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The Effects of Professor Gender on the Post-Graduation Outcomes of Female Students

Abstract

Although women earn approximately 50 percent of science, technology, engineering and math (STEM) bachelor's degrees, more than 70 percent of scientists and engineers are men. We explore a potential determinant of this STEM gender gap using newly collected data on the career trajectories of United States Air Force Academy students. Specifically, we examine the effects of being assigned female math and science professors on occupation choice and postgraduate education. We find that, among high-ability female students, being assigned a female professor leads to substantial increases in the probability of working in a STEM occupation and the probability of receiving a STEM master's degree.

JEL-Codes: I200, J160, J240.

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1. INTRODUCTION

Women are underrepresented in the science and engineering workforce. In 2015, the most recent year for which data are available, only 28 percent of employed scientists and engineers were women.[1] One reason for this substantial gender gap is that, up until the late 1990s, the majority of all science, technology, engineering and math (STEM) bachelor's degrees were earned by men (National Science Foundation 2017). Another contributing factor is that women who earn STEM degrees are more likely than their male counterparts to pursue careers in education or healthcare as opposed to science or engineering (Beede et al. 2011, p. 6).[2]

Interventions intended to address the STEM gender gap are often predicated on the assumption that female students who are interested in math and science suffer from a lack of same gender-role models (e.g., Handelsman et al. 2005). In fact, several studies provide evidence that exposure to female math and science professors encourages female college students to pursue STEM degrees (Rask and Bailey 2002; Bettinger and Long 2005; Carrell, Page and West 2010). Much less, however, is known about the relationship between professor gender and longer-run post-graduation outcomes.

Using newly collected data on the career trajectories of United States Air Force Academy (USAFA) students who graduated during the period 2004-2008, we examine the impact of professor gender in freshman-year math and science courses on post-graduation outcomes. Information on these outcomes was obtained from the Air Force Personnel Center for the period 2004-2016, so we are able to follow students for a minimum of 8 years after graduation,

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[1] These figures come from the 2015 National Survey of College Graduates, conducted by the National Center for Science and Engineering Statistics (www.nsf.gov/statistics/wmpd/).

[2] Approximately 40 percent of men with a STEM bachelor's degree work in STEM jobs, while 26 percent of women with a STEM degree work in STEM jobs (Beede et al. 2011, p. 6).

provided they remained in the Air Force. One of the advantages of using data from the USAFA is that students there are quasi-randomly assigned to freshman-year math and science classes, which are mandatory.

Non-economists have proposed a variety of interventions aimed at encouraging women to choose STEM majors and careers (Cronin and Roger 1999; Blickenstaff 2005; Lagesen 2007; Redden 2007; Bilimoria, Joy and Liang 2008; Dworkin et al. 2008; Mavriplis et al. 2010). These interventions include ensuring students have equal access to classroom resources (Blickenstaff 2005), promoting a more inclusive workplace culture (Cronin and Roger 1999), and providing more networking opportunities for women working in STEM fields (Mavriplis et al. 2010). Economists have, by and large, focused on increasing the supply of female professors in mathematics and the hard sciences. Increasing the supply of female professors is often justified on the grounds that female students interested in STEM lack role models, but can also be justified on the grounds that they simply learn more from female professors, perhaps as a result of gender-based differences in teaching style or expectations about academic performance (Carrell, Page and West 2010, p. 1103). It is also possible that professors influence the career choices of STEM students through providing emotional support, encouragement, and networking opportunities (Johnson 2007; Carlone and Johnson 2007; Thiry, Laursen and Hunter 2011).

2. LITERATURE AND DATA

2.1. Previous studies

Only a handful of studies have examined the relationship between professor gender and post-graduation outcomes. For instance, Rothstein (1995) found a positive correlation between the fraction of female faculty and the likelihood that female undergraduates would go on to obtain an advanced degree, while Kofoed and McGovney (2019) found that quasi-random assignment to a female mentor at the U.S. Military Academy led to an increase in the probability that female cadets chose their mentor's occupation. Jagsi et al. (2014), who examined data on U.S. medical school graduates for the period 2006-2008, found no evidence that specialty choice was related to the fraction of full-time faculty who were female.[3]

By contrast, researchers have expended considerable effort exploring how instructor (i.e., teacher or professor) gender affects academic outcomes such as test scores, grades, and choice of major. Previous studies in this area include: Canes and Rosen (1995), Neumark and Gardecki (1998), Bettinger and Long (2005), Hoffman and Oreopoulos (2009), Carrell, Page and West (2010), Fairlie, Hoffmann and Oreopoulos (2014), Muralidharan and Sheth (2016), Kato and Song (2018), Canaan and Mouganie (2019), and Lim and Meer (forthcoming). However, with some notable exceptions (Carrell, Page and West 2010; Muralidharan and Sheth 2016; Kato and Song 2018; Canaan and Mouganie 2019; Lim and Meer forthcoming), the results of these studies should be viewed with some skepticism given that students are not typically assigned to their instructors at random.

One of the best known (and most often cited) studies in this literature is by Carrell, Page and West (2010). These authors used detailed data on students from the USAFA to examine the effects of professor gender on academic performance and major choice. They found that female students who were assigned to a female professor received higher grades in freshman-year math and science classes than their counterparts who were assigned to a male professor. Among high-

[3] See also Gaule and Piacentini (2018) and Gershenson et al. (2018). Gaule and Piacentini (2018) found that female Ph.D. candidates who worked with female advisors were more likely to pursue an academic career. Gershenson et al. (2018) found that random assignment to a black teacher increased the likelihood of black students graduating from high school and enrolling in college.

ability female students (as measured by math SAT scores), assignment to female professors was also associated with an increase in the likelihood of graduating from the USAFA with a STEM degree. We begin our empirical analysis, below, by examining the effects of being assigned a female professor on the same outcomes as were used by Carrell, Page and West (2010).

2.2. The USAFA and its Students

The students and academic curriculum at the USAFA are similar in many respects to other selective liberal arts colleges, with an emphasis on balancing "Science, Technology, Engineering, and Mathematics (STEM) with the arts and humanities" (USAFA n.d.). Students complete a fully accredited academic program that offers 27 majors and 4 minors, and graduates earn a Bachelor's of Science degree along with a commission in the U.S. Air Force. The average SAT math and verbal scores of entering students are 672 and 642, respectively, and the admission rate is 13 percent. A regimented daily schedule includes military training and athletics in addition to approximately 8 hours of dedicated academic time for a typical student. Students at the USAFA are required to take a series of core courses, totaling approximately 85 semester hours, in the basic sciences, engineering, social sciences, and humanities.[4]

Course scheduling is completed in a centralized process that amounts to pseudo-random assignment of students to professors. Courses are offered in multiple sections usually containing no more than 24 students. Each section may be offered in any of approximately 14 designated time slots, called "periods", and the first-year mandatory math and science courses that are the focus of this study generally have sufficiently high enrollment so that multiple sections are

[4] The mandatory set of core courses required for the 2004-2008 graduating classes can be found in the USAFA Curriculum Handbooks. The handbooks for each academic year can be found at (https://www.usafa.edu/academics/registrar/curriculum/).

offered in each period. Students register for courses (but not sections or periods) before the start of each semester, and then the registrar assigns students to sections in a two-step process. First, students are assigned to periods by an algorithm that seeks to minimize scheduling conflicts, for example, due to sports practice; students are then randomly assigned to a section within their assigned period.

The scheduling process results in two primary sources of variation in professor gender. First, while the assignment of students to periods gives no weight to student preferences, some students (e.g., intercollegiate athletes) are more likely to be assigned to certain periods based on scheduling constraints, and female (or male) professors may prefer teaching in these same periods. Although this process could produce systematic relationships between unobservable student and professor characteristics, we expect that any such relationships are far weaker and more idiosyncratic than in a typical scheduling system in which students choose sections based on personal preference and knowledge of professors. Second, assignment of students to sections within each period is randomized by a computer algorithm, ensuring that observable and unobservable student and professor characteristics are uncorrelated within periods.

2.3. The USAFA Data

Our analysis draws upon longitudinal data for 838 female and 3,925 male students who graduated from the USAFA during the period 2004-2008. Forty-two students who graduated during this period were excluded from the analysis because of missing data. We merged academic records with information on post-graduation outcomes obtained from the Air Force Personnel Center (AFPC) for the period 2004-2016. Table 1A provides summary statistics pertaining to the students who contributed data to the analysis; summary statistics for their

USAFA professors are reported in Table 1B, with introductory STEM courses summarized in Table 1C.

Throughout the analysis, student pre-treatment characteristics are used as controls. Information from the USAFA Registrar's office allowed us to create indicators for attending a preparatory school, enlistment in the military prior to entering the USAFA, having been recruited as an intercollegiate athlete, gender, race, and age. We also use three numerical scores created by the USAFA Admissions office to describe a candidate's academic, leadership, and athletic potential.[5] On average, female students entered the USAFA with better academic and leadership composite scores than their male counterparts, while male students entered with better fitness test scores (Table 1A).

We linked every freshman-year math and science course taught at the USAFA to its professor using records from the registrar's office and the USAFA's historical archives. We obtained information on 280 professors (48 female and 232 male) who taught introductory math and science courses during the academic years 2000-2006. Female professors taught approximately 19 percent of the 1,350 first-year math and science sections (Table 1A and 1C).

Classroom and student characteristics by professor gender are reported in Table 1C. Male professors, on average, taught slightly larger classes than their female counterparts (19.35 versus 18.83 students per class). The other characteristics, however, are quite similar across the

[5] The academic composite score is a weighted average of two academic performance factors: 1) prior academic record (PAR) and 2) college admission test scores. The PAR is a measure of academic performance based on a combination of high school class rank, high school GPA, and the quality of the high school attended. College admission test scores include the scores earned on either the SAT Reasoning test (verbal and math) or the ACT test (English, reading, math, and science reasoning). The leadership composite score is computed by the USAFA admissions office and measures high school leadership activities such as student council offices, Eagle Scout participation, and captaining a sports team. The fitness score is from a fitness assessment required of all students prior to admittance. See Carrell, Page and West (2010) or (https://www.academyadmissions.com/admissions/) for more details on the academic composite, leadership composite, and fitness test scores.

genders. As a formal test of whether course assignment can be thought of as random, we regress faculty gender on the pre-enrollment characteristics (e.g., math and verbal SAT scores, academic score, leadership score, and fitness score). The results of this exercise, which are reported in Table 2, provide no evidence of a systematic relationship between pre-enrollment characteristics and professor gender in the full sample. Even when the sample is broken into quartiles based on math SAT scores, only one out of the 24 estimated coefficients are significant at conventional levels (Panel A). A similar pattern of results is obtained when the sample is restricted to female students (Panel B).

2.4. Post-Graduation Outcomes

The primary source for occupation and other post-graduation outcomes of USAFA students is the AFPC. During their senior year, USAFA students are assigned to a job in a three-step process. First, students decide whether they wish to pursue one of approximately 4 rated occupations (which primarily involve piloting aircraft) or whether they wish to pursue a non-rated occupation such as intelligence, developmental engineer, or scientist.[6] Second, students submit their top 6 occupation choices to the AFPC, along with a relative weight for each choice. Finally, using these choices and weights, an algorithm matches USAFA graduates with their first job.[7] However, this initial assignment may not correspond to the occupation into which the

[6] Rated occupations include pilot (both conventional and unmanned), navigator, combat systems operator, and air battle manager. Hereafter, we refer to all rated occupations as “pilots”.

[7] The matching algorithm has the joint objectives of satisfying Air Force staffing needs, ensuring the student is qualified for the job to which he or she is assigned, and meeting student preferences. Students must satisfy eligibility requirements for an occupation before listing it. While many occupations are open to all students, some require a specific academic degree (e.g., listing “physicist/nuclear engineer” requires a bachelor’s degree in physics, astronomy, astrophysics, engineering physics, or nuclear physics). Appendix Table A8 lists all the occupations observed in our data. Of the 178 distinct occupations listed, 9 are defined as STEM and 169 (including pilot) are defined as non-STEM. The algorithm gives more weight to the occupational preferences of the highest-ranked students within a graduating class, where rank is primarily determined by grade point average.

graduate eventually settles. There are ample opportunities to switch jobs and the initial assignments include "graduate study", which we code as non-STEM despite the fact that graduate school may prepare students for a STEM career.[8] Of the 4,311 USAFA graduates in our sample whose occupation history is observed, 3,673 were initially assigned to a non-STEM occupation (including pilot and graduate student). Two years after graduation, 160 had switched from a non-STEM to a STEM occupation; 4 years after graduation, 182 had switched from a non-STEM to a STEM occupation.[9]

We report the percentage of USAFA graduates in our sample who worked in a STEM occupation by gender in Table 1A. Any USAFA graduate who held a STEM-related job before 2016 (or before leaving the Air Force) is counted as having worked in a STEM occupation. Female graduates were more likely to have worked in a STEM occupation than their male counterparts (22% vs. 20%), but they were less likely to have been a pilot (22% vs. 51%) and more likely to have worked in what we are describing as a "professional occupation" (5% vs. 2%).[10] Twenty-eight percent of female students obtained a STEM bachelor's degree but, of those who obtained a STEM bachelor's degree, only 42 percent went on to work in a STEM

[8] There are 84 students whose initial occupational assignment is coded as "graduate study", out of which 80 were awarded a graduate degree. Although we do not observe their field of study, we can infer that 57 were awarded a STEM graduate degree. As we report in Table Appendix A3, the results do not significantly change if we instead classify "graduate study" as STEM or if we classify the initial assignment as STEM for the 57 students who earned a STEM graduate degree.

[9] Of the 1,036 high-ability students (i.e., those with math SAT scores in the top quartile) with occupation history, 846 were assigned to a non-STEM occupation upon graduation. Two years after graduation, 53 had switched from a non-STEM to a STEM occupation; 4 years after graduation, 64 had switched to from a non-STEM to a STEM occupation.

[10] Specifically, the category "professional occupation" includes chaplain, dentist, general practice physician, judge advocate, lawyer, and surgeon.

occupation.[11] Approximately one percent of female students who obtained a STEM bachelor's degree went on to work in a professional occupation.

In addition to occupation, we observe receipt of a master's degree, receipt of STEM master's degree, and receipt of a professional degree (e.g., a medical, dental, or law degree). Graduates of the USAFA are not expected to obtain a graduate or professional degree unless they are assigned to an occupation that requires it. Although a graduate degree is required for advancement in some occupations (e.g., operations research analyst, scientist, or academic instructor), whether and when to pursue additional education is ultimately the individual's choice.[12]

Female USAFA graduates were more likely to earn a master's degree within 6 years (49% vs. 36%), and were equally likely to earn a STEM master's degree within 6 years (12%). Among female graduates with a STEM bachelor's degree, 33 percent went on to earn a STEM master's degree within 6 years. Slightly less than 2 percent (1.7%) of female graduates with a STEM bachelor's degree earned a professional degree within 6 years.

3. STATISTICAL METHODS

We begin by examining the effects of being assigned a female professor on the academic outcomes used by Carrell, Page and West (2010). Following these authors, we estimate:

[11] Throughout the paper, we exclude biological sciences from STEM bachelor's degrees because the gender gap is most pronounced for other STEM fields. This exclusion also aligns with Air Force STEM occupations and with the findings emphasized by Carrell, Page, and West (2010).

[12] It is important to note that, although pursuing an advance degree is not typically required of USAFA graduates, it increases the likelihood of promotion. See Switzer (2011) and the *Air Force Times* (www.airforcetimes.com) for more information detailing the Air Force policies towards the obtainment of advanced academic degrees.

$$(1) \qquad Y_{icsjt} = \phi_1 + \beta_1 F_i + \beta_2 F_j + \beta_3 F_i F_j + \boldsymbol{X}_i \boldsymbol{\phi}_2 + \boldsymbol{P}_j \boldsymbol{\phi}_3 + \gamma_{ct} + \varepsilon_{icsjt},$$

where Y_{icjst} is the normalized grade for student i in freshman math/science course c and section s taught by professor j in semester t.[13] F_i is an indicator equal to 1 if student i was female and equal to 0 otherwise. F_j is an indicator equal to 1 if professor j was female and equal to 0 otherwise. The coefficient β_1 represents the mean difference in performance between male and female students when they are assigned to a male professor, β_2 represents the effect of being taught by a female professor on the grades of male students, and β_3 represents the effect of assignment to a female professor on the grades of female students (relative to those of male students). Because freshman-year math and science courses are mandatory, and because assignment to sections is quasi-random, the estimate of β_3 can be given a causal interpretation.

The vector of controls, $\boldsymbol{X}_i$, is composed of student characteristics including race, ethnicity, SAT verbal score, SAT math score, academic composite score, leadership composite score, and fitness score. In addition, we include indicators for graduating class (i.e., cohort), age, whether the student attended preparatory school, whether the student was a recruited athlete, and whether the student enlisted in the Air Force prior to entering the USAFA. Professor characteristics, represented by the vector $\boldsymbol{P}_j$, include indicators for academic rank, terminal degree (the highest degree available for a given academic field), and civilian status. Course-by-semester fixed effects are represented by the term γ_{ct}. Standard errors are corrected for clustering at the professor level.

We use a modified version of equation (1) to examine academic outcomes in follow-on STEM courses:

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[13] There are three semesters per year at the USAFA (spring, summer, and fall) and our data on academic outcomes cover 5 years, or 15 semesters (t = 1,2,3…15).

$$(2) \qquad Y_{ic's't'} = \phi_1 + \beta_1 F_i + (\beta_2 + \beta_3 F_i) \frac{\sum_{j|i} F_j}{n_i} + \boldsymbol{X}_i \boldsymbol{\phi}_2 + \gamma_{c's't'} + \varepsilon_{ic's't'},$$

where $Y_{ic's't'}$ is the normalized grade for student *i* in the follow-on course c', section s', and semester t'. $\frac{\sum_{j|i} F_j}{n_i}$ is the fraction of student *i*'s first-year math and sciences courses that were taught by female professors. β_2 is the effect for male students of having more female professors in their first-year math and science courses, and β_3 is the effect of having more female professors on the academic outcomes of female students relative to their male counterparts. In equation (2), the vector $\boldsymbol{X}_i$ also includes other professor characteristics from student *i*'s freshman year (i.e., the proportion who held the rank of Associate Professor, the proportion who held the rank of Professor, the proportion who were civilian, and the proportion who held a terminal degree). Following Carrell, Page and West (2010), these regressions include course-by-section-by-semester fixed effects, represented by the term $\gamma_{c's't'}$.

A modified version of equation (2) is used to examine whether student *i* took an advanced math course, whether student *i* graduated with a STEM degree, and whether student *i* left the USAFA without graduating:

$$(3) \qquad D_i = \phi_1 + \beta_1 F_i + (\beta_2 + \beta_3 F_i) \frac{\sum_{j|i} F_j}{n_i} + \boldsymbol{X}_i \boldsymbol{\phi}_2 + \varepsilon_i,$$

where D_i is one of the three outcomes described above. Again, β_2 is the effect of having more female professors on the outcomes of male students while β_3 is the effect of having more female professors on the outcomes of female students relative to their male counterparts. Equation (3) is also used to examine the effects of professor gender on several post-graduation outcomes, including: working in a STEM occupation, receipt of a master's degree, receipt of STEM master's degree, receipt of a professional degree, and separation from the Air Force.

4. RESULTS

4.1. Effects of Professor Gender on Academic Outcomes

Estimates of equations (1) and (2) for the full sample are reported in the top panel (Panel A) of Table 3. Although the estimates of β_3 (i.e., the relative effect for female students) are positive, they are, without exception, generally small and statistically indistinguishable from zero at conventional levels.

In Figure 1, we explore the role of pre-treatment ability as measured by math SAT scores. Specifically, we report estimates of β_3 restricting the sample to different ranges of the SAT math distribution. The outcomes correspond to those reported in columns 1-4 of Table 3.

Consistent with the results of Carrell, Page and West (2010), there is evidence that professor gender matters most among high-ability students. The estimates of β_3 are small and statistically insignificant when the sample is restricted to students in the bottom quartile of the ability distribution. Likewise, when the sample is restricted to students between the 5th and 30th, the 10th and 35th, or the 15th and 40th percentiles of the ability distribution, the estimates of β_3 are small and insignificant. In fact, it is not until the sample is restricted to students between the 70th and 95th percentiles of the ability distribution that we consistently observe positive and significant estimates of β_3 for all academic outcomes. Based on the estimates of β_3 reported in Figure 1, we focus on students in the top quartile of ability distribution for the remainder of the analysis. On average, these students received higher grades in their first-year STEM courses, were more likely to graduate with a STEM degree, and were more likely to work in a STEM occupation as compared to their lower-ability counterparts.[14] As noted by Carrell, West and Page (2010, p. 1104), women in the top quintile of the ability distribution are arguably "most suited for entering science and engineering careers".

Among female students in the upper quartile of the ability distribution, it is clear that assignment to female professors improves relative academic performance (Panel B, Table 3). For instance, high-ability female students, on average, score 14.4% of a standard deviation lower than their male counterparts when assigned to a male professor. However, when they are assigned to a female professor, their performance in first-year math and science courses improves dramatically.[15]

Assignment to female professors also increases the relative probability of graduating with a STEM degree. Female students in the upper quartile of the ability distribution are, on average, 37.1 percentage points less likely to graduate with a STEM degree than their male counterparts if all of their first-year math and science courses are taught by male professors (Panel B, Table 3), but increasing the fraction of first-year classes taught by female professors from 0 to 20 percent is associated with more than a one-third reduction in this gap.[16] Carrell, Page and West (2010, p. 1127) estimated a positive but smaller interaction effect for STEM degree completion (0.258 versus 0.665) in the top quartile, but these authors had three additional years of data which we

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[14] For instance, 26 percent of high-ability students went on to work in a STEM occupation as compared to 18 percent of students in the bottom quartile of the ability distribution. Sixteen and 18 percent of students in the middle two quartiles of the ability distribution went on to work in a STEM occupation.

[15] This pattern of results is consistent with a gender-based teaching style mechanism, which may also explain why previous students have found that male students give their female instructors systematically lower teaching evaluations. See, for instance, Boring (2017) and Mengel et al. (2019).

[16] β_3 represents the effect of increasing the fraction of first-year female professors from 0 to 100 percent for female students relative to their male counterparts. The estimated effect of increasing the fraction of first-year female professors by 20 percentage points is $0.2 \times 0.665 = 0.133$, which is 36 percent of the 0.371 gap.

did not have access to and they used a narrower definition of first-year math and science courses. Consistent with the results of Carrell, Page and West (2010), we find no evidence that the fraction of first-year female professors in math and science classes is associated with leaving the USAFA without graduating.

4.2. Effects of Professor Gender on Occupation

Our principal interest is in the relationship between professor gender and post-graduation outcomes, beginning with occupation. Only about a quarter of U.S. women who earn a bachelor's degree in math, science or engineering go on to work in a STEM occupation (Beede et al. 2011, p. 6), but this figure is much higher among the USAFA graduates: in fact, 42.4 percent of female students in our sample who earned a STEM bachelor's degree from the USAFA went on to work in a STEM occupation at some point during their Air Force career.

In Table 4, we report OLS estimates of equation (3). Specifically, we examine three dichotomous outcomes: whether a USAFA graduate became a pilot, whether he/she worked in a STEM occupation, and whether he/she worked in a professional occupation. These occupational categories (pilot, STEM, and professional) are not mutually exclusive. If, for example, a USAFA graduate started her career as a pilot and then went on to work in a STEM occupation before 2016 (or before leaving the Air Force), then she was counted as having worked in both occupational categories.

In the full sample, there is little evidence that being assigned to female first-year STEM professors affects whether female graduates work in a STEM occupation (second column of Table 4, Panel A). However, when the sample is restricted to students in the top quartile of the ability distribution as measured by math SAT scores, the estimates of β_2 and β_3 are clearly distinguishable from zero in a statistical sense.[17] These estimates suggest that, by doubling the fraction of first-year math and science classes taught by female faculty (from 20 to 40 percent), the USAFA could increase the probability of high-ability female students working in STEM by 0.053, which represents a 14 percent increase relative to the sample mean (0.338).[18] At the same time, doubling the fraction of first-year math and science classes taught by female faculty would reduce the probability of high-ability male students working in STEM by 0.039, or 16 percent of their mean (0.250).[19, 20]

As noted above, USAFA students submit their top 6 occupation choices to the AFPC in their senior year. In Appendix Table A2, we explore whether professor gender in first year STEM courses affects these choices, but our estimates are small and statistically insignificant.[21] However, there is evidence that being assigned female professors in freshman-year math and science courses encourages high-ability female students to switch from non-STEM to STEM

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[17] In Figure 2, we report estimates of β_3 for three post-graduation outcomes restricting the sample to different ranges of the SAT math distribution. Again, there is evidence that professor gender matters most among high-ability students.

[18] $\beta_2 + \beta_3$ represents the effect of increasing the fraction of first-year female professors from 0 to 100 percent on the probability that female students worked in STEM. The estimated effect of increasing the fraction of first-year female professors by 20 percentage points is 0.2 x (-0.196 + 0.463) = 0.053.

[19] The estimated effect of increasing the fraction of first-year female professors by 20 percentage points is 0.2 x -0.196 = -0.039.

[20] In Appendix Table A1, we examine whether the relationship between assignment to first-year female STEM professors and the probability of female graduates working in STEM is mediated by academic performance or major choice. Controlling for the student's average grades across first-year STEM courses (column 2) does not change the estimate of β_3. However, adding a control for graduating with a STEM bachelor's degree (column 3) reduces the estimate of β_3 by about a third (to 0.309). We interpret this pattern of results as suggestive evidence that major choice mediates the effect of professor gender on the likelihood of working in a STEM occupation.

[21] Specifically, we used the following indicators on the left-hand side of equation (3): whether the student's first job choice was to become a pilot, whether their first job choice was in a STEM-related occupation, whether their first or second job choice was in a STEM-related occupation, and whether any of their 6 job choices were in a STEM-related occupation. The estimate of β_3 was positive and sizable among high-ability students for whether any job choice was in STEM, but not statistically significant at conventional levels.

occupations within 2, 4, and 6 years of graduating (Appendix Table A3).[22] For example, by doubling the fraction of first-year math and science classes taught by female faculty (from 20 to 40 percent), the USAFA could increase the probability of high-ability female students working in STEM within 6 years of graduating by 0.089, which represents a 28 percent increase relative to the sample mean (0.323).[23]

In the military, earnings are based on time served and rank, not occupation. To gauge the return to being taught by a female professor and taking a STEM job outside the military, we used predicted earnings as an outcome. Specifically, we predicted the earnings of USAFA graduates after 6 years using data from the American Community Survey (ACS). USAFA graduates were matched with ACS respondents based on personal characteristics, work schedules, and occupations.[24] The results of this exercise, reported in Appendix Table A4, are consistent with those reported in Table 4 and Appendix Table A3: being assigned female professors is associated with an increase in the relative earnings of high-ability female USAFA students. It should be

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[22] The estimate of β_3 in column (1) of Appendix Table A3 shows that professor gender does not affect the likelihood that high-ability female students start their career in a STEM occupation. In the next two columns of Appendix Table A3, we experiment with different definitions of starting in a STEM occupation. Specifically, in column (2) we change the initial assignment of 84 students from "graduate study" to "STEM occupation" irrespective of the degree earned. In column (3) we change the initial assignment of 57 students from "graduate study" to STEM occupation based on the graduate degree they obtained. Although the estimates of β_3 increase, they remain statistically insignificant. In the remaining columns of Table A3, we examine the relationship between professor gender and working in a STEM occupation within 2, 4, and 6 years of graduating.

[23] The estimated effect of increasing the fraction of first-year female professors by 20 percentage points is $0.2 \times (-0.177 + 0.620) = 0.089$. Doubling the fraction of first-year math and science classes taught by female faculty would come at the cost of decreasing the probability of high-ability male students working in STEM within 6 years of graduating by 0.035 $(.2 \times -.177) = -.035$.

[24] To predict earnings, we used data from the ACS for the years 2014-2017 and limited the sample to respondents ages 25-31 who had completed at least a bachelor's degree. We excluded respondents employed by the U.S. military and part-time workers. Part-time employment was defined as working 26 or fewer weeks per year. In addition, we dropped respondents who reported usually working less than 30 hours per week or more than 75 hours per week. Finally, workers who reported less than $2000 in earnings or more than $180,000 in earnings were excluded from the analysis. Predicted earnings were calculated at the 3-digit SOC occupation code level and by highest completed degree (i.e., BA, MA, or above).

noted, however, that the estimates of β_3 reported in Appendix Table A4 are only marginally significant (p-values = 0.101 and 0.110 for the linear and semi-log models, respectively).

Up to this point in the analysis, we have assumed that the effects of professor gender on our outcomes are linear. In Appendix Table A5, we relax that assumption for STEM occupation by estimating a more flexible model that allows for nonlinear effects. Although the coefficient estimates are a bit noisy, they do not appear to indicate a clear nonlinear pattern.[25]

4.3. Effects of Professor Gender on the Receipt of Advanced Degrees

Upon graduating from the USAFA, students typically begin their occupation training immediately. The length of this training varies from less than a year (aircraft maintenance officers, intelligence officers, space and missiles officers) to multiple years (pilots, medical doctors and surgeons). After completing occupation training, students may choose to pursue a master's degree, although it should be noted that, if a student is assigned to a professional occupation (e.g., lawyer, medical doctor, or chaplain), earning a professional degree is usually considered part of the formal occupation training process. In addition, the Air Force offers several programs through which officers can receive monetary support to obtain advanced degrees. These programs include tuition assistance for degrees completed concurrent with another assignment and sponsorships for full-time study.

Of the 4,416 students who graduated the USAFA between 2004 and 2008 (and who served in the Air Force at least 4 years after graduation), 800 received a master's degree, 274

[25] At the USAFA, female professors are less likely to have the rank of associate or full professor and more likely to be civilian (Table 1B). Interacting professor gender with the proportion of assistant professors, proportion of associate/full professors, proportion of professors with a terminal degree, and proportion of professors who are civilian in equation (3) has little impact on the main results reported in Tables 3 through 5 (Appendix Table A6).

received a master's degree in a STEM field, and 65 received a professional degree. In the Panels A and C of Table 5, we report the estimates of the relationship between professor gender and the probability of pursuing an advanced degree within 4 years of graduating from the USAFA. In the Panels B and D of Table 5, we explore the relationship between professor gender and receipt of an advanced degree within 6, as opposed to 4, years of graduation.

The results suggest that the effects of professor gender are not limited to occupation.[26] For instance, our estimates of β_2 and β_3 suggest that by doubling the fraction of first-year math and science classes taught by female faculty (from 20 to 40 percent), the USAFA could increase the probability of high-ability female students obtaining a STEM master's degree within 6 years of graduation by .070. Doubling the fraction of first-year math and science classes taught by female faculty would also decrease the probability of high-ability male students obtaining STEM master's degree within 6 years of graduation by 0.028.[27]

As noted in the introduction, women who earn STEM degrees are less likely than their male counterparts to work as a scientist or engineer but are more likely to pursue careers in education or healthcare (Beede et al. 2011, p. 6). Estimates of β_2 and β_3 reported in Table 5 suggest that any tendency among female undergraduates to obtain a professional degree may be counteracted by assignment to female professors. Specifically, increasing the fraction of female professors in first-year math and science courses from 0 to 100 percent is associated with a 0.110 decrease in the probability that high-ability female students receive a professional degree within

[26] Panels B and C of Figure 2 show little impact of professor gender until the sample is restricted to students above the 70th ability percentile, motivating our continued focus on the top quartile.

[27] The estimated effect of increasing the fraction of first-year female professors by 20 percentage points is 0.2 x (-0.140 + 0.488) = 0.070 for female students. The estimated effect of increasing the fraction of first-year female professors by 20 percentage points is 0.2 x -.140 = -.028 for male students. In Appendix Table A5, we estimate a more flexible model that allows for nonlinear effects on educational attainment outcomes. The results do not indicate a clear nonlinear pattern of relative effects.

4 years of graduation (Panel C) and a 0.201 decrease in the probability that high-ability female students receive a professional degree within 6 years of graduation (Panel D).[28]

4.4. Effects of Professor Gender on Separation from the Air Force

Students are contractually obligated to serve as an active-duty commissioned officer in the Air Force for a minimum of 5 years after graduating from the USAFA. However, approximately 11 percent of female students and 7 percent of male students in our sample left the Air Force within 4 years of graduation.[29]

Separation from the Air Force could have been non-voluntary, although some graduates likely voluntarily transferred to reserve or guard positions. Once a USAFA graduate separates from the active duty Air Force, we have no method of tracking their career trajectories. If separation were related to professor gender and the outcomes under study, our inability to track graduates could produce biased, and even misleading, estimates of β_1 through β_3.

In Table 5, we report estimates of the relationship between professor gender and the probability of separating from the Air Force within four years of graduating from the USAFA. Female graduates of the USAFA are 4.4 percentage points more likely to separate from the Air Force than their male counterparts, but there is no evidence that professor gender affects this gap: the estimate of β_3 is small and statistically insignificant (Panel A). Likewise, there is no

[28] Controlling for academic performance and graduating with a STEM bachelor's degree reduces the estimate of β_3 from 0.426 to 0.270 (Table Appendix A7). We interpret this result as suggestive evidence that academic performance and major choice mediate the effect of professor gender on the receipt of STEM graduate degrees.

[29] The 5-year active-duty service commitment is for non-pilot occupations. Pilots have a 10-year active-duty service commitment after successful completion of pilot training. The mean years of active-duty service in our sample was 8.5.

evidence that professor gender affects separations within 4 years among high-ability students (Panel C).

Finally, in Panels B and D of Table 5, we report estimates of the relationship between professor gender and the probability of separating from the Air Force within 6 years of graduating from the USAFA, an outcome that captures the behavior of students who completed their obligatory 5 years of post-graduation service. Again, professor gender does not appear to influence whether USAFA graduates left the Air Force.

5. CONCLUSION

Researchers and policymakers alike have searched for effective methods of increasing the representation of women in STEM occupations. Economists have focused much of their attention on evaluating efforts to provide young women with STEM role models by, for instance, assigning them to female math and science professors (Rask and Bailey 2002; Bettinger and Long 2005; Carrell, Page and West 2010). However, there is a dearth of evidence with regard to whether the effects of such efforts persist after graduation.

Using newly collected data on the academic outcomes and career trajectories of students from the USAFA who graduated during the period 2004-2008, we examine the effects of being assigned female math and science professors as a freshman on a variety of outcomes. One of the advantages of using data from the USAFA is that students there are quasi-randomly assigned to first-year math and science classes. We find evidence that, among high-ability female students, being assigned female professors increases the likelihood of working in STEM and increases the likelihood of receiving a STEM master's degree. By contrast, being assigned female professors decreases the likelihood that high-ability male students work in STEM and decreases the likelihood that they receive a STEM master's degree. This pattern of results suggests that a policy aimed at increasing the supply of female STEM workers could have the unintended effect of discouraging male students from entering STEM.

Our results mirror and extend those of Carrell, Page and West (2010). These authors, who also used USAFA data, found that high-ability female students who were assigned female math and science professors did better in follow-on math courses and were more likely to choose a STEM major. They concluded that, "something about the classroom environment created by female math and science professors has a powerful effect on the performance of women with very strong math skills" (Carrell, Page and West 2010, p. 1123). Our findings, which are not explained by attrition from military service, suggest that actively recruiting more female math and science professors could have long-lasting effects on the career trajectories of these very same students.

Future research might fruitfully explore why professor gender appears to be such an important determinant of choosing STEM majors and occupations. While gender-based teaching styles may affect student academic performance, the post-graduation effects we find are also consistent with the argument that female professors serve as role models whose influence extends past graduation; therefore, it is possible that interventions aimed at encouraging female professors to interact with and mentor their female students could, over time, substantially narrow the STEM gender gap.

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Table 1A. Student Summary Statistics

	Female students		Male students	
	Mean	Std. dev.	Mean	Std. dev.
Student-level variables				
SAT math	646.5	61.8	665.2	64.4
SAT verbal	636.3	68.3	628.9	68.3
Academic composite score	3274.1	277.8	3266.3	291.7
Leadership composite score	1764.6	187.2	1723.2	183.1
Fitness score	449.3	92.4	478.3	95.7
White	0.733	0.443	0.816	0.388
Black	0.072	0.258	0.046	0.209
Hispanic	0.073	0.260	0.058	0.234
Asian	0.087	0.282	0.044	0.205
Other race	0.036	0.186	0.036	0.187
Recruited athlete	0.288	0.453	0.251	0.433
Preparatory school attendance	0.142	0.349	0.197	0.398
Prior enlisted	0.125	0.331	0.131	0.338
Age 17-19	0.964	0.186	0.921	0.271
Cohort (expected graduation year)	2006.1	1.4	2006.0	1.4
Proportion female professors	0.188	0.183	0.192	0.187
Took higher-level math	0.377	0.485	0.554	0.497
STEM bachelors degree	0.276	0.447	0.474	0.499
Pilot	0.219	0.414	0.513	0.500
STEM occupation	0.216	0.412	0.196	0.397
Professional occupation	0.045	0.207	0.016	0.126
Masters degree ≤4 years	0.268	0.443	0.163	0.370
STEM masters degree ≤4 years	0.067	0.250	0.061	0.240
Professional degree ≤4 years	0.025	0.157	0.013	0.111
Separated from Air Force ≤4 years	0.105	0.307	0.066	0.248
Masters degree ≤6 years	0.488	0.500	0.361	0.480
STEM masters degree ≤6 years	0.119	0.325	0.124	0.330
Professional degree ≤6 years	0.044	0.206	0.015	0.120
Separated from Air Force ≤6 years	0.271	0.445	0.135	0.342
Observations	838		3,925	
Course-level variables				
Initial course grade, standardized	-0.012	0.965	0.127	0.929
Observations	3,873		17,694	
Follow-on course grade, standardized	0.018	0.964	0.044	0.974
Observations	5,835		27,740	

Notes: The sample is limited to students who graduated from the USAFA and are not missing SAT scores or other admissions scores (academic composite, leadership composite, or fitness score). 15 females and 84 males are missing data on occupation outcomes. Due to attrition from the Air Force, advanced degree outcomes are limited to 750 females and 3,666 males for 4-year outcomes, and 611 females and 3,396 males for 6-year outcomes.

Table 1B. Professor Summary Statistics

	Female professors		Male professors	
	Mean	Std. dev.	Mean	Std. dev.
Lecturer	0.458	0.504	0.397	0.490
Assistant professor	0.333	0.476	0.293	0.456
Associate or full professor	0.125	0.334	0.267	0.443
Terminal degree	0.313	0.468	0.418	0.494
Civilian	0.354	0.483	0.211	0.409
Observations	48		232	

Notes: The sample is limited to professors of students who graduated from the USAFA and are not missing SAT scores or other admissions scores (academic composite, leadership composite, or fitness score). Terminal degree is an indicator variable equal to 1 if the professor has the highest degree available in their field and equal to zero otherwise.

Table 1C. Introductory STEM Course Summary Statistics

	Female professors		Male professors	
	Mean	Std. dev.	Mean	Std. dev.
Students per class	18.83	5.10	19.35	5.60
SAT math	649.0	33.4	649.6	36.2
SAT verbal	621.6	27.2	625.1	29.8
Academic composite score	3185.7	162.8	3200.0	176.6
Leadership composite score	1727.4	54.5	1730.9	56.8
Fitness score	474.6	36.7	472.1	35.3
Observations	273		1077	

Notes: The sample is limited to introductory STEM courses with students who graduated from the USAFA and are not missing SAT scores or other admissions scores (academic composite, leadership composite, or fitness score).

Table 2. Randomness Checks: Predicting Professor Gender

	All students (1)	1st quartile (2)	2nd quartile (3)	3rd quartile (4)	4th quartile (5)
Panel A. Male and female students					
Female student	-0.002	-0.014	-0.013	0.005	0.039
	(0.010)	(0.013)	(0.014)	(0.015)	(0.026)
SAT math (100's)	0.007	0.007	-0.028	0.028	-0.004
	(0.013)	(0.021)	(0.060)	(0.054)	(0.031)
SAT verbal (100's)	-0.008	0.002	-0.001	-0.013	-0.024**
	(0.006)	(0.009)	(0.009)	(0.014)	(0.010)
Academic composite score (100's)	-0.005	-0.004	-0.003	-0.008*	-0.003
	(0.003)	(0.005)	(0.004)	(0.004)	(0.004)
Leadership composite score (100's)	-0.002	0.003	-0.005*	-0.002	-0.005
	(0.002)	(0.003)	(0.003)	(0.003)	(0.004)
Fitness score (100's)	0.003	0.002	0.002	0.002	0.005
	(0.006)	(0.009)	(0.008)	(0.009)	(0.008)
Observations	21,567	7,042	5,701	4,546	4,278
Joint significance p-value	.149	.418	.441	.067	.045
Panel B. Female students					
SAT math (100's)	0.026	-0.027	0.089	0.074	0.021
	(0.020)	(0.042)	(0.109)	(0.128)	(0.081)
SAT verbal (100's)	-0.004	0.015	0.008	-0.058**	-0.012
	(0.013)	(0.021)	(0.018)	(0.029)	(0.037)
Academic composite score (100's)	-0.004	-0.001	-0.007	-0.001	-0.010
	(0.004)	(0.007)	(0.007)	(0.011)	(0.012)
Leadership composite score (100's)	-0.003	-0.002	-0.000	-0.015	-0.001
	(0.004)	(0.006)	(0.008)	(0.010)	(0.012)
Fitness score (100's)	0.018	0.018	0.017	0.021	0.023
	(0.012)	(0.014)	(0.015)	(0.020)	(0.027)
Observations	3,873	1,578	1,097	670	528
Joint significance p-value	.526	.737	.463	.002	.802

*Statistically significant at the 10% level; ** at the 5% level; *** at the 1% level.

Notes: Each column shows estimates from a separate course-level regression of an indicator for professor gender on student characteristics. Quartiles are based on SAT math score. The sample is limited to students who graduated from the USAFA and are not missing SAT scores or other admissions scores. Student characteristics include SAT math score, SAT verbal score, academic composite score, leadership composite score, fitness score, and (not shown in table) indicators for race, recruited athlete, preparatory school attendance, enlisted prior to entering the Academy, and age 17-19. SAT scores, academic, leadership and fitness scores are divided by 100. Pooled regressions based on courses taken by both male and female students include a female indicator. Standard errors clustered at the professor level are reported in parentheses.

Table 3. Professor Gender and Undergraduate Outcomes

	First year course grade	Follow-on course grade	Took higher math course	STEM bachelor's degree	Left before graduating
	(1)	(2)	(3)	(4)	(5)
		Panel A. All students			
Proportion of female professors (STEM first-year courses)		0.001	0.040	0.037	0.048
		(0.031)	(0.039)	(0.041)	(0.033)
Female student	-0.106***	-0.028	-0.135***	-0.176***	-0.035*
	(0.020)	(0.019)	(0.026)	(0.025)	(0.019)
Female student x proportion of female professors		0.041	0.007	0.104	0.040
		(0.063)	(0.094)	(0.093)	(0.075)
Female student x female professor	0.045				
	(0.041)				
Observations	21,567	33,575	4,763	4,763	5,887
Dependent var. mean (female students)	-0.012	0.018	0.377	0.276	0.169
Dependent var. mean (male students)	0.127	0.044	0.554	0.474	0.195
		Panel B. SAT math top quartile			
Proportion of female professors (STEM first-year courses)		-0.003	-0.070	-0.022	-0.020
		(0.061)	(0.066)	(0.075)	(0.054)
Female student	-0.144***	-0.192***	-0.280***	-0.371***	0.024
	(0.042)	(0.054)	(0.060)	(0.062)	(0.044)
Female student x proportion of female professors		0.494***	0.419**	0.665***	-0.092
		(0.163)	(0.184)	(0.203)	(0.142)
Female student x female Professor	0.179**				
	(0.093)				
Observations	4,278	8,046	1,146	1,146	1,343
Dependent var. mean (female students)	0.413	0.471	0.593	0.450	0.152
Dependent var. mean (male students)	0.480	0.430	0.791	0.688	0.146

*Statistically significant at the 10% level; ** at the 5% level; *** at the 1% level.

Notes: Regressions in columns (1) and (2) are at the student-course level, with normalized course grade as the dependent variable. Regressions in columns (3)-(5) are at the student level, with indicators for taking a higher-level math course, obtaining a STEM bachelor's degree, and attrition before graduation as the respective dependent variables. Column (1) shows coefficients based on the gender of the professor of the first-year course, while the remaining columns show coefficients based on the proportion of female professors in first-year courses. The sample is limited to students who graduated from the USAFA for all regressions except column (5). Controls in all regressions include SAT math score, SAT verbal score, academic composite score, leadership composite score, fitness score, and indicators for race, recruited athlete, preparatory school attendance, enlisted prior to entering the Academy, age 17-19, and cohort. In addition, the student-course level regressions include course-semester fixed effects (column 1) or course-section-semester fixed effects (column 2). Furthermore, column (1) controls for indicators for professor being female, holding the rank of Associate Professor or Professor, having a terminal degree, and being a civilian; columns (2)-(5) controls for the proportion of the student's professors in first-year STEM courses with each of these characteristics. Standard errors clustered at the professor level (columns 1 and 2) or robust standard errors (columns 3-5) are reported in parentheses.

Table 4. Professor Gender and Career Outcomes

	Pilot (1)	STEM occupation (2)	Professional occupation (3)
Panel A. All students			
Proportion of female professors	0.033	-0.041	0.022
(STEM first-year courses)	(0.044)	(0.035)	(0.014)
Female student	-0.276***	0.006	0.026**
	(0.024)	(0.023)	(0.012)
Female student x proportion of female professors	0.008	0.100	0.005
	(0.089)	(0.087)	(0.048)
Observations	4,664	4,664	4,664
Dependent variable mean (female students)	0.219	0.216	0.045
Dependent variable mean (male students)	0.513	0.196	0.016
Panel B. SAT math top quartile			
Proportion of female professors	0.126	-0.196***	0.075**
(STEM first-year courses)	(0.080)	(0.065)	(0.036)
Female student	-0.286***	-0.017	0.077**
	(0.054)	(0.062)	(0.036)
Female student x proportion of female professors	-0.098	0.463**	-0.110
	(0.188)	(0.210)	(0.121)
Observations	1,116	1,116	1,116
Dependent variable mean (female students)	0.201	0.338	0.086
Dependent variable mean (male students)	0.540	0.250	0.025

*Statistically significant at the 10% level; ** at the 5% level; *** at the 1% level.

Notes: Each column reports the results of a separate student-level regression. The dependent variable is an indicator for the student ever working in the occupation indicated in the column heading. See Table A8 in the Appendix for a list of STEM occupations; professional occupations include doctor, surgeon, dentist, lawyer, and chaplain. See Table 3 for list of student controls. All regressions also control for the proportion of each student's professors in first-year STEM courses who held the rank of Associate Professor or Professor, the proportion who held a terminal degree, and the proportion who were civilian. Robust standard errors in parentheses.

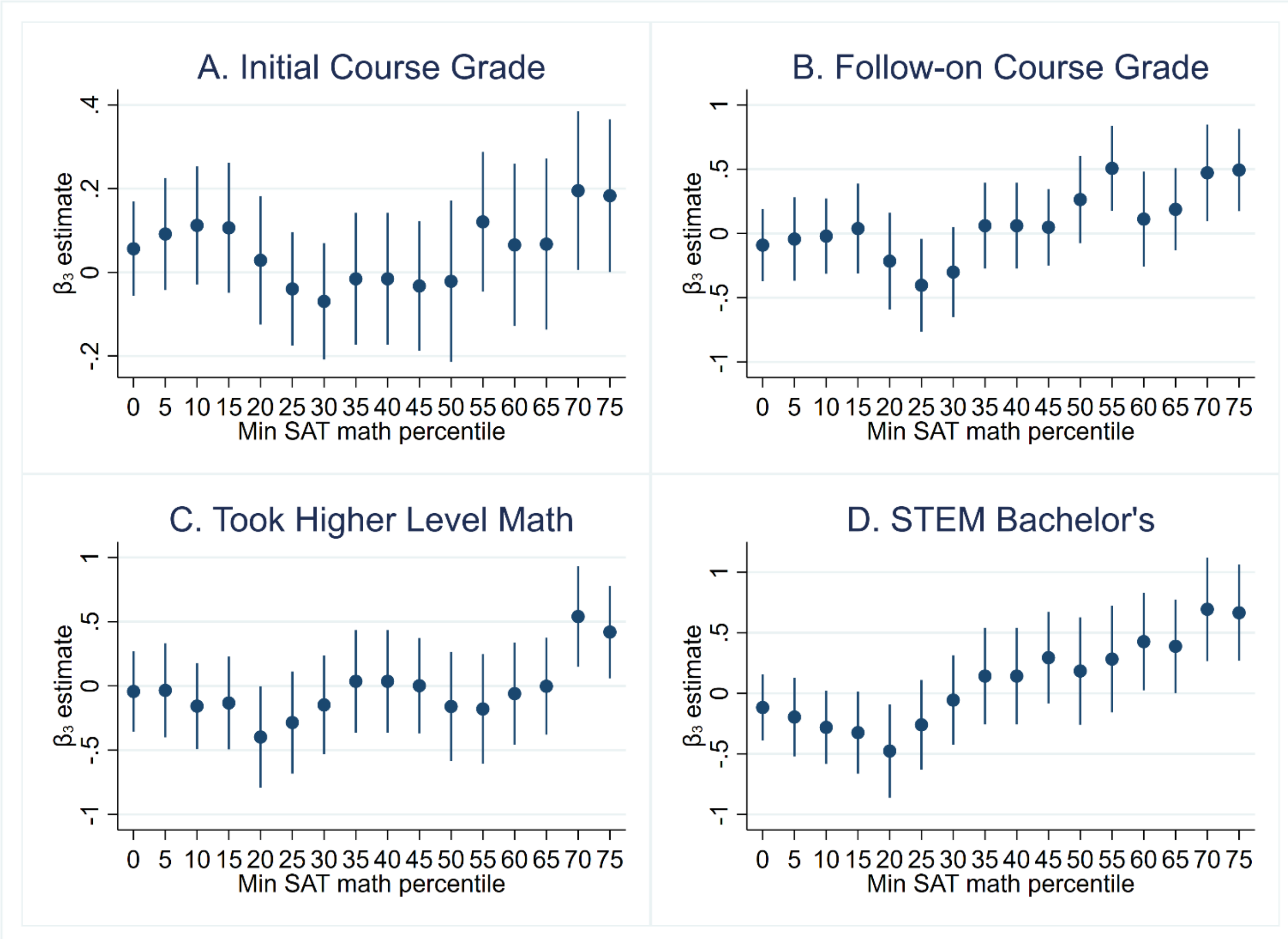
Table 5. Professor Gender and Graduate Degrees, Separation from Air Force

	Master's degree (1)	STEM master's (2)	Professional degree (3)	Separated from Air Force (4)
Panel A. Outcomes 4 years after graduation, all students				
Proportion of female professors	-0.003	-0.042**	0.036**	-0.002
(STEM first-year courses)	(0.033)	(0.021)	(0.014)	(0.022)
Female student	0.127***	-0.011	0.021**	0.044***
	(0.025)	(0.014)	(0.010)	(0.015)
Female student x proportion of female professors	-0.158*	0.099*	-0.046	-0.002
	(0.090)	(0.056)	(0.035)	(0.061)
Observations	4,416	4,416	4,416	4,763
Dependent variable mean (female students)	0.268	0.067	0.025	0.105
Dependent variable mean (male students)	0.163	0.061	0.013	0.066
Panel B. Outcomes 6 years after graduation, all students				
Proportion of female professors	-0.024	-0.049	0.042***	-0.009
(STEM first-year courses)	(0.045)	(0.030)	(0.015)	(0.029)
Female student	0.110***	-0.011	0.046***	0.147***
	(0.031)	(0.021)	(0.013)	(0.023)
Female student x proportion of female professors	-0.002	0.048	-0.088**	-0.032
	(0.116)	(0.074)	(0.045)	(0.087)
Observations	4,007	4,007	4,007	4,763
Dependent variable mean (female students)	0.488	0.119	0.044	0.271
Dependent variable mean (male students)	0.361	0.124	0.015	0.135
Panel C. Outcomes 4 years after graduation, SAT math top quartile				
Proportion of female professors	-0.005	-0.081*	0.101**	0.018
(STEM first-year courses)	(0.064)	(0.048)	(0.040)	(0.037)
Female student	0.137**	-0.064	0.060*	0.047
	(0.063)	(0.042)	(0.031)	(0.036)
Female student x proportion of female professors	0.003	0.426**	-0.211**	0.056
	(0.220)	(0.183)	(0.090)	(0.134)
Observations	1,068	1,068	1,068	1,146
Dependent variable mean (female students)	0.366	0.154	0.049	0.121
Dependent variable mean (male students)	0.206	0.119	0.021	0.061
Panel D. Outcomes 6 years after graduation, SAT math top quartile				
Proportion of female professors	-0.017	-0.140**	0.104**	0.013
(STEM first-year courses)	(0.082)	(0.059)	(0.043)	(0.053)
Female student	0.132*	-0.106**	0.117***	0.150***
	(0.070)	(0.052)	(0.044)	(0.054)
Female student x proportion of female professors	-0.050	0.488**	-0.305***	0.050
	(0.231)	(0.208)	(0.113)	(0.179)
Observations	978	978	978	1,146
Dependent variable mean (female students)	0.540	0.220	0.090	0.286
Dependent variable mean (male students)	0.378	0.195	0.025	0.127

*Statistically significant at the 10% level; ** at the 5% level; *** at the 1% level.

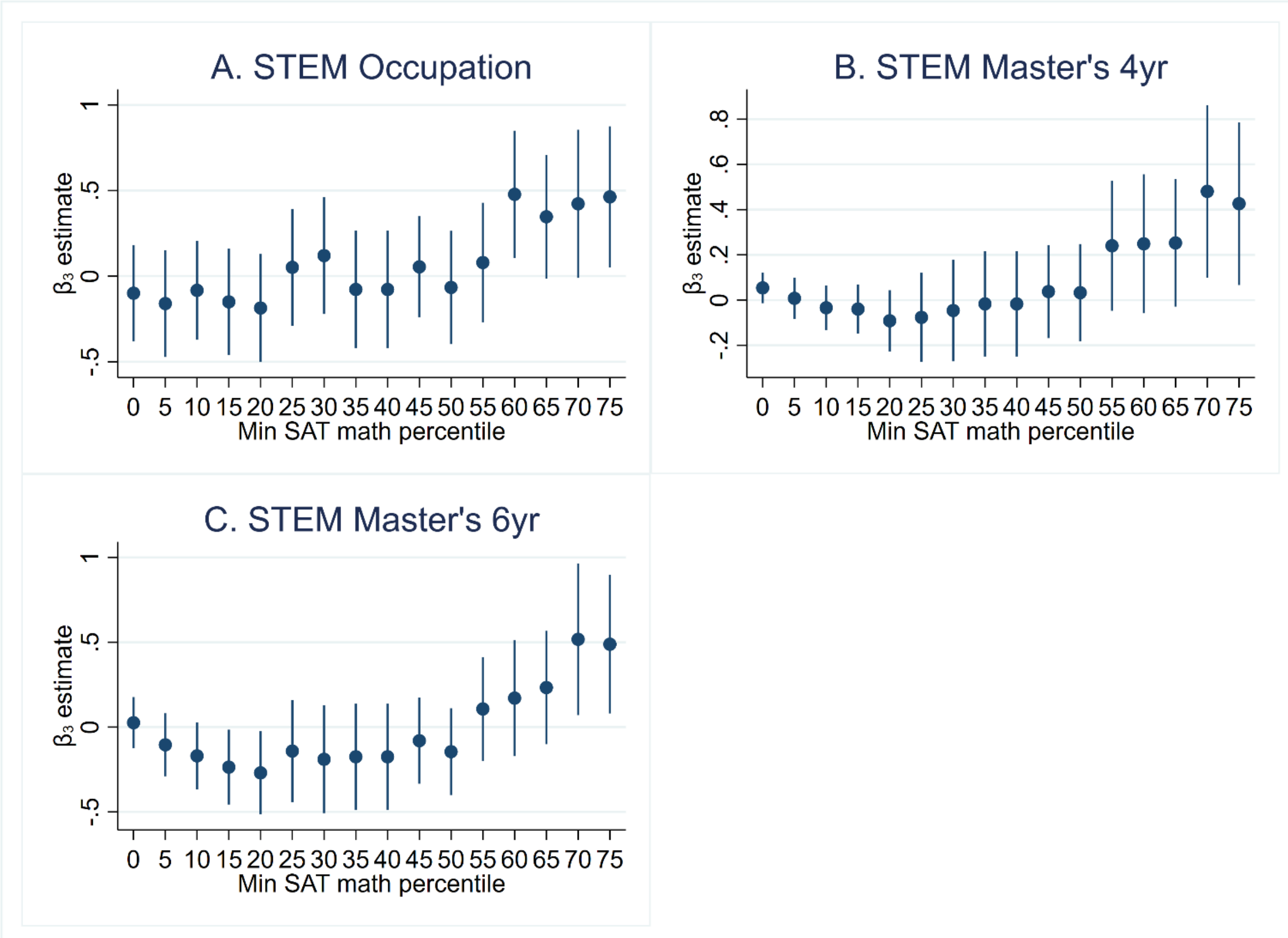
Notes: The dependent variable is an indicator for attainment of the specified degree (columns 1-3) or separating from the Air Force (column 4) within 4 years (Panels A and C) or 6 years (Panels B and D). The sample is restricted to USAFA graduates who served in the Air Force at least 4 years (Panels A and C) or 6 years (Panels B and D) for columns 1-3 and to all USAFA graduates in column 4. Panels C and D are further limited to students in the top quartile of SAT math. See Table 3 for list controls. Robust standard errors in parentheses.

Figure 1. SAT Math Cutoff Sensitivity, Academic Outcomes



Notes: Each panel shows estimates of β_3, the coefficient of the interaction between the female student indicator and either the female professor indicator (Panel A) or the fraction of female freshman-year STEM professors (Panels B-D). Estimates are shown for 16 different quartiles along the student ability distribution (as measured by math SAT scores): 0 - 25th, 5th - 30th, 10th - 35th, 15th - 40th , 20th - 45th, 25th - 50th, 30th - 55th , 35th - 60th , 40th - 65th, 55th - 70th, 50th - 75th, 55th - 80th, 60th - 85th, 65th - 90th , 70th - 95th, and the 75th - 100th percentiles. Vertical bars indicate 95 percent confidence intervals.

Figure 2. SAT Math Cutoff Sensitivity, Post-Graduation Outcomes



Notes: Estimates of β_3, the coefficient of the interaction between the female student indicator and the fraction of female freshman-year STEM professors from equation (3), are shown for 16 different range of the student ability distribution (as measured by math SAT scores and detailed in Figure 1). Vertical bars indicate 95 percent confidence intervals.

Online Appendix

Table A1. Professor Gender and Occupation Controlling for First-Year Math and Science Grades and STEM Bachelor's Degree

	STEM occupation (1)	STEM occupation (2)	STEM occupation (3)
Panel A. All students			
Proportion of female professors	-0.041	-0.040	-0.049
(STEM first-year courses)	(0.035)	(0.035)	(0.034)
Female student	0.006	0.006	0.042*
	(0.023)	(0.023)	(0.022)
Female student x proportion of	0.100	0.096	0.080
female professors	(0.087)	(0.087)	(0.081)
Grade control		X	X
STEM bachelor's control			X
Observations	4,664	4,664	4,664
Dep. var. mean (female students)	0.216	0.216	0.216
Dep. var. mean (male students)	0.196	0.196	0.196
Panel B. SAT math top quartile			
Proportion of female professors	-0.196***	-0.196***	-0.188***
(STEM first-year courses)	(0.065)	(0.065)	(0.064)
Female student	-0.017	-0.014	0.069
	(0.062)	(0.062)	(0.059)
Female student x proportion of	0.463**	0.448**	0.309
female professors	(0.210)	(0.210)	(0.193)
Grade control		X	X
STEM bachelor's control			X
Observations	1,116	1,116	1,116
Dep. var. mean (female students)	0.338	0.338	0.338
Dep. var. mean (male students)	0.250	0.250	0.250

*Statistically significant at the 10% level; ** at the 5% level; *** at the 1% level.

Notes: Each column reports the results of a separate student-level regression. The dependent variable is an indicator for the student working in a STEM occupation at any point in his or her career. See Table A8 for a list of STEM occupations. Controls include SAT math score, SAT verbal score, academic composite score, leadership composite score, fitness score, and indicators for race, recruited athlete, preparatory school attendance, enlisted prior to entering the Academy, age 17-19, and cohort. In addition, regressions include controls for the proportion of the student's professors in first-year STEM courses who held the rank of Associate Professor or Professor, the proportion who held a terminal degree, and the proportion who were civilian. Regressions in columns (2) and (3) additionally control for the average student grade across first year STEM courses, and column (3) further controls for an indicator for earning a bachelor's degree in a STEM field. Robust standard errors in parentheses.

Table A2. Professor Gender and Occupational Preferences

	Pilot #1 choice (1)	STEM #1 choice (2)	STEM top 2 choices (3)	STEM anywhere among choices (4)
Panel A. All students				
Proportion of female professors	0.023	-0.011	0.012	0.051
(STEM first-year courses)	(0.044)	(0.030)	(0.048)	(0.048)
Female student	-0.311***	0.059***	-0.009	-0.133***
	(0.029)	(0.022)	(0.028)	(0.030)
Female student x proportion of female professors	0.074	-0.011	-0.115	-0.083
	(0.115)	(0.087)	(0.110)	(0.117)
Observations	3,840	3,840	3,840	3,840
Dependent variable mean (female students)	0.403	0.160	0.308	0.469
Dependent variable mean (male students)	0.718	0.103	0.344	0.623
Panel B. SAT math top quartile				
Proportion of female professors	0.167**	-0.131**	-0.025	-0.022
(STEM first-year courses)	(0.083)	(0.064)	(0.097)	(0.088)
Female student	-0.317***	0.089	-0.026	-0.133**
	(0.066)	(0.060)	(0.070)	(0.066)
Female student x proportion of female professors	0.156	0.014	0.019	0.173
	(0.236)	(0.207)	(0.264)	(0.232)
Observations	941	941	941	941
Dependent variable mean (female students)	0.405	0.250	0.474	0.655
Dependent variable mean (male students)	0.733	0.135	0.456	0.713

*Statistically significant at the 10% level; ** at the 5% level; *** at the 1% level.

Notes: Each column reports the results of a separate student-level regression. The dependent variable is an indicator for the student ranking the indicated occupation or occupation category as inputs to the occupational matching system. See the text (section 2.4) for a description of the occupational matching system and Table A8 for a list of STEM occupations. The sample is limited to USAFA graduates for whom occupational preference data were available. Controls include SAT math score, SAT verbal score, academic composite score, leadership composite score, fitness score, and indicators for race, recruited athlete, preparatory school attendance, enlisted prior to entering the Academy, age 17-19, and cohort. In addition, regressions include controls for the proportion of the student's professors in first-year STEM courses who held the rank of Associate Professor or Professor, the proportion who held a terminal degree, and the proportion who were civilian. Robust standard errors in parentheses.

Table A3. Professor Gender and Occupational Progression

	STEM occupation first job (1)	STEM occupation first job (2)	STEM occupation first job (3)	STEM occupation ≤2 years (4)	STEM occupation ≤4 years (5)	STEM occupation ≤6 years (6)
Panel A. All students						
Proportion of female professors	-0.004	-0.012	-0.018	-0.043	-0.040	-0.036
(STEM first-year courses)	(0.031)	(0.033)	(0.032)	(0.035)	(0.035)	(0.035)
Female student	0.027	0.033	0.022	0.012	-0.004	-0.019
	(0.022)	(0.023)	(0.022)	(0.023)	(0.024)	(0.025)
Female student x proportion of	0.030	0.036	0.069	0.091	0.112	0.203**
female professors	(0.081)	(0.085)	(0.083)	(0.086)	(0.091)	(0.098)
Observations	4,642	4,642	4,642	4,534	4,311	3,902
Dep. var. mean (female students)	0.177	0.202	0.191	0.215	0.205	0.194
Dep. var. mean (male students)	0.150	0.166	0.161	0.187	0.187	0.172
Panel B. SAT math top quartile						
Proportion of female professors	-0.083	-0.153**	-0.146**	-0.203***	-0.198***	-0.177***
(STEM first-year courses)	(0.059)	(0.063)	(0.062)	(0.065)	(0.064)	(0.062)
Female student	0.074	0.047	0.040	0.003	-0.015	-0.035
	(0.059)	(0.061)	(0.061)	(0.062)	(0.064)	(0.066)
Female student x proportion of	0.103	0.253	0.281	0.399*	0.425*	0.620***
female professors	(0.190)	(0.204)	(0.203)	(0.210)	(0.219)	(0.221)
Observations	1,110	1,110	1,110	1,082	1,036	946
Dep. var. mean (female students)	0.283	0.333	0.326	0.328	0.32	0.323
Dep. var. mean (male students)	0.182	0.214	0.211	0.233	0.235	0.215

*Statistically significant at the 10% level; ** at the 5% level; *** at the 1% level.

Notes: Each column reports the results of a separate student-level regression. The dependent variable is an indicator for the student working in a STEM occupation in the indicated time frame. See Table A8 for a list of STEM occupations. In column (2), we change the initial assignment of 84 students from "graduate study" to "STEM occupation" irrespective of the degree earned. In column (3) we change the initial assignment of 57 students from "graduate study" to STEM occupation based on the graduate degree they obtained. The sample is limited to students who served in the Air Force for at least 2, 4, and 6 years in columns (4), (5), and (6), respectively. Controls include SAT math score, SAT verbal score, academic composite score, leadership composite score, fitness score, and indicators for race, recruited athlete, preparatory school attendance, enlisted prior to entering the Academy, age 17-19, and cohort. In addition, regressions include controls for the proportion of the student's professors in first-year STEM courses who held the rank of Associate Professor or Professor, the proportion who held a terminal degree, and the proportion who were civilian. Robust standard errors in parentheses.

Table A4. Professor Gender and Predicted Earnings

	Earnings Full sample (1)	Earnings Top quartile (2)	ln(Earnings) Full sample (3)	ln(Earnings) Top quartile (4)
Proportion of female professors	-882	-3,048***	-0.014	-0.045**
(STEM first-year courses)	(686)	(1,115)	(0.012)	(0.019)
Female student	1,613**	686	0.022**	0.004
	(637)	(1,605)	(0.011)	(0.028)
Female student x proportion of	-1,544	9,063	-0.028	0.149
female professors	(2,494)	(5,527)	(0.043)	(0.093)
Observations	3,410	847	3,410	847
Dependent variable mean female students	60,670	61,981	11	11.02
Dependent variable mean male students	59,117	59,455	10.98	10.99

*Statistically significant at the 10% level; ** at the 5% level; *** at the 1% level.

Notes: Each column reports the results of a separate student-level regression. The dependent variable is the predicted annual civilian earnings ($) 6 years after graduation (columns 1 and 2) or the log of predicted earnings (columns 3 and 4). See text for detail on the procedure for predicting earnings. Controls include SAT math score, SAT verbal score, academic composite score, leadership composite score, fitness score, and indicators for race, recruited athlete, preparatory school attendance, enlisted prior to entering the Academy, age 17-19, and cohort. In addition, regressions include controls for the proportion of the student's professors in first-year STEM courses who held the rank of Associate Professor or Professor, the proportion who held a terminal degree, and the proportion who were civilian. Robust standard errors in parentheses.

Table A5. Professor Gender and Post-Graduation Outcomes Using a Non-Linear Specification

	STEM bachelor's degree (1)	STEM occupation (2)	STEM masters ≤4 years (3)	STEM masters ≤6 years (4)
Female student	-0.374***	0.043	-0.055	-0.098*
	(0.069)	(0.069)	(0.043)	(0.055)
1 female professor	-0.017	-0.017	0.007	-0.006
(first-year STEM courses)	(0.032)	(0.032)	(0.024)	(0.030)
2 female professors	-0.091*	-0.100**	-0.048*	-0.091**
	(0.050)	(0.042)	(0.028)	(0.036)
3+ female professors	-0.142	-0.222***	-0.080**	-0.126***
	(0.124)	(0.062)	(0.034)	(0.048)
Female student x 1 female professor	0.220**	0.046	0.089	0.090
	(0.097)	(0.095)	(0.071)	(0.090)
Female student x 2 female professors	0.346**	0.074	0.219*	0.327**
	(0.144)	(0.133)	(0.127)	(0.153)
Female student x 3+ female professors	0.157	0.172	0.391	0.387
	(0.258)	(0.226)	(0.283)	(0.293)
Observations	1,146	1,116	1,068	978
Dependent variable mean female students	0.450	0.338	0.154	0.220
Dependent variable mean male students	0.688	0.250	0.119	0.195

*Statistically significant at the 10% level; ** at the 5% level; *** at the 1% level.

Notes: Each column reports the results of a separate student-level regression. The sample is limited to students in the top quartile of SAT math. The dependent variable is an indicator for the indicated STEM outcome. Controls include SAT math score, SAT verbal score, academic composite score, leadership composite score, fitness score, and indicators for race, recruited athlete, preparatory school attendance, enlisted prior to entering the Academy, age 17-19, and cohort. In addition, regressions include controls for the proportion of the student's professors in first-year STEM courses who held the rank of Associate Professor or Professor, the proportion who held a terminal degree, and the proportion who were civilian. Robust standard errors in parentheses.

Table A6. Professor Gender and Post-Graduation Outcomes with Professor Characteristic Interactions

	STEM bachelor's degree (1)	STEM occupation (2)	STEM masters ≤4 years (3)	STEM masters ≤6 years (4)
Proportion of female professors	-0.021	-0.198***	-0.073	-0.129**
(STEM first-year courses)	(0.076)	(0.065)	(0.048)	(0.059)
Female student	-0.462***	-0.024	-0.200***	-0.262***
	(0.103)	(0.103)	(0.064)	(0.074)
Female student x proportion of female	0.576***	0.400*	0.336*	0.317
Professors	(0.205)	(0.212)	(0.184)	(0.208)
Female student x proportion of assistant	0.257	0.165	0.230	0.318*
Professors	(0.171)	(0.172)	(0.143)	(0.169)
Female student x proportion of associate/	-0.323	-0.523	0.329	0.231
full professors	(0.388)	(0.404)	(0.354)	(0.380)
Female student x proportion of professors	0.435	0.403	-0.223	-0.253
with terminal degree	(0.284)	(0.284)	(0.224)	(0.274)
Female student x proportion of civilian	-0.290	-0.242	0.189	0.281
Professors	(0.269)	(0.269)	(0.235)	(0.270)
Observations	1,146	1,116	1,068	978
Dependent variable mean female students	0.450	0.338	0.154	0.220
Dependent variable mean male students	0.688	0.250	0.119	0.195

*Statistically significant at the 10% level; ** at the 5% level; *** at the 1% level.

Notes: Each column reports the results of a separate student-level regression. The sample is limited to students in the top quartile of SAT math. The dependent variable is an indicator for the indicated STEM outcome. Controls include SAT math score, SAT verbal score, academic composite score, leadership composite score, fitness score, and indicators for race, recruited athlete, preparatory school attendance, enlisted prior to entering the Academy, age 17-19, and cohort. In addition, regressions include controls for the proportion of the student's professors in first-year STEM courses who held the rank of Associate Professor or Professor, the proportion who held a terminal degree, and the proportion who were civilian. Robust standard errors in parentheses.

Table A7. Professor Gender and Graduate Controlling for First-Year Math and Science Grades and STEM Bachelor's Degree

	STEM masters ≤4 years (1)	STEM masters ≤4 years (2)	STEM masters ≤4 years (3)
Panel A. All students			
Proportion of female professors	-0.042**	-0.042**	-0.046**
(STEM first-year courses)	(0.021)	(0.021)	(0.021)
Female student	-0.011	-0.010	0.008
	(0.014)	(0.014)	(0.013)
Female student x proportion of	0.099*	0.093*	0.081
female professors	(0.056)	(0.055)	(0.053)
Grade control		X	X
STEM bachelor's control			X
Observations	4,416	4,416	4,416
Dep. var. mean (female students)	0.0670	0.0670	0.0670
Dep. var. mean (male students)	0.0610	0.0610	0.0610
Panel B. SAT math top quartile			
Proportion of female professors	-0.081*	-0.078*	-0.076
(STEM first-year courses)	(0.048)	(0.047)	(0.046)
Female student	-0.064	-0.054	-0.002
	(0.042)	(0.041)	(0.040)
Female student x proportion of	0.426**	0.370**	0.270
female professors	(0.183)	(0.177)	(0.169)
Grade control		X	X
STEM bachelor's control			X
Observations	1,068	1,068	1,068
Dep. var. mean (female students)	0.154	0.154	0.154
Dep. var. mean (male students)	0.119	0.119	0.119

*Statistically significant at the 10% level; ** at the 5% level; *** at the 1% level.

Notes: Each column reports the results of a separate student-level regression. The dependent variable is an indicator for the student obtaining a masters degree in a STEM field within 4 years of graduation. The sample is limited to USAFA graduates who remained in the Air Force for at least 4 years following graduation. Controls include SAT math score, SAT verbal score, academic composite score, leadership composite score, fitness score, and indicators for race, recruited athlete, preparatory school attendance, enlisted prior to entering the Academy, age 17-19, and cohort. In addition, regressions include controls for the proportion of the student's professors in first-year STEM courses who held the rank of Associate Professor or Professor, the proportion who held a terminal degree, and the proportion who were civilian. Regressions in columns (2) and (3) additionally control for the average student grade across first year STEM courses, and column (3) further controls for an indicator for earning a bachelor's degree in a STEM field. Robust standard errors in parentheses.

Table A8. STEM and Non-STEM Occupations

Occupation Code	STEM Occupation
13S	Space Operations
14W, 15W[+]	Weather
32E	Civil Engineer
61A	Operations Research Analyst
61B[+]	Behavioral Scientist
61C	Chemist/Nuclear Chemist
61D	Physicist/Nuclear Engineer
61S[+]	Scientist
62E[++]	Developmental Engineer

Occupation Code	Non-STEM Occupation
11B	Bomber Pilot
11E	Experimental Test Pilot
11F	Fighter Pilot
11G	Generalist Pilot
11H	Rescue Pilot
11K	Trainer Pilot
11M	Mobility Pilot
11R	Reconnaissance/Surveillance/Electronic Warfare Pilot
11S	Special Operations Pilot
11U	Remotely Piloted Aircraft Pilot
11X	Pilot
12B	Bomber Combat Systems Officer
12E	Experimental Test Combat Systems Officer
12F	Fighter Combat Systems Officer
12G	Generalist Combat Systems Officer
12H	Rescue Combat Systems Officer
12K	Trainer Combat Systems Officer
12M	Mobility Combat Systems Officer
12R	Reconnaissance/Surveillance/Electronic Warfare Combat Systems Officer
12S	Special Operations Combat Systems Officer
12U	Remotely Piloted Aircraft Pilot
12X	Combat Systems Officer
13A	Astronaut
13B	Air Battle Manager
13C	Special Tactics
13D	Combat Rescue Officer
13L	Air Liaison Officer
13M	Airfield Operations
13N	Nuclear and Missile Operations
14F	Information Operations
14N	Intelligence

Table A8 (continued).

16F	Regional Affairs Strategist
16G	Air Force Operations Staff Officer
16P	Political Military Affairs Strategist
16R	Planning and Programming
16X	Operations Support
17C	Cyberspace Operations Commander
17D	Cyberspace Operations
17S	Cyber Warfare Operations
18A	Attack Remotely Piloted Aircraft Pilot
18E	Experimental Test Remotely Piloted Aircraft Pilot
18G	Generalist Remotely Piloted Aircraft Pilot
18R	Reconnaissance Remotely Piloted Aircraft Pilot
18S	Special Operations Remotely Piloted Aircraft Pilot
18X	Remotely Piloted Aircraft Pilot
20C	Logistics Commander
20X	Logistics
21A	Aircraft Maintenance
21M	Munitions and Missile Maintenance
21R	Logistics Readiness
21X	Logistics Utilization
30C	Support Commander
31P	Security Forces
33S[+]	Communication and Information
34M[+]	Services
35B	Air Force Band
35P	Public Affairs
36P[+], 37F[+], 38P[+]	Personnel
38F	Force Support
38M[+]	Manpower
40C	Medical Commander
41A	Health Services Administrator
42B	Physical Therapist
42E	Optometrist
42F	Podiatrist
42G	Physician Assistant
42N	Audiologist
42P	Clinical Psychologist
42S	Clinical Social Worker
42T	Occupational Therapist
42X	Biomedical Clinician
43A	Aerospace and Operational Physiologist
43B	Biomedical Scientist
43D	Dietitian
43E	Bioenvironmental Engineer

Table A8 (continued).

43H	Public Health Officer
43P	Pharmacist
43T	Biomedical Laboratory
43X	Biomedical Specialist
44A	Chief Hospital/Clinic Services
44B	Preventive Medicine
44D	Pathologist
44E	Emergency Services Physician
44F	Family Physician
44G	General Practice Physician
44H	Nuclear Medicine Physician
44J	Clinical Geneticist
44K	Pediatrician
44M	Internist
44N	Neurologist
44O	Physician
44P	Psychiatrist
44R	Diagnostic Radiologist
44S	Dermatologist
44T	Radiotherapist
44U	Occupational Medicine
44X	Physician
44Y	Critical Care Medicine
44Z	Allergist
45A	Anesthesiologist
45B	Orthopedic Surgeon
45E	Ophthalmologist
45G	Obstetrician and Gynecologist
45N	Otorhinolaryngologist
45P	Physical Medicine Physician
45S	Surgeon
45U	Urologist
45X	Surgery
46A	Nursing Administrator
46F	Flight Nurse
46N	Clinical Nurse
46P	Mental Health Nurse
46S	Operating Room Nurse
46X	Nurse
46Y	Advanced Practice Registered Nurse
47B	Orthodontist
47D	Oral and Maxillofacial Pathologist
47E	Endodontist
47G	Dentist

Table A8 (continued).

47H	Periodontist
47K	Pediatric Dentist
47P	Prosthodontist
47S	Oral and Maxillofacial Surgeon
47X	Dental
48A	Aerospace Medicine Specialist
48G	General Medical Officer Flight Surgeon
48R	Residency Trained Flight Surgeon
48V	Pilot Physician
48X	Aerospace Medicine
51J	Judge Advocate
52R	Chaplain
60C	Senior Materiel Leader-Upper Echelon
63A	Acquisition Manager
63F, 65F⁺	Financial Management
63G	Senior Materiel Leader-Lower Echelon
63S	Materiel Leader
64P	Contracting
65W	Cost Analysis
71S	Special Investigations
81T	Instructor
82I	Recruiting Service
84H	Historian
85G	Air Force Honor Guard
86M	Operations Management
86P	Command and Control
87G	Wing Inspector General
87I	Director Wing Inspections
87Q	Director Complaints Resolution
88A	Aide-De-Camp
90G	General Officer
91C	Commander
91W	Wing Commander
92J	Air Force Reserve Officer Training Corps Educational Delay Law Student
92M	Health Professions Scholarship Program Medical Student
92P	Physician Assistant Student
92R	Chaplain Candidate
92S	Student Officer Authorization
92T	Pilot Trainee
92W	Combat Wounded Warrior
93P	Patient
95A	USAFA Liaison Officer or Civil Air Patrol Reserve Assistance Program Officer
96A	Disqualified Officer-Reasons Beyond Their Control
96B	Disqualified Officer-Reasons Within Their Control

Table A8 (continued).

96D	Officer Not Available For Use in Awarded Air Force Specialty Code for Cause
96U	Unclassified Officer
96V	Unallotted
97E	Executive Officer
99A	Unspecified AFSC
99G	Gold Bar Diversity Recruiter

+ Occupation no longer exists or occupation code was changed during the time period of analysis.

++ Developmental engineer includes the following occupations: Aeronautical Engineer, Astronautical Engineer, Computer Systems Engineer, Electrical/Electronic Engineer, Flight Test Engineer, Project Engineer, and Mechanical Engineer.