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Women in STEM Occupations in the Federal Government: Supervisors and Turnover

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Representation and Retention of Women in STEM Jobs in U.S. Federal Agencies:

A Note on the Potential Importance of Female Role Models

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Abstract

This paper provides an examination of the underrepresentation of women in STEM positions in federal employment and the problem of quitting behavior among those women. We document the representation and quitting of women in STEM positions from 2005 to 2018 in Cabinet-level Departments and two executive agencies (the EPA and NASA). We then look at the impact of factors that may be associated with the employment and quitting of women in STEM occupations across federal departments and agencies. Our major focus is on the importance of female role models in fostering representation and retention among these women. We find evidence that the presence of women in supervisory positions may be associated with increased representation of women in STEM occupations and decreased quitting behavior among women in those positions.

Representation and Retention of Women in STEM Jobs in U.S. Federal Agencies: A Note on the Potential Importance of Female Role Models

There is a relatively long history in the United States of efforts to promote equality of opportunity and to combat racial, ethnic, and sex-based discrimination in employment (see, for example, Gooden 2014, Kellough 2006, and Reed 1991). Despite this struggle, however, minorities and women remain underrepresented in many organizations and occupational fields. For example, in the public sector, which arguably should be a model of employment equity, African Americans remain substantially underrepresented in certain federal departments and agencies. In the U.S. Department of the Interior, for instance, they held only 4.7 percent of the Department's total positions in 2018. Similarly, African Americans comprised only slightly more than 4 percent of the employees within the U.S. Forest Service within the Department of Agriculture that same year.

Areas of notable underrepresentation are also found for women, and in this case, one of the most significant concerns is the extensive and persistent underrepresentation of women in occupational fields associated with science, technology, engineering, and mathematics, i.e., the STEM fields. According to a 2011 report by the U.S. Department of Commerce, women held approximately half of all jobs in the U.S. economy, but filled only 24 percent of all STEM jobs (Beede, et al. 2011). This level of underrepresentation carries significant implications, not only because we are deprived in these fields of the talents of a large proportion of our population, but also because women in STEM jobs earn as much as 33 percent more than comparable women in non-STEM jobs (Beede, et al. 2011). Recent data from 2018 show that women hold less than 27 percent of all STEM jobs within the federal civil service.

This paper provides an examination of the problem of the underrepresentation of women in STEM positions in federal employment. We document the representation of women in these positions from 2005 to 2018 in Cabinet-level Departments and two executive agencies (the EPA and NASA). We then look at the impact of factors that may be associated with the employment of women across federal departments and agencies. But the entry into STEM jobs is only half of the problem. The other half is retention. Women are disproportionally found among employees who resign or quit STEM jobs (see, e.g., Corbett and Hill 2015). For this reason, we also examine quit rates for women in federal STEM fields in our sample of departments and agencies. We find that women are overrepresented among those who resign from these positions, but that these quit rates vary by agency and department. We then examine factors associated with the frequency with which women quit federal STEM jobs. In our models of both representation and retention, we are particularly interested in the effect of the presence of women in supervisory or leadership positions in STEM fields.

Women in STEM: Gaging the Problem

As noted, there are two core aspects of the problem of the underrepresentation of women in STEM occupations. The first issue is initial entry into STEM fields as undergraduate students, graduate students, and as working professionals. For a variety of reasons, having to do with patterns of socialization that direct girls and young women to other fields and sexual biases that create environments unreceptive to women with STEM undergraduate and graduate programs and professions, women have not entered STEM occupations at a rate equal to that of men. One study found that by the time girls are in middle school or high school, they are likely to have formed beliefs that they lack an aptitude for math or science even when those beliefs may be

unfounded (Burke 2007). Teacher expectations and attitudes often reinforce these views, and science textbooks that rarely represent the accomplishments of women add further to the problem (Ford and Varney 1989). This situation continues as women enter college. Science majors are seen often as male preserves, and many young women, because of prior socialization patterns, lack confidence in their abilities in math and science. The fact that there are few women on the faculties in STEM fields to serve as positive role models compounds the problem further. In addition, some male students and professors may be hostile to women in STEM majors. Generally then, the environment within STEM majors at the undergraduate level may, to say the least, be described as "chilly" for women (Burke 2007). Since the year 2000, the number of women in STEM fields at the bachelor's degree level has declined significantly, although those who remain are particularly tenacious in their drive to succeed and move on to graduate programs (Miller and Wai 2015). Once women do move into graduate school in STEM areas, however, the problems encountered earlier continue (Lott 2009). The combination of these pernicious forces means ultimately that too few women have the advanced degrees necessary to enable them to work professionally within STEM occupations.

The second aspect of the problem of women in STEM is retention. Women who persist and do enter into work in STEM fields continue to face numerous obstacles including isolation and exclusion, the downplaying of their abilities, sexual harassment, and a lack of female role models and mentors (Burke 2007, Van Veelen et al. 2019). Not surprisingly, this situation results in women leaving STEM occupations (i.e., quitting or resigning from their positions) at rates significantly higher than the rates for men. This pattern of disproportionate attrition of women from the STEM workforce, in turn, exacerbates the problem of the underrepresentation of women in these occupational fields (Xu 2008).

There is a vast literature across multiple disciplines that examines the underrepresentation of women in STEM fields, reviews probable causes for that underrepresentation, and proposes strategies for improvement. Those proposals include efforts to increase interest in STEM among girls in elementary and middle schools (Valla and Williams 2012); programs to combat stereotypes that portray STEM fields as areas best suited for men (DiBella and Crisp 2016, Ryan 2014, Saucerman and Vasquez 2014); and the implementation of family-friendly policies within the workplace (Feeney, et al. 2014). Numerous scholars also point to the importance of having positive female role models available for women in undergraduate and graduate programs and in work settings in STEM areas (Bottia, et al. 2015, Conklin 2015, and Feeney and Bernal 2010). The presence of successful women in STEM disciplines effectively demonstrates to other women who may be entering these fields that they also can do well, that they belong, and that they have much to contribute. Successful women in STEM fields, especially those in leadership or supervisory positions may provide inspiration for other women to be successful.

With this in mind, we are particularly interested in understanding whether the presence of women in STEM fields who can serve as positive role models for other women is associated with higher levels of representation and lower rates of attrition of women in STEM occupations.

Methods and Data

We are examining two specific research questions in this work: (1) what are the levels of representation of women in STEM jobs in federal departments and agencies and the factors associated with variation in that representation, and (2) what is the representation of women among employees who quit STEM jobs in federal departments and agencies and what variables may help to explain variation among agencies in that behavior. Our data on employment come

from the U. S. Office of Personnel Management's (OPM) FedScope data source. We observe employment levels and quit rates for women in STEM occupations in all 15 of the cabinet-level executive departments and two independent agencies (the EPA and NASA) for the years 2005 through 2018. For the Department of Defense, we examine the Departments of the Airforce, Army, and Navy separately from the remainder of Defense. As a result, our sample includes 20 distinct federal organizations. Table 1 shows basic gender representation statistics for employees in STEM occupations in these departments and agencies averaged across the time period analyzed (2005-2018). As one can see, women's representation in STEM fields varies significantly—from a low of 16.7 percent at the Department of the Air Force to a high of 42.9 percent in the Department of Health and Human Services.

[Table 1 About Here]

Table 2 shows that women are generally over-represented among those who quit depending on the agency or department in which they work. The Environmental Protection Agency (EPA) has the worst disparity, with women making up 37.9 percent of STEM employees on average across the time period we analyze, but they comprise nearly 53 percent of the employees who quit those jobs. STEM employment and quit rates at the Department of Justice are even and nearly even at the Department of Health and Human Services. Interestingly, however, numbers at the Department of the Treasury are almost the inverse of the EPA. There, women make up 41.6 percent of STEM employees and only 27.3 percent of those who quit.

[Table 2 About Here]

Given the state of representation and quitting among women in STEM fields, we seek to understand what variables contribute to those patterns across the agencies we examine. In both cases we employ fixed effects regression models to control for unobserved time invariant characteristics of federal departments and agencies[1]. In our first model, the dependent variable is women's representation among those employed in STEM jobs. Again, the data come from FedScope Employment Cubes for the years 2005 to 2018. The independent variables used in this model are the proportion of each agency's authorized budget used for social equity purposes, the organization's size (as measured by the number of employees in each department or agency), the proportion of supervisors in STEM occupations who are women, and the proportion of work leaders in STEM occupations who are women.[2]

We include the social equity spending variable in our model because previous evidence suggests that departments or agencies that are more committed to social equity tend to attract more female employees than other departments or agencies (Cornwell and Kellough, 1994; Brown and Kellough, 2019). Of course, this finding may or may not hold true for employees in STEM occupations. We test that proposition here. Data come from a historical budget authority dataset from the GPO (U.S. GPO). We gauge an agency's commitment to social equity by determining the proportion of authorized funds in each agency which are dedicated to education, training, employment, and social services; income security; health; Social Security; Medicare; community and regional development; and veterans' benefits and services.

[1] We ran the same models using random effects regression, finding similar substantive results.

[2] The models investigating the representation of women in STEM fields do not include employees in the Department of the Army, Department of the Air Force, or Department of the Navy because spending data needed to construct the social spending variable are not available in the GPO's budget authority spreadsheet for those Departments..

Organization size is another variable that we believe may positively affect the representation of women in STEM jobs. Larger organizations tend to have greater opportunities for promotion and advancement and for that reason may be more attractive as employers. In addition, they are likely to have more resources than smaller organizations to effectively recruit diverse job candidates.

We include two variables of primary interest to test the impact of the presence of potential positive female role models. These are variables measuring the proportion of supervisors in STEM occupations in the departments and agencies analyzed who are women and the proportion of work leaders in STEM jobs who are women. Women in supervisor and work leader jobs can provide the kinds of positive role models that will encourage and inspire other women. In addition, we expect that women will feel more comfortable applying for and accepting jobs in workplaces that have other women in leadership positions. Likewise, organizations with diverse leadership may be more likely to hire diverse job applicants, especially when that leadership has a voice in hiring decisions. We note that work Leaders often act as liaisons between non-supervisory employees and supervisors. The OPM's General Schedule Leader Grade Evaluation Guide (U.S. OPM 1998) provides a table comparing work leaders and supervisors in more detail. We have included this table in our Appendix. Generally, supervisors have considerably more authority than work leaders. [3]

In our second model, the dependent variable is the proportion of women among quitters in STEM occupations in the departments and agencies examined. These data come from

[3] A covariance matrix shows that our work leader and supervisor variables are not strongly correlated. Indeed, none of our independent variables in either of our models are highly correlated and none are well predicted by linear combinations of the other independent variables. VIF statistics are very small, indicating no evidence of problems of multicollinearity.

FedScope's Separations Data Cubes for the years 2005 to 2018. The independent variables in this second model are the proportion of female STEM employees who are young (age 29 and younger), the organization's size, and our role model variables, i.e., the proportion of supervisors in STEM who are women, and the proportion of work leaders in STEM who are women.

We include the proportion of female STEM employees who are young because prior research indicates that younger workers (regardless of field) quit more often than older workers (Meyer et al, 1979; Lewis and Park, 1989; Lewis, 1991; Kellough and Osuna, 1995; GPP, 2007; Llorens and Stazyk, 2011; Bradbury et al 2013). We constructed the "Young" variable by determining the proportion of women employed in STEM occupations who are age 29 and younger among all women employed in STEM occupations. We expect that as the proportion of women in STEM who are young increases among our departments and agencies, quit behavior by women in STEM will increase.

In addition, prior research also suggests that organizational size may have a negative relationship to quit rates (Smith, 1979; Kellough and Osuna, 1995; Selden and Moynihan, 2000; Bradbury et al 2013). Those who work in larger organizations will have more opportunities to transfer to other desirable positions within the same organization—presenting a potential alternative to quitting when one desires to leave his or her current occupation. We constructed the "Organizational Size" variable using the total number of people employed in STEM and non-STEM positions within each agency.

Finally, we expect the presence of women in supervisory and leadership positions in STEM positions in our departments and agencies to be negatively related to the rate at which women quit STEM jobs. The reasoning, again, is that women in supervisory and leadership positions will provide positive role models for other women. Prior research looking at teachers

and school principals, for example, suggests that the gender of leaders can increase job satisfaction and lower turnover intentions of subordinates (Grissom et al, 2012).

Findings

Table 3 provides the findings for our model for the representation of women in STEM occupations. Organizational size produces a very small negative coefficient – opposite the direction we hypothesized ($b = -4.22e^{-07}$). However, our expectation regarding the proportion of supervisors who are women is as we expected. The coefficient is positive, large ($b = 0.511$), and significant. This finding may suggest that the availability of women who can serve as role models may lead to higher levels of female employment in STEM jobs.[4] We are surprised that we find no relationship between social equity spending and the representation of women in STEM fields. Similarly, the proportion of work leaders who are women shows no relationship to female employment. The model accounts for over 63 percent of the variance in the employment of women in STEM jobs among the departments and agencies studied over time.

Table 4 provides the findings for the model for the representation of women among those who quit STEM jobs. As expected, we find a strong positive relationship between quitting and employee youth ($b = 0.539$). As the proportion of women in STEM who are young increases, the proportion of women in STEM who quit also increases. Also as expected, we find a negative relationship between quitting and the proportion of supervisors who are women ($b = -0.438$). This finding suggests that agencies in which women are well-represented among STEM supervisory staff will have fewer women than other agencies in STEM occupations who quit. It

[4] Because the processes and factors that influence the selection of supervisors is different from that leading to the selection of nonsupervisory employees, we believe this variable (proportion of supervisors who are women) is largely exogenous.

provides further support of the importance of positive role models for women in STEM occupations, but we note that our model explains less than 8 percent of the variance in quitting by women in STEM occupations.

Conclusion

In this study, we have taken a small step toward understanding two important issues regarding the representation of women in STEM positions in the U.S. federal government. We have found that women are significantly underrepresented among federal STEM employees, and that they are typically overrepresented among STEM employees who quit. We examine several variables that may be related to representation in the workforce and representation among those who quit, and we find evidence consistent with the argument that the availability of women in supervisory positions who can serve as positive role models could lead to increased representation and reduced quit behavior. Of course, causality is difficult to establish in a correlational study such as this, and in the case of the representation model (see Table 3), even the direction of influence is unclear. It may be the case that women feel more comfortable joining the STEM workforce in departments and agencies where there are more women in supervisory positions, but on the other hand, agencies with higher proportions of women in STEM occupations may have a higher representation of women in supervisory roles simply because there are more women available for promotion into those roles. We regard this study as largely exploratory in nature.

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Tables

Table 1: Representation in STEM Occupations by Gender (Average from 2005 to 2018)		
Agency	Women in STEM Occupations	Men in STEM Occupations
DEPARTMENT OF THE AIR FORCE	16.7%	83.3%
DEPARTMENT OF AGRICULTURE	32.6%	67.4%
DEPARTMENT OF THE ARMY	21.0%	79.0%
DEPARTMENT OF COMMERCE	29.3%	70.7%
DEPARTMENT OF DEFENSE	26.8%	73.2%
DEPARTMENT OF JUSTICE	34.3%	65.7%
DEPARTMENT OF LABOR	31.5%	68.5%
DEPARTMENT OF ENERGY	21.7%	78.3%
DEPARTMENT OF EDUCATION	39.0%	61.0%
ENVIRONMENTAL PROTECTION AGENCY	37.9%	62.1%
DEPARTMENT OF HEALTH AND HUMAN SERVICES	42.9%	57.1%
DEPARTMENT OF HOMELAND SECURITY	29.0%	71.0%
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT	34.8%	65.2%
DEPARTMENT OF THE INTERIOR	29.8%	70.2%
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION	22.8%	77.2%
DEPARTMENT OF THE NAVY	18.9%	81.1%
DEPARTMENT OF STATE	28.3%	71.7%
DEPARTMENT OF TRANSPORTATION	19.8%	80.2%
DEPARTMENT OF THE TREASURY	41.6%	58.4%
DEPARTMENT OF VETERANS AFFAIRS	25.9%	74.1%

Table 2: Difference Between Women's Representation Among Quitters in STEM Occupations and Women's Representation in STEM Occupations (Average from 2005 to 2018)

Agency	Women in STEM Who Quit	Women in STEM Occupations	Difference
DEPARTMENT OF THE AIR FORCE	19.9%	16.7%	3.2%
DEPARTMENT OF AGRICULTURE	41.5%	32.6%	9.0%
DEPARTMENT OF THE ARMY	24.9%	21.0%	3.9%
DEPARTMENT OF COMMERCE	39.4%	29.3%	10.2%
DEPARTMENT OF DEFENSE	24.1%	26.8%	-2.6%
DEPARTMENT OF JUSTICE	34.3%	34.3%	0.0%
DEPARTMENT OF LABOR	31.7%	31.5%	0.1%
DEPARTMENT OF ENERGY	30.4%	21.7%	8.7%
DEPARTMENT OF EDUCATION	39.6%	39.0%	0.5%
ENVIRONMENTAL PROTECTION AGENCY	52.8%	37.9%	14.9%
DEPARTMENT OF HEALTH AND HUMAN SERVICES	42.5%	42.9%	-0.5%
DEPARTMENT OF HOMELAND SECURITY	31.7%	29.0%	2.7%
DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT	38.5%	34.8%	3.7%
DEPARTMENT OF THE INTERIOR	38.4%	29.8%	8.5%
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION	28.7%	22.8%	5.9%
DEPARTMENT OF THE NAVY	22.1%	18.9%	3.2%
DEPARTMENT OF STATE	36.7%	28.3%	8.5%
DEPARTMENT OF TRANSPORTATION	25.1%	19.8%	5.3%
DEPARTMENT OF THE TREASURY	27.3%	41.6%	-14.3%
DEPARTMENT OF VETERANS AFFAIRS	27.9%	25.9%	2.0%

Table 3. Representation of Women in STEM

VARIABLES	Representation of Women
Social Spending	-0.0141
	(0.0150)
Organization Size	-4.22^{e-07}
	(1.26^{e-07})
Proportion of Supervisors who are Women	0.511***
	(0.0310)
Proportion of Work Leaders who are Women	-0.00374
	(0.0111)
Constant	0.206
	(0.0121)
Observations	189
R-squared (within)	0.637
R-squared (between)	0.332

Standard errors in parentheses
(one-tailed tests) *** p<0.001

Table 4. Quitting Among Women in STEM

VARIABLES	Proportion of Quitters who are Women
Young Women in STEM	0.539**
	(0.223)
Organization Size	$-5.06e^{-07}$
	(5.53e-07)
Proportion of Supervisors who are Women	-0.438*
	(0.223)
Proportion of Work Leaders who are Women	0.0498
	(0.0681)
Constant	0.426
	(0.0750)
Observations	227
R-squared (within)	0.076
R-squared (between)	0.003

Standard errors in parentheses
(one-tailed tests) ** p<0.01, * p<0.05

Appendix

Team Leaders and Supervisors Comparison (U.S. OPM 1998)

TEAM LEADERS:	SUPERVISORS:
Explain team goals and objectives to assigned team members and assist team in organizing to accomplish work	Set team goals, select team leaders, assign team members and administratively and technically direct the work of subordinates
Coach, facilitate, solve work problems and participate in the work of the team	Plan, assign, review and accept, amend or reject work done by teams and subordinates
Provide information to the supervisor on performance of the team and individuals	Assign performance ratings, approve awards and take performance-based corrective actions
Communicate assignments, milestones and deadlines to the team and individuals based on supervisor's instructions	Make work assignments, set or negotiate deadlines and completion dates
Observe training needs and relay training needs and requests to supervisor	Schedule and approve funding for team and individual training
Inform supervisor of attendance and behavioral problems	Counsel employees on behavior and initiate disciplinary actions if required
Relay requests for resources and supplies	Allocate resources to teams