terms of producing articles against the amount of funding allocated, the quality of their works are among the lowest. However, researchers of University of Saskatchewan are the performing the worst from this perspective comparing their share of funding allocated against the rate and quality of their published articles.

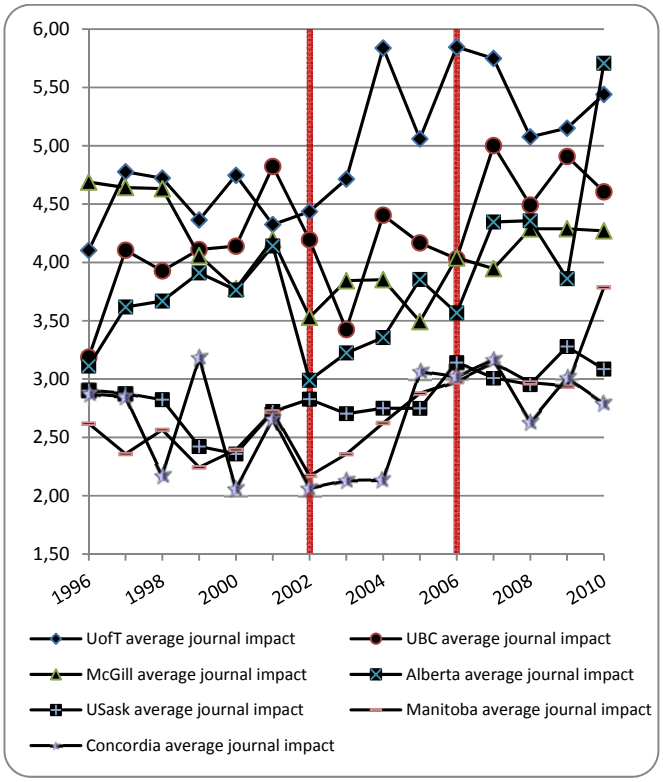


Fig. 14 Average impact factor of articles in the top selected Canadian universities, 1996-2010

In order to investigate the trend of scientific collaboration patterns of the researchers from the selected Canadian universities, the co-authorship patterns of the mentioned researchers were analyzed. For this purpose, we assigned the articles to the researchers of the subject universities whenever at least one of the authors was from that university. As it can be seen in Fig. 15, it is interesting that in general researchers from all the selected universities tried to be involved in larger scientific teams as the trend of number of papers with more than three authors is increasing while the number of single-authored articles is declining gradually. This change in the co-authorship pattern of the researchers has become bolder especially after 2003. This is in line with the findings from Fig. 13 where we see a drastic increase in the average number of articles after 2002. Moreover as it was observed earlier in Fig. 12, the average funding for all the selected universities follows an increasing trend. Hence, it seems that having more funding available has encouraged researchers to expand their scientific teams or to be involved in larger projects in order to increase their scientific productivity (published articles).

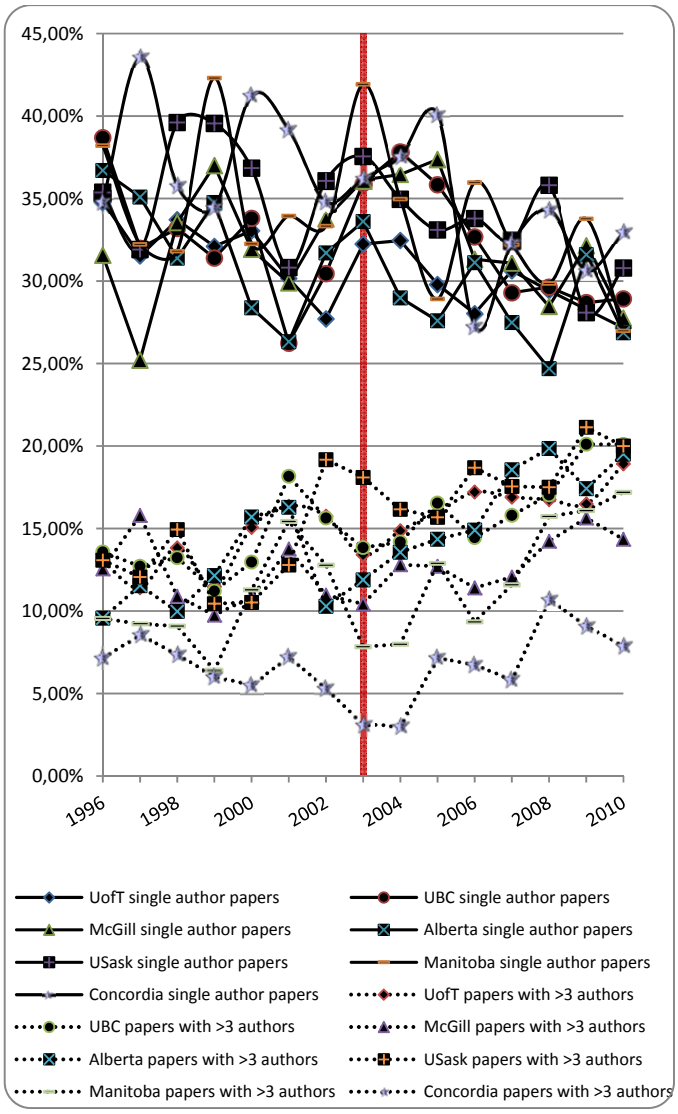


Fig. 15 Co-authorship patterns in the top selected Canadian universities, 1996-2010

IV. Conclusion

In this paper, we analyzed the impact of NSERC funding on the productivity and collaboration of the funded researchers. Stunning progresses in information technology and the availability of more accurate and integrated data in one hand and the considerable amounts of annual investments on R&D on the other hand, has encouraged the data scientists to focus more on the scientific evaluations. Several factors can influence the scientific activities where the financial support and collaboration patterns are among the most important ones. According to our results, funding seems to have played an important role not only in enhancing scientific productivity of the researchers but also in the formation of scientific teams and collaboration patterns. Although the increase in the funding level has been followed by higher productivity and collaboration in most of the periods of the examined time interval, one should notice that there may exists other factors rather than funding (*e.g.* research policies and priorities, cultural issues, *etc.*) that could have influenced the scientific development. Hence, complementary analysis is needed in this regard to make any final conclusions. However, it seems that funding, directly or indirectly, influences the scientific activities in a way that funded researchers tend to produce more articles through getting involved in larger scientific teams while caring more about the quality of their work. The positive impact of funding on the scientific output has been also confirmed in [22] that assessed the impact of NSERC funding in the period of 1990-1999. However, he found no impact of funding on the quality of the papers where in our study a positive relation was observed.

Almost all the Canadian provinces had the same total funding share per researcher. In addition, the total productivity of the researchers from all the provinces was almost at the same level. However, as it was expected work of the researchers from the provinces in the first group on average were of the higher quality. Although researchers from Quebec showed the lowest scientific productivity in terms of average share of publications, the quality of their works were among the highest. As discussed, the language factor could also play a minor role here in a way that the researchers from Quebec may also publish in French language that is not counted in SCOPUS. Another interesting observation was about the researchers from Saskatchewan who had the highest amount of funding share, reasonable rate of publication but on average in low quality journals. Regarding the co-authorship patterns, in general the trend showed the interest of the researchers to be involved in larger research teams. In addition, during the steady funding periods researchers tended more towards publishing single authored articles. This partially confirms the importance of role of funding in the formation of the scientific teams in a way that higher amounts of funding available may enable researchers to expand their scientific activities by forming larger teams setting involved in larger projects.

The results for the top selected Canadian universities showed that although there were some differences in the share of allocated funding, the average productivity of the high ranked universities were almost at the same level. Moreover, despite the existence of steady funding periods for the provinces, NSERC constantly increased the average funding allocated to the high ranked universities. Researchers from the University of Toronto have on average published in higher quality journals. University of Saskatchewan showed the lowest performance among the studied universities since in spite of having high level of funding available the rate of their publications and the quality of their work was among the lowest. Interestingly, researchers from Concordia University showed high efficiency in terms of the funding allocated and number of articles produced. However, it was observed that the work of Concordia's researchers had lower quality in comparison with other high ranked universities. Another interesting point was that during the period of 2002 to 2006 where the average funding level was almost constant for the Canadian provinces, researchers of the selected universities have published more articles but of lower quality. This may indicate that they focused on producing more articles in order to at least secure their funding level during the steady funding periods. And, the increase in the number of articles after 2002 was synchronous with the increase in the size of the research teams. Hence, researchers may have benefited from larger teams and better collaboration to increase the scientific output.

V. Limitations and Future Work

We were exposed to some limitations in this paper. First, we selected SCOPUS for gathering information about the NSERC funded researchers' articles. Since SCOPUS and other similar databases are English biased, hence, non-English articles are underrepresented [29]. Secondly, since SCOPUS data were less complete before 1996, we chose the time interval of 1996 to 2010 for our analysis. Another inevitable limitation about the data was the spelling errors and missing values. Although SCOPUS is confirmed in the literature to have a good coverage of articles, as a future work it would be recommended to focus on other similar databases to compare and confirm the results.

Different scientific disciplines follow different patterns in publishing articles, collaborating with other researchers, or even getting and allocating grants to the tasks. Hence to better examine scientific productivity and efficiency, a future work direction could be assessing the impact of funding on the rate of publications for different scientific disciplines separately. In addition, the impact could be separately analyzed for different types and programs of funding, and also other funding councils can be considered as the source of funding data. This kind of analyses and comparing the efficiency of different funding organizations may help the decision makers to set the best funding allocation strategy.

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