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Impact of research funding and scientific production on scientific impact: Are Quebec academic women really lagging behind?

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Abstract

The article examines whether scientific productivity, impact factor of journals, size of collaborative teams and research funding has an influence on the propensity to receive more citations on average and whether these factors differ across genders. Using a very complete database of bibliometric indicators, we estimate instrumental variable ordinary least square regressions on the normalised citation rates of individual academics in Quebec. Our results show that although most of the indicators examined have a positive influence on citations, when it comes to gender differences, only collaboration appears slightly detrimental for women. No impact is found for productivity or funding.

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1 Introduction

A recent Nature paper (Larivière et al., 2013) confirms that women are lagging behind in terms of worldwide scientific production and in terms of citations, taking into account the authors' ranking (first or last), collaborative practices and well as the citation density of various disciplines. It therefore seems that the glass ceiling is still very much present despite more than a decade of specific policies aimed at supporting women in science. As Xie and Shauman (1998) state, "Women scientists publish fewer papers than men because women are less likely than men to have the personal characteristics, structural positions, and facilitating resources that are conducive to publication" (: p .863). Although the literature on scientific production is extensive and cover several decades (see, among others, Cole and Zuckerman, 1984; Xie and Shauman, 2003; Zuckerman, 1991), few papers have been published on the subject of what resources, structural positions, teams of collaborators are necessary to improve the impact and quality of articles published by women. Inequalities are noted regarding access to research funding and equipment (Xie et Shauman, 1998), but that is generally where the arguments stop. For instance, Larivière et al. (2011) showed that in Quebec women have raised less research funds than men and that their funding is less diversified, especially in the middle of their careers. The authors suggested that the smaller global scientific production of women is likely to be linked to the fact that women receive less funding than men, but as the authors state: "the data can only establish the correlation and not a causal relationships between these two findings" (2011:491).

This paper aims to provide a different portrait of the performance of women using advanced econometric methods, and to examine whether it is still worse than that of their male colleagues, taking the province of Quebec, identified by Larivière et al. (2013) as one of the Canadian provinces closest to achieving gender parity, as an example. With 14.5% women working in the natural sciences and engineering fields, and 26.5% women in the health fields in our sample, one could argue that this still remains far from gender parity. Similarly, while women represent more than half of the students at the bachelor level (the first university degree in Quebec), their proportion decreases dramatically after graduation and very few venture into academia. In fact, the highest the academic rank, the lowest is the proportion of women in academia. Although we acknowledge the rarity of women in science in Quebec and their slightly inferior performance, our goal is to try to elucidate where the discrepancies are, to explain the differences (using the data available) and to propose avenues to reverse the tendency.

A large part of the literature on the subject of women in science tends to be bibliometric based. For this research, we build on this literature and use classic bibliometric indicators as dependent and explanatory variables in econometric models that allow the analysis of many factors at a time. Using panel data to account for the evolution of the various attributes, we are able to establish the causality of these factors on scientific impact, something that bibliometrics alone cannot address. The paper also differs from the main sociology of science literature that considers socio-demographic factors such as marriage and children to explain the lesser performance of academic women. These factors, although important are not taken into account in this article.

The remainder of the paper is organised as follows: Section 2 presents the theoretical framework and the resulting hypotheses; Section 3 describes the data and explains the research methodology; Section 4 briefly examines the evolution of the main variables of the regression models that are presented and analysed in Section 5; Finally, Section 6 discussions the implication of the results and concludes.

2 Theoretical framework

A great number of scholars have examined the gender differences in research output and scientific impact. Despite their different methods, and disciplines and countries on which they focus, these studies generally show that women publish less than their male colleagues (Fox, 2005; Hesli and Lee, 2011; Kyvik and Teigen, 1996; Long, 1992; Nakhaie, 2002; Prpić 2002; Xie and Shauman, 1998 and 2003; Zuckerman, 1991); a phenomenon that Cole and Zuckerman (1984) refer to as “the productivity puzzle”. In their thorough analysis of the phenomenon, Xie and Shauman (1998), however, showed that the gender differences regarding scientific productivity are declining with time as the number of women in science increases; a finding also observed by Abramo et al. (2009). This contrasts with what Prpić (2002) showed; in Croatia, the productivity gap is increasing.

It is generally accepted that this lower scientific productivity is widespread and observed across countries, although it varies across disciplines (Larivière et al., 2013). In Canada, Nakhaie (2002) has examined factors that might explain why Canadian female researchers publish less than men, and showed that seniority, discipline, type of institution and time devoted to research have a negative effect of women’s output. In some studies however, the gender differences in scientific productivity appear somewhat smaller than what is generally portrayed in the literature. For instance, Turner and Mairesse (2005) suggested that female physicists publish on average 0.9 articles less than men, while Gonzalez-Brambila and Veloso (2007) found a difference of 0.07 publications in favour of Mexican male academics. In this latter study, the largest gap is found in the health sciences (0.25 articles) and in physics (0.20 articles).

Less information is known regarding the citation record of female academics when compared to men, and the evidence presented is rather inconclusive, mainly because of the various methods used as well of discipline and country of focus. Long (1992), for instance, found that the average number of citations per article published by women in biochemistry was higher than that of men. Several other studies have obtained similar citation rates for both men and women (Lewison, 2001; Long and Fox, 1995; Mauleón and Bordons, 2006). In a large-scale study, Gonzalez-Brambila and Veloso (2007) highlighted disciplinary differences in the impact gap, and found that Mexican female natural scientists and health scientists receive 0.05 and 0.14 fewer citations than their male colleagues, while in the social sciences and humanities as well as in engineering, female scientists receive slightly more citations than men (0.02 and 0.04 citations respectively). Other authors found that it takes more time for women to receive their maximal number of citations (Ward, Gast and Grant, 1992), which may explain the differences if the number of citations is calculated up to a specific number of years after publication.

More recently, Aksnes et al. (2011) showed that gender differences observed in terms of scientific impact (measured by the number of citations) is attributable to gender differences in scientific productivity (measured by the number of publications). The marginal increase in citation grows with the increase in publication output and because men have more publications, they can benefit more from this advantage, and hence have more citations (Aksnes et al., 2011). Both men and women, when they are less productive tend to be less cited. As women are less productive – and thus visible to the scientific community – they tend to be less cited; a phenomenon that one could call the cumulative disadvantage of women or Mathilda effect (Rossiter, 1993). Long (1992) argues, along these lines, that the "smaller number of citations received by females results from their fewer publications, not from the quality of their publications" (1992:159). In the very few disciplines where men and women are equally prolific, as in dendrochronology (Copenheaver et al., 2010) or academic surgery (Housri et al., 2008), the citation rate of both genders is similar. In other disciplines, such as librarianship and information science, however, even though men contribute to a greater number of papers, their work is not more cited than that of women (Peñas and Willett, 2006). This supports the often-invoked hypothesis that, in research, women focus more on quality than quantity (Sonnert and Holton, 1995). Symonds et al. (2006) even found that in a sample of evolutionary biology and ecology scientists in life sciences departments of British and Australian universities, men tend to go for quantity of publications while women prefer quality of scientific publications and hence are more cited when controlling for the quantity of articles.

In light of the evidence presented, our first hypothesis reflects the fact that less productive scientists, because they are less visible or perceived as such, will be less cited. In addition, as the author ranking seem to matter a great deal in some circles, we will modulate this hypothesis by the number of articles published according to the position of the individual in the author list.

H1a (i) Academics that publish a smaller number of publications will also be less cited; (ii) Academics with a higher number of first-author publications will be more cited; (iii) Academics with a higher number of last-author publications will be more cited; (iv) Academics with a higher number of middle-author publications will be less cited.

Women who co-author a smaller number of papers should therefore be less cited than their male colleagues.

H1b (i) Female academics that publish a larger number of publications will be less cited than men; (ii) Female academics with a higher number of first-author publications will be less cited than men; (iii) Female academics with a higher number of last-author publications will be less cited than men; (iv) Female academics with a higher number of middle-author publications will be less cited than men.

In a manner similar to Nakhaie (2002), we will adopt a short-term input-output framework as opposed to a total career output framework but will account for changes over the years using panel data. We also follow his recommendation to the effect that "one has to include a large number of the covariates in a multivariate analysis in order to fully account for gender differences in publication" (2002: 156). The next few paragraphs present the relevant literature for the other covariates of the models described in section 3.

Bordons et al. (2003) found no significant difference between men and women in terms of the Impact Factor of the journals in which Spanish research council scientists in natural resources and chemistry publish. Housri et al. (2008) even found that women in the academic surgery publish in journals with higher Impact Factors. The notoriety of these journals offer a greater visibility to scientists, which in turn should increase the number of citations received, hence contributing to a somewhat positive feedback loop, or Matthew Effect (Larivière and Gingras, 2010). Because papers published in journals with higher Impact Factors, or for that matter because journals with higher Impact Factors publish articles that are more cited, we anticipate a strong and positive relationship between the number of citations and the Impact Factor of the journal:

H2a Academics that publish in journals with higher Impact Factors will be more cited.

Following the often-invoked argument that women prefer quality to quantity of articles, female scientists may then target better journals. Because they may concentrate their publications in better journals, their average citation rate may be higher than that of men, which brings us to our third hypothesis:

H2b Female academics that publish in journals with higher Impact Factors will be more cited than their male colleagues.

A number of studies argue that networking and collaborating is beneficial to both men and women. As Copenheaven et al. (2010) suggests, collaborating with male co-authors brings the work of female co-authors to their attention. The fact that most papers are now written in collaboration may contribute to reducing the gender differences in citations.

H3a Academics that collaborate with a greater number of scientists will be more cited.

Opportunities for women to collaborate are significantly less than those of men because women have young children (Long, 1990). Childcare and lack of research collaboration are the main obstacles to increasing productivity (Kyvik and Teigen, 1996). We would therefore expect that women work in smaller and more localised teams that may have a lesser impact.

H3b Female academics that collaborate with a greater number of scientists will be less cited than their male colleagues.

Almost no evidence exists as to the influence of research funding on the impact of publications (a recent exception being Fortin and Currie, 2013). What little evidence there is, focuses on the impact on scientific productivity. Stack (2004) as well as Xie and Shauman (1998) showed that federal support in the form of grants has a positive impact on scientific productivity. These studies use a dummy variable taking the value 1 if the scientist as a grant from the federal government and 0 otherwise. In a study of nanotechnology scientists, Beaudry and Allaoui (2012) compared the impact of the amounts of grants and contracts on scientific production and showed that a larger amount of funding in the form of grants has a positive impact on the number of papers published by an individual scientist. Related to our prior hypotheses that greater scientific productivity augments visibility and should thus increase the number of citations obtained, we suggest that more funding, which directly impact research productivity, should also indirectly influence the citation rate. Obviously, these double influences (i.e. potential endogeneity) will have to be taken into account in the regression models as will be explained in section 3. Our fourth hypothesis therefore goes as follows:

H4a Academics that have raised a greater amount of (i) public funding will be more cited, but greater amounts of (ii) private and (iii) not for profit funding should reduce the citation rate.

It is not obvious that because women are less funded, they should receive less citations. For an equivalent amount of dollars raised in research funding, both men and women may exhibit similar citation rates. Nevertheless, because of the productivity argument described for the prior hypothesis, we suspect that women with less funding will attract a smaller number of citations.

H4b Female academics that receive more (i) public funding, (ii) private funding, (iii) not-for-profit funding will nevertheless be less cited than their male counterparts.

At this point it is important to emphasise that it is not individual researchers that are cited but the individual publications, which are the result of the efforts of a team of researchers. In light of this, citation analysis performed at the individual level is always based on the overall publication record of the individual. What the paper examine is whether the publications of women in a particular year, to which men have also contributed, have a higher impact than those of men, to which some women may also have contributed. We will bear this in mind in the analysis of the results.

3 Data and methodology

3.1 Data

Two data sources are required for this study: data on scientific output and on funding. The first source of information is the Thomson Reuters Web of Science database that lists scientific publications of a widely recognized set of journals (about 12,000 in 2013). For the second source of information, we are fortunate in Quebec to have access to a very comprehensive database of university funding, the University Research Information System ("*Système d'information sur la recherche universitaire*" or SIRU). This database provides information on all university accounts held by academics in the province on a yearly basis. As each project is attributed a different university account, we are able to distinguish grants from contracts, public funding from private funding, operation costs from infrastructure costs, provincial and Canadian sources from foreign sources, and so on. In addition, all interuniversity transfers are accounted for, which implies that collaborative grants are divided into real amounts (as opposed to averages based on the total amounts divided by the number of co-PIs) according to the funds that were truly transferred from one institution to another. The only drawback so far in the database stems from the fact that we are not yet able to identify the principal investigator (PI) for each grant and from the assumption that we make that the amount held in each university account is divided equally between the co-applicants listed for each account, in the same university. In other words, we are not able to distinguish 'within' university transfers, as such mechanisms do not exist. We are currently discussing with the ministry to try to improve the quality of the data they provide.

The *Observatoire des sciences et des technologies* (OST) in Quebec has disambiguated and uniquely identified every academic in Quebec and provides a comprehensive database of their scientific output and funding (see Larivière et al., 2011). The traditional homonymy and synonymy problems that normally plague all bibliometric databases have thus been resolved prior to us gaining access to the data and have given rise to a vast number of publications in bibliometrics and scientometrics.

With these data, we are able to construct a number of variables to characterize scientific output and research funding. Our dependent variable counts the number of citations up to 10 years following the publication year of each article (**normCit10**[1]) relative to the average citation rate of the papers published worldwide in the same discipline during the same year. For this calculation, the US National Science Foundation classification of journals into 143 disciplines and specialties is used. This normalised measure allows the comparison between disciplines without having to introduce dummy variables for each of the disciplines if we were to simply count the raw number of citations per article or even the fractional number of citations (i.e. divided by the number of authors).

The variable of interest is obviously the gender of the scientist, which we model using a dummy variable (**dFemale**) taking the value 1 if the scientist is a woman and 0 otherwise.

Because a more prolific author may have more visibility, we add the number of articles published in a given year (**nbArticles**) as an explanatory variable. To account for the fact that the order of the author list may provide a better reflection of the importance of each author, as an alternative, we propose to use the number of first-author articles (**nbArtFirst**), the number of last-author articles (**nbArtLast**) and the number of middle-author articles (**nbArtMiddle**). Single-author articles are counted solely as first-author articles, two-author articles are counted as 1 first author and 1 last author so as not to overinflate the publication rates of individuals with small authorship papers.

In order to take into account co-authorship, it is common practice in bibliometrics to fractionally count the number of papers of an individual or, in other words, counting the number of papers divided by the number of contributors on the author list. A paper with ten authors then only counts for 0,1 article for each of its contributor. We will therefore use the fractional number of articles (**fracArticles**), and the fractional number of articles as first author (**fracArtFirst**), last author (**fracArtLast**) and as middle author (**fracArtMiddle**) as an alternative to the simple full counting of articles.

To take into consideration these teams of authors, we also add the number of authors per paper and averages the value per researcher per year (**avgAuthors**), i.e. over all the papers published by an individual in a given year. The reason for introducing such a

[1] Regressions with normCit10 suffered from a strong size effect which we have corrected by taking the natural logarithm of the variable. The regressions will therefore be estimated on ln(normCit10).

measure is two-fold: first, it gives an idea of the underlying collaboration necessary to produce the paper and second, more authors provide a greater visibility to an article, which may yield a greater number of citations[2].

In addition, the prestige of specific journals may induce a greater visibility and yield a greater number of citations. We account for the "quality" of the journal by introducing the 5-year impact factor of the journal in which an individual has published a specific paper in a given year, averaging over all the papers published by an individual in that year (**ImpactFact5**).

In terms of funding variables, we had a vast choice for classification of each funded project. We compared two classifications, one that opposes grants and contracts regardless of sources and the second that opposes public funding, private funding and what can be construed as philanthropic or not-for-profit funding. For each of these categories, we separated the amounts into infrastructure funds and operation funds. In order to smooth out any sudden rise in funding from a given category, we calculate a three-year moving average of the amount of public funding for operation costs (**avgPubFundO3**), of the amount of private funding for operation costs (**avgPrivFundO3**), of the amount of philanthropic funding for operation costs (**avgPhilFundO3**) and of the amount of public funding dedicated to equipment and infrastructure funds (**avgPubFundI3**)[3].

Finally, it has been shown that women often work in universities with a lesser research intensity (Sonnert and Holton, 1995; Xie and Shauman, 1998). And when they work in universities with high research intensity, women occupy lower academic ranks than men (Fox, 1991; Leahey, 2007; Sonnert and Holton, 1995). We therefore expect that the university environment has an impact on the citation rate. To account for any time or university effects, we add year dummy variables (d2001 to d2012) and university dummy variables for each Quebec university (the dummy variable for McGill University is the omitted dummy variable).

3.2 Methodology

The database is built as an unbalanced panel providing data for the years 2000 to 2012 for each individual scientist. Because our dependent variable has been normalized, and is thus continuous, we can use ordinary least squares regressions for panel data (i.e. the procedure *xtreg* in Stata). We however suspect that our model suffers from endogeneity

[2] Similarly, we have tested a second variable counting the number of affiliations listed on the paper and averages the value per researcher per year (**nbAffiliations**). This second measure can be considered a proxy for inter-institution collaboration. Once again, the rationale is that a greater number of affiliations should provide an increased visibility to a paper. We are conscious of the fact that some authors may list more than one affiliation on a single paper. Because of the structure of the Web of Science database, which does not link authors with their affiliations, we have no direct way of addressing this issue and correcting for multi-affiliation authors. Probabilistic analyses of these affiliations may provide some insight but are not an exact correction to the problem. We have therefore simply counted the number of affiliations but taken into account the potential bias it may introduce in our analysis. Because of these reasons and of the fact that the results are very similar to those with the number of authors and will therefore not be presented in this paper.

[3] All monetary values have been deflated by the consumer price index and are therefore presented and analysed as constant Canadian dollars of 2002.

due to the fact that scientific production influences the capacity to raise funds and in return, more funds provide greater resources to produce more scientific papers. To correct for potential endogeneity, we use instrumental variables and instrument for the average amount of public funding (and hence use the procedure *xtivreg* in Stata).

The first instrument proposed regards the age of a scientist (**Age**). With greater maturity generally comes greater research responsibilities, kudos, larger grants due to a larger experience in supervising teams of students, etc. It has been argued that women are less productive in the first decade of their career but are more productive afterwards (Long, 1992). Larivière et al. (2011) showed that this also applies to both genders. It has not directly been shown to have an impact on citations. We have nonetheless verified that age does not influence the normalised citation rate prior to using it as an instrument.

When applying for public funding, academics must always provide a complete list of their publications, hence the need to also add as an instrument the average number of publications in the past three years (**avgArticles3**), lagged by one year (to avoid overlapping with some of the exogenous variables). Academics responsible for important infrastructure, for which they generally raise funds from the public purse (**avgPubFundI3**), may require and obtain a greater amount of public funds for the research that uses the said infrastructure. Finally, to control for the size of faculties in various universities, we include the aggregated amount of public funding raised by academics in a given division (group of departments) in a specific university divided by the aggregated amount of funding raised by all academics of the same division in the entire province over the past three years (**normPubFundDU3**). The rationale is that better funded university divisions (or groups of departments) may attract more funding because of the latent quality of their faculty. Kyvik (1995) found no evidence of an impact of the size of the department on scientific production, which suggest that this variable may be a good instrument for our endogenous variable.

4 Descriptive statistics

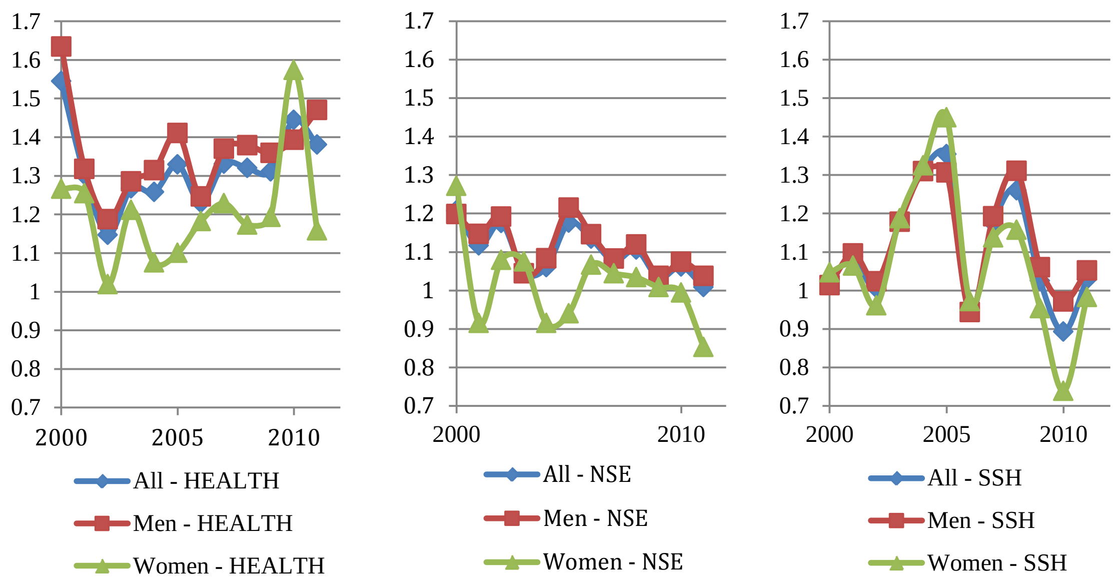
Once the observations for which one of the variables is missing are removed, our sample comprises 5,419 scientists over a period of 12 years (resulting in 34,604 observations), of which 1,436 or are women (resulting in 7,973 observations or 23.04% of the sample). The descriptive statistics of the sample are presented in Table 1. In our sample, women are on average 3 years younger than their male colleagues (55.1 years old). A greater proportion of women work in the social sciences and humanities fields (31.6%), followed by the health fields (26.5%) and natural sciences and engineering (14.5%)[4].

Comparing the overall characteristics of men and women, we find that men are more cited, produce more papers, occupy more often the last-author rank and the middle-author rank, and raise more funds from public, private and philanthropic sources. Women are more often first author on their papers. These results are very much in line with most of the literature on women in academia and women in science.

[4] The three fields are subdivided into 9 divisions, which are then further divided into 42 clusters of disciplines. Social sciences and humanities (SSH) comprises Social sciences, Business and management, Humanities, Education, and Non-health professional divisions, the HEALTH field comprises the Basic medical sciences and Health sciences divisions, and Natural sciences and Engineering (NSE) is composed of the Sciences and Engineering divisions.

Individual academics usually raise more research funds in the health fields – with the exception of infrastructure investments which are larger in the natural sciences and engineering fields (NSE). In comparisons, the funds obtained by social scientists and humanities scholars are more modest, but a direct consequence of the type of research that is performed in these fields.

While the descriptive statistics are informative, because the analysis relies on panel data, examining the evolution of the main variables over the course of the sample is more informative. The descriptive statistics have highlighted a number of differences between both men and women and across the three fields of research, we will therefore illustrate the variations over the years of the dependent and independent variables by gender and by field. Let us start with the normalized number of citations (in Figure 1). With the exception of the social sciences and humanities (SSH) fields, Quebec women generally contribute to papers that are less cited than Quebec men. A number of factors will be examined in this section then put to the test collectively in the regression results section. Among the factors under scrutiny, we will examine the number of publications, as a greater visibility may attract more citations, the number of first- and last-author rankings, hence signalling the 'importance' of an author, the amount of research funds raised, thereby allowing more or less research to be performed, and the size of the teams involved.

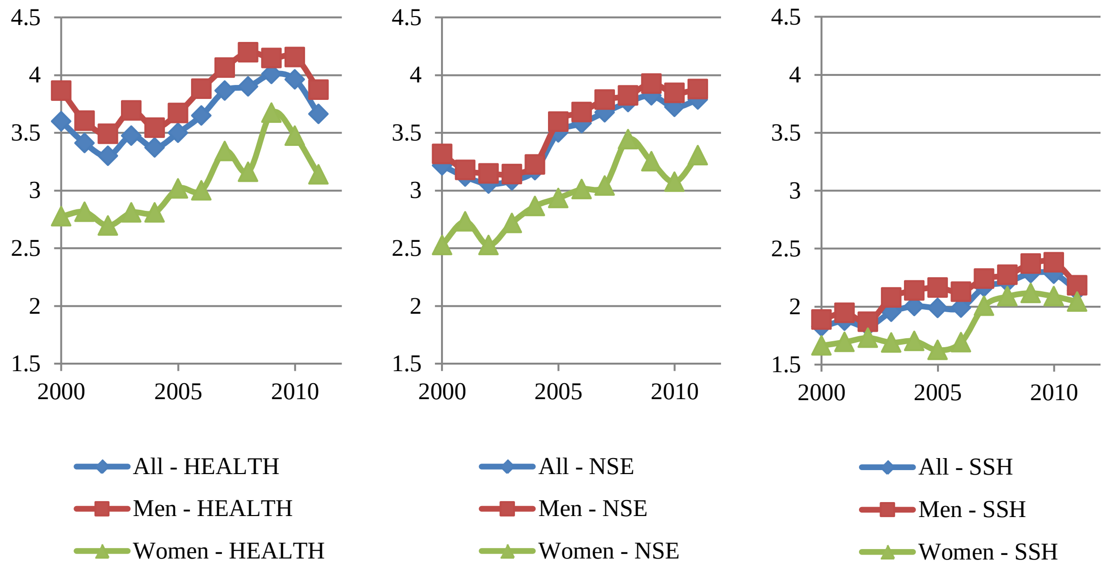


(a) Health **(b) NSE** **(c) SSH**

Figure 1 – Average normalized number of citations per field (2000-2012)

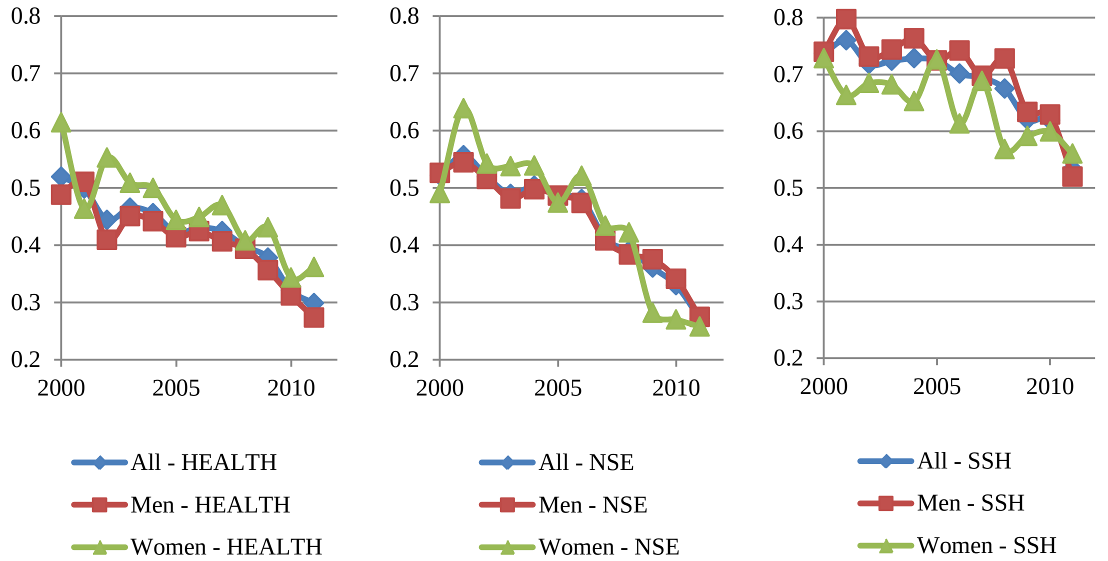
Although women in the health and NSE fields are less productive than their male colleagues, they produce more papers as first authors. In contrast, in the SSH fields, women produce less first-author papers (compare Figure 2 and Figure 3) than their male counterparts, and more first-author papers than their female colleagues in other fields. The importance of the author order is strongly perceived in all the disciplines, it is therefore surprising to observe the decline of the number of first-author position to the benefit of last-author (see Figure 4) and middle-author (see Figure 5) positions. The comparison between the three fields by gender yields interesting results. In all fields, women coauthor a smaller number of articles in which they are listed as the last author. Furthermore, in the health and NSE disciplines, men contribute to a greater number of papers in which they are listed as middle-authors while in the SSH disciplines, no difference can be observed. Because of these differences in author order behaviour across the disciplines, the regressions presented below will have to first include dummy variables for the field and then be estimated per field.

An interesting trend to note is on the one hand the increasing number of articles per individual in the first place and on the other hand the decreasing number of first-author papers. The latter is partly attributable to the general augmentation of the number of authors per paper observed in all these fields over the period examined: from around 6 authors to more than 7.5 authors in the health fields, from less than 8 authors to more than 10 authors in the NSE fields, and from around 3 authors to more than 3.5 authors in the SSH fields.



(a) Health **(b) NSE** **(c) SSH**

Figure 2 – Average number of articles per gender per field (2000-2012)



(a) Health **(b) NSE** **(c) SSH**

Figure 3 – Average number of first-author articles per gender per field (2000-2012)

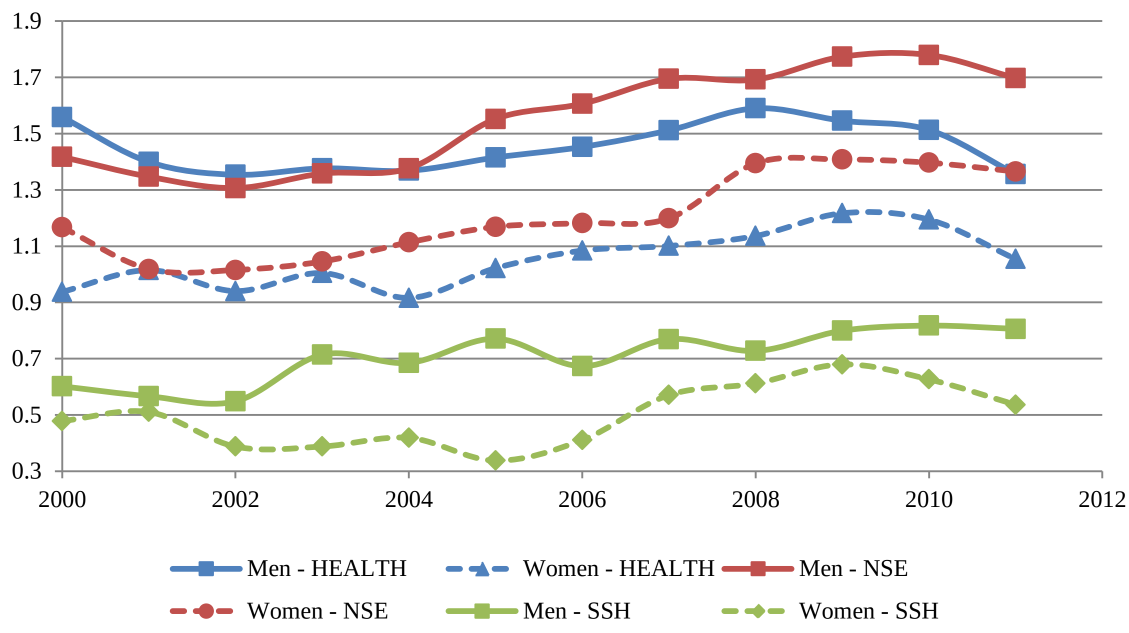


Figure 4 – Average number of last-author articles per gender per field (2000-2012)

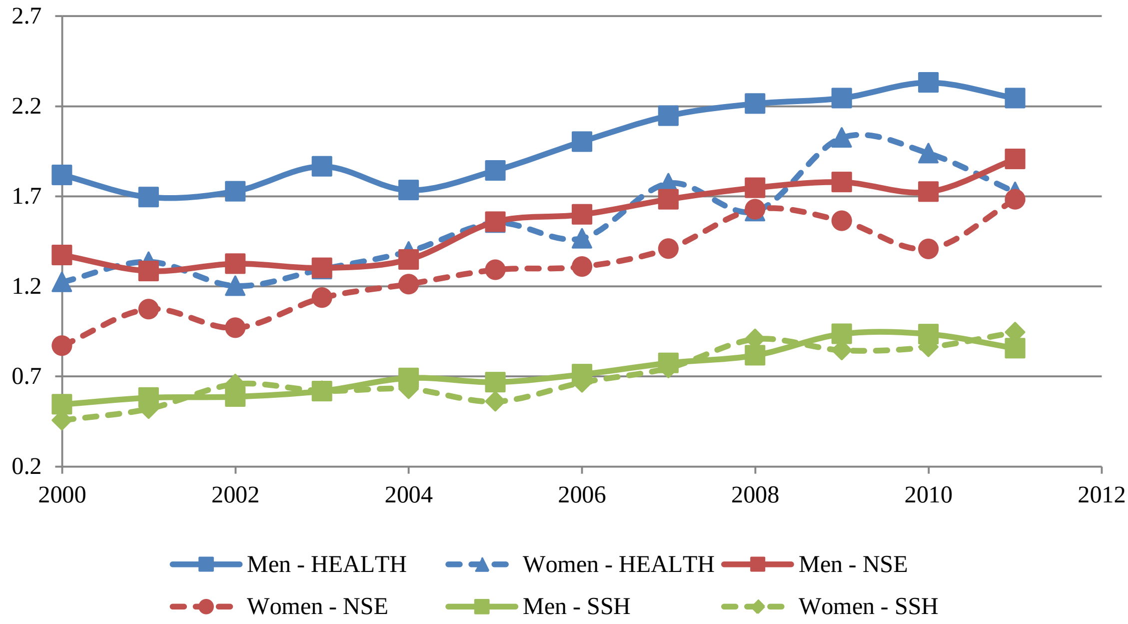


Figure 5 – Average number of middle-author articles per gender per field (2000-2012)

It has been suggested in the literature that women publish in journals with lesser Impact Factors. While we observe that this is generally true in the health fields, it is not at all clear that this is the case in the NSE and SSH fields as illustrated by Figure 6. Comparing the number of articles published by men and women in the NSE fields (in Figure 2b) and the 5-year Impact Factor of the journals they both target (in Figure 6), one would be inclined to think that women aim for quality and not necessarily quantity (Duch et al., 2012). Let's not forget here that most of these articles are written collaboratively; one would not necessarily find many articles written solely by women. However, considering that a non-negligible number of articles are written by an academic and his/her students in addition to the fact that our data consists purely of university professors in Quebec, we are confident that at least some of the articles published by women, only involve one female academic.

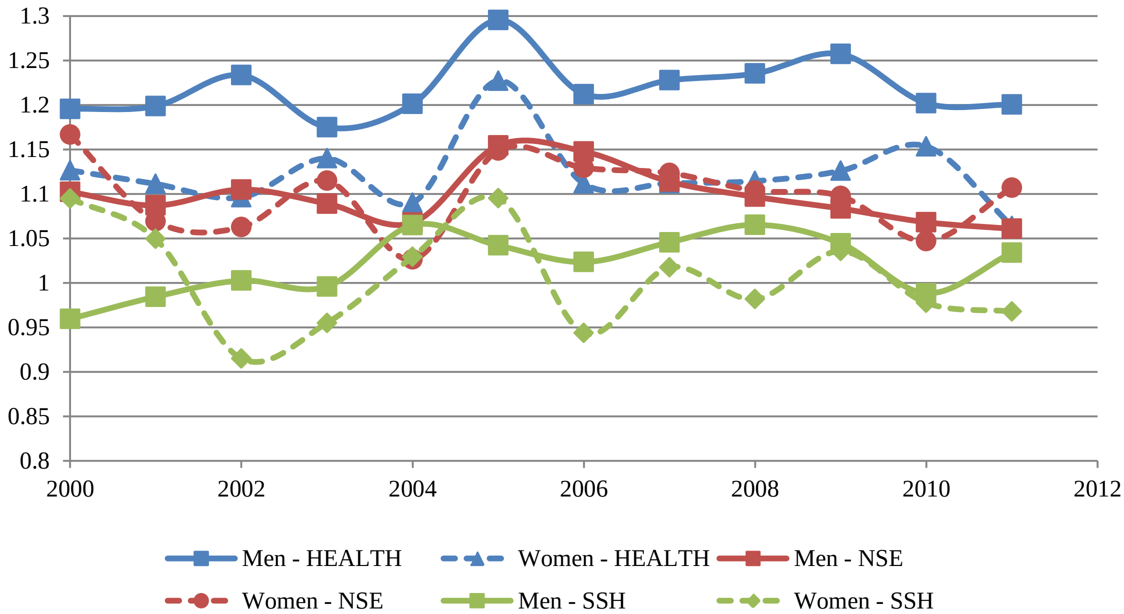


Figure 6 – Average 5-year Impact Factor of the journals in which articles are published per gender per field (2000-2012)

Another factor that may affect the number of citations received by publications is the capacity to perform research measured by the amount of funds obtained by individual scholars. Figure 7 presents the average amount of public funding raised by Quebec academics per gender and per field over the years. The gap between men and women in the health fields is rather large, more than 35,000$ on average. In contrast, the difference between men and women in the NSE and SSH fields is considerably less, about 12,000$ and 11,000$ respectively in favour of men. This alone cannot fully explain why women generate fewer citations than their male colleagues. The private sector may contribute to this discrepancy since women raise much smaller amounts of funds from private sources: The amount raised by women is reduced fourfold in the health fields and almost twofold in the other two fields.

None of the abovementioned factors can uniquely explain the poor performance of female health and NSE scientists. We must therefore turn to regression analyses to take into consideration all these factors at once to try to find the factors that are the most important towards improving one's citation rate.

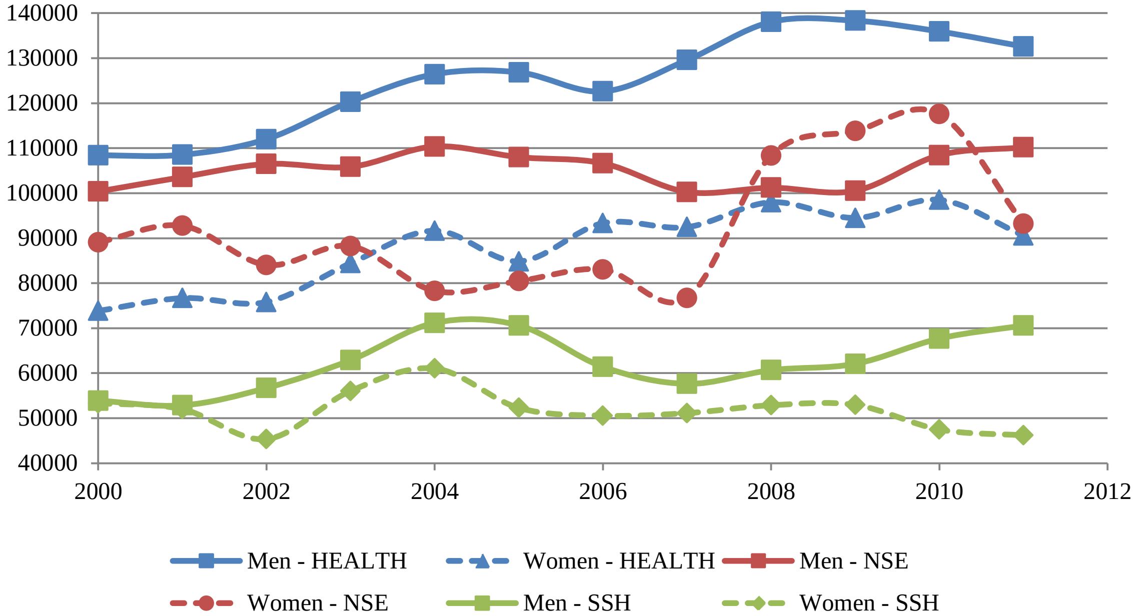


Figure 7 – Average yearly amount of public funds raised dedicated to operation costs per gender per field (in constant 2002 dollars) (2000-2012)

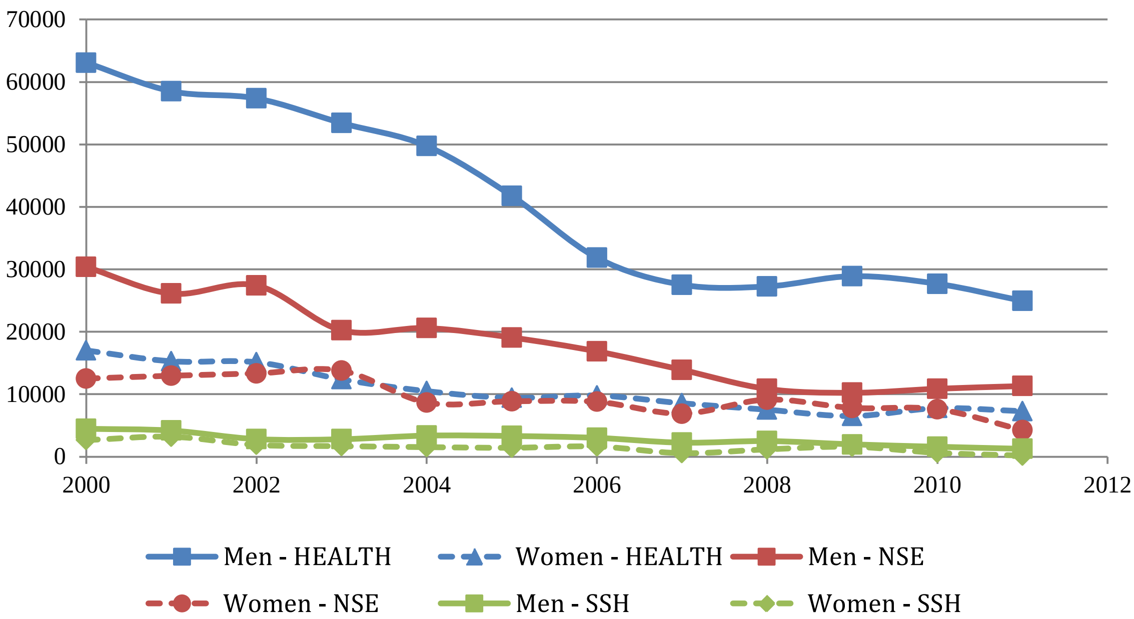


Figure 8 – Average yearly amount of private funds raised dedicated to operation costs per gender per field (in constant 2002 dollars) (2000-2012)

5 Results

5.1 General results

Regressions for the pooled sample did not provide very good insight and will therefore not be presented here for the sake of brevity. The results of the field regressions are presented in two distinct sets of tables (Table 3 and Table 5) for the health fields, Table 4 and Table 6 for the NSE fields[5]), with the first stage regressions when instrumental variables are used to correct for potential endogeneity shown in two sets of tables (Table 7 and Table 9 for the health fields, and Table 8 and Table 10 for the NSE fields). The first two columns of the first four regression tables (Table 3 to Table 6) reports the OLS regression results of the full model, i.e. without treating endogeneity. The other columns to the right present the instrumental variable regressions. For both the health and NSE fields, the first regression table presents the results for the number of articles (total, first author, middle author and last author), while the second regression table presents the results for the fractional count of the number of articles.

The first striking result is the fact that the amount raised in public funding does not seem to matter when it comes to attracting citations. Better-funded scientists and engineers, as well as health related scientists, are not more cited than their colleagues, when accounting for potential endogeneity (columns 3 to 8). In other words, when we account for the fact that more public funding is a consequence of a greater scientific production, more maturity, a greater publicly funded infrastructure and a better funded close environment in general, public funding for operation costs looses its significance. In the simple ordinary least squares (OLS) regressions for panel data (column 1) we find a positive and significant coefficient of public funding for the NSE fields only (not for the health fields). Adding the square of the public funding variable (column 2) yields a non-significant linear effect and a positive and significant quadratic effect, implying a J-shaped curve, but for the NSE fields only. Two little public funding is therefore not enough and more money has a positive effect. This contrasts with the decreasing returns of funding on quality-adjusted publications (a mix of number of publications and citations) found by Arora et al. (1998). This result is however not robust to a change in the way to count the number of articles. In Table 5 and Table 6, public funding loses its significance when accounting for endogeneity.

What matters instead is the number of articles (column 6) but to our great surprise, there is a maximum number of articles (30 and 27 for the health and NSE fields respectively) for which this is true and beyond which a greater number of articles published per year results in the decrease in the citation rate. This finding results from the introduction a quadratic term for the number of articles (column 7). A way to elucidate this conundrum consists in splitting the number of articles according to the rank of each individual in the author list.

[5] Although we have performed the regression analysis for the SSH fields, the results are not conclusive and very few variables are significant. We know that some fields are not properly represented by merely counting articles published in the Web of Science and we are currently seeking alternative sources of data to account for the scholarly output of SSH scholars. The regressions for the SSH fields will therefore be omitted from the paper.

Doing so, we find that a higher number of first- and last-author papers positively influences the number of citations received, for both the health and NSE fields. A higher number of middle-author articles is generally positive and significant for the health fields but never significant for the NSE fields. Similarly to the regressions in the seventh column of the results tables, in column 8, we also added a quadratic term for the number of middle-author articles. This quadratic term is consistently negative implying again an inverted U-shaped curve for the citation rate with a optimum amount corresponding to around 16 or 17 middle-author articles, for the health and NSE fields respectively. Introducing a quadratic term for the number of first-author and last-author articles yields similar results (not shown here), the optimum amount being about 5 first-author articles and 17 last-author articles.

We also examined whether a higher proportion of articles in different author ranks gave the same results. Adding the proportion of first-author articles and the proportion of middle-author articles (including the proportion of last-author articles would lead to multicolinearity) to the number of articles (with and without the quadratic term) yields a positive and significant coefficient only for a higher proportion of first-author articles (column 7). This implies that when controlling for the fact that contributing to too many articles (from the negative quadratic term) is generally accompanied by a drop in citation rate, a higher proportion of first-author articles, but not of middle-author articles, has a positive impact on the citation rate.

One way to account for this non-linearity in the impact of the number of articles would be to the natural logarithm of the variables. A very elegant alternative consists in counting the fractional number of articles. In other words, each article is counted as a fraction of the number of authors. For instance, a four-author publication counts for 0,25 articles for all the authors. Transforming the number of articles variables into fractional counts yields the results presented in Table 5 and Table 6. This time, all the fractional counts of articles, regardless of the author ranking are significant but none of the quadratic terms (column 8). And once again, only the proportion of first-author articles matters (column 7).

Similar to the rationale that with publishing a greater number of articles an individual scholar is more visible, have a more numerous author list, or a wider affiliation[6] list may also improve the visibility of a paper and hence attract more citations. Our results indeed show that a higher number of authors per paper does increase the citation rate of a paper. This is true for both the health and NSE fields.

Regarding the quality of the scientific production, across all fields, targeting journals with higher Impact Factors is the common factor that contributes to improving one's citation rate. Although this seems rather tautological, it is however important as a gender comparison factor. This therefore brings us to the matter at the heart of this paper, i.e. whether women produce research of a lesser impact than that of their male counterparts.

5.2 Results specific to gender

Comparing the coefficients of dFemale between the health and NSE fields, suggests striking differences between the two fields. When only dFemale is included in the

[6] The results for the number of affiliations are similar to those for the number of authors per article and will therefore not be shown here.

regressions, its coefficient is positive in the health fields and negative in the NSE fields, but neither is significant. Hence our results do not give credence to the hypothesis that women are less capable in terms of science.

To try to disentangle the forces that may be at play here, we now interact gender with all the other explanatory variables. Before presenting the specific results, we have to emphasise that the research does not examine the composition of the author list, and as such is not an analysis at the article level but at the individual academic level. We must also reiterate that most articles published by women are also published with a number of male colleagues and/or male students. There are no single-gender articles considered in this analysis. Instead, we count the number of articles to which women have contributed as first, last and middle author. It is therefore entirely possible that the number of citations obtained by an article be driven by the notoriety of only one of the authors of the team, but then benefits to the entire co-authoring group.

All else being equal, our results show that women in the health and NSE fields with the same number of publications are equally cited as their male colleagues (the coefficient of the interactive variables between dFemale and nbArticles is non significant in column 6). When we add the interaction between dFemale and the square of nbArticles (column 7) however, a small difference between men and women is noticeable: women health fields are very slightly more cited than men until they reach about 11 publications per year and in the NSE fields up to about 38 publications per year.

Breaking down the number of publications into first- last- and middle-author articles, reverts to the non-significance of all interaction terms with dFemale hence implying that *ceteris paribus* women are equally cited as men, regardless of their rank in the author list. There is a weak significance in the NSE fields between dFemale and nbArtMiddle suggesting that female scientists and engineers benefit from being listed as middle authors to improve their citation rate. Because female scientists and engineers seem to benefit more from their co-author notoriety then their male counterparts, we investigated further by first adding the square of the number of middle-author articles and its interactive term with dFemale (in column 8). Doing so, we loose all significance of the interactive term: the quadratic term is then negative but not significant and the linear interactive term remains positive but not significant. In contrast, when we turn to proportions, while controlling for the total number of articles (in column 7), we obtain similar results, the interactive terms with dFemale of the proportions of first-author (propArtFirst) and of middle-author articles (propArtMiddle) are neither significant. In other words, women are no different from men, *ceteris paribus*, in terms of author ranking impact on citation rates.

If we now turn to the fractional counting of articles (in Table 5 and Table 6), the results emphasise that female health scientists are more cited than their male counterparts when they occupy the first rank in the author list, while for female natural scientists and engineers, the position of last author is more favourable. Although very nearly significant in terms of proportions (in column 7), these results are robust to a variety of models (not presented in the paper).

The influence of the five-year Impact Factor of journals is where the health fields and the NSE fields differ the most between men and women. While for basic medicine and health sciences the coefficient of ImpactFact5 is positive and significant, when interacted with dFemale, it becomes negative and significant. The overall coefficient for women is still positive (the sum of both coefficients), suggesting that women benefit less from the visibility provided by high impact journals. To investigate whether this could be due to the inclusion of nursing, or other health science dominated by female scientists, we removed these disciplines from the regressions, but the results remains the same. In contrast, for female natural scientists and engineers, the interactive term between ImpactFact5 and dFemale is not significant. This would tend to show that when women publish in the same journals, they get the same level of citations.

Another discriminant factor between the genders is the size of the author list. Not so much in the NSE fields, but in the health fields, women appear to benefit less from the networking that generally comes from large author lists. Their impact for women is about 5% small than that of men on their citation rate. Although not a very important difference, it is nevertheless there, and remains a significant difference when nursing and other health science disciplines are removed from the sample.

If we now turn to the impact of funding dedicated to research operation costs, we find no impact of the interactive variables with dFemale. We can therefore suggest that given the same amount of research funds, of all types of sources, whether public, private or philanthropic, women perform as well as men in terms of citation rate.

6 Discussion and conclusion

At the beginning of this paper, we set out to validate four hypotheses, each of which was separated into general impact and impact for women. Here, we discuss each of these hypotheses prior to presenting the general conclusion. The first hypothesis aimed to validate the argument that with the accrued visibility ensuing from a greater number of publications, scientists should be more cited. Not surprisingly, there is an overwhelming support for hypothesis H1a. Regarding H1b, we report that women and men perform equally well, thereby refuting most of our hypothesis. Given the same scientific production and visibility as first, last or middle author, women appear to receive similar numbers of citations. There are nevertheless some subtleties in the results when we employ fractional counting of articles. Because women tend to work with slightly smaller teams of authors, we find that in the health fields, women with a higher number of first-author articles obtain more citations and in the health fields the same is true for women in the last-author rank. This could not be shown by simply counting the number of articles. These results find echo in the findings of Housri et al. (2008).

Our second hypothesis examined the influence of the Impact Factor of journals in which scientists publish. H2a is overwhelmingly supported by our results, which is, again, not surprising. The average Impact Factor of journals has a direct impact on the citation rate of individuals who publish in those journals. Contrarily to all expectations, however, it is not in the NSE fields that women are less cited given an equal Impact Factor of the journal but in health fields. H2b is therefore supported in the NSE fields but not in the health fields. After the social sciences and humanities fields, the health fields are where women are the most present. Even when removing from the analysis the disciplines traditionally occupied by women, such as nursing and other health science disciplines, the results are similar. Is it possible that in promoting women in science for a great number of years now, we have neglected women in the health sciences? Further reflection is needed regarding the state of female health scientists.

Our third hypothesis examined the teams with which scientists publish. Once again, the general wisdom dictates that a wider visibility provided by a larger author[7] base has a positive impact on the propensity to attract citations, hence supporting H3a. While the picture is similar for both men and women in the NSE fields, in the health fields, for women in the health fields, the impact of a larger team is roughly 5% less than that of their male colleagues, although small, the difference in nonetheless significant and validates H3b. It would therefore appear that collaboration, albeit in the health fields, remains an obstacle for women (Kyvik and Teigen, 1996). International collaboration, as shown by Larivière et al. (2013), is likely to play a role here.

Our last hypothesis examined the influence of funding. While in the NSE fields, only public funds first appear to have a positive effect on the propensity to be more cited than average, the result is not robust to a variation in the count of the number of articles to fractional counting. As a consequence, H4a is rejected and neither public, private nor philanthropic funding as a positive influence on the propensity to gain more citations for one's work. Turning now to the impact of gender on this hypothesis, we found no effect that would indicate that women are less cited given the same amount of funding as men, hence rejecting H4b altogether.

The observed result that given the same amount funding, or similar publication record, women are equally cited as men tend to argue against Lawrence Summers' remarks at the now infamous NBER conference of 2005 to the effect that few women in academia had reached the highest echelons of the profession because of a lack of aptitude for science and not because of discrimination (Summers 2005). All things being equal, women generally perform as well as men… with maybe the exception of the collaboration aspect of their work, as well as in health disciplines.

Following this work, a number of avenues for future research are open. It has been suggested by Leahey (2006) that women specialise less than men and that this fact hinders their capacity to get published and cited. This specialisation argument may have repercussions on the choice of collaborators and on the constitution of research teams. Another aspect to consider is the suggestion by Xie and Shauman (1998) that access to graduate and postdoc students is biased in favour of male scientists. Beaudry and Allaoui (2012) had found a strong impact of the position of individual researchers in the co-publication network. Introducing social network analysis indicators in the regressions to provide a richer analysis of the structure of collaborations is an obvious avenue to pursue. Women, who often devote more time to teaching and administrative duties than men (Barzebat, 2006; Bellas and Toutkoushian, 1999; DesRoches et al., 2010; Xie et Shauman, 1998) to the detriment of research activities, may have less time to devote to maintaining the necessary links of an efficient collaborative team.

Lastly, this research has a number of limitations, the most obvious being the sample chosen. Larivière et al. (2013) mentioned Quebec as one of the regions closest to achieving gender parity in science. The picture presented in this paper may not reflect at all the realities of other regions or countries. The second is the fact that not all academics

[7] And a larger affiliation base as we have tested both during the course of this research.

are included in Quebec. Those for which we do not have the age or the gender where excluded from the study. Third, this research is at the confluent of bibliometrics and econometrics, more information on socio-demographic attributes and on the collaborative aspect of science is missing from this study.

7 References

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8 Appendices – Results tables

Table 1 – Descriptive statistics

Variable	mean	std. err.	min	max	mean	std. err.	min	max	mean	std. err.	min	max
	ALL (N = 34 604, n = 5 419)				**MEN** (N = 26 631, n = 3 983)				**WOMEN** (N = 7 973, n = 1 436)			
normCit10	1.1992	(1.8225)	0	74.575	**1.2224**	(1.8775)	0	74.575	1.1219	(1.6232)	0	53.17
nbArticles	3.4310	(3.6230)	1	85	**3.6186**	(3.8691)	1	85	2.8045	(2.5411)	1	48
avgArticles3	2.9231	(3.2500)	0.3333	64	**3.1074**	(3.4764)	0.3333	64	2.3072	(2.2325)	0.3333	34.3333
nbArtFirst	0.4724	(0.8625)	0	17	0.4667	(0.8835)	0	17	**0.4917**	(0.7882)	0	8
nbArtLast	1.3626	(1.9157)	0	44	**1.4771**	(2.0352)	0	44	0.9803	(1.3797)	0	13
nbArtMiddle	1.5959	(2.6815)	0	84	**1.6748**	(2.8694)	0	84	1.3325	(1.9023)	0	48
avgAffiliations	3.3708	(5.6942)	0	248.7	3.3392	(5.8264)	0	243.5	**3.4766**	(5.2275)	0	248.7
avgAuthors	7.2652	(50.9780)	1	3174.5	**7.5237**	(51.8545)	1	3174.5	6.4016	(47.927)	1	3037.8
ImpactFact5	1.1327	(0.6369)	0.016	12.476	**1.1433**	(0.6343)	0.016	12.476	1.0972	(0.6444)	0.021	11.417
avgPubFundO3	110,289	(197,225.8)	0	1.01E+07	**116,899.3**	(206,133)	0	1.01E+07	88,209.5	(162,073.5)	0	5,333,932
avgPrivFundO3	21,823.6	(97,274.9)	0	4,928,962	**25,749.1**	(108,885.1)	0	4,928,962	8,712.1	(35,278.7)	0	790,537.8
avgPhilFundO3	20,828.2	(123,457.3)	0	8,383,077	**22,680.4**	(117,083.5)	0	6,604,800	14,641.8	(142,531.9)	0	8,383,077
avgPubFundI3	28,439.7	(213,356.9)	0	1.28E+07	**33,030.8**	(238,453.4)	0	1.28E+07	13,105.0	(85,699.9)	0	3,989,448
normPubFundDU3	0.2266	(0.1080)	0	0.4526	0.2240	(0.1059)	0	0.4526	0.2355	(0.1143)	0	0.4526
Age	50.2	(9.4)	14	92	50.8	(9.5)	21	92	48.1	(8.6)	14	92

Table 2 – Descriptive statistics

	HEALTH (N = 11952, n = 1 597)				**NSE** (N = 12407, n = 1 771)				**SSH** (N = 5632, n = 1 477)			
normCit10	1.3206	(2.0713)	0	56.121	1.0976	(1.6261)	0	74.575	1.1080	(1.9808)	0	55.985
nbArticles	3.6592	(3.3296)	1	34	3.4851	(4.0668)	1	85	2.0685	(1.8159)	1	24
avgArticles3	3.1790	(2.9740)	0.3333	29.6667	2.9670	(3.6309)	0.3333	64	1.5541	(1.6262)	0.3333	19.6667
nbArtFirst	0.4163	(0.8170)	0	9	0.4375	(0.9145)	0	17	0.6799	(0.8468)	0	7
nbArtLast	1.3517	(1.7549)	0	20	1.5141	(2.0251)	0	25	0.6504	(1.0249)	0	12
nbArtMiddle	1.8911	(2.2591)	0	34	1.5335	(3.4230)	0	84	0.7383	(1.1900)	0	14
avgAffiliations	3.9459	(3.3928)	0	80	3.0978	(8.5720)	0	248.8	2.5190	(2.2416)	0	98
avgAuthors	7.2024	(19.2262)	1	917	9.5321	(82.8597)	1	3174.5	3.4225	(3.1911)	1	131
ImpactFact5	1.1951	(0.7134)	0.022	12.476	1.0989	(0.5416)	0.016	7.702	1.0174	(0.6583)	0.018	10.048
avgPubFundO3	116,015.6	(238,452.9)	0	1.01E+07	103,410.7	(159,953.1)	0	5,333,932	59,208.9	(93,862.4)	0	2,260,332
avgPrivFundO3	32,036.8	(133,834.9)	0	4,928,962	16,366.0	(60,575.6)	0	1,316,860	2,280.8	(11,898.2)	0	230,932.9
avgPhilFundO3	31,305.6	(149,071.2)	0	6,604,800	8,147.5	(34,233.2)	0	1,106,413	3,559.1	(17,260.2)	0	431,562.6
avgPubFundI3	18,966.2	(128,512.5)	0	4,264,652	37,458.6	(213,662.2)	0	1.17E+07	5,083.6	(24,555.7)	0	520,629.4
normPubFundDU3	0.2887	(0.1250)	0	0.4526	0.1919	(0.0718)	0.0003	0.3247	0.1901	(0.0920)	0	0.40334
Age	51.2	(9.1)	14	92	50.1	(9.7)	27	86	49.0	(9.6)	29	85
dFemale	0.2651	(0.4414)	0	1	0.1451	(0.3522)	0	1	0.3157	(0.4648)	0	1

Table 3 – Regression results – Health fields (*, **, * show significance at the 1%, 5% and 10% level respectively, standard errors in parentheses)**

Health	OLS(1)	OLS(2)	IV(3)	IV(4)	IV(5)	IV(6)	IV(7)	IV(8)
ln(avgPubFundO3$_t$)	0.0021	-8.60E-04	-0.0020	-0.0024	-0.0024	-0.0054	-0.0019	-0.0012
	(0.0013)	(0.0050)	(0.0050)	(0.0050)	(0.0050)	(0.0049)	(0.0051)	(0.0049)
ln(avgPubFundO3$_t$)2		2.54E-04						
		(4.13E-04)						
ln(avgPrivFundO3$_t$)	0.0019 *	0.0018 *	0.0015 *	0.0014	0.0014	0.0014	0.0014	0.0014
	(0.0010)	(0.0010)	(9.24E-04)	(0.0010)	(0.0010)	(0.0010)	(0.0010)	(0.0010)
ln(avgPhilFundO3$_t$)	-4.79E-04	-5.48E-04	-6.20E-05	7.51E-04	6.70E-04	9.27E-04	3.52E-04	4.14E-04
	(0.0010)	(0.0010)	(0.0010)	(0.0012)	(0.0012)	(0.0012)	(0.0012)	(0.0012)
nbArticles$_t$						0.0133 ***	0.0198 ***	
						(0.0017)	(0.0026)	
nbArticles$_t^2$							-3.24E-04 ***	
							(8.00E-05)	
nbArtFirst$_t$	0.0414 ***	0.0414 ***	0.0395 ***	0.0396 ***	0.0380 ***			0.0378 ***
	(0.0056)	(0.0056)	(0.0050)	(0.0050)	(0.0058)			(0.0058)
nbArtLast$_t$	0.0074 ***	0.0072 ***	0.0085 ***	0.0087 ***	0.0092 ***			0.0094 ***
	(0.0025)	(0.0026)	(0.0028)	(0.0028)	(0.0029)			(0.0030)
nbArtMiddle$_t$	0.0082 ***	0.0081 ***	0.0120 ***	0.0117 ***	0.0113 ***			0.0177 ***
	(0.0022)	(0.0022)	(0.0021)	(0.0021)	(0.0023)			(0.0038)
nbArtMiddle$_t^2$								-5.50E-04 **
								(2.40E-04)
propArtFirst$_t$							0.0902 ***	
							(0.0213)	
propArtMiddle$_t$							-0.0066	
							(0.0149)	
ImpactFact5$_t$	0.2752 ***	0.2750 ***	0.2628 ***	0.2634 ***	0.2749 ***	0.2757 ***	0.2742 ***	0.2747 ***
	(0.0061)	(0.0061)	(0.0054)	(0.0054)	(0.0062)	(0.0062)	(0.0062)	(0.0062)
avgAuthors$_t$	0.2220 ***	0.2221 ***	0.1821 ***	0.2051 ***	0.2019 ***	0.1948 ***	0.2080 ***	0.1989 ***
	(0.0094)	(0.0094)	(0.0086)	(0.0099)	(0.0101)	(0.0096)	(0.0105)	(0.0102)
dFemale	0.2529 ***	0.2518 ***	0.0044	0.1489 ***	0.1694 ***	0.1737 ***	0.1380 ***	0.1689 ***
	(0.0405)	(0.0413)	(0.0116)	(0.0316)	(0.0342)	(0.0326)	(0.0368)	(0.0342)
dFemale x avgPubFundO3$_t$	-0.0037	-0.0017						
	(0.0026)	(0.0099)						
dFemale x avgPubFundO3$_t^2$		-1.74E-04						
		(8.32E-04)						
dFemale x avgPrivFundO3$_t$	2.99E-04	3.27E-04		2.80E-04	3.19E-04	1.11E-04	9.70E-05	3.79E-04
	(0.0022)	(0.0022)		(0.0022)	(0.0022)	(0.0022)	(0.0022)	(0.0022)

Health	OLS(1)	OLS(2)	IV(3)	IV(4)	IV(5)	IV(6)	IV(7)	IV(8)
dFemale x $avgPhilFundO3_t$	-0.0002	-0.0002		-0.0028	-0.0026	-0.0028	-0.0025	-0.0024
	(0.0019)	(0.0019)		(0.0019)	(0.0020)	(0.0020)	(0.0020)	(0.0020)
dFemale x $nbArticles_t$						0.0013	0.0150 **	
						(0.0034)	(0.0075)	
dFemale x $nbArticles_t^2$							-0.0014 **	
							(5.38E-04)	
dFemale x $nbArtFirst_t$	-0.0049	-0.0050			0.0062			0.0067
	(0.0112)	(0.0112)			(0.0116)			(0.0116)
dFemale x $nbArtLast_t$	-0.0045	-0.0044			-0.0021			-0.0025
	(0.0061)	(0.0062)			(0.0061)			(0.0061)
dFemale x $nbArtMiddle_t$	0.0040	0.0041			0.0014			1.63E-04
	(0.0049)	(0.0049)			(0.0049)			(0.0097)
dFemale x $nbArtMiddle_t^2$								-1.69E-04
								(0.0011)
dFemale x $propArtFirst_t$							0.0176	
							(0.0339)	
dFemale x $propArtMiddle_t$							0.0242	
							(0.0263)	
dFemale x $ImpactFact5_t$	-0.0438 ***	-0.0437 ***			-0.0443 ***	-0.0450 ***	-0.0447 ***	-0.0441 ***
	(0.0119)	(0.0119)			(0.0121)	(0.0121)	(0.0120)	(0.0120)
dFemale x $avgAuthors_t$	-0.0965 ***	-0.0966 ***		-0.0778 ***	-0.0619 ***	-0.0619 ***	-0.0647 ***	-0.0606 ***
	(0.0179)	(0.0179)		(0.0166)	(0.0184)	(0.0173)	(0.0192)	(0.0187)
Constant	-0.1077 ***	-0.1059 ***	-0.0716	-0.1136 **	-0.1213 ***	-0.0870 *	-0.1569 ***	-0.1320 ***
	(0.0237)	(0.0239)	(0.0456)	(0.0463)	(0.0464)	(0.0459)	(0.0481)	(0.0458)
Year dummies	yes	yes	yes	yes	yes	yes	yes	yes
University dummies	yes	yes	yes	yes	yes	yes	yes	yes
Nb observations	11886	11886	11080	11080	11080	11080	11080	11080
Nb academics	1606	1606	1591	1591	1591	1591	1591	1591
χ^2	4328.6	4328.32	4114.19	4142.64	4157.08	4103.93	4196.57	4164.74
Avg number of years	7.401	7.401	6.96417	6.96417	6.96417	6.96417	6.96417	6.96417
R^2 within	0.229798	0.22975	0.227629	0.229279	0.230774	0.228646	0.233173	0.231133
R^2 overall	0.309149	0.309252	0.303806	0.30539	0.306207	0.301293	0.308891	0.307247
R^2 between	0.438353	0.438378	0.444845	0.442026	0.435908	0.426029	0.439286	0.437893

Table 4 – Regression results – NSE fields (*, **, * show significance at the 1%, 5% and 10% level respectively, standard errors in parentheses)**

NSE	OLS(1)	OLS(2)	IV(3)	IV(4)	IV(5)	IV(6)	IV(7)	IV(8)
$\ln(avgPubFundO3_t)$	0.0077 ***	-0.0059	0.0140 *	0.0144 **	0.0149 **	0.0126 *	0.0136 *	0.0144 **
	(0.0018)	(0.0062)	(0.0072)	(0.0072)	(0.0072)	(0.0072)	(0.0072)	(0.0072)
$\ln(avgPubFundO3_t)2$		0.0011 **						
		(5.00E-04)						
$\ln(avgPrivFundO3_t)$	-0.0007	-0.0013	-0.0021 *	-0.0022 *	-0.0022 *	-0.0017	-0.0020	-0.0023 *
	(0.0010)	(0.0011)	(0.0012)	(0.0013)	(0.0013)	(0.0013)	(0.0013)	(0.0013)
$\ln(avgPhilFundO3_t)$	0.0017	0.0013	0.0023 **	0.0015	0.0015	0.0018	0.0013	0.0013
	(0.0011)	(0.0011)	(0.0011)	(0.0012)	(0.0012)	(0.0012)	(0.0012)	(0.0012)
$nbArticles_t$						0.0072 ***	0.0203 ***	
						(0.0014)	(0.0022)	
$nbArticles_t^2$							-3.67E-04 ***	
							(4.24E-05)	
$nbArtFirst_t$	0.0462 ***	0.0461 ***	0.0434 ***	0.0434 ***	0.0417 ***			0.0419 ***
	(0.0049)	(0.0049)	(0.0047)	(0.0047)	(0.0051)			(0.0050)
$nbArtLast_t$	0.0177 ***	0.0168 ***	0.0194 ***	0.0194 ***	0.0185 ***			0.0181 ***
	(0.0022)	(0.0022)	(0.0024)	(0.0024)	(0.0025)			(0.0025)
$nbArtMiddle_t$	-0.0018	-0.0019	-0.0014	-0.0014	-0.0022			0.0058 **
	(0.0016)	(0.0016)	(0.0016)	(0.0016)	(0.0017)			(0.0029)
$nbArtMiddle_t^2$								-1.64E-04 ***
								(4.80E-05)
$propArtFirst_t$							0.0705 ***	
							(0.0156)	
$propArtMiddle_t$							-0.0071	
							(0.0125)	
$ImpactFact5_t$	0.2804 ***	0.2795 ***	0.2742 ***	0.2742 ***	0.2757 ***	0.2751 ***	0.2765 ***	0.2761 ***
	(0.0074)	(0.0074)	(0.0072)	(0.0072)	(0.0078)	(0.0078)	(0.0078)	(0.0078)
$avgAuthors_t$	0.1692 ***	0.1675 ***	0.1754 ***	0.1776 ***	0.1787 ***	0.1475 ***	0.1628 ***	0.1732 ***
	(0.0086)	(0.0086)	(0.0083)	(0.0087)	(0.0088)	(0.0083)	(0.0090)	(0.0090)
dFemale	0.0894	0.0936	-0.0183	-0.0093	-0.0091	-0.0085	-0.0206	-0.0146
	(0.0601)	(0.0628)	(0.0161)	(0.0339)	(0.0422)	(0.0391)	(0.0433)	(0.0422)
dFemale x $avgPubFundO3_t$	-0.0062	-0.0115						
	(0.0046)	(0.0164)						
dFemale x $avgPubFundO3_t^2$		4.60E-04						
		(0.0013)						
dFemale x $avgPrivFundO3_t$	-1.54E-04	-2.87E-04		8.47E-04	7.80E-05	-3.92E-04	-1.13E-04	5.90E-05
	(0.0028)	(0.0029)		(0.0028)	(0.0029)	(0.0029)	(0.0029)	(0.0029)

NSE	OLS(1)	OLS(2)	IV(3)	IV(4)	IV(5)	IV(6)	IV(7)	IV(8)
dFemale x avgPhilFundO3$_t$	0.0043	0.0044		0.0051 *	0.0048 *	0.0044	0.0046 *	0.0046 *
	(0.0027)	(0.0027)		(0.0028)	(0.0028)	(0.0028)	(0.0028)	(0.0028)
dFemale x nbArticles$_t$						0.0111 **	0.0131 **	
						(0.0043)	(0.0063)	
dFemale x nbArticles$_t^2$							-3.41E-04	
							(2.14E-04)	
dFemale x nbArtFirst$_t$	0.0175	0.0185			0.0157			0.0168
	(0.0138)	(0.0138)			(0.0141)			(0.0141)
dFemale x nbArtLast$_t$	0.0080	0.0074			0.0108			0.0112
	(0.0073)	(0.0074)			(0.0074)			(0.0074)
dFemale x nbArtMiddle$_t$	0.0100 *	0.0097 *			0.0093 *			0.0118
	(0.0056)	(0.0056)			(0.0056)			(0.0084)
dFemale x nbArtMiddle$_t^2$								-2.32E-04
								(2.25E-04)
dFemale x propArtFirst$_t$							0.0135	
							(0.0376)	
dFemale x propArtMiddle$_t$							-0.0095	
							(0.0320)	
dFemale x ImpactFact5$_t$	-0.0189	-0.0189			-0.0109	-0.0095	-0.0101	-0.0105
	(0.0191)	(0.0191)			(0.0199)	(0.0200)	(0.0199)	(0.0199)
dFemale x avgAuthors$_t$	-0.0481 *	-0.0487 **		-0.0185	-0.0311	-0.0317	-0.0226	-0.0285
	(0.0247)	(0.0248)		(0.0217)	(0.0253)	(0.0233)	(0.0256)	(0.0253)
Constant	-0.0883 ***	-0.0725 ***	-0.2636 ***	-0.2676 ***	-0.2729 ***	-0.1949 ***	-0.2628 ***	-0.2680 ***
	(0.0262)	(0.0271)	(0.0690)	(0.0691)	(0.0689)	(0.0703)	(0.0699)	(0.0689)
Year dummies	yes	yes	yes	yes	yes	yes	yes	yes
University dummies	yes	yes	yes	yes	yes	yes	yes	yes
Nb observations								
	12390	12390	11534	11534	11534	11534	11534	11534
Nb academics	1774	1774	1760	1760	1760	1760	1760	1760
χ^2	2696.89	2707.47	2739.55	2741.9	2753.78	2570.75	2784.41	2789.89
Avg number of years	6.98422	6.98422	6.55341	6.55341	6.55341	6.55341	6.55341	6.55341
R^2 within	0.131986	0.131484	0.145021	0.145139	0.145017	0.145155	0.146	0.145038
R^2 overall	0.231323	0.232734	0.237996	0.238097	0.238687	0.222593	0.2397	0.241778
R^2 between	0.359125	0.362539	0.354051	0.354069	0.355993	0.321945	0.3585	0.362239

Table 5 – Regression results – Health fields (*, **, * show significance at the 1%, 5% and 10% level respectively, standard errors in parentheses)**

Health	OLS(F1)	OLS(F2)	IV(F3)	IV(F4)	IV(F5)	IV(F6)	IV(F7)	IV(F8)
ln(avgPubFundO3$_t$)	0.0017	0.0012	-4.36E-04	-0.0011	-0.0016	-0.0042	-0.0036	-0.0015
	(0.0013)	(0.0050)	(0.0049)	(0.0049)	(0.0049)	(0.0047)	(0.0051)	(0.0049)
ln(avgPubFundO3$_t$)2		4.30E-05						
		(4.12E-04)						
ln(avgPrivFundO3$_t$)	0.0018 *	0.0018 *	0.0016 *	0.0014	0.0014	0.0014	0.0013	0.0014
	(0.0010)	(0.0010)	(9.21E-04)	(0.0010)	(0.0010)	(0.0010)	(0.0010)	(0.0010)
ln(avgPhilFundO3$_t$)	-6.37E-04	-6.49E-04	-2.94E-04	4.84E-04	3.96E-04	6.47E-04	4.52E-04	3.79E-04
	(0.0010)	(0.0010)	(0.0010)	(0.0012)	(0.0012)	(0.0012)	(0.0012)	(0.0012)
fracArticles$_t$						0.0694 ***	0.1136 ***	
						(0.0072)	(0.0149)	
fracArticles$_t^2$							-0.0128 ***	
							(0.0031)	
fracArtFirst$_t$	0.0879 ***	0.0878 ***	0.0935 ***	0.0946 ***	0.0845 ***			0.0842 ***
	(0.0110)	(0.0110)	(0.0103)	(0.0103)	(0.0114)			(0.0114)
fracArtLast$_t$	0.0558 ***	0.0556 ***	0.0513 ***	0.0537 ***	0.0594 ***			0.0589 ***
	(0.0098)	(0.0099)	(0.0106)	(0.0106)	(0.0114)			(0.0114)
fracArtMiddle$_t$	0.0471 ***	0.0470 ***	0.0527 ***	0.0520 ***	0.0593 ***			0.0668 ***
	(0.0136)	(0.0136)	(0.0129)	(0.0129)	(0.0147)			(0.0209)
fracArtMiddle$_t^2$								-0.0067
								(0.0127)
propfracArtFirst$_t$							0.0530 ***	
							(0.0193)	
propfracArtMiddle$_t$							-0.0037	
							(0.0143)	
ImpactFact5$_t$	0.2740 ***	0.2740 ***	0.2608 ***	0.2614 ***	0.2733 ***	0.2739 ***	0.2731 ***	0.2733 ***
	(0.0061)	(0.0061)	(0.0054)	(0.0054)	(0.0062)	(0.0062)	(0.0062)	(0.0062)
avgAuthors$_t$	0.2451 ***	0.2451 ***	0.2093 ***	0.2348 ***	0.2297 ***	0.2276 ***	0.2413 ***	0.2294 ***
	(0.0094)	(0.0094)	(0.0084)	(0.0098)	(0.0099)	(0.0096)	(0.0104)	(0.0099)
dFemale	0.2526 ***	0.2531 ***	0.0080	0.1656 ***	0.1818 ***	0.1975 ***	0.1464 ***	0.1819 ***
	(0.0414)	(0.0424)	(0.0115)	(0.0317)	(0.0358)	(0.0353)	(0.0407)	(0.0359)
dFemale x avgPubFundO3$_t$	-0.0029	-0.0033						
	(0.0025)	(0.0098)						
dFemale x avgPubFundO3$_t^2$		3.50E-05						
		(8.25E-04)						
dFemale x avgPrivFundO3$_t$	0.0006	5.87E-04		0.0004	0.0007	4.02E-04	3.38E-04	6.63E-04
	(0.0021)	(0.0021)		(0.0022)	(0.0022)	(0.0022)	(0.0022)	(0.0022)

Health	OLS(F1)	OLS(F2)	IV(F3)	IV(F4)	IV(F5)	IV(F6)	IV(F7)	IV(F8)
dFemale x avgPhilFundO3$_t$	-7.00E-05	-8.40E-05		-0.0025	-0.0022	-0.0025	-0.0024	-0.0022
	(0.0019)	(0.0019)		(0.0019)	(0.0019)	(0.0019)	(0.0020)	(0.0019)
dFemale x fracArticles$_t$						-0.0069	0.0487	
						(0.0145)	(0.0315)	
dFemale x fracArticles$_t^2$							-0.0236 **	
							(0.0095)	
dFemale x fracArtFirst$_t$	0.0317	0.0316			0.0537 **			0.0539 **
	(0.0262)	(0.0262)			(0.0272)			(0.0272)
dFemale x fracArtLast$_t$	-0.0300	-0.0303			-0.0245			-0.0245
	(0.0224)	(0.0229)			(0.0226)			(0.0227)
dFemale x fracArtMiddle$_t$	-0.0140	-0.0141			-0.0287			-0.0295
	(0.0272)	(0.0273)			(0.0276)			(0.0401)
dFemale x fracArtMiddle$_t^2$								3.43E-04
								(0.0268)
dFemale x propfracArtFirst$_t$							0.0509	
							(0.0312)	
dFemale x propfracArtMiddle$_t$							0.0207	
							(0.0255)	
dFemale x ImpactFact5$_t$	-0.0451 ***	-0.0451 ***			-0.0459 ***	-0.0452 ***	-0.0467 ***	-0.0459 ***
	(0.0119)	(0.0119)			(0.0121)	(0.0120)	(0.0120)	(0.0121)
dFemale x avgAuthors$_t$	-0.0937 ***	-0.0938 ***		-0.0860 ***	-0.0619 ***	-0.0707 ***	-0.0624 ***	-0.0619 ***
	(0.0179)	(0.0179)		(0.0166)	(0.0184)	(0.0176)	(0.0192)	(0.0184)
Constant	-0.1497 ***	-0.1493 ***	-0.1287 ***	-0.1730 ***	-0.1772 ***	-0.1565 ***	-0.2085 ***	-0.1784 ***
	(0.0241)	(0.0243)	(0.0434)	(0.0440)	(0.0442)	(0.0426)	(0.0456)	(0.0441)
Year dummies	yes	yes	yes	yes	yes	yes	yes	yes
University dummies	yes	yes	yes	yes	yes	yes	yes	yes
Nb observations	11886	11886	11080	11080	11080	11080	11080	11080
Nb academics	1606	1606	1591	1591	1591	1591	1591	1591
χ^2	4380.09	4379.7	4136.13	4170.79	4192.57	4161.38	4233.45	4191.42
Avg number of years	7.401	7.401	6.96417	6.96417	6.96417	6.96417	6.96417	6.96417
R^2 within	0.230523	0.230513	0.227268	0.229113	0.23106	0.229704	0.234099	0.231102
R^2 overall	0.312639	0.312658	0.306572	0.308593	0.309611	0.306827	0.311376	0.309656
R^2 between	0.445228	0.445172	0.45354	0.450719	0.443942	0.43884	0.44563	0.443998

Table 6 – Regression results – NSE fields (*, **, * show significance at the 1%, 5% and 10% level respectively, standard errors in parentheses)**

NSE	OLS(F1)	OLS(F2)	IV(F3)	IV(F4)	IV(F5)	IV(F6)	IV(F7)	IV(F8)
$\ln(avgPubFundO3_t)$	0.0073 ***	-0.0041	0.0086	0.0089	0.0093	0.0078	0.0079	0.0092
	(0.0018)	(0.0062)	(0.0071)	(0.0071)	(0.0071)	(0.0070)	(0.0071)	(0.0071)
$\ln(avgPubFundO3_t)2$		9.63E-04 *						
		(5.01E-04)						
$\ln(avgPrivFundO3_t)$	-0.0007	-0.0012	-0.0017	-0.0017	-0.0016	-0.0017	-0.0016	-0.0017
	(0.0010)	(0.0011)	(0.0012)	(0.0013)	(0.0013)	(0.0013)	(0.0013)	(0.0013)
$\ln(avgPhilFundO3_t)$	0.0015	0.0012	0.0025 **	0.0017	0.0017	0.0017	0.0017	0.0018
	(0.0011)	(0.0011)	(0.0011)	(0.0012)	(0.0012)	(0.0012)	(0.0012)	(0.0012)
$fracArticles_t$						0.0576 ***	0.1050 ***	
						(0.0052)	(0.0097)	
$fracArticles_t^2$							-0.0099 ***	
							(0.0016)	
$fracArtFirst_t$	0.0769 ***	0.0767 ***	0.0745 ***	0.0747 ***	0.0721 ***			0.0720 ***
	(0.0087)	(0.0087)	(0.0088)	(0.0088)	(0.0092)			(0.0092)
$fracArtLast_t$	0.0494 ***	0.0475 ***	0.0568 ***	0.0566 ***	0.0530 ***			0.0528 ***
	(0.0063)	(0.0064)	(0.0067)	(0.0067)	(0.0069)			(0.0069)
$fracArtMiddle_t$	0.0478 ***	0.0458 ***	0.0541 ***	0.0540 ***	0.0503 ***			0.0583 ***
	(0.0113)	(0.0114)	(0.0113)	(0.0113)	(0.0120)			(0.0154)
$fracArtMiddle_t^2$								-0.0074
								(0.0089)
$propfracArtFirst_t$							0.0512 ***	
							(0.0148)	
$propfracArtMiddle_t$							2.40E-05	
							(0.0123)	
$ImpactFact5_t$	0.2795 ***	0.2787 ***	0.2749 ***	0.2749 ***	0.2765 ***	0.2768 ***	0.2763 ***	0.2765 ***
	(0.0074)	(0.0074)	(0.0072)	(0.0072)	(0.0078)	(0.0078)	(0.0077)	(0.0078)
$avgAuthors_t$	0.1722 ***	0.1704 ***	0.1792 ***	0.1813 ***	0.1801 ***	0.1774 ***	0.1908 ***	0.1797 ***
	(0.0079)	(0.0080)	(0.0076)	(0.0080)	(0.0081)	(0.0078)	(0.0085)	(0.0081)
dFemale	0.0591	0.0635	-0.0142	-0.0034	-0.0371	-0.0378	-0.0399	-0.0377
	(0.0600)	(0.0631)	(0.0159)	(0.0336)	(0.0427)	(0.0419)	(0.0478)	(0.0427)
dFemale x $avgPubFundO3_t$	-0.0059	-0.0106						
	(0.0046)	(0.0164)						
dFemale x $avgPubFundO3_t^2$		0.0004						
		(0.0013)						
dFemale x $avgPrivFundO3_t$	-0.0006	-0.0007		0.0002	-0.0007	-5.96E-04	-2.59E-04	-6.84E-04
	(0.0028)	(0.0029)		(0.0028)	(0.0029)	(0.0028)	(0.0028)	(0.0029)

NSE	OLS(F1)	OLS(F2)	IV(F3)	IV(F4)	IV(F5)	IV(F6)	IV(F7)	IV(F8)
dFemale x avgPhilFundO3$_t$	0.0041	0.0042		0.0049 *	0.0043	0.0043	0.0047	0.0043
	(0.0027)	(0.0027)		(0.0027)	(0.0028)	(0.0028)	(0.0028)	(0.0028)
dFemale x fracArticles$_t$						0.0389 **	0.0430	
						(0.0160)	(0.0337)	
dFemale x fracArticles$_t^2$							-0.0066	
							(0.0089)	
dFemale x fracArtFirst$_t$	0.0381	0.0392			0.0318			0.0335
	(0.0286)	(0.0286)			(0.0296)			(0.0296)
dFemale x fracArtLast$_t$	0.0335	0.0325			0.0441 **			0.0437 **
	(0.0208)	(0.0210)			(0.0212)			(0.0212)
dFemale x fracArtMiddle$_t$	0.0234	0.0227			0.0344			0.0473
	(0.0324)	(0.0326)			(0.0327)			(0.0458)
dFemale x fracArtMiddle$_t^2$								-0.0117
								(0.0294)
dFemale x propfracArtFirst$_t$							0.0237	
							(0.0358)	
dFemale x propfracArtMiddle$_t$							-0.0209	
							(0.0315)	
dFemale x ImpactFact5$_t$	-0.0186	-0.0186			-0.0113	-0.0112	-0.0114	-0.0116
	(0.0191)	(0.0191)			(0.0199)	(0.0199)	(0.0199)	(0.0199)
dFemale x avgAuthors$_t$	-0.0207	-0.0216		-0.0181	-0.0049	-0.0047	0.0042	-0.0054
	(0.0229)	(0.0230)		(0.0216)	(0.0232)	(0.0223)	(0.0241)	(0.0233)
Constant	-0.1002 ***	-0.0862 ***	-0.2332 ***	-0.2369 ***	-0.2375 ***	-0.2210 ***	-0.2768 ***	-0.2374 ***
	(0.0262)	(0.0272)	(0.0672)	(0.0672)	(0.0672)	(0.0657)	(0.0668)	(0.0671)
Year dummies	yes	yes	yes	yes	yes	yes	yes	yes
University dummies	yes	yes	yes	yes	yes	yes	yes	yes
Nb observations	12390	12390	11534	11534	11534	11534	11534	11534
Nb academics	1774	1774	1760	1760	1760	1760	1760	1760
χ^2	2699.85	2706.83	2778.61	2781.07	2792.31	2791.49	2892.78	2892.78
Avg number of years	6.98422	6.98422	6.55341	6.55341	6.55341	6.55341	6.55341	6.55341
R^2 within	0.132398	0.131972	0.147461	0.147645	0.147802	0.147677	0.1511	0.14779
R^2 overall	0.231494	0.232551	0.241062	0.241253	0.241789	0.242371	0.2485	0.242042
R^2 between	0.357828	0.360387	0.355453	0.355603	0.35744	0.357485	0.3689	0.357931