Why so few? The gender representation gap in academic STEM fields, a system dynamics approach

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Extended abstract:

In a generation when more women than ever before have earned doctoral degrees in STEM (Science, Technology, Engineering, and Mathematics fields) (National Science Foundation, 2014); women continue being underrepresented in high-ranked academic positions. This is particularly the case when it comes to attaining full professorship roles (The World University Rankings, 2017). In the last few years, within STEM programs, only 34 percent of associate professors were women. What is more, women representation from associate to full professors has increased by no more than 25 percentage points (The World University Rankings, 2017), a number that brings awareness about a persistent gender representation gap in the high-ranked professorships in academic STEM fields. Despite broad recognition of this problem, our understanding of the reasons that derive to this source of gender inequality remains fragmented. For instance, whether women's lifestyle choices and their preference to stay or leave this career (Hunt, 2016; Seymour, Hewitt, & Friend, 1997) or to what extent gender bias holds women's career back (Moss-Racusin, Dovidio, Brescoll, Graham, & Handelsman, 2012; Reuben, Sapienza, & Zingales, 2014) is hard to say. As a consequence, policies to overcome the gender representation gap in STEM also seem to be challenging to articulate as well as easily replicate.

Despite the difficulties in understanding this gender representation gap, prior work has pointed out different factors that influence the leaky pipeline of women in STEM fields. Women's personal choices and career aspirations from major studies to faculty positions are important departure points (Cech & Blair-loy, 2019; Zeng & Xie, 2008). Furthermore, persistent gender bias, mainly, in male-typed jobs such as STEM can also be a determinant of the lack of women in high-ranked academic positions (Bornmann, Mutz, & Daniel, 2007; Moss-Racusin et al., 2012; Rivera & Tilcsik, 2019; Sheltzer & Smith, 2014; Tinkler, Bunker Whittington, Ku, & Davies, 2015). Even though these factors have been highly documented and addressed by prior studies as explanations of this gender representation gap, it remains unclear, which are the cause and effect. For example, gender bias towards women can explain in part why women receive fewer grants than men do (Bornmann et al., 2007; Faulkner, 2013; Oliveira, Ma, Woodruff, & Uzzi, 2019). Because women receive fewer grants than men, women's productivity is affected; this, in turn, negatively influence women's chances of getting promoted. Similarly, the work-family balance can affect women's attrition in academia, affecting as well women's representation in high-ranked positions in STEM (Cech & Blair-loy, 2019; Fox, 2005). Although prior work has made some effort in systematically examine, independently, the different factors that influence this gender representation gap, we lack a holistic perspective to examine the phenomenon (Diehl & Sterman, 1995; Lomi, Larsen, & Wezel, 2010; Morecroft et al., 1994). We propose, therefore, a systemic view of the most confounding factors and their interrelations over time to understand how these cause the gender representation gap in STEM fields. By providing this overarching perspective

of this gender gap over time, we can suggest interventions to address gender disparities and hopefully reduce not only the lack of women in high-ranked STEM positions but also other gender gaps.

Because STEM professions are abundant in human capital, the lack of well-trained and experienced women in the academic STEM workforce can be disadvantageous for both universities and the society in general. The reason behind this is that as prior research has shown, the increased representation of women in the workforce is associated with the generation of new ideas, and the enhancement of problem-solving skills (Hoffman & Maier, 1961; Phillips, Liljenquist, & Neale, 2009; Phillips, Northcraft, & Neale, 2006; Van Knippenberg, De Dreu, & Homan, 2004). Within STEM fields, for example, there is evidence suggesting that the lack of female researchers can be associated with under-explored diseases related to women and drug development efforts that ignore sex differences (Johnson, Fitzgerald, Salganicoff, Wood, & Goldstein, 2014; Koning, Samila, & Ferguson, 2019). These arguments suggest that increasing women's representation in academic STEM, especially at high-ranked positions and leveraging their human capital, can benefit individuals, organizations as well as communities and societies in general.

We link the different factors that influence the gender representation gap in academic STEM in a simple simulation model of the academic pipeline in STEM fields over time. According to the model, gender bias decreases women's chances of being hired as assistant professors as well as their opportunities to be promoted to associate or full professors. Besides, such bias can also affect women's odds of getting grants, which in turn directly affect their productivity and, therefore, their likelihood of being promoted. Because bias also affects women's assessment of their capacities, they may perceive themselves as less successful in getting grants, being hired, and getting promoted. This, in turn, affects their willingness to apply for faculty positions throughout all different stages of their career affecting, therefore, the gender representation gap. We also incorporate lifestyle choices like women's decision to stay or leave academia because of family constraints as well as the quality of the collaborators that faculty members have because this has been proved to influence men's and women's career outcomes. We simulate the behavior of the model over time under different experimental conditions and test its sensitivity to variations in assumptions about the expectation of the underlying mechanisms. We also conduct a sensitivity analysis combined with an extensive quasi-empirical investigation and show that both empirical estimates reported in studies on gender gaps and para estimate from synthetic data fall within the similarly defined range.

Our results show that the reduction of gender bias weakens the gender representation gap in academic STEM by 12% around 2040 as compared to 2010. Related to tenured positions, the reduction of such bias increases women's participation to 30% by 2040. This represents a reduction in the gender representation gap of 10%. Similarly, we also found that women's lifestyle choices, particularly their decision to stay or leave academia, also affect the gender representation gap. Even though these results are not the first in demonstrated how gender bias and attrition affect gender gaps (Cech & Blair-loy, 2019; Heilman, Wallen, Fuchs, & Tamkins, 2004; Hunter & Leahey, 2010; Moss-Racusin et al., 2012; Sheltzer & Smith, 2014), we build on extensive theories that have addressed gender gaps, and through these lenses, we expand our understanding of gender gaps in at least two ways. First, we demonstrate that, indeed, gender bias and attrition play a central role in the gender representation gap in academic STEM fields over time. However, the improvement in both aspects does not guarantee that this gap can be closed shortly. Second, we establish a link between these two factors – i.e., gender bias and women's attrition – over time and propose a systemic view of their interrelation and their effect in the gender representation gap.

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