ARC NETWORK
A STEM EQUITY BRAIN TRUST

STEM Faculty Networks and Gender: A Meta-Analysis

By Ethel L. Mickey, PhD

About the ARC Network

Funded by the National Science Foundation ADVANCE Program, Award HRD-1740860, the ADVANCE Resource and Coordination (ARC) Network seeks to achieve gender equity for faculty in higher education science, technology, engineering, and mathematics (STEM) disciplines. As the STEM equity brain trust, the ARC Network recognizes the achievements made so far while producing new perspectives, methods and interventions with an intersectional, intentional and inclusive lens. The leading advocate for women in STEM the Association for Women in Science (AWIS) serves as the backbone organization of the ARC Network.

About the Virtual Visiting Scholars

The Virtual Visiting Scholars (VVS) program provides a unique opportunity for select scholars across disciplines to pursue research meta-analysis, synthesis, and big data curation on topics crucial to STEM faculty equity. VVS analyze existing research and data, synthesizing different, sometimes competing, perspectives, frameworks, metrics, and outcomes to offer new insights and applications to the broader community.

About the Author

Ethel L. Mickey, PhD is the 2018 Virtual Visiting Scholar for the ARC Network. A sociologist studying gender, work and organizations, STEM, and social networks, Dr. Mickey is a visiting lecturer in the Department of Sociology at Wellesley College, where she teaches courses on gender, technology and society, and the sociology of education. Her doctoral research draws on a qualitative case study of a high-tech firm in the United States to explore gendered practices, experiences and outcomes of professional networking. This work revealed the exclusionary nature of networking and how networking can reinforce intersecting institutional inequalities in one of the country's leading industries. Dr. Mickey holds a Doctorate of Sociology from Northeastern University and Bachelor of Sociology and English from Vanderbilt University.

Introduction

Social networks represent a form of social capital – a resource for individuals to locate opportunities, acquire information and skills and gain support and legitimacy (Burt 2000; Coleman 1988). Scientific and technical work especially relies on the cooperation of people, research teams, and groups, who often work on interdisciplinary projects (Fox 2001). Academic

networks consist of informal relationships and mentoring, as well as formal collaborations including co-authorship. Despite the theorized benefits of social capital, sociologists recognize that social networks contribute to the production and maintenance of social stratification (Bourdieu 1986). There is ever-increasing evidence that marginalization and exclusion from networks may, in part, contribute to the underrepresentation of women and minorities in STEM (Fox 2001; Lariviere et al. 2011; NAS 2007). The current state of knowledge on gender and networks in STEM focuses on gender differences in network characteristics and the implications of these differences for academic careers. The latter research describes network exclusion as part of the discriminatory practices contributing to the "chilly climate" for women and people of color in STEM.

Research on gender and network characteristics focuses on the size, structure, and composition of faculty collaboration networks. Larger networks suggesting greater access to resources (e.g. Haslam and Laham 2009). While some research shows women to have smaller collaboration networks compared to men (Kyvik and Teigen 1996; McDowell and Smith 1992), more recent studies find no gender differences in either the number of collaboration partners or the percentage of publications that are co-authored (Bozeman and Gaughan 2011). Studies on gender variations in network quality look instead at the structure and composition of network ties, often examining the extent of diversity in faculty networks. Having heterogeneity among one's connections should provide access to unique and diverse perspectives, but the theory of homophily argues that people are attracted to similar others to facilitate trust, communication, and reciprocity (McPherson et al. 2001). In STEM, gender and ethnoracial homophily results in cumulative career disadvantages for women and faculty of color, as they are often tokens in white, male-dominated departments and disciplines; for example, women's less diverse networks contribute to their difficulty securing research grants and funding relative to men (Bozeman and Corley 2004; Rosser 2004). Gender network differences also contribute to women's poor returns on mentorship and consequent biased information (Fox 2001).

Women's exclusion from social networks also contributes to their perceived sense of isolation and exclusion within the STEM fields, part of the metaphorical "chilly climate" (Bystydzienski and Bird 2006; Britton 2017; Hall and Sandler 1982). Women tend to lack senior women colleagues to serve as role models and mentors, and experience heightened cultural boundaries and exclusion from membership in the elite group of scientists (Kanter 1977; Morimoto and Zajicek 2012). Informal and formal practices institutionalize men's dominance over women in STEM, creating what has often been called an "old boys' club" or network (Sonnert and Holton 1995; see also McDonald 2011). Price (1963) first introduced the concept of "invisible colleges," describing the elite, in-group of scientists within each discipline that shapes the development of new scientific ideas according to their interests. Professional societies, for example, will hold invitation-only "specialty" conferences the day prior to the main conference, during which "leading scholars" (predominantly men) offer their thoughts on the future of the field (Page et al. 2009). Women faculty tend to feel excluded from informal social events which can inhibit collaborative relationships and network formation (Sonnert and Holton 1995). Women's exclusion from informal, male-dominated networks also creates unequal access to tacit knowledge, or the "unwritten rules" of academia and science – knowledge ingrained within the paradigm and implicitly known by "insiders" (Rankin et al. 2007). These social-relational

inequalities accumulate over careers, contributing to gendered variations in material benefits, faculty satisfaction, and patterns of inclusion.

This meta-analysis identifies structural barriers to women and minority faculty's inclusion in social networks. This project is especially timely as networking and mentoring programs are increasingly used as anti-discrimination measures, part of a plethora of diversity management programs to counter the social isolation of women and minorities (Kalev et al. 2006). Yet these efforts may inadvertently reproduce the gendered division of labor in STEM fields, as they are often run and organized by a handful of senior women (Morimoto and Zajicek 2012). Additionally, some studies find women to experience negative repercussions when forming their own networks, as their male colleagues actively delegitimize these networks (Mickey 2018; Williams et al. 2012). Understanding the paradoxical effects of networking as diversity management is critical for organizations and policymakers seeking to improve gender equity in STEM. This synthesis of the literature on gender and networks of STEM faculty also serves as a necessary bridge between the sub-fields currently engaging in this topic. Through this meta-analysis, I link studies engaging in social network theory with sociological research on gendered organizations and STEM. Understandings of gender inequality in academic STEM disciplines would be further strengthened through an integration of these bodies of research.

Findings reveal that networks provide a variety of key resources for faculty in STEM; indeed, some argue that networks are crucial for success in academic careers, providing social capital in the form of jobs and job information, productivity including collaboration and networking opportunities, visibility and prestige, industry and government connections, financial resources, advice, friendship, and the exchange of ideas on research, teaching, and service. However, I also find that women – and especially women of color – remain marginalized in faculty networks despite institutional efforts surrounding diversity and inclusion. I suggest that the more complicated and important question centers on understanding *how* men and women's networks differ; that is, through what structures are women and minorities excluded? And, what can be done to alleviate or resolve this exclusion?

The meta-analysis suggests that there are three primary ways in which faculty networks are gendered to disadvantage women in STEM. First, women have **smaller** networks than their male counterparts. Women STEM faculty also tend to be more disconnected from the most **central** actors in research networks as compared to men. And finally, both men and women scientists tend to have **homophilous** networks, **but** for women, their gender-homophilous networks are negatively associated with organizational status, and thus provide them with lesser quality information and resources. From an intersectional perspective, there is less research looking at race and faculty networks in STEM, but a handful of important studies examine how race and gender intersect to shape faculty experiences. Women of color faculty tend to be the most marginalized group in academia, facing isolation and exclusion from network opportunities afforded to their white and male counterparts. However, some important research suggests that black women rely on gender and racially-homophilous networks for career support. Black women faculty are most likely to maintain strong relationships with advisors and mentors from their former campuses, and they tend to network with other black women faculty through

professional associations for both personal and research support. These studies signal the importance of looking within-gender groups, and future research should center the experience of women of color faculty in STEM.

Research Questions

Using thematic analysis (Bearman and Dawson 2013) and meta-ethnography (Dixon-Woods et al. 2005), this meta-analysis addresses the following research questions: (1) Are there intersectional gender differences in faculty network characteristics? and (2) Can gender differences in faculty networks explain gendered variations in faculty career outcomes, including productivity, retention, and advancement?

Methods

This study is a qualitative meta-analysis of existing research on gender and faculty networks. Specifically, I employ thematic analysis (Bearman and Dawson 2013) and meta-ethnography (Dixon-Woods et al. 2006). The aim of a meta-analysis is to use and synthesize existing research knowledge to answer focused questions to develop new insights and conclusions. In this section, I outline the two phases of the study's research methods: data collection and data analysis.

(1) Data Collection

Inclusion Criteria: The first task of the data collection phase was developing inclusion criteria for studies in the meta-ethnography. In this early stage, I decided to be as comprehensive as possible in the search, casting a wide net initially and then later screening papers for their relevance and significance to this project. Full published studies that explore gender variations in STEM faculty networks were included in the initial searches. This includes peer-reviewed journal articles, book chapters, books, reports, and conference papers published up to September 2018. Limited to English Language. In defining STEM, I included social sciences and medicine. Networks were defined broadly, allowing inclusion of studies that feature research collaborations, coauthorships, mentors and general professional relationships.

Approach to Searching: I utilized a comprehensive search strategy to seek all available studies.

Data Sources: Six electronic databases up until September 2018 (Web of Science, Google Scholar, ProQuest/Sociological Abstracts, ProQuest/GenderWatch, JSTOR, ScienceDirect/Elsevier) supplemented by hand-searching table of contents of specific journals for 2010-2018 and citation tracking.

Electronic Search Strategy: I combined various search terms as well as thesaurus terms to identify relevant studies. Search terms included: "gender" "sex" "race" "STEM" "science" "scientist*" "engineer*" "faculty" "academi*" "network*" "social network*" "intersectional*"

Electronic Search Results: Initial electronic searches of the six databases produced nearly 12,000 records, including Web of Science: 191; Sociological Abstracts: 2,196; GenderWatch: 2,177; JSTOR: 3,734; and ScienceDirect: 3,735.

Study Screening Methods: I screened the titles of the identified articles to determine their relevance for this study. If I was uncertain after reading the title, then I read the abstract, and then the full text was checked. This screening process was timely, but important as it greatly reduced the number of articles to a more manageable number. All relevant articles were downloaded as records into an Endnote library. Once entered in Endnote, I removed all duplicate records. I then categorized papers as either a "key paper" (conceptually rich and could potentially make an important contribution to the meta-ethnography); a "satisfactory paper"; or an "irrelevant paper."
I also consider the impact of a paper through its citation count. This categorization approach is in line with Toye et al. (2013). This screening process has led to a dataset of 99 key papers that I am currently working with from across disciplines including social network studies, sociology, women and gender studies, and education.

Data Extraction: PDF versions of the complete "key papers" have been loaded onto NVivo 12 software for analyzing and coding as qualitative data. Citation records for the key papers are also stored in Endnote X6.

(2) Data Analysis

The first step of data analysis is thematic analysis, which is a descriptive form of analysis. This involves systematically reviewing the key papers to identify prominent and recurrent themes, summarizing the key findings and conclusions. The aim of thematic analysis is to summarize the collective or aggregate conclusions of the body of research as a whole. First, I used NVivo 12 to code and annotate included studies. I classified each study classified by publication type; year of publication; discipline. I also grouped articles based on attributes including qualitative/quantitative research; country (US or international); sample size; network measure (self-report, coauthorship, mentoring, etc.); and outcome measures (productivity, income, satisfaction, etc.). These classifications allow for analytic comparisons both between and within groups of studies to identify). Then, I read through each key paper, coding for research questions, hypotheses, methods, key findings, and conclusions. Summary files and memos on each article are also stored in NVivo.

Key codes centered around relevant concepts emerged from the thematic analysis, including but not limited to social capital, homophily, gender differences, gender similarities, race, strong ties, mentoring ties, career outcomes, sponsorship, friendship, support programs, networking strategies. These substantive or topical codes led me to identify early patterns across the studies, which I delved into more deeply in the second step of data analysis: meta-ethnography.

The goal of meta-ethnography is interpretive analysis, to identify third order interpretations beyond original study findings to develop new concepts, theoretical ideas, and also to identify remaining questions. I engaged in what is called *reciprocal translations* (Noblit and Hare 1988), mapping key themes across studies, translating the findings into each other to build general interpretations from the research that more directly answer my research questions.

Although I have described data collection and data analysis here as two separate steps of the research methods, they proved to be two intertwined processes throughout this study. For example, oftentimes reading a key paper would point me towards additional studies that were not originally included in the meta-analysis. I kept an ongoing list of new studies to check. I determined that some of these new studies were relevant and important for inclusion in the meta-analysis, while others were not. Additionally, after reading some of the original key papers, I determined that they were not relevant to the study or poor quality, and thus I chose to drop them from the analysis. This iterative process between data collection and analysis, with findings and new questions emerging from the data, is in line with inductive approaches to research and grounded theory (Charmaz 1996).

Meta-ethnography Findings

I. Defining Networks

Respondents identify network members

- Gaughan et al. (2018): egocentric network survey, questions ask respondents to name the "closest members of their professional network alters including the names of dissertation chair, postdoctoral supervisor, mentors, individuals with whom they regularly discuss teaching issues, individuals who are closest research collaborators, and individuals with whom they discuss university or department issues." Up to 26 people
    - Then prompted to list specific activities related to instrumental and general advice resources
- Bozeman and Gaughan (2011) and Rhoten and Pfirman (2007) use surveys

- Cain and Leahey (2014) distinguish between "formal" and "informal" relationships mentioned in autobiographical essays. Formal relationships are indicated by mentions of collaborators, co-authors, students, teachers and mentors. Informal relationships are indicated by mentions of colleagues (mostly in one's department or university, but also other professional contacts who were not collaborators), work friends, invited opportunities (to give a talk or submit a paper) and other relationships with family members or spouses. While invited opportunities are formally valued professional activities, they typically emerge from informal relationships.
- Casciaro (2008) compares individual perceptions of friendship and work-related advice networks in one university to the actual organizational network structure
- Kegen (2013): (1) instrumental network links that involve the exchange of information and transfer of knowledge and (2) advice and help ties which incorporate an affective component; also acknowledges social acquaintances that engage outside of work – provide a form of soft social capital that enhances self-confidence and adds development of a professional self-conception, builds mutual trust, problem-solving → accounts for the ***multiplexity*** of network relations

Collaboration

- Abramo et al. 2013: intramural, extramural, domestic/international collaborations including across disciplines and field (analysis of publications indexed in Web of Science) – bibliometric analysis
- McDowell and Smith (1992); Larievere et al. 2011, Moya Anegon et al. (2009); Badar et al. (2012) all use bibliometric analyses – total numbers of coauthored publications
- However, many scholars believe that the use of co-authorship as the sole measure of research collaboration is insufficient because collaboration between researchers may not result in co-authorship (Cimenler et al. 2015). Collaborations involve informal communications and conversations. They use self-reports from engineering faculty to construct networks from communication relationships and collaborations in 3 areas: joint publications, joint grant proposals, and joint patents – they argue that this covered both in-progress and completed collaborative outputs, also includes a rating from researchers on the importance of relationship to them and obtains multiple types of relationship ties, accounting for multiple networks
- Bozeman and Corley (2004): define research *cooperation* as "working closely with others to produce new scientific knowledge" (609) – less emphasis on outputs

Affiliation with Research Centers

- Corley (2005) – affiliation with interdisciplinary science centers serves as new type of scientific work environment that can improve the networks of faculty and relates to the productivity of academic scientists

- Ding, Murray & Stuart (2013) examine academic scientists' participation in corporate scientific advisory boards

Mentorship

- Fox and Fonesca (2006); Fox 2001

Sponsorship

- Ayyala et al. (2019: sponsors are "career-established and well-connected talent scouts" that have access to networks provide support in promoting their proteges

II. Benefits of Networking for Faculty

- *Jobs:* Academic hiring norms and procedures often rely on networks, with social capital having an impact on which candidates acquire prestigious STEM jobs (Hadani et al. 2012; Mai et al. 2012). The influence of social capital has especially become relevant in a post-recession labor market with an influx of PhDs. Women also utilize their networks to locate information and advice about promotion and tenure opportunities (Guerrero 2017).
    - Also includes information about career options outside of the traditional tenure-track system (Anderson et al. 2016), information about dual-career hires, assistance in navigating difficult choices surrounding families and careers

- *Productivity*: "Successful scientists rely on professional networks of collaborators and advisers to share resources and information that foster scientific productivity" (Gaughan, Melkers, Welch 2018). Productivity can be measured in terms of publication rates as well as grant-related productivity (Fox 1991, 2005; Leahey 2006; Long, Allison, McGinnis 1993; Xie and Shauman 1998). Also, due to the increasing collaborative nature of science, faculty also benefit from one another through coauthorship (Gaughan and Bozmean 2016).
    - Larger networks suggest more opportunities for coauthorship, funding, information, and other resources, whereas smaller networks limit opportunities for advancement (Gaughan et al. 2018)
    - Collaborations positively correlated with scientific productivity (Abramo et al. 2013), and collaborations have a strong impact on women's productivity compared to men's (Badar et al. 2013; Kyvic and Teigen 1996)

- Support networks serve the basic function of staying current in the field (Anderson et al. 2016), including sharing ideas for research and publication outlets, reading each other's manuscripts and sharing guidelines for journal submission processes
- Corley (2005): university-based science centers might serve as an equalizing mechanism for male and female productivity levels. Yet, women scientists affiliated with these centers are significantly more likely to feel discriminated against—and they are less likely to embrace the most promising career strategy for the current structure of these centers

- *Industry and Government Connections*: In STEM, professional networks are not only academic, but also can include government and industry relationships often necessary for research resources, funding, equipment, patenting, etc. (Zhou 2016).
  - Hong and Zhao (2016): impact of professional ties on scientific outcomes varied by sector of tie

- *Career Information:* Network relationships provide faculty both informal and formal information around job expectations, including clarity around tenure and promotion practices (Fox 2015). This kind of "unwritten" but vital career information is often referred to as tacit knowledge and affects career mobility and advancement (Rankin et al. 2007).
  - Fox (2015): intensity of informal discussion networks about research was more important for women academics than formal institutional mechanisms in terms of conveying tenure clarity (equally important for men)
  - Anderson et al. (2016): female support networks teach the rules of academic life – the "rules of the game"

- *Financial Resources*: often in the form of funded research and grants (Gaughan and Bozeman 2016; Katz and Martin 1997), but also research support through funded graduate students (Rothstein and Davey 1995). Ding et al. (2013) also point to implications for gender gap in compensation resulting from gendered networks, in the form of fewer corporate board seats or inclusion on patents.

- *Prestige or Visibility*: Access to high-status networks offers researchers with visibility, in turn elevating their own status and reputation in the field (a type of social capital). Recognition by peers in gaining rewards is widely accepted as a form of merit in academia. Ferber (1988) discusses how networks shape which publications get cited and by whom within subfields, and she finds that women as members of the out-group in many academic disciplines tend to be disadvantaged in accumulating citations. Men tend to cite other men, thereby reproducing their own recognition.
  - Joshi (2014): looks at peer evaluation and recognition of expertise among scientific team members

- *Advice/Guidance*: This advice can be both professional or personal, often labeled as mentoring (de Janasz and Sullivan 2004; Steffen-Fluhr 2012). Network relationships can provide faculty with work-family balance support (Watanbe 2015; Anderson et al. 2016), as parents – especially mothers, offer advice and guidance for navigating academia with children; for example, how to navigate childbearing and the tenure clock. This kind of social capital is considered "expressive" versus the more "instrumental" resources described above (Lin 2001).
    - Anderson et al. (2016): Support networks help women establish their identities as professional women in the academy; learn how gender shapes experiences as an academic and how to frame gendered issues in useful ways; finding one's place and validating one's experiences; help with decisions about taking on administrative responsibilities; serve as "sounding board" for career moves; and "cheerleaders" during moments of success

- *Friendship:* Somewhat like the expressive social capital above, friendship network ties are key to the wellbeing of faculty, often included as an indicator of department or campus climate and job satisfaction (Falci et al. 2014).

- *Teaching Practices*: A newer (and smaller) subgroup of research examines how network ties can lead to the spread of new teaching ideas, as faculty discuss teaching with their colleagues (Quardokus and Henderson 2015).

III. How do men and women's networks compare?

Network Size

- Miller and Shrum (2012) women have smaller networks than men and networks shrink over time (scientists in 3 developing countries not in meta-analysis because not looking at faculty)
- Gaughan et al. (2018): women have larger networks and size directly positively related to productivity → size matters, and bigger networks confer greater benefits (but composition also matters, see below)

Network Structure

- Badar et al. (2012): look at network centrality – an important facet of structural dimension of social capital – in co-authorship networks. Centrality is defined as the extent to which a focal actor is connected to other actors in a network (Freeman 1977). Centrality specifies structurally advantageous positions of actors in the network; typically, higher values of centrality (degree, closeness, betweenness) are beneficial to network members, provide different kinds of resources – the more centrally located an actor, the greater access or enhanced access to certain resources. Their findings indicate a positive relationship of centrality on research performance for both women and men faculty, but there is a stronger relationship for women (study of chemists in Pakistan) – this suggests that women seem to utilize the quick flow of knowledge and skills (by virtue of having low distances to other authors) better than their male counterparts. They suggest that women make use of the overall structure of their network by capitalizing off both indirect and direct ties.

Network Composition

Individuals are typically embedded in multiple networks, which in turn provide different types of resources important for career advancement.

In context of scholarly science, instrumental resources = directly related to producing scholarship (these include collaboration, financial support); expressive = advice or guidance including how to navigate collegial interactions, departmental culture, or psychosocial support (Fox 2015 describes as "informal information resources"). Hong and Zhao (2016) conceptualize as "resource acquisition" and "information communication" resources. Cain and Leahey (2014) differentiate between formal relationships (with teachers, mentors, collaborators) and informal relationships (with colleagues). Formal relationships can serve to equalize information flow and can vary in terms of quality and accessibility, often along gender lines. Informal relationships can enhance job satisfaction and collegiality but also can perpetuate a sense of exclusion from old boys' networks and an overall chilly climate.

Kegen 2013: In general, *formal* relations are defined to be explicit, impersonal and functionally specific.

On the contrary, an *informal* relation is specified by being implicit, personal, unspecific and not codified. The latter type is critical for transferring relevant information, exchanging ideas and support as well as for evaluation of research work.

- Gaughan et al. 2018: Men and women differ in network composition
    - white men are especially advantaged by instrumental networks, women especially advantaged by advice networks (using Lin's framework of expressive vs. instrumental ties)
    - Women's networks composed of more advice resources and fewer instrumental resources

    - "Bivariate analysis shows that there are systematic social network differences between men and women, and between different race and ethnic groups, that may explain productivity differences." (584)
    - Instrumental networks increase productivity while advice networks associated with lower productivity
- Fox (2015): intensity of informal discussion networks about research was more important for women academics than formal institutional mechanisms in terms of conveying tenure clarity (equally important for men)
- Women have fewer international collaborators than men (Abramo et al. 2013) and develop networks that are less "cosmopolitan" (Bozeman and Corley 2004) and less prestigious (Long 1990; Fuchs et al. 2001) but greater propensity to collaborate beyond their own specialties (Leahey 2006) and interdisciplinary (Rhoten & Pfirman 2007; van Rijnsoever et al. 2008)
- Anderson et al. (2016): women have a harder time finding senior scholars to be their mentors than their male counterparts do
- Zimmer, Krimmer and Stallmann (2007) found out that women in academia feel less integrated into informal networks than their male colleagues
- Cain and Leahey (2014): Formal relationships provide assistance to all scholars when they start out careers, but they typically benefitted men. Men reported mentoring other men and establishing long-term collaborations from those mentorships. They find that informal relationships only seem to benefit women (and their persistence and integration) when they have moved beyond token status in their discipline. Although it can be difficult for women to become integrated into informal work-related networks, results suggest that this is mostly the case when women are poorly represented in their fields: when they constitute less than 15 per cent of their field and can thus be considered 'occupational tokens.' Once women have surpassed this mark, a cultural emphasis on collegiality and supportive relationships is conducive to women's participation in science and engineering
- Frehill and Zippel (2001) and Zippel (2017): women engage in lower rates of international collaborations than men

Homophily

- Abramo et al. 2013: Women academics' lack of social capital caused first of all by mechanisms of gender homophily that stimulate search for collaborations primarily among colleagues of the same gender, with whom one is more likely to share values and methodological approaches (Boschini & Sjogren 2007, Ferber and Teiman 1980, McDowell and Smith 1992) – women face greater isolation because they are still the minority in principle disciplines
- Women face greater isolation in disciplines dominated by "old boy networks" where "scientific debate, reputations of scientists, access to collaboration and research funds are heavily influenced

by informal networks composed exclusively of male academics" (Fox 1991; O'Leary and Mitchell 1990)

- Cimenler et al. (2015): racial homophily but not gender significantly elevates the chance of a network tie between individuals for collaboration on grant proposals. In the network of joint publications, a tie between two researchers is significantly more likely if they are similar on gender and race. In the network of joint patents, similarity on gender and race do not matter.
- In academic medicine, junior faculty women are more likely than their male colleagues to value gender concordance (homophily) in mentoring relationships and may fail to recognize the need for support from more senior faculty and from leaders and mentors outside of their own department and/or institution. This may limit women's success, as there are fewer women than men in high-level leadership positions with power and influence (Ayyala et al. 2019)
- Cain and Leahey (2014): women were more likely to report having a woman serve as their formal mentor. Women's formal relationships are beneficial when they are tied to high status women. Given the dearth of high-status women in these fields, formal relationships alone cannot provide inroads for more women.
- Kegen (2013): Having a look at gender homophily, it seems that sex does not play a considerable role in joint activities of scientists in cutting-edge research institutions. But, the results could to some extent be explained by the low proportion of women in the study
    - Neither the relationship between gender homophily and cooperation nor between homophily and support nor between homophily and social acquaintance pointed significantly to the proposed effects
- But also gender homophily in networks can be beneficial for women – a network of female colleagues can be a "vital source of information and support" … allowing women to "survive" graduate school and academic careers (Anderson et al. 2016)

Network Resources (as a proxy for network quality?)

- No gender differences in relationship between networks and publication productivity in China (Hong and Zhao 2016) or Philippines (Ynalvez and Shrum 2011)
- Women evaluate their mentors as less satisfactory than their male colleagues (Sambunjak, Straus & Marusic 2006)
- Women are perceived as being less likely to seek sponsorship (sponsors are "career-established and well-connected talent scouts" that have access to networks provide support in promoting their proteges) but as needing the extra support from sponsorship in order to be successful (Ayyala et al. 2019). They point to key differences between mentors and sponsors as network members, arguing that women may align themselves with mentors who are not able to serve as sponsors and fully advance their careers.

- Ding et al. (2013): Analyses show that women scientists are much less likely than men to join the advisory boards of for-profit biotechnology companies. With controls for scientists' professional accomplishments, social networks, employer characteristics and proxies for their interest in commercial science, we find that male scientists are almost twice as likely to join science advisory boards (SABs). This gender gap is roughly comparable to that of the rate of patenting among scientists found in previous studies (Ding et al., 2006; Whittington & Smith-Doerr, 2005)

Networking Strategies

- Women academics collaborate in a different and less effective manner than male colleagues (Cole and Zuckerman 1984; Sonnert 1995)
- Women develop more formal collaborations (Sonnert 1995)
- Women have greater propensity to collaborate with colleagues belonging to other domestic institutions (Moya Anegon et al. 2009) whereas men greater propensity to collaborate internationally (Frehill et al. 2010; Lariviere et al. 2011)
- Both men and women practice gender while they are networking, including entering, building, maintaining, using, and exiting their relationships (Berger et al. 2015). Gender practices include marginalizing the role of gender, referring to women's gender, men connecting with men, and maneuvering the gender order. They find that humor is a way through which identities are constructed and work relations are built. Women navigating male-dominated environments may tend to deny the importance of gender or distance themselves from their womanhood/exceptionally feminine characteristics or activities, in order to fit in with the masculine culture of STEM fields. This practicing of gender is done unreflexively, often without much awareness.
- Guerrero (2017): The findings suggest that women in higher education develop their networks through self-agency by building relationships and self-promoting. When seeking answers about higher education, women rely on informal networks and doctoral program advisors. Professional organizations, conferences, and social media platforms are essential tools in establishing academic space for both untenured and tenured professors. Furthermore, professional organizations and conferences were a tool for networking.

IV. Race and Intersectionality

Little is known about the structure and functioning of the professional networks of women and minority academic scientists in comparison to white men (Gaughan et al. 2018) Research suggests that underrepresented racial minority scientists are often excluded from professional networks (Brown et al. 2013; Pearson and Pearson 1985, cited in Gaughan 2018 but not directly related to networks research), particularly those related to productivity (Etzkowitz, Kemelgor, and Uzzi 2000). Members of racially underrepresented groups more likely to

have smaller networks that comprise of lower-status and homophilous ties (Freeman and Huang 2014; Mehra, Kilduff, Brass 1998) and tend to not be part of more general collegial groups and networks.

- Ethnically homophilous collaborations are associated with lower publication productivity and impact (Freeman and Huang 2014)
- Unwelcoming local climates may result in smaller networks with minority faculty, resulting in fewer proximal ties (Pinherio and Melkers 2011) – limited access **to high-value networks** that are important for productivity because of chilly climates, discrimination, and exclusion (Fagen and Olson 2007)
- Baez (2000): unrepresented minority groups may seek out supportive networks that provide support and advice, possibly substituting these relationships for other collaborative ones (not STEM specific, n=16)
- Aparicio (1999): Women of color reaffirm the need for diverse models of mentoring that transcend the traditional paradigm of individual mentor-senior member who advises the junior faculty
    - Women of color instead prefer "communal and group-based sources of support rather than the individual mentor" (128). They want communities who will help them do their research – intellectual support
    - Given difficulties in finding such support in their own departments and universities, women of color faculty look for support online, via email lists and social networks, sometimes continuing relationships with their dissertation advisors, with colleagues from minority sections of national associations
- Gaughan et al. 2018:
    - Asians have smaller networks compared to other groups, but predominantly instrumental resources, low levels of advice resources
    - Blacks and Hispanics do not differ in relative composition of networks from whites

V. Institutional Change Efforts

In some STEM disciplines, there are examples of institutional interventions aimed at building women's networks, often through formal mentoring programs or professional groups.

- Earth Science Women's Network (EWSN) – grassroots organization, mentoring of women in atmospheric sciences since 2002; provides career development, build community, provide informal mentoring and support, facilitate professional collaborations (Adams et al. 2016); includes women at all career stages

  - Different kinds of mentoring: formal (set program with defined roles); informal (mutually selected relationship outside of a formal program); one-on-one; multiple mentoring; peer mentoring; collective mentoring
  - EWSN utilizes "multipronged approach" that they call "community-driven mentoring" to address mentoring gaps for women in Earth Sciences. Emphasize flexibility and informality to allow women to engage in mentoring. Have an online forum and virtual support group as well as in-person networking events at national meetings and workshops. Members opt into programs they want on their own terms.
  - Mentoring philosophy based on 5 principles
    - 1) Support community-driven mentoring
    - 2) Encourage diverse mentoring approaches for diverse individuals
    - 3) Facilitate mentoring across career phases
    - 4) Promote combined personal and professional mentoring
    - 5) Champion effective mentoring in a safe space
- Some programs specifically aim to support the networks of racial/ethnic minority researchers. The Native Investigator Development Program (NIDP) is a career development program for junior Native researchers in academic medicine. Buchwald and Dick (2011) find that participants in NIDP created a rich network that became heavily involved in collaborations on manuscripts and grants. Program activities included regular seminars on career development; intensive statistics and writing instruction; mentored pilot studies; frequent in-person group meetings; regular telephone and e-mail contact with mentors between meetings; mock review of grant applications. Each Native investigator worked with an individualized mentorship team, including a statistics mentor and a writing mentor – rigorous, hands-on support, brainstorm publication venues and funding sources
- Carter-Johnson et al. (2016) evaluate a networking workshop as a pilot intervention for Hispanic women faculty, funded through NSF's PAID program, which supported an alliance between two institutions: Puerto Rico's Universidad Metropolitana and University of Maryland Baltimore County. The intended outcomes of the workshop included opportunities for new research and knowledge and improved evidence to support institutionally transformative mechanisms for new policies and practices responsive to the needs of Hispanic women faculty in STEM. Adopted a culturally relevant and collaborative needs assessment approach. The researchers argue that intentional mentoring aimed at assisting Hispanic women faculty acquire strategic skills for support and navigating institutional politics is key. They also recommend providing mentor training for established faculty, establishing a professional society or organization or strategic research collaborative.

But I suggest that a key question remaining is whether and how women in STEM may be *disadvantaged* from joining these women-only networks (see for example, Williams et al. 2012, in their study of women professional in the oil and gas industry).

Advice for Women?

- Gaughan et al. 2018: invest in instrumental networks
- Adams et al. 2016: encourage women and minorities to seek out multiple avenues of mentoring early in their careers and at new career stages; encourage to invest in diverse mentors (including men)

VI. Additional cites to check

(last updated 7/11/19)

Fox, Mary Frank. 2015. "Gender and Clarity of Evaluation among Academic Scientists in Research Universities." Science, Technology, & Human Values 40 (4): 487-515.

Etzkowitz, Henry, Carol Kemelgor, and Brian Uzzi. 2000. Athena Unbound: The Advancement of Women in Science and Technology. New York: Cambridge University Press.

Freeman, Richard B., and Wei Huang. 2014. Collaborating with People Like Me: Ethnic Co-authorship within the US. No. w19905, Cambridge, MA: National Bureau of Economic Research.

Pinheiro, Diogo Lemieszek, and Julia E. Melkers. 2011. "The Need to Look Elsewhere: The Push and Pull of Underrepresented Minority Faculty Professional Networks." Science and Innovation Policy, 2011 Atlanta Conference on Science and Innovation, Atlanta: IEEE.

Hong, Wei, and Yandong Zhao. 2016. "How Social Networks Affect Scientific Performance: Evidence from a National Survey of Chinese Scientists." Science, Technology, & Human Values 41 (2): 243-73. doi: 10.1177/0162243915592020.

Meta-Analysis Citation List

Last updated: July 15, 2019

Abramo, Giovanni, Ciriaco Andrea D'Angelo, and Gianluca Murgia. 2013. "Gender Differences in Research Collaboration." *Journal of Informetrics* 7(4):811-822.

Adams, Amanda S., Allison L. Steiner, and Christine Wiedinmyer. 2016. "The Earth Science Women's Network (Eswn) Community-Driven Mentoring for Women in the Atmospheric Sciences." *Bulletin of the American Meteorological Society* 97(3):345-354.

Anderson, Karrin Vasby, Sarah L. Bonewits, McDorman Kelly Carter, Pierce Jennifer Burek, and et al. 2004. "Voices About Choices: The Role of Female Networks in Affirming Life Choices in the Academy." *Women's Studies in Communication* 27(1):88-110.

Aparicio, Frances R. 1999. "Through My Lens: A Video Project About Women of Color Faculty at the University of Michigan." *Feminist Studies* 25(1):119-130.

Ayyala, M. S., K. Skarupski, J. N. Bodurtha, M. Gonzalez-Fernandez, L. E. Ishii, B. Fivush, and R. B. Levine. 2019. "Mentorship Is Not Enough: Exploring Sponsorship and Its Role in Career Advancement in Academic Medicine." *Academic Medicine* 94(1):94-100.

Badar, Kamal, Julie M. Hite, and Yuosre F. Badir. 2013. "Examining the Relationship of Co-Authorship Network Centrality and Gender on Academic Research Performance: The Case of Chemistry Researchers in Pakistan." *Scientometrics* 94(2):755-775.

Bearman, Margaret and Phillip Dawson. 2013. "Qualitative Synthesis and Systematic Review in Health Professions Education." *Medical Education* 47(3):252-260.

Berger, Laura, Yvonne Benschop, and Marieke van den Brink. 2015. "Practising Gender When Networking: The Case of University-Industry Innovation Projects." *Gender, Work & Organization* 22(6):556-578.

Bozeman, Barry and Elizabeth Corley. 2004. "Scientists' Collaboration Strategies: Implications for Scientific and Technical Human Capital." *Research Policy* 33(4):599-616.

Bozeman, Barry and Monica Gaughan. 2011. "How Do Men and Women Differ in Research Collaborations? An Analysis of the Collaborative Motives and Strategies of Academic Researchers." *Research Policy* 40(10):1393-1402.

Buchwald, Dedra and Rhonda Weigman Dick. 2011. "Weaving the Native Web: Using Social Network Analysis to Demonstrate the Value of a Minority Career Development Program." *Academic Medicine* 86(6):778-786.

Cain, Cindy L. and Erin Leahey. 2014. "Cultural Correlates of Gender Integration in Science." *Gender, Work & Organization* n/a-n/a.

Cameron, Susan Wilson. 1978. "Women Faculty in Academia: Sponsorship, Informal Networks, and Scholarly Success." Ph.D. Thesis, University of Michigan, Ann Arbor, Michigan.

Carter-Johnson, Frances D., Angela Byars-Winston, Renetta G. Tull, Beatriz Zayas, and Carlos Padin. 2016. "Hispanic Female Stem Faculty in Puerto Rico: Results from an Nsf Advance Networking Workshop." 22(3):223-243.

Casciaro, Tiziana. 1998. "Seeing Things Clearly: Social Structure, Personality, and Accuracy in Social Network Perception." *Social Networks* 20(4):331-351.

Cimenler, O., K. A. Reeves, and J. Skvoretz. 2015. "An Evaluation of Collaborative Research in a College of Engineering." *Journal of Informetrics* 9(3):577-590.

Clauset, Aaron, Samuel Arbesman, and Daniel B. Larremore. 2015. "Systematic Inequality and Hierarchy in Faculty Hiring Networks." *Science Advances* 1(1).

Corley, Elizabeth A. 2005. "How Do Career Strategies, Gender, and Work Environment Affect Faculty Productivity Levels in University-Based Science Centers?" *Review of Policy Research* 22(5):637-655.

Deborah, Belle, Laurel Smith-Doerr, and Lauren M. O'Brien. 2014. "Gendered Networks: Professional Connections of Science and Engineering Faculty." Pp. 153-175 in *Gender Transformation in the Academy*, vol. 19, *Advances in Gender Research*: Emerald Group Publishing Limited.

Ding, Waverly W., Fiona Murray, and Toby E. Stuart. 2013. "From Bench to Board: Gender Differences in University Scientists' Participation in Corporate Scientific Advisory Boards." *The Academy of Management Journal* 56(5):1443-1464.

Etzkowitz, Henry. 2000. "The 'Kula Ring' of Scientific Success." in *Athena Unbound: The Advancement of Women in Science and Technology*, edited by C. Kemelgor and B. Uzzi. Cambridge; New York: Cambridge University Press, 2000.

Ferber, Marianne A. 1988. "Citations and Networking." *Gender and Society* 2(1):82-89.

Fox, Mary Frank. 1991. "Gender, Environmental Milieu, and Productivity in Science." Pp. 188-204 in *The Outer Circle: Women in the Scientific Community.*, edited by H. Zuckerman, J. R. Cole, and J. T. Bruer. New York, NY: W. W. Norton & Co.

—. 2001. "Women, Science, and Academia: Graduate Education and Careers." *Gender & Society* 15(5):654-666.

Fox, Mary Frank and Carolyn Fonseca. 2006. "Gender and Mentoring of Faculty in Science and Engineering: Individual and Organisational Factors." *IJLC International Journal of Learning and Change* 1(4).

Frehill, Lisa M. and Kathrin S. Zippel. 2011. "Gender and International Collaborations of Academic Scientists and Engineers: Findings from the Survey of Doctorate Recipients, 2006." *Journal of the Washington Academy of Sciences* 97(1):49-69.

Fried, Linda. P., Clair. A. Francomano, S. M. MacDonald, E. M. Wagner, E. J. Stokes, K. M. Carbone, W. B. Bias, M. M. Newman, and J. D. Stobo. 1996. "Career Development for Women in Academic Medicine: Multiple Interventions in a Department of Medicine." *JAMA* 276(11):898-905.

Gaetke-Udager, K., U. S. Knoepp, K. E. Maturen, J. R. Leschied, S. Chong, K. A. Klein, and E. Kazerooni. 2018. "A Women in Radiology Group Fosters Career Development for Faculty and Trainees." *American Journal of Roentgenology* 211(1): W47-W51.

Gaughan, M. and B. Bozeman. 2016. "Using the Prisms of Gender and Rank to Interpret Research Collaboration Power Dynamics." *Social Studies of Science* 46(4):536-558.

Gaughan, Monica and Elizabeth A. Corley. 2010. "Science Faculty at US Research Universities: The Impacts of University Research Center-Affiliation and Gender on Industrial Activities." *Technovation* 30(3):215-222.

Gaughan, M., J. Melkers, and E. Welch. 2018. "Differential Social Network Effects on Scholarly Productivity: An Intersectional Analysis." *Science Technology & Human Values* 43(3):570-599.

Gersick, C. J. G., J. M. Bartunek, and J. E. Dutton. 2000. "Learning from Academia: The Importance of Relationships in Professional Life." *Academy of Management Journal* 43(6):1026-1044.

Gottlieb, A. S. and E. L. Travis. 2018. "Rationale and Models for Career Advancement Sponsorship in Academic Medicine: The Time Is Here; the Time Is Now." *Academic Medicine* 93(11):1620-1623.

Griffin, Kimberly A. and Richard J. Reddick. 2011. "Surveillance and Sacrifice: Gender Differences in the Mentoring Patterns of Black Professors at Predominantly White Research Universities." *American Educational Research Journal* 48(5):1032-1057.

Guerrero, Andrea. 2017. "Women Networking to Achieve Tenure in Higher Education." Ph.D. Thesis, The University of Nebraska - Lincoln, Ann Arbor.

Hall, Roberta M. and Bernice R. Sandler. 1983. *Academic Mentoring for Women Students and Faculty: A New Look at an Old Way to Get Ahead.*

Hart, Jeni. 2008. "Mobilization among Women Academics: The Interplay between Feminism and Professionalization." *NWSA Journal* 20(1):184-208.

—. 2016. "Dissecting a Gendered Organization: Implications for Career Trajectories for Mid-Career Faculty Women in Stem." *Journal of Higher Education* 87(5):605-634.

Henley, M. M. 2015. "Women's Success in Academic Science: Challenges to Breaking through the Ivory Ceiling." *Sociology Compass* 9(8):668-680.

Hesli, Vicki L. and Jae Mook Lee. 2013. "Job Satisfaction in Academia: Why Are Some Faculty Members Happier Than Others?" *PS: Political Science & Politics* 46(02):339-354.

Howe-Walsh, L. and S. Turnbull. 2016. "Barriers to Women Leaders in Academia: Tales from Science and Technology." *Studies in Higher Education* 41(3):415-428.

Howe-Walsh, Liza, Sarah Turnbull, Emmanouil Papavasileiou, and Nikos Bozionelos. 2016. "The Influence of Motherhood on Stem Women Academics' Perceptions of Organizational Support, Mentoring and Networking." *Advancing Women in Leadership* 3654-63.

Ismail, Maimunah and Roziah Mohd Rasdi. 2007. "Impact of Networking on Career Development: Experience of High-Flying Women Academics in Malaysia." *Human Resource Development International* 10(2):153-168.

Johnson, J. C., B. Williams, and R. Jayadevappa. 1999. "Mentoring Program for Minority Faculty at the University of Pennsylvania School of Medicine." *Academic Medicine* 74(4):376-379.

Joshi, Aparna. 2014. "By Whom and When Is Women's Expertise Recognized? The Interactive Effects of Gender and Education in Science and Engineering Teams." *Administrative Science Quarterly* 59(2):202-239.

Kachchaf, R., L. Ko, A. Hodari, and M. Ong. 2015. "Career-Life Balance for Women of Color: Experiences in Science and Engineering Academia." *Journal of Diversity in Higher Education* 8(3):175-191.

Kegen, Nadine V. 2013. "Science Networks in Cutting-Edge Research Institutions: Gender Homophily and Embeddedness in Formal and Informal Networks." *Procedia - Social and Behavioral Sciences* 7962-81.

Kegen, N. V. 2015. "Cohesive Subgroups in Academic Networks: Unveiling Clique Integration of Top-Level Female and Male Researchers." *Scientometrics* 103(3):897-922.

Kyvik, Svein and Mari Teigen. 1996. "Child Care, Research Collaboration, and Gender Differences in Scientific Productivity." *Science, Technology & Human Values* 21(1):54-71.

Layton, R. L., P. D. Brandt, A. M. Freeman, J. R. Harrell, J. D. Hall, and M. Sinche. 2016. "Diversity Exiting the Academy: Influential Factors for the Career Choice of Well-Represented and Underrepresented Minority Scientists." *Cbe-Life Sciences Education* 15(3).

Lee, Sang Eun. 2017. "Career Advancement Outcomes in Academic Science, Technology, Engineering and Mathematics (Stem): Gender, Mentoring Resources, and Homophily."

Lloyd-Jones, Brenda. 2014. "African-American Women in the Professoriate: Addressing Social Exclusion and Scholarly Marginalization through Mentoring." *Mentoring & Tutoring: Partnership in Learning* 22(4):269-283.

Longo, D. R., D. A. Katerndahl, D. B. Turban, K. Griswold, B. Ge, J. E. Hewett, T. W. Dougherty, and S. Schubert. 2011. "The Research Mentoring Relationship in Family Medicine: Findings from the Grant Generating Project." *Family Medicine* 43(4):240-247.

Maranto, C. L. and A. E. C. Griffin. 2011. "The Antecedents of a 'Chilly Climate' for Women Faculty in Higher Education." *Human Relations* 64(2):139-159.

McDowell, John M., Larry D. Singell, and Mark Stater. 2006. "Two to Tango? Gender Differences in the Decisions to Publish and Coauthor." *Economic Inquiry* 44(1):153-168.

McDowell, John M. and Janet Kiholm Smith. 1992. "The Effect of Gender-Sorting on Propensity to Coauthor: Implications for Academic Promotions." *Economic Inquiry* 30(1):68-82.

Meng, Y. 2016. "Collaboration Patterns and Patenting: Exploring Gender Distinctions." *Research Policy* 45(1):56-67.

Murray, F. and L. Graham. 2007. "Buying Science and Selling Science: Gender Differences in the Market for Commercial Science." *Industrial and Corporate Change* 16(4):657-689.

Nielsen, M. W. 2016. "Limits to Meritocracy? Gender in Academic Recruitment and Promotion Processes." *Science and Public Policy* 43(3):386-399.

O'Meara, KerryAnn and Nelly P. Stromquist. 2015. "Faculty Peer Networks: Role and Relevance in Advancing Agency and Gender Equity." *Gender and Education* 27(3):338-358.

Parker, Marla and Eric W. Welch. 2013. "Professional Networks, Science Ability, and Gender Determinants of Three Types of Leadership in Academic Science and Engineering." *The Leadership Quarterly* 24(2):332-348.

Parker, Marla A. 2014. "Social Network Determinants of Self-Perceived Influence among Minority and Non-Minority Stem Faculty."

Perna, L. W. 2005. "Sex Differences in Faculty Tenure and Promotion: The Contribution of Family Ties." *Research in Higher Education* 46(3):277-307.

Pinheiro, D. L., J. Melkers, and S. Newton. 2017. "Take Me Where I Want to Go: Institutional Prestige, Advisor Sponsorship, and Academic Career Placement Preferences." *Plos One* 12(5).

Ponjuan, Luis, Valerie Martin Conley, and Cathy Trower. 2011. "Career Stage Differences in Pre-Tenure Track Faculty Perceptions of Professional and Personal Relationships with Colleagues." *The Journal of Higher Education* 82(3):319-346.

Price, E. G., N. R. Powe, D. E. Kern, S. H. Golden, G. S. Wand, and L. A. Cooper. 2009. "Improving the Diversity Climate in Academic Medicine: Faculty Perceptions as a Catalyst for Institutional Change." *Academic Medicine* 84(1):95-105.

Rankin, Patricia, Joyce Nielsen, and Dawn M. Stanley. 2007. "Weak Links, Hot Networks, and Tacit Knowledge." Pp. 31-47 in *Transforming Science and Engineering. Advancing Academic Women*, edited by A. J. Stewart, J. E. Malley, and D. LaVaque-Manty. Ann Arbor, MI: The University of Michigan Press.

Realff, Mary Lynn, Carol Colatrella, and Mary Frank Fox. 2007. "Interconnected Networks for Advancement in Science and Engineering." Pp. 62-78 in *Transforming Science and Engineering: Advancing Academic Women*, edited by A. J. Stewart, J. E. Malley, and D. LaVaque-Manty. Ann Arbor: University of Michigan Press.

Rhoton, Laura A. 2011. "Distancing as a Gendered Barrier: Understanding Women Scientists' Gender Practices." *Gender and Society* 25(6):696-716.

Roos, Patricia A. and Mary L. Gatta. 2009. "Gender (in)Equity in the Academy: Subtle Mechanisms and the Production of Inequality." *Research in Social Stratification and Mobility* 27(3):177-200.

Rosser, Sue Vilhauer. 2004. "Using Power to Advance: Institutional Barriers Identified by Women Scientists and Engineers." *NWSA Journal* 1650-78.

Roth, Wendy D. and Gerhard Sonnert. 2011. "The Costs and Benefits of 'Red Tape': Anti-Bureaucratic Structure and Gender Inequity in a Science Research Organization." *Social Studies of Science* 41(3):385-409.

Rothstein, Mitchell G. and Liane M. Davey. 1995. "Gender Differences in Network Relationships in Academia." *Women in Management Review* 10(6):20-25.

Šadl, Zdenka. 2009. "'We Women Are No Good at It': Networking in Academia." *Sociologický Časopis / Czech Sociological Review* 45(6):1239-1263.

Settles, Isis H., NiCole T. Buchanan, and Kristie Dotson. 2018. "Scrutinized but Not Recognized: (in)Visibility and Hypervisibility Experiences of Faculty of Color." *Journal of Vocational Behavior*.

Smith, Janice W. and Toni Calasanti. 2005. "The Influence of Gender, Race, and Ethnicity on Workplace Experiences of Institutional and Social Isolation: An Exploratory Study of University Faculty." *Sociological Spectrum* 25(3):307-334.

Smith-Doerr, Laurel. 2004. "Flexibility and Fairness: Effects of the Network Form of Organization on Gender Equity in Life Science Careers." *Sociological Perspectives* 47(1):25-54.

Steffen-Fluhr, Nancy. 2006. "Advancing Women Faculty through Collaborative Research Networks." in *WEPAN National Conference*. Pittsburgh, PA.

Steffen-Fluhr, Nancy, Regina Collins, Anatoliy Gruzd, Mingzhu Zhu, Brook Wu, and Katia Passerini. 2012. "Leveraging Social Network Data to Support Faculty Mentoring: Best Practices from NJIT Advance." Pp. 2-13 in *2012 WEPAN Conference, Getting to the Heart of it All: Connecting Gender Research, WIE Programs, Faculty & Corporate Partners*. Columbus, OH: WEPAN.

Steffen-Fluhr, Nancy, Anatoliy Gruzd, Regina Collins, and Babajide Osatuyi. 2010. "N Is for Network: New Tools for Mapping Organizational Change." in *WEPAN 2010 National Conference Proceedings*. Baltimore, MD.

Stephan, P. E. and A. El-Ganainy. 2007. "The Entrepreneurial Puzzle: Explaining the Gender Gap." *Journal of Technology Transfer* 32(5):475-487.

Sun, Xiao-e and Yanjie Bian. 2012. "Ethnic Networking in the Transnational Engagement of Chinese American Scientists." *Asian Perspective* 36(3):435-461.

Terosky, A. L., K. O'Meara, and C. M. Campbell. 2014. "Enabling Possibility: Women Associate Professors' Sense of Agency in Career Advancement." *Journal of Diversity in Higher Education* 7(1):58-76.

Turner, Caroline Sotello Viernes. 2002. "Women of Color in Academe: Living with Multiple Marginality." *The Journal of Higher Education* 73(1):74-93.

Uhly, K. M., L. M. Visser, and K. S. Zippel. 2017. "Gendered Patterns in International Research Collaborations in Academia." *Studies in Higher Education* 42(4):760-782.

Van den Brink, M. 2011. "Scouting for Talent: Appointment Practices of Women Professors in Academic Medicine." *Social Science & Medicine* 72(12):2033-2040.

van den Brink, Marieke and Yvonne Benschop. 2013. "Gender in Academic Networking: The Role of Gatekeepers in Professorial Recruitment." *Journal of Management Studies* 51(3):460-492.

Van den Brink, Marieke and Lineke Stobbe. 2014. "The Support Paradox: Overcoming Dilemmas in Gender Equality Programs." *Scandinavian Journal of Management* 30(2):163-174.

van Emmerik, Iijh. 2006. "Gender Differences in the Creation of Different Types of Social Capital: A Multilevel Study." *Social Networks* 28(1):24-37.

Villanueva-Felez, A., R. Woolley, and C. Canibano. 2015. "Nanotechnology Researchers' Collaboration Relationships: A Gender Analysis of Access to Scientific Information." *Social Studies of Science* 45(1):100-129.

Walkington, Lori. 2017. "How Far Have We Really Come? Black Women Faculty and Graduate Students' Experiences in Higher Education." *Humboldt Journal of Social Relations* 3951-65.

Warner, E. T., R. Carapinha, G. M. Weber, E. V. Hill, and J. Y. Reede. 2017. "Gender Differences in Receipt of National Institutes of Health R01 Grants among Junior Faculty at an Academic Medical Center: The Role of Connectivity, Rank, and Research Productivity." *Journal of Women's Health* 26(10):1086-1093.

Watanabe, Megumi. 2015. "Faculty Parental Status: An Investigation of Network Homophily, Marginalization, and Supportive Work-Family Academic Culture." Sociology, University of Nebraska-Lincoln.

Watanabe, Megumi and Christina Falci. 2017. "Workplace Faculty Friendships and Work-Family Culture." *Innovative Higher Education* 42(2):113-125.

Whittington, Kjersten Bunker. 2018. ""A Tie Is a Tie? Gender and Network Positioning in Life Science Inventor Collaboration"." *Research Policy* 47(2):511-526.

Williams, B. N. and S. M. Williams. 2006. "Perceptions of African American Male Junior Faculty on Promotion and Tenure: Implications for Community Building and Social Capital." *Teachers College Record* 108(2):287-315.

Xu, Y. and C. Martin. 2011. "Gender Differences in Stem Disciplines: From the Aspects of Informal Professional Networking and Faculty Career Development." *Gender Issues* 28(3):134-154.

Zambrana, Ruth Enid, Rashawn Ray, Michelle M. Espino, Corinne Castro, Beth Douthirt Cohen, and Jennifer Eliason. 2015. ""Don't Leave Us Behind": The Importance of Mentoring for Underrepresented Minority Faculty." *American Educational Research Journal* 52(1):40-72.

Zeng, X. H. T., J. Duch, M. Sales-Pardo, J. A. G. Moreira, F. Radicchi, H. V. Ribeiro, T. K. Woodruff, and L. A. N. Amaral. 2016. "Differences in Collaboration Patterns across Discipline, Career Stage, and Gender." *Plos Biology* 14(11).