

**The Structure of Collaborative and Career Development  
Social Networks of Women and Men in Academic Science**

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**ABSTRACT**

The low level of representation of women in many fields of science and engineering has inspired a significant stream of research that addresses various categories of discrimination and barriers faced by women. In particular, studies of women in science have addressed publishing and productivity patterns, and sought personal and organizational explanations for gender differences in career outcomes, career paths, and overall representation in the field. Studies have explored work environment issues in the academic setting, demands placed on women regarding work-family balances, and the effectiveness of interventions such as faculty mentoring and career development programs (Long and Fox 1995; Levin and Stephan 1998; Rosser 2003; Fox 2005; Levin 2005; Muller, Ride et al. 2005; Leahey 2006). An important thread in much of this research implicitly addresses the ability of women to identify and access **networks** that are important in career development and success. Social networks are comprised of a set of individuals or entities that are connected by sets of ties (Wasserman and Faust 1994). Within a network, individuals gain access to resources through those ties, some of which provide more access to resources than others. Importantly, the lack of inclusion and access to effective networks has been linked to diminished career outcomes for women in science (Long and McGinnis 1981; Long, Allison et al. 1993; Fox 2001; Rosser 2003). From studies of social networks, we know that the characteristics of networks differ, as do the extent to which individuals participate in those networks and the resources or social capital that they gain. In the academic science environment, critical relationships exist in the form of collaborative ties, and related ties that help to enhance productivity.

Yet, access to networks can be limited. Research findings from studies of women in various organizational settings have pointed to the dependence of women's advancement and success on early identification of, participation in, and adequate access to, networks. Building dense, interconnected networks and participating in them produces social structure and social capital from which members may then benefit (Coleman 1988). However, some evidence suggests that women have significantly different access to career-related social capital: the features of social organization such as networks, norms, and social trust that facilitate coordination and cooperation for mutual benefit (Putnam 1995; Burt 1998; Gupta, Kemelgor et al. 2005). Research has also provided evidence that men and women's networks differ (Moore 1990) and that women may not be as effective in creating social capital through network participation (van Emmerik 2006). Further, the organizational context in which men's and

women's networks exist can have profound implications for the realization of benefits from those networks (Ibarra 1993). This work (Ibarra 1993) suggested that structural differences in the networks of women and minorities have important implications for career development, but may also create long-term career effects. Yet, little quantitative evidence regarding the specific of the nature of women's networks in science outside of bibliometric-based studies

Studies of scientific productivity underscores the importance of effective collaborative ties (Bozeman and Corley 2004; Cummings and Kiesler 2005). In the academic setting, understanding ties between individuals has been addressed through co-authorship and citation patterns using bibliometric data (for recent examples, see (Hicks, Breitzman et al. 2000; Chen and Hicks 2004; Geisler 2005; Li, Chen et al. 2007; Larsen 2008). These studies have been important in examining patterns and outcomes related to collaboration and publications, as well as scientific impact.

Additionally, academic scientists engage with departmental and institutional colleagues in a range of departmental functions. From a career development perspective, these individuals may provide psychosocial support, career relevant advice and often mentoring functions (Kram 1985). Within institutional settings, they may provide the resources central to navigation of and participation in departmental decisions and other organizational functions. While productivity in academic science determines the ability to advance and succeed, individuals also engage in networks relevant to other aspects of the scientists work life.

Increasingly, there has been a great deal of attention to the notion of social capital in science and the role of collaborative activities in building those resources (Bozeman and Dietz 2001; Bozeman and Corley 2004). Network methods can be used to quantitatively capture the structure and characteristics, and resources of networks such as those in the science area. The growth of social network methods and analysis have been particularly remarkable in the area of social capital, where it has been described as the "value of connections" (Borgatti and Foster 2003; Cummings and Kiesler 2005; Mote 2005).

This paper addresses the issue of social networks for women in academic science by examining gender differences in the structure of networks. We ask: how does the structure of women's professional networks in academic science differ from those of men? How is the composition and hierarchy of networks different, if at all, by gender? What are the sources of network ties? How do network ties for women originate? What access do women scientists have to relevant social networks that provide resources critical for career success? What access do women's networks provide relative to men's in the academic science setting? We address these questions using data drawn from a national survey of academic scientists in Research Extensive universities in six STEM (science, technology, engineering and math) fields. To address these questions, we provide detailed descriptive analysis of the characteristics of the collaborative and career development networks of academic scientists. In particular, we examine collaborative networks within respondent's institutions and external collaborative ties. Academic scientists may also develop networks of individuals with whom they seek advice regarding their research. Here, we assess distinctions in the structure, characteristics, resources and exchange that occur within these networks. Our analysis involved in-depth examination of the individual networks, but also comparison across the networks. It provides focused gender based comparison of network structures and resources across rank and field. We also provide develop explanatory models to test the how gender matters in distinctions in core networks variables.

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