Analyzing Common Narratives: An Empirical Investigation of Women in Academic Science

Mary K. Feeney
Associate Professor and Lincoln Professor of Ethics in Public Affairs
Center for Science, Technology, and Environmental Policy Studies
mkfeeney@asu.edu

Eric W. Welch
Professor and Director
Center for Science, Technology, and Environmental Policy Studies
ericwelch@asu.edu

Abstract: It has long been accepted that there is a dearth of women in many science, technology, engineering, and mathematics (STEM) fields in the United States. The underrepresentation of women in STEM in universities is of key policy importance as these institutions inspire, teach and train future generations of scientists and engineers and produce new knowledge that is the foundation of an advanced society. Numerous prior studies have identified the behavioral, structural, and institutional barriers to access, participation and advancement of women in academic STEM and numerous federal, state, and university policies and programs have been established to address these barriers. In this paper, we test the common assumptions and understandings that exist about the academic careers or women in science. We draw from the literature on women in STEM and our own national surveys of women in science, to separate fact from myth about women's productivity, salaries, and satisfaction; the effects of family-friendly policies on women's careers in STEM; and the professional networks of women in academic science. We conclude with a discussion of the implications of our findings for an adaptive policy agenda for the dynamic challenges that face women in academic science.

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Introduction

It has long been accepted that there is a dearth of women in science, technology, engineering, and mathematics (STEM) fields in the United States. The underrepresentation of women in STEM is particular important at universities, which not only train future scientists but also house important cutting edge research and development. Women have historically been underrepresented in the pipeline of students in STEM fields, and while there is a great deal of research aimed at understanding the barriers to women progressing through that pipeline, our work focuses on the work life and status of women STEM faculty.

Since women are typically underrepresented as students in STEM fields, it follows that they make up a smaller number of potential PhD hires for universities. But this is not the only explanation for the dearth of women in faculty positions in STEM fields. Research has found that women face behavioral, structural, and institutional barriers in the academic marketplace. For example, the promotion and tenure process often requires academic scientists to stay on track with research, not allowing for delays or time off for family obligations. Additionally, successful academic scientists need to navigate a complex environment requiring informal networks, collaborative networks, and accessing key resources for pursuing resource and advancing one's reputation.

There has been extensive research identifying the behavioral, structural, and institutional barriers to the advancement of women in academic STEM and a vast number of federal, state, and university programs, policies, and initiatives to address these barriers. The federal government has invested in a variety of programs and granting initiatives to advances the training of STEM women, but also to enable the advancement of women in faculty positions (e.g. ADVANCE: Increasing the Participation and Advancement of Women in Academic Science and Engineering Careers). AAAS program. Universities have developed programs ranging from Women in Science and Engineering (WISE) Programs aimed to advance the number of women in STEM fields, to formal mentoring programs, to trailing spouse hiring programs, which often target women. Universities have also adopted formal policies (e.g. maternity leave, tenure clock stopping, on-site childcare) to provide support for women during their careers, enabling them to achieve a better work-life balance and thus stay on the tenure track.

As of 2015, there have been an assortment of federal, state, and university level policies and programs aimed at increasing the number of women in STEM faculty positions. Unfortunately, most of the research in this area relies on case studies, interviews, and other qualitative methods to identify challenges and opportunities facing women faculty and then ties those barriers and opportunities to national counts of the number of women in each STEM field. There is less research collecting systematic, national individual level data on women scientists with the goal of assessing how recent efforts have been directly related to individual career outcomes for women university scientists (one exception is Ceci et al. 2014 which investigates outcomes for math-intensive fields).

We have been studying academic scientists in the US for a number of years. Most of our research relies on egocentric surveys of academic scientists, asking them about their work life, work activities, work outcomes (grants, publications), work-life balance, and perceptions about their work environment. These surveys take a network approach, asking the respondent about a variety of people in their networks including colleagues, collaborators, advisers, students, mentors, and which whom they are connected. From these surveys we have been able to investigate a number of research questions about academic scientists including issues particular to women in STEM fields, such as balancing teaching and research responsibilities, the role of mentors in women's careers, work-life balance, productivity, family-friendly policies, and collaboration and advice network structure. This type of data is especially useful for investigating issue facing women scientists as researchers argue that the dearth of women in academic STEM fields is explained by a complex inter-action of a variety of factors including department climate, socialization systems, challenges to family and work balance, career choice, and a culture that disadvantages women or discourages them from pursuing science careers (Callister 2006; Kemelgor and Etzkowitz 2001; National Academies of Science 2003; NSF 2004). We are now at a point in the research where we can take stock of what we know and what we don't know about women in academic science by drawing on national data on the careers of women scientists at research extensive and intensive universities.

In this paper, we draw from data collected from two studies conducted in 2007 and 2014. The 2007 Netwise I survey was completed by a sample of 1,628 faculty in six fields: biology, chemistry, computer science, earth and atmospheric sciences, electrical engineering, and physics at 151 universities that were then categorized as Carnegie Research I universities (now research intensive / extensive)[1]. The 2014 Netwise II survey was completed by 1,324 faculty in four fields biology, biochemistry, engineering, and mathematics at Carnegie Research Extensive and Intensive universities, Master's I/II institutions, tenured and tenure track faculty at HBCUs identified by the White House Initiative on HBCUs, all Hispanic Serving Institutions that met our institutional criteria, Women's Colleges offering degrees in the target disciplines, and the Oberlin 50 baccalaureate institutions throughout the US[2]).

In this paper, we draw from these two studies and a number of our papers and presentations to investigate narratives about women's productivity, salaries, and satisfaction; the effects of family-friendly policies on women's careers in STEM; and the professional networks of women in academic science. We then discuss the

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ways that university policies may or may not remove barriers to attracting, retaining, and supporting women scientists' in academic careers.

I. Differences in Work Life between Men and Women Scientists

1. NARRATIVE: Women scientists have larger teaching loads than men scientists, leaving men scientists with more time to dedicate to research.

The job description of academic faculty in Research Extensive and Research Intensive institutions includes research, teaching, and service. Of these teaching and service are more fundamentally linked to the structure and functioning of the academic departments within which scientists work. While teaching and service loads are considered to be standard such that each faculty member is assigned to the same amount of time in the classroom, in practice there are many intervening factors that affect teaching and service loads. Prior research has found that women teach more and provide more service than men (Bellas & Toutkoushian 1990; Park 1996; Menges & Exum, 1983). Implicit in this discussion of increased teaching and service among women faculty is that these two activities come at the expense of time dedicated to research, thus men who teach less have more research time than women. As a first step, it is useful to examine the balance of teaching and service loads among men and women in the Netwise I and Netwise II studies.

Table 1: Number of courses taught/co-taught in past academic year, Netwise I

Rank*Sex	Mean	N	Std. Deviation
Assistant Men	3.20	217	0.998
Associate Men	3.86	248	1.173
Full Men	3.45	396	1.127
Assistant Women	3.20	204	1.116
Associate Women	3.48	194	1.059
Full Women	3.31	324	1.098
Total	3.42	1583	1.121

ANOVA: Number of courses taught/co-taught in past academic year, by Rank*Sex, Netwise I

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups (Combined)	72.552	5	14.510	11.945	0.000
Within Groups	1915.718	1577	1.215		
Total	1988.270	1582			

Q. How many courses did you teach or co-teach in the previous year? Response Categories: (1=0, 2=1; 3=2; 4=3; 5=4; 6=5 or more).

Results from the NETWISE I survey indicate that women scientists report teaching fewer courses, on average in the past academic year than men. Among women scientists, 4.7% taught zero courses and 4% taught 5 or more classes. Among men, only 2.9% taught zero courses and 6.5% taught 5 or more classes. These differences in teaching load by sex were statistically significant at the .05 level (Pearson Chi-Square 12.186, df=5, Asymp. Sig. (2-sided) .032).

Comparing teaching loads by rank and sex, we still find statistically significant differences (Sig. .000). As noted in Table 1, the highest average teaching loads are among Associate men, followed by Associate women, and Full men. Teaching loads are lightest for both men and women assistant professors, likely due to incentives to support research activities among junior faculty.

Bottom Line: The Netwise I data indicate significant differences in teaching loads between men and women scientists, with women reporting lighter teaching loads than men and junior faculty members reporting lighter teaching loads.

2. NARRATIVE: Women scientists have larger service loads than men scientists.

Analysis of Netwise II data shows that women and men scientists, on average, serve on the same number of committees. We aggregated three types of committee service: (1) faculty search committee service, (2) other department committees, and (3) university or college committees. According to the data presented in Table 2, women serve on an average of 3.89 committees and men serve on an average of 3.90 committees. The Netwise II data includes scientists working at a large variety of institution types including research extensive, research intensive, master comprehensive, liberal arts colleges, and historically black colleges and universities. When we restrict the data analysis to examine only research extensive and research intensive institutions, we find that women have slightly higher service loads, but the differences are not statistically significant, even at the 0.10 level. Overall, women on average serve on 3.58 committees while men serve on 3.45 committees.

Table 2: Service Load, Number of Department and University Committees Last Year, Netwise II

	N	Mean	Std. Deviation	T Test Significance
All institutions	4195	3.90	3.56	
Men	2383	3.91	3.67	NS
Women	1812	3.89	3.41	
Research Extensive and Intensive	2125	3.52	3.59	
Men	1187	3.58	3.91	NS
Women	938	3.45	3.16	

Q. During the past academic year on how many of the following did you serve? (1) faculty search committees, (2) other department committees, and (3) university of college committees.

Bottom Line: There are no statistically significant gender-based differences in service loads found in the Netwise II data.

3. NARRATIVE: Women scientist have fewer leadership roles than men scientists.

In a recent paper on this subject, coauthors Parker and Welch (working paper) examine whether there were differences in the likelihood that men and women academic scientists hold different types of leadership positions in academia. The paper examines three types of leadership positions: research center director, university level administrative leader and discipline leader. Using Netwise I data, the coauthors developed robust econometric models predicting whether or not scientists would hold one or more of the three leadership positions.

Controlling for multiple factors including productivity, awards, social capital, discipline, age and minority status, women are less likely to hold research center or university leadership positions, but more likely to hold discipline-level leadership positions. Lower likelihood of leading a research center or being an administrator in a university is concerning as these positions control the allocation of research dollars and make decisions that have direct effects on the production of new knowledge. Women may be more likely to serve as discipline leaders because they are fewer in number and may be more likely to be asked to serve, particularly given the need for many professional associations to address gender balance (Chamberlain, 1988; Twale & Shannon, 1996).

Bottom Line: Based on analysis using the Netwise I data, women are less likely to hold positions of leadership in research centers and university administration, but more likely to hold discipline-level leadership positions.

II. Differences in Productivity between Men and Women Scientists

4. NARRATIVE: Women scientists produce fewer papers than men scientists.

Substantial efforts have been undertaken to examine whether women and men publish at the same rates. Early work by Clemente (1973) demonstrated that publication differences based on sex are not statistically significant. Work since that time tended to show that women had lower publication rates as compared to men (Cole & Zuckerman, 1984; Long, 1978; Bellas & Toutkoushian, 1999). More recently, other researchers have shown that the differences are declining or non-existent (Xie & Shauman, 1998; Lee and Bozeman, 2005;).

Drawing on Netwise I and Netwise II data, we find significant differences in mean publications of journal articles by men and women. Table 3 indicates that women produce fewer publications in both studies. In Netwise I analysis the differences are only significant if the analysis includes the sample weights. The Netwise II data show that women produce fewer articles than men whether or not sample weights are used. Nevertheless, these simplified analyses are not sufficient to test for sex-based differences in productivity as they do not control for important factors such as academic rank (as more women in these samples are likely to be junior) and discipline. It is necessary to control for field of science, academic rank, and sundry other factors that are essentially hidden in difference of means tests.

Table 3. Netwise I and II Productivity, Number of Publications Last Two Years

NETWISE I	N	Mean	Std. Deviation	T Test Significance
Publications (with sample weights)	1489	3.88	4.42	
Men	806	3.93	5.66	p<0.001
Women	683	3.59	2.16	

Q. Please indicate how many peer reviewed academic publications (accepted or published) and invited or other presentations you had in the past two academic years: (Categories: 1=0; 2=1-2; 3=3-4; 4=5-6; 5=7-9; 6=10-14; 7=15 or more).

Netwise II	N	Mean	Std. Deviation	T Test Significance
Publications (with sample weights)	1578	6.80	22.22	
Men	861	7.36	28.80	p<0.001
Women	717	5.20	9.21	

Q. During the past two academic years, how many of the following have you produced (1) Peer reviewed journal articles.

The authors have written several manuscripts that examine publication productivity and that use more sophisticated statistical models to predict publication numbers. One manuscript examines network structure over time to see if changes in the size and composition of scientists networks has an effect on their productivity (Jha and Welch, working paper). In that research, we included a discrete variable indicator for whether the scientists was a woman or not. Our results found that once we control for important other predictors of publications, there is no difference between men and women, e.g. the variable controlling for sex is not significant.

Similarly, Jha and Welch (unpublished manuscript) conducted a study using the Netwise I data in which they examine the role of relative seniority and structural hierarchy on productivity. In those models, the authors also controlled for many other factors and when they did, the discrete variable for sex was not significant. To demonstrate our approach, we present a simple model using the Netwise I data to predict publication outcomes, see Table 4. Here the dependent variable is the number of Publications and the independent variables are Woman, Assistant Professor, Associate Professor, Full Professor and the six disciplines in the sample: Biology, Chemistry, Earth and Atmospheric Sciences, Electrical Engineering, Physics and Computer Science. Shown in Table 4, being a woman is not a significant determinant of publication outcomes.

Table 4. Predicting Publication Productivity, Netwise I Data

Variable	Coefficent	Std. Error	t value	Pr > |t|
Intercept	4.20	0.13	31.64	0.00
Woman	**-0.11**	**0.08**	**-1.37**	**0.17**
Biology	-0.34	0.15	-2.22	0.03
Chemistry	0.30	0.15	1.93	0.05
Physics	0.55	0.15	3.57	0.00
EAS	-0.02	0.15	-0.16	0.87
Computer Science	-0.80	0.16	-5.13	0.00
Assistant	-0.71	0.10	-6.94	0.00
Associate	-0.35	0.10	-3.51	0.00

N=1499; F=19.72, p<0.0001; Adj R-Sq 0.09; no violation of normality assumptions; Dependent variable: Please indicate how many peer reviewed academic publications (accepted or published) and invited or other presentations you had in the past two academic years: (Categories: 1=0; 2=1-2; 3=3-4; 4=5-6; 5=7-9; 6=10-14; 7=15 or more). *Full Professor* and *Electrical Engineering* are reference dummy variables in the model.

Bottom Line: There is no statistically significant difference in publications between men and women scientists.

5. NARRATIVE: Women scientists have lower grant success than men scientists.

As Ceci and colleagues (2014) have noted, there has been some controversy and disagreement in the literature on whether women receive equal treatment on grant proposal reviews. In their review of the literature, they noted that there is little evidence of differences between men's and women's funding rates and in their own research they conclude that in math-intensive fields, men and women principal investigators are equally likely to have their grants funded. Our work tends to support these findings.

Drawing from our first study, Netwise I, we investigated the number of Principal Investigator (PI) grant submissions reported by STEM faculty, comparing men and women faculty. First, we found no significant correlation between the number of PI grant submissions and sex (Pearson Correlation -.043, sig. (2-tailed) .087, N=1553). Looking at PI grant submissions by sex, we found that 11.7% of men and 12.3% of women reported not submitting a PI grant application in the previous year. Among men, 12.3% reported one submission, 17.2% submitted two, 11.2% submitted three, and 13.8% submitted four grant submissions as a PI. In comparison, 13.5% of women reported one submission, 11.8% two submissions, 13% three submissions, and 11.5% four submissions. Overall, the proportion of men and women applying for grants in the role of PI are relatively matched. A crosstabulation found no significant difference in PI grant submissions by sex, (Pearson Chi Square 46.889, df=34, sig. (2-tailed) .070, N=1553).

We also asked respondents about success with grant applications. We found no significant correlation between sex and the number of PI grants awarded (Pearson Correlation -.029, sig. (2-tailed) .278, N=1451). 27.4% of women respondents reported being awarded one PI grant proposal compared to 29.6% of men, 18% of men and 21.4 of women respondents reported two awards, and 26.6% of men reported no grant awards in the previous year as compared to 27.6% of men. A crosstabulation indicated that these minor differences in percentage of grants awarded, by sex, were not statistically significant (Pearson Chi Square 34.173, df=28, sig. (2-tailed) .195, N=1451).

In a study investigating the relationship between collaborative networks and grant getting, Haller and Welch (2014) concluded that networks play a critical role in grant getting. So much so that they noted that "the size and strength of relationships with collaborators and not the ability of these collaborators that matters for scientists' decisions to commit to pursue grant opportunities" (p 823), thus reinforcing the important role that collaboration networks play in the advancement of all academic scientists, and women in particular (Defazio et al., 2009; Fox & Mohapatra, 2007; Lee & Bozeman, 2005).

Bottom Line: Analysis of the Netwise I data finds no statistically significant difference in grant success among men and women in STEM fields.

III. Salary and Satisfaction

6. NARRATIVE: Women scientists are paid less than men scientists.

In the US, women, on average, are paid less than men. Currently estimates put women's pay at .77 cents to each dollar that men earn (The White House, 2015). Research on academic salaries confirms this discrepancy, noting that on average at all types of universities and at all faculty ranks women earn less than men (Curtis & Thornton 2014). Unfortunately, drawing conclusions from the Chronicle of Higher Education (CHE) data compares apples to oranges. Those data are limited to a comparison of average salaries by men and women across all fields, combining STEM fields with liberal arts and humanities, which on average would have lower salaries and more women faculty. Thus while women faculty, on average, are earning less than men faculty, we do not see differentiation across field, type of science, type of department, or even years on the job - a first year associate professor might make a lot more than a fifth year associate. A faculty hire from another institution has more negotiating power than a faculty member who has stayed at the same institution. Recent research has found that in math-intensive fields (with the exception of economics), women and men had comparable pay rates (Ceci et al. 2014). In fact, "Gender differences in promotion and salaries can largely be explained by observable characteristics, including productivity and field" (Ceci et al. 2014, p. 46).

We asked STEM faculty about their salaries and also about strategies for negotiating salaries. Our results, presented in table 5, show that when aggregated across disciplines and rank, salary differences between men and women are statistically significant. These findings echo the CHE findings, with women on average making significantly less than men. However, recognizing the need to compare apples-to-apples, we regressed salary on sex, discipline, and rank (Table

6). We found that the significance identified in the difference of means test, disappeared once we controlled for discipline and rank. These findings support prior work by Ceci, et al. (2014) which finds that women, while underrepresented in many of these fields, are making comparable salaries to men.

Table 5. Mean Annual Salary of Men and Women, Netwise I and II

Netwise I	**N**	**Mean**	**Std. Deviation**	**T Test Significance**
Salary (with sample weights)	1361	97,997	116,644	
Men	738	99,731	148,539	p<0.001
Women	623	87,306	57,892	
Q. What is your approximate current salary?				
Netwise II	N	Mean	Std. Deviation	T Test Significance
Salary (with sample weights)	1506	97,853	67,485	
Men	799	102,448	81,714	p<0.001
Women	707	85,946	42,113	

Q. What is your current annual salary excluding summer appointments?

Table 6. Predicting Salary, NETWISE I Data

Variable	**Coefficent**	**Std. Error**	**t value**	**Pr > |t|**
Intercept	132411	3324	39.84	0.00
Woman	-1792	2101	-0.85	0.39
Biology	-20232	3857	-5.25	0.00
Chemistry	-22409	3831	-5.85	0.00
Physics	-18556	3882	-4.78	0.00
EAS	-26605	3808	-6.99	0.00
Computer Science	-8072	3965	-2.04	0.04
Assistant	-42073	2577	-16.33	0.00
Associate	-32618	2495	-13.07	0.00

N=1360; F=47.89, p<0.0001; Adj R-Sq 0.22; no violation of normality assumptions; Dependent variable (continuous variable): What is your current annual salary excluding summer appointments? *Full Professor* and *Electrical Engineering* are reference dummy variables in the model.

Bottom Line: Women and men in STEM fields report similar salaries after considering discipline and rank.

Beyond simply looking at salary levels, the negotiation of salaries is also considered to be an important factor for explaining any discrepancy of pay between men and women. Prior research indicates that women expect lower pay, are less likely to negotiate their pay, and when they do negotiate often ask for less than men (Babcock et al. 2003; Kaman & Hartel, 1994). We asked men and women STEM faculty to describe what happened when they were given the salary offer for their current position. The response categories were: 1) I accepted the offer as is; 2) I negotiated for more money or other resources, and received ALL of it; 3.) I negotiated for money or other resources; and 4) I negotiated for more money or other resources, but didn't get it.

Results from the Netwise I survey, presented in Table 7, indicate significant differences in negotiating responses by sex. Specifically, men (59.49%) accepted the offer "as is" at a higher rate than did the proportion of women (50/63%), dispelling a common myth that women do not negotiate for more pay or resources. Men and women reported around 11-13% success receiving all of their requested pay and resources. A higher proportion of women (29.85%) reported getting some of their request (men 24.33%) and a slightly higher percentage of women (6.56%) reported not getting the request (men 5.01%). These differences in reported negotiation strategies of men and women scientist are statistically significant (Pearson Chi-Square 12.655, df=3, Asymp. Sig. (2-sided) = 0.005), indicating that men are significantly more likely than women to accept an offer as is. Women are significantly more likely to negotiate their salaries. When negotiating salaries, women are more likely to report getting some or all of the request.

Table 7: Crosstabulation of Salary Negotiation and Sex, Netwise I

	Accepted as is	Received all of request	Received some of request	Didn't get request	Total
Men	511	96	209	43	859
% of men	59.49%	11.18%	24.33%	5.01%	
Women	363	93	214	47	717
% of women	50.63%	12.97%	29.85%	6.56%	
Total	874	189	423	90	1576
	55.46%	11.99%	26.84%	5.71%	

Pearson Chi-Square 12.655, df=3, Asymp. Sig. (2-sided) = 0.005

Bottom Line: Women and men faculty scientists are paid similar amounts after considering discipline and rank. Among those who negotiate for salaries, women negotiate more than men and women are more successful in receiving what they request.

7. NARRATIVE: Women academic scientists are less satisfied at work than men academic scientists.

Several prior studies have shown that women scientists are less satisfied with their jobs than men scientists (Callister, 2006; Ecklund & Lincoln, 2011; Trower and Bleak, 2004). Meanwhile, the survey of doctoral recipients has also documented that the differences between job satisfaction of men and women is narrowing over time (Ceci et al. 2014).

Both the Netwise I and II surveys asked multiple questions about satisfaction including general job satisfaction as well as more specific questions on satisfaction with professional relationships, recognition, visibility, resources and support, and student quality, among others. Table 8 presents findings from the Netwise I data showing differences between men and women across several different types of satisfaction. For six of the fifteen satisfaction items there are significant differences between men and women scientists: teaching, relationships with colleagues, scholarly recognition, equipment and instruments, reward system, and home and work life balance.

Table 8. Differences in Satisfaction between Men and Women Scientists, Netwise I

	Men (n=)		Women (n=)		P value
	Mean	SD	Mean	SD	
The courses you teach	3.24	0.58	3.16	0.60	P<0.05
Relationships with colleagues in your department	3.04	0.69	2.88	0.79	P<0.001
Your recognition as a scholar	2.85	0.68	2.78	0.72	P<0.01
Your salary	2.69	0.77	2.69	0.77	NS
The reputation of your academic department	2.64	0.75	2.68	0.76	NS
The reputation of your institution	2.68	0.76	2.72	0.74	NS
Job placement of your doctoral students	2.94	0.57	2.99	0.60	NS
Availability of research equipment & instruments	2.85	0.72	2.78	0.78	P<0.10
Quality of research assistants	2.64	0.72	2.68	0.73	NS
The faculty reward system at your institution	2.45	0.77	2.33	0.78	P<0.01
Support from your department chair	2.88	0.84	2.85	0.89	NS
The visibility of your research	2.83	0.65	2.77	0.70	NS
Reviewer feedback on grant submissions	2.50	0.73	2.51	0.75	NS
Reviewer feedback on journal submissions	2.80	0.57	2.79	0.63	NS
Ability to balance home and work life	2.73	0.70	2.54	0.78	P<0.001

Q. At this point in your career, how satisfied are you with the following? (1=very dissatisfied; 2=dissatisfied; 3=satisfied; 4=very satisfied)

As with the analysis conducted for the salary, it is critical to conduct more complex analysis to accurately assess differences for satisfaction among men and women. In a recent paper, Welch and Jha (2015) conducted a factor analysis on the set of satisfaction items using the Netwise I data. The authors identified three separate general types of satisfaction: satisfaction with rewards, satisfaction with visibility as a scholar, and satisfaction with the reputation of the institution. The authors then used the three constructed variables as dependent variables in a regression equation that controlled for a full set of demographic variables including sex, discipline, salary, department size, perceived influence over hiring and teaching and multiple network variables. The results of the regression estimation indicated that women were significantly less satisfied than men for all three satisfaction measures.

Bottom Line: : Women and men faculty scientists report significantly different levels of satisfaction on single measures of satisfaction and also as related to satisfaction with *rewards, satisfaction with visibility as a scholar, and satisfaction with the reputation of the institution. Overall, we find that women academic scientists report lower levels of satisfaction than men.*

IV. Institutional policies

8. NARRATIVE: Family-friendly policies improve the work place for women scientists (e.g. they will increase productivity for women scientists and reduce gender inequality in the work place)

In their paper "Enabling work? Family-friendly policies and academic productivity for men and women scientists", Feeney, Bernal, and Bowman (2014) investigated the ways in which formal university family-friendly policies are related to work outcomes for both men and women scientists. They used data from the Netwise I and coded organizational-level data about family-friendly policies from faculty handbooks and university Status of Women reports to empirically investigate the relationships between formal family-leave policies, tenure-clock stopping policies, on-site childcare, and spousal hiring policies and publication rates and teaching loads, two important measures of faculty work activities. They found that formal university-level family-friendly policies were related to both teaching loads and publication rates, but that these relationships differed for men and women and that in some cases exacerbated the gender inequities they aim to address.

Feeney et al. (2014) found that formal university-level family-friendly policies are differently related to outcomes for women and men academic scientists. Specifically, they found that generous university family-leave policies are weakly significantly related to increased production of journal articles for women, but there is no relationship between family-leave policies and men's productivity. More generous leave policies are significantly and negatively related to teaching loads for men scientists, but not significantly related to teaching loads for women faculty. They argue that this result shows the net positive gains that universities can achieve buy offering generous family-leave policies, which are often cited as an important recruitment tool for women faculty.

Feeney et al. (2014) found no significant relationship between formal policies for stopping or delaying the tenure clock, formal spousal hiring policies, and academic productivity for women. Meanwhile, on-site childcare was significantly related to an increase in teaching loads for women and increased publication rates for men. The authors concluded that these findings highlight important gender disparity in the provision of on-site childcare, possibly indicating the need for more nuanced approaches to ensure that these services aimed to enhance universities as family-friendly environments do not lead to unintended consequences (e.g. benefits to men but not women, or vice versa).

Feeney et al. (2014) argued that university policies aimed at creating a more family-friendly work environments, often with the goal of altering the environmental and structural barriers facing women in STEM fields, can have the result of mimicking current inequalities in the workplace. For example, onsite childcare appears to be related to increased teaching loads for women and increased journal publication rates for men, a work distribution that may further inequities that on-site childcare is hoping to address.

In a more positive vain, this research indicates that university family-leave policies are related to increased journal publications for women and do not significantly affect men's teaching loads or publication rates, thus indicating a potentially powerful tool for universities to use for attracting faculty, while not resulting in negative productivity outcomes, but in fact the exact opposite, higher productivity. Most important, the findings indicate that generous formal family-leave policies, on-site childcare, and spousal hiring policies differently affect the productivity of women and men academic scientists, making it increasingly important to understand how these policy tools will or will not achieve their intended goals and if they also inadvertently result in other consequences.

Bottom Line: University based policies aimed to enhance family-work balance result in different productivity outcomes for men and women.

V. Networks, Social Capital, and Advice

9. NARRATIVE: Men and women academic scientists have significantly different network structures and resources.

The structures and resources of men's and women's professional networks help explain access to and participation in science, their productivity, and their overall success and satisfaction. Network studies are often informed by social capital theory which is the sum of actual or potential resources available though the connections with others (Bourdieu, 1985; Coleman 1988; Lin 2002). Academic science research has shown that "[w]omen's networks tend to be poorer in social capital than those of their male peers" (Etzkowitz et al. 2000, p. 171) and that "[o]ne of the underlying barriers to the success of women scientists is the structure of their social networks" (Etzkowitz et al. 2000, p. 176). The fundamental questions related to these observations formed the basis and served as a motivation for the Netwise I and II studies. It remains vitally important to understand how policy can best address professional networks to affect the outcomes of women and men in science.

We examined the differences in several measures of network structure (e.g. size, proximity, homophily), relationship characteristics (e.g. communication frequency and length of relationship) and network resources (e.g. introductions, nominations, and paper reviews). Based on a statistical comparison of Netwise I data using t-tests presented in Table 9, we find that women have significantly larger collaboration networks, more external (outside the home institution) ties, more women in their networks (Feeney & Bernal, 2012), and more senior collaborators. While women and men on average have known their collaborators for a similar length of time, women report more frequent communication with network ties. In terms of resources received, the only significant difference is that women are more likely to report that their collaborators provide informal reviews of their research.

Table 9. Differences in Collaboration Network Structure and Resources, by Sex, Netwise I

	Men			Women			
	N	Mean	SD	N	Mean	SD	P-value
STRUCTURE							
Collaboration Network Size	785	4.94	2.46	651	5.3	2.43	P<0.10
External-Internal Ratio	785	-0.03	0.53	651	0.05	0.53	P<0.05
Number Women	785	0.52	0.85	651	0.97	1.24	P<0.01
Number Close Ties	785	1.16	1.59	651	1.18	1.48	NS
Number Senior Collaborators	785	1.59	1.85	651	1.92	1.94	P<0.01
RELATIONSHIP CHARACTERISTICS							
Length of Relationship	675	2.4	0.5	567	2.39	0.49	NS
Communication Frequency	661	2.4	0.6	557	2.3	0.6	P<0.01
RESOURCES							
Average Invitations	632	0.16	0.32	551	0.19	0.32	NS
Average Introductions	632	0.18	0.32	551	0.16	0.31	NS
Average Informal Paper Reviews	632	0.16	0.3	551	0.2	0.33	P<0.01

Table source: Melkers, J., and Welch EW. 2010. Collaborative and Career Development Social Networks of Women and Men in Academic Science: Are They Different? 2010 Annual Meeting of AAAS, San Diego, CA. February 19, 2010

Bottom Line: Men and women scientist networks have significantly different structural and relational attributes.

Beyond these descriptive statistics, it is also important to know whether structural or relational differences matter for key career outcomes. Prior work shows that women's credentials do not get translated to scientific career attainments at par with their male counterparts (Fox, 2001). The Netwise I study examined how research collaborative network was related to the salaries of men and women scientists after controlling for rank, discipline, and other factors. Two dependent variables were used: salary in 2007 and change in salary from 2007 to 2010. Findings showed that most of the collaborative network structural measures contribute similarly to both men and women's salary in 2007. However, findings for change in salary show very different results by sex.

Research collaboration network size measured in 2007 was associated with an increase in salary in 2010 for men, but there was no relationship between network size and salary for women. It is possible that for men larger sized networks produce recognition and visibility that results in salary increases, but the same mechanism does not work for women. Similar results were found for other types of networks structures. Men's salary increases from 2007 to 2010 were significantly and positively associated with the number of senior collaborators in their networks in 2007, but women did not gain the same benefit from senior collaborators in their networks. The same is true for network resources: men's salary increases were significantly and positively associated with reported introductions and nominations from people in their networks, while the same statistical association was non-existent for women (Jha and Welch, unpublished manuscript).

Bottom Line: Some measures of social capital within men's networks are associated with salary increases over time, but the same measures of women's social capital does not convert to salary increases over the same time period.

10. NARRATIVE: Women scientists are more likely to seek advice and support from women(men) scientists.

There are two narratives about advice seeking among women scientists. The first narrative, and probably the most common, is that women scientists will (or need to) seek out the advice and sponsorship of men scientists because men hold the majority of resources and power in STEM fields. This narrative is based on a number of facts and assumptions. First, in fields historically dominated by men, it would follow that new entrants to the field would seek the advice and sponsorship of more senior, successful scientists, which are more likely to be men. Researchers note that women consistently lack access to important informal networks that are critical for support, confidence, perseverance, and success (Acker 1990; Etzkowitz et al. 1994; Etzkowitz et al. 2000; Kanter 1977; Kemelgor and Etzkowitz 2001). Second, if STEM fields are structurally or culturally biased against women, it makes sense for women to access members of the "club" to gain access to these resources and power. Etzkowitz et al. (2000) calls this accessing the 'Kula Ring' where informal organizing results in the sharing of key resources, information, and power.

The second narrative is that women scientists will actively seek the advice of other women scientists. As an underrepresented group in STEM fields, women will seek the support and advice of others in similar situations. Some scholars argue that this networking among homophily groups will be more likely among women, or when women make up a critical mass in the field (Etzkowitz et al. 2000; Ibarra 1993). Though one of the negative potential outcomes of same-sex networks is that women will increase their numbers in the field at large, but remain isolated (Kemelgor & Etzkowitz 2001).

Feeney and Bernal (2010) used data from the Netwise I survey to investigate the structure of women scientists advice[3] and support[4] networks. Specifically, they looked at the presence of women in men and women scientists' networks. They found that 55% of men and 80% of women scientists report having at least one woman in their advice and support networks (p. 777) and that women make up around one tenth of all respondents' advice networks (13%) and support networks (10%). They reported that women make up at least one-fifth of women's advice and

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[3] Advice Networks: What advice do you typically seek from the following individuals? (Check all that apply): Publishing, Grant getting, Overall career development strategies, Interactions with colleagues, work/family balance.

[4] Support Networks: Q: Colleagues often support each other in aspects of career development. Please indicate if the people you named have: (1) reviewed your papers or proposals prior to sub- mission (on which they were not a co-author); (2) Introduced you to potential collaborators outside of your university; and (3) Nominated you for an award or as an invited speaker.

support networks, though women report seeking more work/family balance advice (46%) than publishing advice (23%) from other women.

They find that the presence of women in women's networks is significantly different from the presence of women in men's networks. Women scientists report 12% more women in their networks than do men, with 15% more women in women's advice networks and 18% more women in women's support networks. They also found differences in the presence of women in women's advice and support networks by field of science. Overall, women in non-medical biology reported more women in their networks than women in physics, chemistry, CS, EAS, and EE, with women in physics and EE being the least likely to have women in their networks. This finding is likely the result of a critical mass of women in biology.

Interestingly, though much of the narrative about women in science indicates that women seek out women's advice because they are junior or they need advice about balancing home and work, Feeney and Bernal (2010) found no significant differences in the presence of women in advice or support networks based on age, time since PhD, marital status, parental status, or race. Though they did find that women associate professors report significantly more women in their advice networks than do full professors, possibly the result of increasing numbers of women in STEM fields over time. Feeney and Bernal (2010) conclude that women are more likely than men to have women in their advice and support networks and the proportion of women in these networks varies by field of science, citizenship, and in some cases time since PhD and rank.

Bottom Line: Women scientists are more likely than men to have women in their networks, but the presence of women in advice and collaboration networks varies by field of science and not by age or family status.

Discussion

There has long been a view that women are disadvantaged in science, technology, engineering, and mathematics fields due to structural, behavioral, and institutional barriers. Recent research focused on math-intensive fields (Ceci et al 2014) has found that many of the previous inequities in those fields have been ameliorated at the university faculty level. That is, while gender inequities persist in the pipeline of science (e.g. the educational system training women scientists) there are few or no significant differences between men and women faculty in math-intensive fields with regards to productivity, grant-getting, salary, and other critical outcomes. Our research, focused on a variety of STEM fields confirms some of these advancements in academic science.

First, we find little evidence supporting a common narrative that women are overburdened with teaching and service obligations, while men are given more time for research among STEM faculty at research intensive/extensive universities. In fact, we find the opposite. Junior women STEM faculty report significantly lighter teaching loads than men, a finding that runs counter to our common narrative about teaching obligations.

While the narrative often says that women are paid less and produce less than men, we find that once we control for discipline and rank, women and men report similar salaries and productivity levels. There are no significant differences in publication productivity or grant getting success between men and women scientists. Additionally, when we look closely at salary strategies we see that among those who negotiate for salaries, women negotiate more than men and women are more successful in receiving what they request. Thus universities are clearly responding to the demands of women scientists and also valuing women scientists at the same rate as men.

While STEM women are paid at the same rates, assigned similar work loads, and as productive as men, we find that women academic scientists report lower levels of satisfaction as related to rewards, visibility as a scholar, and reputation of the institution, as compared to men. We also find that many of the university based policies aimed to address workplace inequality or facilitate work-life balance, especially for women, might be furthering gender inequities in the workplace as some of these policies increase research productivity for men and not for women. Thus we see potential areas for improvement at universities, in particular efforts to ensure work-life balance and also create a culture where women find their jobs satisfying, rewarding, and potentially, most important, where universities invest in promoting the visibility and work of women scientists.

Finally, moving beyond singular measures of scientist satisfaction and productivity, we investigated how the networks of women scientists affect outcomes. We found that men and women scientist networks have significantly different structural and relational attributes which differently affect salary increases over time, the presence of women collaborators in those networks, and productivity. Thus we see that some of the nuanced differences between men and women in STEM fields can be partially explained by the types of professional, advice, and collaborative networks in which they engage.

So what explains the disconnect between common narratives of women in science and the empirical data that we present here? There are a number of ways to interpret this disconnect. From an empirical standpoint, it is important to note that we are looking at overall averages of performance, satisfaction, and network structures. Women continue to be underrepresented in STEM fields. In some fields, women make up less than 15% of tenure track faculty. While there are clear differences in the numbers of women and men in these fields, we find fewer differences related to productivity, research loads, and salaries. This is partly explained by the fact that the small number of women who make it to these positions are likely to be high performers. Women in academic faculty positions represent women who made it through the STEM pipeline – they have arrived. These women are more likely to be “superstars” and their average performance is compared to a wider range of men scientists, which may include superstars, medium performers, and low performers. Thus, the lack of difference in outcomes does not mean that the system is necessarily fair or easy for women scientists – just that those who make it to this stage in their careers are performing, on average, at the same level as a much larger group of men scientists.

From a policy standpoint, we might argue that the current high level policy environment is just catching up with the issues that were facing women in science 15-50 years ago. Our current narratives draw from previous research and high level policies often can't keep up with current issues and trends. Our findings show that the challenges facing women in academic science are nuanced and require more detailed assessment to develop modern policies that are fluid enough to deal with these evolving issues. Pipeline problems persist and there continues to be underrepresentation of women in many STEM fields. Our research does not address the number of women in STEM or the pipeline preparing women for academic STEM positions, but we do find that once women make it through the pipeline and get to the academic job, they are high performing.

STEM women in research intensive / extensive universities face significant challenges, but this is partly due to untailored (or poorly designed) big 'P' policy navigation. Some policies suggest or require women to get a mentor, or many mentors and advisers, where more network members (e.g. advisers) does not necessarily lead to more success, in fact, we find that the opposite is likely and the reverse is true – less success leads to more advice; and not necessarily the right type of advice for productivity gains. Partly the problem is institutional bias (expected network signals do not predict women's salary changes, but they do for men; women more likely to be in high-level visible leadership positions (positive bias), but not in research-level leadership positions (negative bias). Partly the bias is field related (women are perceived to be less cognitively capable in fields with fewer women). Partly it is the small 'p' policies that universities establish and the way they are enacted (family friendly policies aimed to help women actually make men more productive; women are encouraged and promoted into clinical faculty positions not academic faculty positions). And partly it is a contingent choice – women tradeoff the institutional, behavioral and perceptual mélange with their own interests and decide to pursue science (or not). These choices that occur in the pipeline of STEM training are related to self-selection issues that help to explain perspectives after women enter into academe

Our research, like that of Ceci et al (2014), shows that these issues evolve and that strategic universities will adjust. We cannot engage in simple reductionism and sweeping generalization, but instead need to encourage innovative, flexible research-based policies, that evolve as the social and organizational shape of academic science changes. Our findings point to important policy implications for universities. First, we see that policies that are often considered important for recruiting talented women faculty, spousal hiring policies, on-site childcare, tenure clock stopping policies, and generous family leave, in general, do not reduce the productivity of women scientists. Thus, universities might be encouraged to develop advanced formal policies in these areas as a mechanism for attracting and retaining faculty, without being overly concerned that it will lead to a reduction in productivity. That said, universities should also be cognizant as to how these policies may differently affect men and women faculty and thus result in unintended inequities.

Second, we find that some of the narratives about lower productivity and pay among women STEM faculty may not be explained by sex alone. When we control for type of position and field of science, we see that women scientists are making the same level of pay as men. We also find that women are negotiating for salaries at higher rates than men. Thus, universities need to do a better job articulating the more nuanced reasons for pay discrepancies (e.g. field of science or position) and do a better job promoting their role in advancing equitable pay.

Third, universities should also note that with relatively even productivity (publishing and grant getting) among men and women faculty, programmatic efforts dedicated to networking, advancing collaborative activities, and advancing the development of strong, diverse professional network ties might be advantageous for increasing productivity among faculty. This, taken in conjunction with the family-leave policy findings might point to a need to create an environment for networking and success, not just institutional policies aimed to cater to women or traditional notions of women's obligations to family life. And finally, universities should take notice of the significant differences in satisfaction levels that we find among men and women faculty. While work productivity seems to be at equal rates, dissatisfaction with pay, reputation, and visibility can become serious threats to the retention of talented scientists.

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