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## An advisor like me? Advisor gender and post-graduate careers in science

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### ABSTRACT

We investigate whether having an advisor of the same gender is correlated with the productivity of PhD science students and their propensity to stay in academic science. Our analysis is based on an original dataset – combined from dissertation abstracts, faculty directories and bibliometric data – covering nearly 20,000 PhD graduates and their advisors from U.S. chemistry departments. We find that students working with advisors of the same gender tend to be more productive during the PhD; and that female students working with female advisors are considerably more likely to become faculty themselves. We suggest that the under-representation of women in science and engineering faculty positions may perpetuate itself through the lower availability of same-gender advisors for female students.

### 1. Introduction

In the United States, women obtain half of all science and engineering degrees but remain underrepresented in science and engineering occupations. As of 2012, 50% of science and engineering bachelor's degrees in the United States were granted to women, but fewer than 30% of employed scientists and engineers were female (NSF, 2015). Only 20% of full science and engineering professors in U.S. universities and 4-year colleges are female (ibid.). The discrepancy between degrees and employment partly reflects demographic inertia, resulting from the past, when fewer women received science and engineering degrees (National Research Council, 2001; Hargens and Long, 2002). However, it is also driven by a greater propensity for women to leave science and engineering (Preston, 1994; Hunt, 2010).

The underrepresentation of women among science and engineering professors raise both equity and efficiency concerns. The view that men and women should be equally represented (or at a minimum that they have equal opportunities to enter) in high-status professions has gained widespread acceptance. It would particularly troubling if high exit rates of women from science and engineering were driven by unequal opportunities to succeed, or discriminatory treatment. On the efficiency side, women who leave science and engineering after completing a university degree are forgoing the returns of large human capital investments. More generally, if talent matters for the production of knowledge (Agarwal and Gaule, 2017), it is important for efficiency that talented women go to, and stay in, science and engineering. Hsieh et al. (2013) observe that there has been a large secular decline in the

barriers faced by women (and blacks) in the U.S. labor and education market. Based on the calibration of a Roy occupational choice model, they suggest that this decline explains 15% of the U.S. overall wage growth from 1960 to 2008.

In scientific fields where only a small minority of faculty members are female, most female students will be matched with an advisor of the opposite gender. This could contribute to a higher rate of exit for women (and hence to persistence in the underrepresentation of women in science) either through a *productivity* channel or a *preference* channel. It is possible that students may be less productive when working with an advisor of the opposite gender, for a broad set of reasons ranging from gender differences in communication and work strategies to gender-biased expectations regarding competence. The lower productivity of female scientists during graduate studies (Pezzoni et al., 2016) could then translate into higher exit rates. Alternatively (or additionally) students may have a preference for working with an advisor of the same gender. In that case, the PhD experience is less enjoyable for students with advisors of the opposite gender (Etzkowitz et al., 2000; Robinson, 2011), which could lead to higher drop-out after the PhD.

A natural starting point to understand the nexus between same-gender advisors, productivity and remaining in academia is to compare the career choices and research productivity of students with or without an advisor of their same gender. This is what we do in this paper. The results show that the research productivity during the PhD, and the propensity to become faculty after graduating, are both related to the gender of the advisor. Ideally, one would want to go one step further and identify whether these relations are driven by productivity effects

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stemming from interactions during the PhD, or by preference effects influencing the pairing of students with advisors. This is intrinsically difficult here, as the process by which students select advisors (or advisors select students) is not a random one. Moreover, students only do one PhD (mercifully perhaps) so there is little scope for the within-student comparisons that have often been used in the economics of education (Meghir and Rivkin, 2011). However – and we will expand this point later – we see these descriptive results as useful, as they imply that students whose gender is underrepresented among faculty members are less likely to remain in academia, even if the association between an advisor's gender and students' outcomes arise through sorting rather than a causal effect of same gender on productivity.

Our works sits at the confluence of two related literatures. On the one hand, there is a literature on the effect of instructor gender on student performance and major choices at the undergraduate level (Bettinger and Long, 2005; Hoffman and Oreopoulos, 2009; Carrell et al., 2010). Carrell et al. (2010) find that having a (randomly assigned) female instructor increases female students' performance in math and science courses, as well as the likelihood of graduating with a STEM degree. Results along similar lines, though quantitatively small, are reported in Bettinger and Long (2005) and Hoffmann and Oreopoulos (2009). On the other hand, a couple of papers investigate the link between having female dissertation chairs and initial placement for female students in economics at the PhD level. Neither Neumark and Gardecki (1998) nor Hilmer and Hilmer (2007) find any statistical difference between female students working with female advisors and female students working with male advisors in the field of economics.<sup>1</sup>

Relatively little work has been done on the advisor gender and student outcomes for STEM PhD students. One notable exception is a recent paper by Pezzoni et al. (2016) who study productivity (but not placement) differences among Caltech PhD graduates. They find that female students with female advisors are more productive than female students with male advisors; but male students with a female advisor are more productive than male students with a male advisor. The generalizability of these findings may be limited by the fact that they have only 25 female advisors in the sample, and all students come from a single elite institution.

This paper fills a gap in this literature by focusing on the relationship between the advisors' gender and the academic outcomes of PhD students in science. Both the subject (whether it is male-dominated, such as mechanical engineering, or more gender-balanced, such as social sciences) and the study level (high school, undergraduate or PhD) may be important mediators of the link between a professor's gender on students' outcomes. Our analysis is based on an original dataset covering nearly 20,000 PhD graduates and their advisors, from U.S. chemistry departments. We measure productivity during the PhD by a quality-weighted count of publications; and proxy remaining in academic science by the likelihood of becoming faculty in a U.S. PhD-granting chemistry department.<sup>2</sup> We regress these two outcomes on an indicator variable for having an advisor of the same gender. We do this separately for male and female students. The richness of our data allows us to control for a set of advisor characteristics, including age and productivity.

We first document that female students are considerably more likely to be advised by female advisors than male students. We then report that students with advisors of the same gender tend to be more productive during the PhD than students with advisors of the opposite gender. The difference is quantitatively modest (with point estimates corresponding to a difference between 10% and 20%) and is more robust for male students than for female students. However, we find

quantitatively large effects on placement limited to women: female students with female advisors are more than 50% more likely to become faculty themselves than female students with male advisors.<sup>3</sup>

In light of the literature on female instructors and STEM students, it seems plausible that having an advisor of the same gender may have a causal effect on graduate student productivity and the likelihood of becoming faculty. Alternatively the positive correlation between having a female advisor of the same gender and productivity/becoming faculty may reflect the sorting of more talented and academically oriented students to advisors of their same gender. In the latter case, one would expect that having more female faculty would enable departments to recruit more and better female doctoral students. While the relative importance of these “productivity” or “preference” effects of gender-pairing cannot be disentangled with our data, our results suggest that the underrepresentation of women among faculty members might influence the PhD experience of female students and might thus play a role in the propensity of female students to drop out of science and engineering.

The rest of this paper proceeds as follows. Section 2 briefly reviews the literature on the influence of gender on students' selection of a research team and on the quality of their PhD experience. Section 3 describes the data. Section 4 presents the empirical strategy and the findings. Section 5 concludes.

## 2. Framing the issue: how gender can influence students' doctoral experience and matching to research teams

How cognitive and behavioral differences between men and women intertwine with social forces to determine career outcomes is a subject of spirited debate (Carrell et al., 2010). Differences by gender in access to academic jobs are particularly large in science, and part of these differences might be rooted in early career choices, such as the selection of the research laboratory for the PhD. Several qualitative studies emphasize that male and female students often have different concerns and expectations as they approach their doctoral studies, and can be influenced by different factors when they decide which research team they want to join (Kemelgor and Etkowitz, 2001). When students choose their advisors and lab more generally, they may want to maximize their productivity and postgraduate scientific careers opportunities. But they may also value having a pleasant work experience during the PhD. Similarly, advisors are likely to select students they expect to be productive and with whom they have a good social affinity.

Faculty members play a critical role in the socialization process of PhD students and their development of feelings of belonging to academia (Sallee, 2014). During their training, students learn not only the direct knowledge related to their field, but also the culture and the behaviors associated with success in their particular sphere of academia, reformulating their self-image, attitudes, and expectations (Austin, 2002). Students who have positive relationships with their advisors have smoother trajectories through their graduate programs and develop higher expectations of success in academia (Golde, 1998). A caring and supportive advisor might be particularly important for young female scientists to acquire professional role confidence, defined as individuals' confidence in their ability to successfully fulfill the roles, competencies, and identity features of a profession (Cech et al., 2011). Using a longitudinal sample of engineering students, Cech et al. (2011) show that women's lack of this confidence, compared to men, reduces their likelihood of remaining in engineering majors and careers. Problematic relationships with advisors instead play a significant role in students' decisions to leave their doctoral programs and exit science (Golde, 2000). One of the largest qualitative reviews of the graduate experience in science was conducted by Etkowitz et al. (2000), who interviewed over

<sup>1</sup> Hale and Regev (2014) find that the share of female faculty is correlated with the share of female students in top economics PhD programs.

<sup>2</sup> The competition for faculty positions in chemistry is intense given that the number of doctoral students far exceeds the number of new faculty openings, and virtually all new faculty hires have been through several years of postdoctoral training. We estimate that fewer than 5% of chemistry PhD students of either gender eventually become faculty in a U.S. PhD-granting chemistry department.

<sup>3</sup> Only 2.8% of female doctoral students in our sample become faculty in a research-intensive U.S. chemistry department. Our point estimate for having a female advisor is 1.9 percentage point which corresponds to a 67% (= 1.9/2.8) relative increase. We conduct robustness checks using a broader definition of staying in academia.

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