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The gender gap in early career transitions in the life sciences☆

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ABSTRACT

We examined the extent to which and why early career transitions have led to women being underrepresented among faculty in the life sciences. We followed the careers of 6,336 scientists from the post-doctoral fellowship stage to becoming a principal investigator (PI) – a critical transition in the academic life sciences. Using a unique dataset that connects individuals' National Institutes of Health funding histories to their publication records, we found that a large portion of the overall gender gap in the life sciences emerges at this transition. Women become PIs at a 20% lower rate than men. Differences in "productivity" (publication records) can explain about 60% of this differential. The remaining portion appears to stem from gender differences in the returns to similar publication records, with women receiving less credit for their citations.

1. Introduction

Despite a narrowing of the gender gap, women remain underrepresented in the science, technology, engineering, and mathematics (STEM) academic labor force. According to the National Science Foundation, women earn about half of the doctoral degrees in science, yet represent a mere 22% of the faculty at the full professor level at Research I institutions in the United States (NSF, 2015). This continuing gap, in part, reflects the fact that many of today's senior faculty received their degrees thirty or more years ago. But that fact alone cannot account for this gap. Thirty years ago, women already accounted for more than 30% of doctoral degrees earned in the life sciences (Hill et al., 2010).

In attempting to explain this gap, a large body of research has documented that women produce less measurable output than men. Women, for example, publish fewer papers (Cole and Zuckerman, 1984; Long, 1992; Xie and Shauman, 1998), the papers that they publish appear in less prominent journals (Brooks et al., 2014; Lerchenmüller et al., 2018) and receive fewer citations (Larivière et al., 2013; King et al., 2016), and women receive the prestigious first and last authorships on co-authored articles less often (West et al., 2013; Filardo et al., 2016). Although these differences in publication records may themselves stem from factors such as discrimination, disparity in the time spent on childcare, or insufficient mentoring, to the extent that these elements of the research record factor into hiring, promotion, and funding decisions, one would expect fewer women to attain and retain faculty positions. But, even when men and women have equivalent research records, a parallel literature, based primarily on audit studies, suggests that hiring and promotion committees still prefer men over women (Steinpreis et al., 1999; Moss-Racusin et al., 2012).

We extend this literature on the gender gap in STEM faculty by examining the extent to which disparate publication records versus differential returns to similar records account for a critical early career transition in the life sciences, from being a lab member to being a principal investigator (PI). Because researchers in the academic life sciences require substantial resources – equipment and personnel – for their research, acquiring these grants has effectively become a precursor to being viable for tenure at a research-oriented university (Jena et al., 2015).

This shift to analyzing the correlates of a critical career transition – as opposed to identifying cross-sectional differences between men and women in their publication records – forwards our theoretical understanding of the underrepresentation of women in STEM in at least two respects. Most importantly, it examines whether differential publication records could actually account for the gender gap. Most prior studies have not been capable of disentangling cause from effect. The gender gap at the faculty level might arise from women publishing fewer or less prominent papers (Xie and Shauman, 1998). But the direction of

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causality could run in the reverse direction: Women might have less impressive publication records because they have not had the time and resources for research that come from being senior faculty at research-oriented institutions (Merton, 1968).

Second, our approach allows us to isolate whether – and if so, where – men and women receive differential returns to their publication records. Although audit studies suggest that these differential returns exist (e.g., Moss-Racusin et al., 2012), because those studies, by design, hold constant all elements of the publication record, they cannot determine whether women receive less credit for some specific element of their research portfolios or whether the individuals evaluating applicants simply have a preference for candidates of a particular gender among those with equal qualifications.

Our analysis focuses on a set of similar men and women – those who had received a postdoctoral (F32) training grant from the National Institutes of Health (NIH). We examined the rates at which men and women funded by those grants transitioned to being independent researchers, becoming a PI on an NIH R01 grant, and the extent to which their publishing records could account for those transitions. We first document that the transition to being a PI on an R01 grant can explain a substantial share of the gender gap in the life sciences. Women experienced 20% lower rates of transition than men. We then explored what factors might account for this disparity. Adjusting flexibly for differences in publication records could explain about 60% of this gender gap. But even women with similar publication records received R01 grants at lower rates than men. We then examined the extent to which women might receive less credit for their publication records (differential returns). These differential returns, particularly in the extent to which women benefited from citations, could account for the remainder of the gap.

In addition to the theoretical implications of the results, our study also contributes empirically to the literature on the gender gap in STEM in at least two additional respects. First, most of the prior studies on gender differences in productivity have analyzed samples of scientists who received their doctoral degrees in the 1970s or earlier. We update these findings by studying a sample of scientists who received their degrees in the 1980s, 1990s, and 2000s, a period during which the gap between the numbers of men and women enrolled in doctoral programs in the life sciences closed (Hill et al., 2010).

Second, prior research has focused on the average differences in publication records and on the linear effects of those differences on pay or promotion. But many of the returns in science come from being in the right-hand tail, to being unusually productive or producing research of particular importance, to being perceived as a star (Merton, 1968). We therefore introduce an empirical approach that allows us to capture heterogeneity in the returns to the research record across the distribution of the various dimensions of that record. Doing so can explain a substantial amount of additional variance. But the gender gap in the transition to being a PI remains even allowing for these non-linearities.

2. Career transitions

In trying to understand why women remain underrepresented in STEM fields, researchers have commonly characterized the process as being similar to a pipeline with an almost continuous series of leaks (e.g., Berryman, 1983; Etzkowitz et al., 2000; Lautenberger et al., 2014). Although this view has been criticized as being overly linear and insufficiently sensitive to the importance of social context outside of school or the workplace (Xie and Shauman, 2003), research in this vein has usefully documented the fact that the proportion of women in STEM fields declines through the college years, during graduate school, and as one considers ever more senior positions in these fields (Berryman, 1983; Shen, 2013; Lautenberger et al., 2014). Recent research suggests that the gender gap in the pipeline emerges even before college, as high school students begin to form their career ambitions and expectations (Morgan et al., 2013; Legewie and DePrete, 2014).

However, this pipeline view obscures the fact that most of the loss of women appears to occur within a short segment of the career, and one relatively far down the line. Consider the academic life sciences, the largest among the STEM fields: Women have reached near parity in both of the primary paths for entry, having a medical degree or a doctorate in a life sciences field (Lautenberger et al., 2014; Shen, 2013). They still appear almost equally represented in residency and post-doctoral training positions in research laboratories (Lautenberger et al., 2014; NPA, 2011). Yet, women hold only 40% of assistant professorships and no more than 30% of associate professorships in the life sciences (Jena et al., 2015). Their underrepresentation in the field emerges in the space of only two to ten years out of a career of forty or more. Returning to the pipeline analogy, it is less that the pipe drips continuously along the way and more that it is gushing at one or two of the joints between segments.

Given this fact, we see value in shifting the focus of analysis to understanding these critical career transitions where the gap widens most rapidly – in this case, on the transition to becoming an independent researcher in the life sciences. Individuals who complete a relevant graduate degree – a medical degree (MD) or a doctorate (PhD) – first move into a junior faculty position, either directly or following post-doctoral training. Because of the increasingly expensive nature of research in the life sciences, junior faculty must then find a means of funding their research. That usually means winning a major grant. Those who fail to do so have low odds of securing long-term (tenured) academic positions.

One can readily see from the much lower proportion of women at the associate professor level relative to the assistant professor level that women clear these hurdles at lower rates. What might account for differences in the transition rates experienced by men versus by women? We focused on two potential disparities: differences in publication records and differences in the returns to those publication records.

2.1. The productivity paradox

In academia as in many other settings, productivity represents an important determinant not only of who gets hired but also of who gets promoted. Given the up-or-out nature of the tenure-track job ladder, moreover, it also determines who remains in academia.

Productivity in academia, particularly in the sciences, means publications. Much attention therefore has been given to gender differences in publication records, the so-called “productivity paradox” (Cole and Zuckerman, 1984). Women publish fewer articles than men (Cole and Zuckerman, 1984; Long, 1992; Stack, 2002), and place them in less prominent outlets (Brooks et al., 2014; Lerchenmüller et al., 2018). Articles written by women, moreover, receive fewer citations, an important metric used to assess the influence of scientific research (Larivière et al., 2013).

On the articles they do publish, women appear in less prestigious authorship positions (Jagsi et al., 2006; Filardo et al., 2016). In the life sciences, the first and last authorships carry particular prestige. By convention, the individual who led the research and who analyzed and wrote up the results receives the first authorship. Last authorship goes to the head of the laboratory, who often receives credit not just for funding the research but also for conceiving of it. Interior authorships, meanwhile, go to those who assisted with data collection or analysis. Although women have reached parity in their probability of appearing in the first author position (West et al., 2013), this average belies the fact that women remain less likely to receive this prime position on articles published in the most prestigious journals (Lerchenmüller et al., 2018).

Overall, the reasons for these “productivity” differences remain a puzzle. Women may suffer discrimination both in the research lab and in the publication process, with consequences for their publication records. They may also find themselves with less time for research, either