Research Policy xxx (2016) xxx–xxx

Contents lists available at ScienceDirect

Research Policy

journal homepage: www.elsevier.com/locate/respol

Which gender gap? Factors affecting researchers' scientific impact in science and medicine

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ARTICLE INFO

Article history:
Received 25 February 2015
Received in revised form 13 March 2016
Accepted 23 May 2016
Available online xxx

Keywords:
Gender
Scientific production
Citations
Research funding
Impact Factor

ABSTRACT

The article examines whether scientific production, research funding, Impact Factor of journals and size of collaborative teams have an influence on the propensity to receive more citations, and whether the influence of these factors differs across genders. Using a very complete database of funding, scientific papers and citations compiled at the individual researchers' level, we estimate panel data regressions on the discipline-normalised citation rates of individual academics in Quebec. Our results show that although most of the indicators examined have a positive influence on the relative citation rate, when it comes to gender differences, not having enough public funding and raising private funding appear slightly detrimental for women in the health sciences. In addition, when women collaborate with the same number of co-authors as men, or target similar Impact Factor journals, their articles are less cited then those of their male colleagues. Almost no gender effect is found in the natural sciences and engineering where women are still a minority. Our results worryingly show that academics who publish with a larger proportion of female co-authors are less cited. Furthermore, when targeting similar Impact Factor journals, researchers who collaborate with a higher proportion of female co-authors are consistently less cited in both the health and NSE fields than if they were publishing with a male dominated group of co-authors.

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), countries, collaborative practices as 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" (1998:863). On these inequalities noted regarding access to research funding and equipment, 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). Although the literature on scientific production is extensive and covers 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.

This paper aims to provide a more complete portrait of the performance of women—including both the inputs and outputs of research—, 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 women accounting for 14.7% of Quebec researchers in the natural sciences and engineering fields, and 26.8% of Quebec researchers in the health fields, 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. Similar trends are observed for other Canadian provinces. In fact, the highest the academic rank, the lowest is

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http://dx.doi.org/10.1016/j.respol.2016.05.009
0048-7333/

the proportion of women in academia. Although we acknowledge the rarity of women in science in Quebec and their slightly inferior scientific performance, both in terms of funding received and published outputs, our goal is to try to elucidate where the discrepancies are (in terms of funding, scientific production, Impact Factor and co-authorship), to explain the differences in impact (using the data available).

A large part of the literature on women in science tends to be bibliometric based. In this paper, we build on this literature and use classic bibliometric indicators as dependent and explanatory variables in econometric models. Using panel data to account for the evolution of the various attributes, we are able to establish the incidence of all of these factors on scientific impact, something that bibliometric methods 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, as it was not possible to obtain such information through available data sources. Our approach is therefore somewhat exploratory because we do not have access to data related to maternity leave, parenthood, academic rank, and so on.

Our results show that the visibility accrued by a greater number of articles published, regardless of author rank, publishing in higher Impact Factor journals and collaborating with a greater number of co-authors all have positive effect on the relative citation rate. In contrast, funding has a mitigated effect. Regarding gender differences, not having enough public funding and raising private funding is detrimental for female health scientists. In addition, when women collaborate with the same number of co-authors as men, or target similar Impact Factor journals, their articles are less cited then those of their male colleagues. Almost no gender differences are found in the natural sciences and in engineering where women are still a minority. More worrying is the fact that our results show that researchers who publish with a larger proportion of female co-authors are less cited. Furthermore, when targeting similar Impact Factor journals, researchers who collaborate with a higher proportion of female co-authors are consistently less cited in both the health and NSE fields then if they were co-authoring with a lesser proportion of women. This last result is a worrying trend that suggests systematic gender discrimination.

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 discusses the descriptive statistics of the main variables used in the regression models that are presented and analysed in Section 5; Section 6 examines the results in light of the proposed hypotheses; Finally, Section 7 discusses the implication of the results and concludes.

2. Theoretical framework

Many scholars have examined the gender differences in research output and scientific impact. Despite their different methods, 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; Zuckerman, 1991); a phenomenon that Cole and Zuckerman (1984) refer to as "the productivity puzzle". For instance, a 20–30% difference in terms of research production has been measured in favour of men (Prpić, 2002; Xie and Shauman, 1998, 2003), but the gap is closing as the number of women in science increases (Xie and Shauman, 1998; Abramo et al., 2009). In Croatia, however, the productivity gap is increasing (Prpić, 2002). It is generally accepted that this lower scientific productivity is widespread and observed across countries, although it varies across disciplines (Larivière et al., 2013) and is somewhat smaller than what is often 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 was found in the health sciences (0.25 articles) and in physics (0.20 articles). In Canada, Nakhaie (2002) found that the factors that explain why Canadian women publish less than men are seniority, discipline, type of institution and time devoted to research.

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 as the discipline and country of focus. The scientific impact of women's papers is either similar (Gonzalez-Brambila and Veloso, 2007; Lewison, 2001; Long and Fox, 1995; Mauleón and Bordons, 2006), superior (Bordons et al., 2003; Long, 1992) or lower (Knobloch-Westerwick and Glynn, 2013; Larivière et al., 2013; Maliniak et al., 2013; Peñas and Willett, 2006) than that of their male colleagues. 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 et al., 1992), which may explain the differences if the number of citations is calculated up to a specific number of years after publication. Despite the mixed evidence, our first hypothesis stems from this last observation:

H1. Female academics are generally less cited than men.

The first factor that may explain why women are less cited is their lower scientific production. 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). Larivière et al. (2013) found that gender affects the visibility of research output and demonstrated that women in dominant authorship positions (e.g. first or last author) receive fewer citations than their male colleagues. 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 obtain more citations (Aksnes et al., 2011). 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 Matilda effect (Rossiter, 1993). Long (1992) similarly argued 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, 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 second hypothesis reflects the fact that less productive scientists, because

Please cite this article in press as: Beaudry, C., Larivière, V., Which gender gap? Factors affecting researchers' scientific impact in science and medicine. Res. Policy (2016), http://dx.doi.org/10.1016/j.respol.2016.05.009