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Collaboration patterns and patenting: Exploring gender distinctions

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ABSTRACT

Drawing upon the theory of gender frame, the research on gender in science, and social network studies, this paper focuses on the social mechanism of collaboration, specifically the *boundary-spanning collaboration*, to understand the gender gap in academic patenting in the U.S. Correspondingly, the author developed a few hypotheses for empirical testing. The results show that, else being equal, only collaboration with industry would significantly increase the probability of patenting for female academic scientists, but this helps explain considerable difference in patenting between female and male academics. The findings are discussed along with the limitations and policy implications at the end.

1. Introduction

Both female doctoral degree recipients in science and engineering (S&E) and female professionals in scientific workplace have increased steadily in recent decades (Rossiter, 1995; NSF, 2008), but research has continuously found sexism against women in science (Editorial, 2013). The persistent and pervasive gender inequalities in science are detrimental to social values and economic development by reinforcing negative stereotypes and discouraging talented people from participating in and contributing to science (Hanson, 1996; Fox, 2008). Economically, it is estimated by Hunt et al. (2012) that closing the gap between female and male S&E degree holders would increase gross domestic product (GDP) per capita by 2.7% in the U.S. Other socially harmful consequences include the loss of talents and the exclusion of the specific types of knowledge women develop and maintain (Schiebinger, 2008; Kugele, 2010). Hence, the gender gap in science is deemed an ongoing focus of scholarly research and policy intervention.

Research productivity, because of its central role in the success of a scientific career, has attracted the most attention (Fox and Stephan, 2001). While vast previous research on gender and productivity focused on publication records and documented a pattern favoring male scientists (see Cole and Zuckerman, 1984; Xie and Shauman, 1998; Pripic, 2002 for literature review), concerns have been increasingly cast on another indication of research productivity, *academic entrepreneurship*[1] (Ding and Choi, 2011; Franzoni and Lissoni, 2009) or academic research targeting commercial returns through patents, licenses, products, and many other forms of outcomes. Since commercial involvement is assumed to closely related to established status and a high level of publication productivity (Zucker and Darby, 1996; Stuart and Ding, 2006) and women are generally less successful on these aspects, scholars worry that the change toward commercialization would reinforce women's disadvantages in the profession of science (Whittington and Smith-Doerr, 2005, 2008; Ding et al., 2006; Murray and Graham, 2007; Haeussler and Colyvas, 2011).

Correspondingly, scholars have set out to examine women's status in various forms of academic entrepreneurship, from disclosure (Duque et al., 2005), licensing (Thursby and Thursby, 2005), serving in a firm's scientific advisory board or SAB (Stephan and El-Ganainy, 2007), patenting (e.g., Whittington and Smith-Doerr, 2005; Frietsch et al., 2009; Meng and Shapira, 2010; Blume-Kohout, 2014), to firm founding (Ding, 2004). These efforts have resulted in a consistent finding of a gender gap to women's disadvantage, but have not yet reached to the consensus regarding the underlying explanations. Related to the ambiguity is insufficient attention to collaboration, a process generally assumed to promote academics' research and commercial productivity (see Bozeman et al., 2013

[1] Some scholars use this concept to refer only to firm founding (e.g. Ding and Choi, 2011), but I adopted a broader definition that refers to various commercial activities including patenting, consulting, research collaboration with industry, and firm formation (Franzoni and Lissoni, 2009).

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for the review) and be responsible for women's lower productivity (Kyvik and Teigen, 1996). Attempting to fill the research gaps, this study investigates the gender distinctions in academic patenting with a focus on academics' collaboration ties.

2. Literature review

2.1. The foundation: the theory of gender frame

Gender is one of a very few primary frames in our society that guide the organization of social practices (Ridgeway, 1997, 2007). According to Ridgeway, people have to develop "common" knowledge as a basis for their interaction and coordination with others in everyday life. How to categorize self and others is a piece of common knowledge that is useful to define the situation and make sense of one another in social practices. Meanwhile, such a category system should be simplified to allow for real-time management of actions. Eventually, the developmental process results in only a few cultural categories (gender, race, class, religion, etc.) but they serve as the primary guidance for individual perception and action in relation to others (Brewer and Liu, 1989; Ridgeway, 2006, 2007, 2009).

As gender is used as a primary cultural frame for differentiation and categorization, "difference is easily transformed into inequality through any of a variety of social processes" despite "difference need not logically imply inequality" (Ridgeway, 2009, p. 149). However, during the course of pursuing mutual dependence of groups for societal survival and stabilization, agreement gradually emerged among members across groups on which group is more respected and status-worthy than others (Ridgeway, 2006). While consensual gender beliefs (or *stereotypes* that are held by both men and women) are evidenced, research also found that these beliefs view men to be more proactive and competent in general and especially highly competent at the things that "count most" in society; and view women to be less competent generally but better at more feminine, communal tasks that tend to be socially less valued (see Ridgeway, 2006 for a comprehensive review). For instance, psychological studies (Hilton and von Hippel, 1996; Barbercheck, 2001; Powell et al., 2002) have shown that both sexes tend to consider men are assuming agentive qualities (being assertive, competitive, aggressive, courageous, instrumental, etc.) but not women. The association of sexes with differential attributes in the beliefs operates to women's disadvantage in the workforce, preventing them from participating in work attached with the highest social value.

Like other cultural beliefs, the gender frame endures over time (Heilman et al., 1989; Powell et al., 2002; Tinkler et al., 2015). It is reinforced through cognitive mechanisms and socialization. Even though the frame may change in the presence of disconfirming information, deviants, or new exemplars, people are likely to maintain it than to change it (see the review in Powell et al., 2002). Additionally, the belief is powerful in that even people consciously supporting gender equality would behave in biased ways just because they perceive *others* are influenced by such beliefs (Motowidlo, 1986; Dovidio et al., 1988). Together, the research suggests the gender frame has strong and enduring effects in the contemporary society and works against women's participation and progress in domains that are highly socially valuable such as science.

2.2. Gender and scientific productivity: traditional research and proposed explanations

Scientists work in all workforce sectors, but doctoral-level female scientists tend to work in educational (especially higher education) institutions (Fox, 2001). Given this context, prior research concerning gender inequalities in science primarily focused on academics and their publication productivity. As early as forty years ago, scholars already reported the general lower level of women's publication productivity (Cole, 1979) and, since then, this result has been echoed in a vast number of studies and deemed a puzzle attracting huge efforts. It was claimed recently that "most of the observed sex differences in research productivity can be attributed to sex differences in personal characteristics, structural position and marital status" (Xie and Shauman, 1998, p. 847). But the authors reminded us the puzzle has not been completely resolved as the effects of gender-specific attributes and social processes are not deciphered yet. While these two categories of factors work together to produce disparities, we should note they are not equally important: individual attributes (including demographic characteristics and education background) may explain part of women's disadvantages, but they do not exist in a vacuum but are shaped by social and structural factors (Fox, 1991). In this sense, more attention should be devoted to the social processes and the way they work to differentiate women's locations and access to strategic resources. Then the theory of gender frame, together with some other theoretical explanations, could help us understand how social processes work fundamentally and differently for the sexes in science.

Science closely connects with power (Fox, 2001). As Fox articulated, science not only has critical consequences for human's living but links to powerful social institutions (especially the state and education). Additionally, science has been imprinted as a masculine area as it has long been dominated by men with women's entry being a recent phenomenon (Rossiter, 1982, 1995). Given its close connection with power and its history, it is unsurprising that science would see rather strong gender beliefs that run against women. Indeed, prior research has revealed that women are generally treated in science as "token" (Kanter, 1977a,b), "outsider" (Zuckerman et al., 1991), "stranger" (Sonnert and Holton, 1995a), and "illegitimate group members" (Burt, 1998).

As stated earlier, these beliefs are reinforced by various social processes and thus become further resistant to changes. This is especially true in science. The production of scientific knowledge is a complex process involving many interactions among scientists, like discussing for problem identification, exchanging information for idea generation, and debating experimental design and data interpretation. In these various interactions, men as incumbents and decision-makers tend to select other men to interact and work together, revealing the "similar-to-me" effect that Kanter and other scholars discovered in top management (Rand and Wexley, 1975; Kanter, 1977a; Pulakos and Wexley, 1983). With these arguments in mind, we would expect that women are excluded and thus disadvantaged in almost all interactions of importance to research productivity. However, this does not mean we should regard the various interactions/processes equally or there is no need to investigate in detail how the gender differences emerge in a particular process. On the contrary, these issues are of impelling demand to understand and then convert the currently stalled progress toward gender equality in science. In addition, no matter how hard it is to eliminate the gender stereotypes, the possibilities exist that they may change or the actual effects may vary in specific contexts (Rothbart, 1981; Weber and Crocker, 1983; Ridgeway, 2009). Motivated by the call and the possibility, I inquire (1) what would be the most relevant social process, (2) how the gender beliefs would be introduced to the process, and (3) how the gender beliefs would affect the ultimate productivity level through the process, and let these inquiries lead my further search in the literature.