Gender Ratios at Top PhD Programs in Economics

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Abstract

Analyzing university faculty and graduate students data for ten of the top U.S. economics departments between 1987 and 2007, we find persistent differences in the gender compositions of both faculty and graduate students across departments. There is a positive correlation between the share of female faculty and the share of women in the PhD class graduating 6 years later. Using instrumental variable analysis, we find robust evidence that this relation is causal. These results contribute to our understanding of the persistent under-representation of women in economics, as well as for the persistent segregation of women in the labor force.

JEL classification: J16, J71, I23, M51

Key words: gender, segregation, economists, gender bias, affirmative action, minority

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1 Introduction

The growing concern for the under-representation of women in science and engineering has prompted an interest in the mechanisms driving the share of women in these fields, and in the effect that the gender diversity of the faculty has on the share of female students. Interestingly, some universities are more successful than others in recruiting and retaining women, and in particular female graduate students. Why is this the case? This paper explores the uneven distribution of female faculty and graduate students across ten of the top U.S. PhD programs in economics. We find that the share of female faculty is correlated with the share of female graduate students and show that this correlation is causal. We instrument for the share of female faculty by using the number of male faculty leaving the department as well as the simulated number of leavings. We find that a higher share of female faculty has a positive effect on the share of female graduate students graduating 6 years later.

Women are under represented in science and engineering. In 2010, Men outnumbered women in nearly every science and engineering field in college, and in some fields, women earned only 20 percent of bachelor's degrees, with representation declining further at the graduate level (Hill et al., 2010). In economics, women constituted 33 percent of the graduating PhD students, and only 20 percent of faculty at PhD granting institutions (Fraumeni, 2011). Women in economics have been shown to have different career paths than men and to be promoted less (Kahn, 1993; Dynan and Rouse, 1997; McDowell et al., 1999; Ginther and Kahn, 2004). Focusing on the progression of women through the academic ladder, most research has failed to fully account for the effect that successful women in the field have had on the entrance and success of other women. More specifically, the gross effect that women faculty have on the share of female students have not been fully explored. In this study we address this gap in the literature and focus on the causal relationship between the share of female faculty in top economics departments and the share of graduating female PhD students.

Women in the faculty of top departments may contribute to the share of female students in four ways: First, the higher the share of women in the faculty, the greater their influence on the admission of students. Thus, if female faculty advocated for the admission of female students, a greater female faculty share would result in a higher share of women in the student body. However, in a related question regarding the effect of women in positions of power on the hiring and promotions of other women, evidence were mixed (Ehrenberg et al., 2012; Bagues and Esteve-Volart, 2010; Zinovyeva and Bagues, 2010). Second, a higher share of female faculty may reduce prejudice against women (Beaman et al., 2008; Goldin, 1990). If prejudice is reduced, the faculty is more likely to admit female graduate students and to assist them through graduation. Third, female students may expect better mentoring, less discrimination, and better outcomes when they study under female instructors or work with female mentors (Hoffmann and Oreopoulos, 2009; Bettinger and Long, 2004; Neumark and Gardecki, 2003; Hilmer and Hilmer, 2007; Blau et al., 2010; Carrell et al., 2010). Thus, female students self-select to attend departments with a larger share of female faculty, and once admitted, they may have higher completion rates (Robst et al., 1998). Fourth, departments with a high share of female faculty may be perceived by students as of lower status. If indeed female students preferred studying in departments with lower share of female faculty and good departments were trying to recruit good female students (Attiyeh and Attiyeh, 1997), then departments with higher share of female faculty would have lower shares of female students. The joint effect of the four forces constitutes the influence of the share of female faculty on the share of female students, which is the object of interest from a policy perspective, and the subject of our analysis. Our results thus show that the positive causal effects of having a larger share of women on the faculty tend to outweigh the negative ones. Although we do not disentangle the four mechanisms in this study, our contribution is actually in testing for their joint effect and showing a causal relation.

We conduct our analysis using matched data on students and individual faculty members of ten of the top U.S. economics departments during the 20 years prior to 2007. We analyze trends in the gender composition of faculty and PhD students and uncover a positive correlation between the share of female faculty in a given economics department and the share of female students graduating 6 years later. The panel nature of our data allows us to control both for institution and year fixed effects. To identify time-varying institution-specific tendencies to accept and retain women, we use the share of non-white students graduating from the PhD program in economics and the share of women graduating from the PhD programs in all other departments of the same university as measures of the departmental minority bias and of the university-wide gender bias, respectively. We find that, indeed, some of the positive correlation between the share of women on the faculty and the female share of the graduate student class that we uncovered in the fixed effects regressions is explained by time-varying minority attitudes of the departments.

To establish a causal effect of the gender composition of the faculty on the gender composition of the PhD class graduating 6 years later, we use instrumental variable approach. To do so, we use the exogenous portion of the variation in the faculty female share in a given department that is due to the number of male faculty leaving the department in the previous two years. This is a good instrument because it has a mechanical effect on the share of female faculty, but no direct effect on the share of women in the cohort of graduate students admitted in the following year and graduating 6 years later. Using this approach we find evidence of a causal relationship between the faculty gender composition and the share of female graduate students. This finding is robust to the choice of the estimation technique, to alternative instruments, and to different sets of control variables.

To alleviate any concerns that male exits are themselves driven by the time-varying attitudes regarding gender at the department level, we predict male exits at the individual level, using only data on the age and the PhD granting institution of 7800 individual-year observations. We find that the age and the PhD granting institution of male faculty are good exogenous predictors for their probability to exit. We then use the predicted number of exits aggregated at the institution-year level as our instrument in the first stage of the regression. Using this simulated IV approach, we continue to find evidence of a causal relationship between the faculty gender composition and the share of women in the PhD class graduating 6 years later.

In Section 2 we describe our data sources and the trends, in Section 3 we present our empirical approach and results, and in Section 4 we offer some concluding thoughts.

2 Data

Our data set contains information on all ladder faculty and graduating students from ten of the top economics departments in the United States over the years 1983 to 2007. We know the gender composition of both faculty and students, as well as full academic history of all faculty, including employment, tenure and publications throughout their careers.

2.1 Data sources

Our faculty data were collected based on faculty lists from 1983 to 2007 of ten top economics departments.[1] For each member of the ladder faculty who appears in the data set, we recorded the gender, rank, and tenure status. Tracking curriculum vitae for each individual who was newly hired during these 25 years, we obtained further information regarding his or her PhD institution and year of graduation, together with yearly data regarding his or her career path, including the rank and tenure status at each institution since graduation.

We further augmented this data set with publication history. To do this, we obtained the cumulative number of publications for each faculty member in each year in our data set using Harzing's Publish or Perish engine, which itself is based on Google Scholar search. The number of publications measured this way provides only a noisy measure of quality. Nevertheless, it is the best measure we could find for constructing historical data. Citation-weighted measures of publications, for instance, use current citations and cannot account for the perceived quality of a paper in the past.

Our source for the graduating students data is the National Science Foundation Survey of

[1] Choice of universities was dictated by data availability. The following institutions provided faculty lists for all years: Berkeley, Chicago, Harvard, MIT, NYU, Northwestern, Penn, Princeton, UCLA and Yale.

Earned Doctorates, which is conducted annually by the University of Chicago National Opinion Research Center. The survey compiles data on all earned doctorates granted by regionally accredited U.S. universities, in all fields, and contains information on race and gender of graduates.

For each university in our sample we examined the gender composition of the graduating PhD class in economics. We used this data source further to construct measures of minority attitudes at the university and department levels: the share of non-whites in the economics graduating class as a measure of minority bias at the department level,[2] and the share of graduating women in all the departments except economics to measure institutional gender preferences. We lag these measures by six years to reflect the minority and gender attitudes in the year these graduate students were admitted to the university.

For the analysis of the gender composition of the graduating PhD class, we matched the faculty and student data by institution and year of admission decision. We take the female faculty share at admissions as our main explanatory variable because is likely to affect students' full graduate career from admission to graduation. We assumed the average time-to-degree is 5 years, so that decisions were made six years prior to graduation.[3] Since we do not have attrition data by institution-year, our analysis relates the share of female faculty at the time of admissions to the share of female students graduating from the program.[4] Thus we capture the overall effect of female faculty shares on the admission and success of female students. As student data is available through 2006, and because we lose a couple of initial years in the data because of the lags, we end up with 140 institution-year observations in ten institutions.

[2]Our results are robust to using the share of non-white and non-Asian students instead. Foreign students are not considered minorities for the analysis.

[3]This corresponds to the 5.6 median time-to-degree found by Stock (2011) for top 50 PhD programs in economics for the entering class of 2002, and reflects the increase in time-to-degree since their prior investigation. Indeed, if we assume the average time-to-degree is 6 years we find our correlation results remain although they are somewhat smaller.

[4]Completion rates for top economic PhD departments are around 75% and slightly higher for males than for females (Stock, 2011).

2.2 Trends

Figure 1 presents the shares of female faculty and female entering graduate students for each institution over time. We can make two main observations regarding the share of female faculty. First, we see that the share of female faculty increased steadily in all but one institution. Second, there is considerable variation in the share of women on the faculty across institutions and in trends in that share across institutions. For instance, the share of women in institution 1 was already high in 1983, compared to the rest of the sample, and only increased slightly over our sample period, while the share of women on the economics faculty at institution 4 and 9 increased steadily. In addition, we observe that the share of female students is very volatile while the share of female faculty is persistent.[5]

Despite the average growth, the share of female faculty remains rather low across all departments in our sample, only reaching over 20 percent in two observations — institution 9 in 2004 and 2005.[6] The share of female students in our sample is as high as 50 percent in one observation, but is mostly below 40 percent. Tables A.1 and A.2 in the Appendix provides the shares of women among faculty and students, respectively, for each institution and year. For the share of women in the PhD class, we report raw data, by the graduation year.

3 Empirical Analysis

3.1 Relationship between female share of faculty and students

We begin our analysis by studying simple correlations between the share of female faculty and the share of women in the entering PhD class. Because both shares tend to increase over time, as we saw before, in all our analysis we control for year fixed effects. Table 1 presents results of our

[5]Since the share of female students is our dependent variable, this observation should reduce concerns regarding serial correlation in the errors. Nevertheless, we have estimated our main regressions including one and two lags of the dependent variable on the right-hand side and found that our results are not affected by this change in specification.

[6]For more recent trends that are based on the survey of a larger number of economics departments, see Fraumeni (2011).

ordinary least squares (OLS) regression analysis, in which we estimate the following equation

$$Students_{it} = \alpha_i + \alpha_t + \beta\ Faculty_{it} + \mathbf{Z}'_{it}\gamma + \varepsilon_{it}, \tag{1}$$

where $Students_{it}$, our dependent variable, is the share of women in the PhD class graduating from the economics department of university i in year $t+6$, meaning that they were likely to be admitted into the program in year t; α_i is a set of institution fixed effects; α_t is a set of year fixed effects, where year stands for the calendar year in which the academic year begins; $Faculty_{it}$ is the share of women on a ladder faculty of the economics department in university i in year t; $\mathbf{Z}_{it}$ is the set of additional control variables described below, ε_{it} is assumed to be i.i.d. The coefficient β measures the change of female student share, in percentage points, associated with a 1 percentage point increase in the share of women on the faculty of the corresponding department and is our coefficient of interest.

Column (1) of Table 1 reports the regression with just time fixed effects as control variables. We find that there is a positive and statistically significant correlation between the share of female faculty and the share of women entering the PhD program that is not due to a common trend in the two variables.

In column (2) we add institution fixed effects to absorb time-invariant differences in gender attitudes and policies across institutions. It appears that on average the share of women in the entering PhD class is not statistically different across institutions, with the exception of institution 5, where the share of women is higher. We will see from further analysis that controlling for additional factors will make this effect insignificant. On the other hand, adding control variables shows that the conditional mean of share of female PhD students is higher for institution 4 than it is for other economics departments.

With institution fixed effects we find that our coefficient of interest increases, suggesting that time-invariant differences actually account for a negative correlation between shares of women on the faculty and in the entering PhD class. The magnitude of the β coefficient is just above 1, suggesting that for every 1 percentage point increase in the share of female faculty, the share of women in the entering PhD class increases by about 1 percentage point as well. In our sample, the standard deviation of the female faculty share is 5 percentage points and the mean is 8, while the standard deviation of the female share in the entering PhD class is 11 percentage points with the mean of 25. Thus, the coefficient of 1 shows that one standard deviation increase in the female faculty share is associated with about a one-half standard deviation increase in the share of women in the entering PhD class.

In the remaining columns we add variables that we think may explain both the share of women on the faculty and the gender composition of the entering PhD class. In column (3) we add the department size, measured as the number of ladder faculty. It does not enter significantly, which is not altogether surprising given that we continue to include institution fixed effects. Our coefficient of interest remains almost the same.

In column (4) we add two more variables that are meant to capture time-varying university-wide gender preferences and department-specific minority attitudes that may affect both the share of women on the faculty and the share of women in the entering PhD class and thus capture some of the correlation between these two shares that is due to common factors. University-wide gender preferences are measured by the overall share of female students entering a PhD program in *all* departments in a given university, excluding the economics department. The minority preferences of the economics departments are measured as a share of non-white students in the incoming PhD cohort. We find a positive effect of both of these measures, but only the effect of minority attitude in the economics department is statistically significant. Including additional controls in the following columns increases the effect of university-wide gender preferences, making it statistically significant. These two measures, however, only capture a small portion of the correlation between female shares — our coefficient of interest only declines by a small amount, while the regression fit improves only slightly.

In column (5) we add controls for the quality of the male and female faculty in each institution in each year, using information on the number of publications by each individual faculty member. Time-varying changes in the quality of the department may be responsible for creating the correlation between share of female faculty and share of female students if admissions and hiring standards change when the quality of the department changes and if women on average have different qualifications than men. We find, however, that these control variables don't have a significant effect on the share of women entering the PhD program and do not significantly affect our coefficient of interest.

Finally, in column (6) we test whether the correlation between female faculty share and female student share could be due to the influence of senior female faculty. To do this, we construct the share of women among senior faculty members, that is those who graduated from a PhD program more than six years ago (older female faculty share), and the share of women among junior faculty, that is those who graduated from a PhD program six or fewer years ago (younger female faculty share). We expect that inasmuch as senior faculty are more influential in admissions decisions, the share of women among senior faculty will have a larger effect on the gender composition of the entering PhD class than the share of women among junior faculty. Indeed, we find such an effect — the effect of the older female faculty share is almost five times as high as that of the younger female faculty share, and the difference between the two coefficients is significant at a 5 percent confidence level.

3.1.1 Robustness of OLS results

These results are robust to including additional control variables and to different specifications, reported in Table A.3. First, we add to our control variables the share of all faculty in the "female-friendly" fields, that is, fields in which we observe larger shares of women among faculty. We define female-friendly fields as fields in which the average share of women in our sample is higher than the overall sample average across all fields, which is 13 percent. According to this definition, labor, development and growth, as well as non-mainstream fields are female-friendly.[7] We believe the share of all faculty in these fields might be an important source of spurious correlation because departments with a larger share of such fields may attract more women both to their faculty and to their graduate student bodies. We find that the coefficient of this variable is not statistically significant, and our coefficient of interest remains unchanged.

Next we control for the number of students in the incoming PhD class. The size of the incoming PhD class may be correlated with the share of female faculty through different admission standards or because women admitted to PhD programs may choose to go to departments with a larger share of female faculty thus increasing the size of the class that is entering for a given number of students admitted. We find, however, that the effect of the class size is not statistically significant, and including this variable among our controls does not affect our results.

Next we test whether our results are robust to different specifications of regression. First, we replace the set of year fixed effects with a time trend and find that our results are not affected by this change. Moreover, while we find that the coefficient on the time trend is positive, it is not significantly different from zero.

We next test for non-linear effects of the share of female faculty.[8] We do so by interacting the continuous measure of female faculty share we used in the main specification with a set of four dummy variables: one that is equal to 1 if the share of female faculty is less than 5 percent, one for the share of female faculty between 5 and 10 percent, one for the share of female faculty between 10 and 15 percent, and finally for the share of female faculty greater than 15 percent. We find that the effect of the female faculty share is higher when the share of females is really low, although the effect is not precisely estimated because of the small number of cases when the share of female faculty is that low. The effect of female faculty share declines as the share increases, although

[7]Non-mainstream fields are: General Economics and Teaching; History of Economic Thoughts; Health, Education, and Welfare Economics; Business Administration; Economic History; Agricultural, Resource and Environmental Economics; Urban and Regional Economics; and Other Special Topics.

[8]Gagliarducci and Paserman (2009) find such non-linear effects of gender composition in the context of municipalities' gender composition and the likelihood that a female mayor survives her full term.

statistically the effects are not estimated precisely enough to be different from one another and are all similar in magnitude to the estimate of our benchmark specification. The four interactions are jointly significant at the 2 percent level according to the F-test.

Next we want to test whether our results are driven by newly hired women on the faculty. If that were the case, we would worry that the correlation we find is driven by overall time-varying gender attitudes of the department which would lead to a higher share of women on the faculty and a higher share of students in the entering PhD class. To test for this possibility we split the overall female faculty share into the share of new female faculty (that is, the number of women who were hired by the department six or fewer years ago divided by the department size) and the share of seasoned female faculty (women hired more than six years ago divided by the department size). We find that the share of seasoned female faculty has the same effect on the gender composition of the PhD class as the share of new female faculty, indicating that our main results are unlikely to be driven entirely by the time-varying gender bias that could create contemporaneous correlation between the share of women hired and the share admitted to the graduate program.

As a final check we verify that there is a positive relationship between the the share of students and the number of female faculty. The number of female faculty may matter for a few reasons. First, students may benefit from the socialization of faculty, and socialization, in turn, requires there be a mass of individuals. Organizing Women's Lunch, for instance, is not likely to happen if there is only one female faculty member at the department. Second, the availability of female advisors may depend more on the number of female faculty than on their share. A single female faculty may be quickly over-subscribed with advisees. Third, students are more likely to infer the department's gender attitude from the number of female faculty than from their share. Observing a department with a single female faculty may suggest that her hiring was an exception, while observing two women on the the faculty may indicate a broader receptiveness to females. These arguments are particularly compelling for small numbers of female faculty which is the case at these top 10 institutions. Indeed we find that the number of female faculty is also significantly related to the share of female students.

3.2 Causal effects

The above analysis rules out some of the potential sources of spurious correlation between the share of women on the faculty and in the PhD cohort, such as common trends, all omitted variables that do not vary over time, university-wide gender attitudes, department-specific minority attitudes, and department quality and field composition. Nevertheless, we cannot be sure that the correlation we find between the two shares reflects a causal effect that a larger share of women on the faculty may have on the gender composition of the PhD class. As we discussed before, such causal effects could be due to women's preferences to work with women, to female faculty advocacy for admission of larger numbers of women, or to the decline in gender bias due to an increase in the share of women on the faculty. While our data do not allow us to distinguish between these mechanisms, they do allow us to establish causality with the use of the instrumental variables (IV) analysis.

Our instrumental variable for the female faculty share is the number of male faculty that left the department in the year prior and two years prior. The number of exiting male faculty has a mechanical positive effect on the share of female faculty by lowering the denominator of the share without affecting the numerator. We use two lags because in our data it appears that it takes two years or more to replace exiting faculty. While exits of individual faculty members may affect decisions of individual prospective PhD students when they choose which department to go to, it is unlikely that the number of resigning male faculty has a direct effect on the gender composition of the PhD class that comes into the program one or two years after they resign. Table A.4 in the Appendix gives the total number of male and female exits in our sample.

Table 2 presents the results of our IV analysis. The first two columns report the results of the first and second stages, respectively, of the IV regression, while column (3) reports the results of the reduced-form regression. Specifically, we estimate, by two-stage least squares (2SLS), the following system

$$Faculty_{it} = \alpha_t + \alpha_i + \delta_1 Exit\_Male_{it-1} + \delta_2 Exit\_Male_{it-2} + \mathbf{Z'}_{it}\nu + \varepsilon_{1it}, \qquad (2)$$

$$Students_{it} = \alpha_t + \alpha_i + \beta \ \widehat{Faculty}_{it} + \mathbf{Z'}_{it}\gamma + \varepsilon_{2it}, \tag{3}$$

where α_i is a set of institution fixed effects, $Exit\_Male_{it-1}$ is the number of male faculty member that announced their resignation as late as year $t-1$ and are no longer members of the department in year t, $\widehat{Faculty}_{it}$ is the fitted value of $Faculty_{it}$ from the first stage, $\mathbf{Z}$ is the same set of control variables as in column (5) of Table 1. We also estimate a reduced form equation

$$Students_{it} = \alpha_t + \alpha_i + \mu_1 Exit\_Male_{it-1} + \mu_2 Exit\_Male_{it-2} + \mathbf{Z'}_{it}\gamma + \varepsilon_{3it}. \tag{4}$$

In the first column of Table 2 we report the results of our first stage. Institution fixed effects are included in all regressions, but are not individually reported in the interest of space. We find that both lags of our instrumental variable have positive and statistically significant effects on the share of female faculty, as we expected, with the second lag having a smaller effect, although not statistically different from the effect of the first lag.

Column (2) of Table 2 reports our main results on causality — the second stage of the IV regression. We find that the effect of instrumented female faculty share on share of women in the entering PhD class is positive and statistically significant. The coefficient of interest is larger than in our main specification, which may be due to one of two factors. First, it is possible that time-varying spurious correlation removed by using the IV approach is negative, much like the correlation that is absorbed by institution fixed effects. Second, a measurement error in the OLS regression could be causing attenuation bias. Finally, this coefficient, although larger, is not statistically different from the one in the benchmark OLS regression. The effects of all our control variables remain the same as in the OLS specification, with the exception of the effect of quality of female faculty, which is now statistically significant.

3.2.1 Specification tests

We test for the validity of our instruments using standard tests. We find that hypotheses of irrelevance, underidentification or overidentification are strongly rejected by Anderson LR, Cragg-Donald, and Sargan tests, respectively. We cannot, however, reject the hypothesis of weak instruments: the partial R^2 of the instruments is only 0.07, the F-statistic is 4.2 with P-value of 0.017, which only passes the 5 percent Wald test for weak instruments at the 25 percent critical value in case of limited information maximum likelihood (LIML) estimation. We therefore compute the Anderson-Rubin test statistic of the significance of endogenous regressor in the main equation, the female faculty share, which is robust in the presence of weak instruments (Stock et al., 2002). We find that the P-value of the χ^2 test is 0.002, rejecting the hypothesis of no effect of female faculty share on the female student share at the 1 percent confidence level. We also report in column (3) the reduced form regression which demonstrates positive effects of both lags of our instrumental variable on the share of female students in the entering PhD class, with the second lag effect being statistically significant and both lags being jointly significant at the 1 percent level.

Columns (4) to (6) of Table 2 report the second-stage results of k-class estimations that have been shown to improve upon the 2SLS approach in the presence of weak instruments.[9] In all cases our result of positive and statistically significant effect of the share of female faculty on the share of women in the entering PhD class remains unchanged. Column (4) reports the results of the LIML estimation, column (5) reports the results of the Fuller's modified LIML estimation with parameter set to 1, and column (6) reports Nagar's bias-adjusted 2SLS estimation. In all of these tests we find that the coefficient on our variable of interest remains positive and statistically significant at the 5 percent level, indicating that our main result is not due to the weakness of the instruments.

Next we test the assumption that male exits are exogenous to the share of female faculty. Table A.5 in the Appendix reports in column (1) the results of the regression of male exits on the contemporaneous share of women on the faculty and all of our control variables. We find that the

[9]See Stock et al. (2002) and references therein.

share of women on the faculty does not predict male exits in the same year, meaning that lagged male exits are strictly exogenous with respect to the female faculty share. This finding is consistent with the study by Tolbert et al. (1995), which shows that the gender composition of academic departments does not affect male faculty turnover rates.

Finally, we find that our results are not sensitive to the choice of covariates, as reported in Table A.6. columns (1) to (3), and to the choice of alternative instrumental variables, as reported in columns (4) and (5).

3.2.2 Addressing potential endogeneity of male exits

Even though we showed before that statistically we cannot reject that male exits are exogenous, potential concerns remain that the share of women on the faculty may induce some male faculty to change departments. Exits can be separated into lateral moves within the ten departments in our sample and moves out of the set of the ten departments. Since the ten departments in our sample are ranked at the top, moves out of that set are likely driven by tenure denial or retirements. Retirements tend to be expected and frequently new faculty are hired in anticipation; as a result, exits of males due to retirement are unlikely to have an effect on female faculty share.[10] We therefore use as an alternative instrument the number of exits of young male faculty (those that graduated six or fewer years ago) out of the top-ten departments, reported in Table A.4. As an alternative, we use the number of all exits by young male faculty. The results reported in columns (4) and (5) of Table A.6 show that our conclusions are not sensitive to these alternative instruments.

Finally, we address the concern that male exits may be driven by unobservable time-varying, department-specific characteristics which are also related to gender preferences. To do so, we predict the probability that each individual male faculty member k exits his department i in year t by using only data on his age and PhD granting institution. We allow for a flexible estimation, differentiating between young males, who earned their PhD during the past 6 years, and seasoned

[10]Indeed, we find no statistically significant effect of exits of older male faculty out of the top-ten departments.

males, who are at least 7 years post graduation ("old"), and alow for the non-linear effect of age. We remove institution and year differences by estimating a preliminary linear probability model

$$Exit\_Male_{kit} = \alpha_i + \alpha_t + \varepsilon_{1kit}, \quad (5)$$

from which we construct the residuals

$$Resid\_Exit\_Male_{kit} = Exit\_Male_{kit} - \alpha_i - \alpha_t, \quad (6)$$

and then run the following regression, to which we refer as stage 0:

$$Resid\_Exit\_Male_{kit} = \alpha + \beta_1 Age_{kit} + \beta_2 Age^2_{kit} + \beta_3 Old_{kit} + \beta_4 Age * Old_{kit} + \beta_5 Age^2 * Old_{kit} + \beta_6 PhD\_Inst_{kit} + \varepsilon_{2kit}. \quad (7)$$

We then calculate the predicted probability of a male exit for each institution and year as the average predicted exit probability in that institution-year,

$$\widehat{Exit\_Male}_{it} = \frac{1}{K} \sum_k Resid\_\widehat{Exit}\_Male_{kit}. \quad (8)$$

Since this predicted number of exits only uses the age and PhD granting institution data, it is free of any endogeneity concern, and is therefore a good instrument.

In columns (1) of Table 3 we presents the results from the above stage zero regressions, as run on 7786 person-year observations of male faculty in our top-10 departments between the years 1983 to 2007. Indeed, the likelihood of an exit is predicted by age and age^2 and is different for young and old faculty, reflecting the tenure system. In column (2) we can see that the constructed instrument is strongly and positively correlated with the share of female faculty. Moreover, we do not have a weak instrument problem as the F statistic on the instrument is 18. Most importantly, in the second stage (column (4)), the IV coefficient on the share of female faculty is 1.61 and significant at the 10 percent confidence level.

We find that these results remain virtually unchanged using various specifications, such as including two lags of male exits or predicting male exits using a probit model (see Table A.7 in the Appendix). In addition, the specification is robust to the omission of the various control variables, to inclusion of the number of faculty in female friendly fields, and to the exclusion of the public universities (Berkeley and UCLA). In all of the above, the coefficient on the faculty female share remains between 1.5 and 1.8 and is statistically significant. This completes our demonstration of the causal relationship from the share of female faculty to the share of female students.

4 Conclusion

Our results provide empirical evidence that a larger share of women on the economics faculty of top universities has led to more female students graduating from these economics PhD programs, above and beyond such factors as secular time trends, time-invariant differences between universities, and differential gender preferences across universities over time.

This causal effect is the gross influence of all four mechanisms discussed in the literature: influence of female faculty on admission decisions, reduced prejudice against women, women's preference for working with female mentors, and the negative influence a high female faculty share has on perceived status and hence on the department's ability to attract scarce female students. Our data indicates that mentorship is an appealing explanation, with 11 percent of female students advised by female faculty members, while only 4 percent of male students had female advisors.[11] Although we cannot disentangle the mechanisms, for policy we care about the overall effect of an increase in the female faculty share which is the sum of the four mechanisms. Whether the positive effect on the female student share that we find is efficient remains an important question to be investigated.

The data on top US economics departments is likely representative of other rungs of academia, as well as other disciplines where women are under-represented. Thus, our results indicate that

[11] This difference is statistically significant and is not explained by the quality of female advisors.

gender segregation is likely to be persistent. This is true across institutions, but may also explain the persistence of gender segregation across academic fields. Disciplines with very few women on faculty of top universities will continue to attract fewer women into their academic programs. With fewer female graduates at top schools, the future academic leadership is likely to continue to under-represent women.

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Figure 1: Shares of female faculty and PhD students, with trend

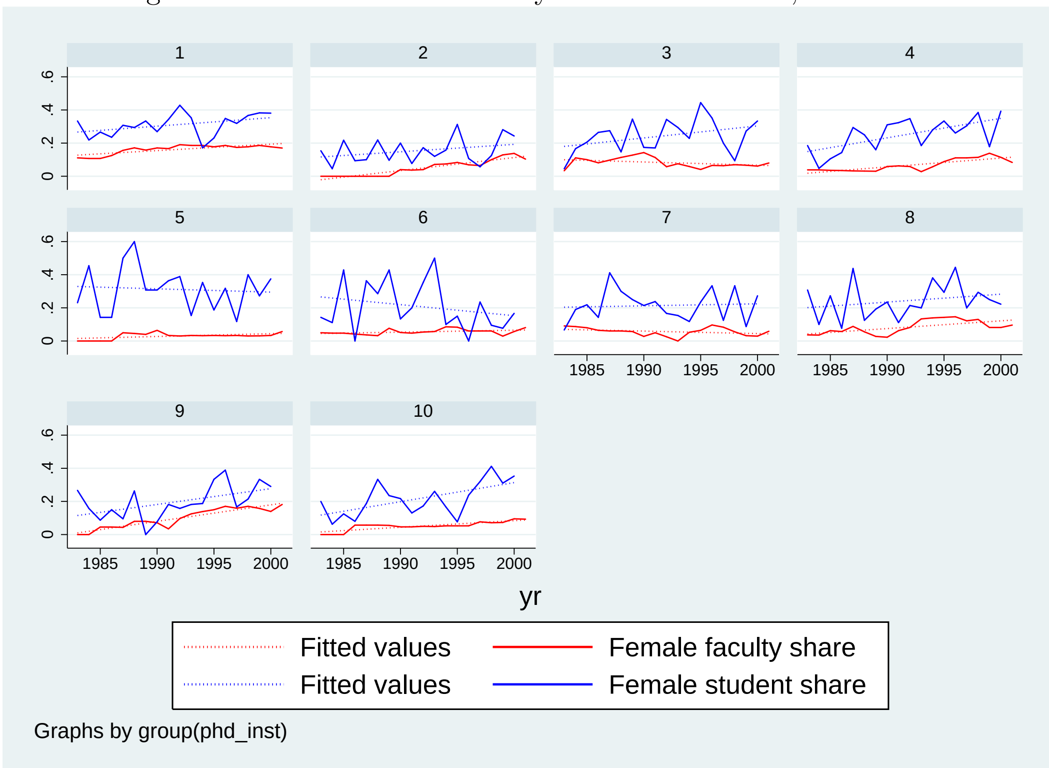

Table 1: OLS regressions of the share of female PhD students

	(1)	(2)	(3)	(4)	(5)	(6)
Female faculty share	0.593***	1.129***	1.049***	1.005***	1.127***	
	(0.194)	(0.305)	(0.320)	(0.312)	(0.322)	
Young fem fac share						0.208**
						(0.091)
Older fem fac share						0.937***
						(0.354)
Department size			0.003	0.003	0.003	0.003
			(0.003)	(0.003)	(0.003)	(0.003)
Minority-Economics				0.002***	0.002***	0.002***
				(0.001)	(0.001)	(0.001)
Gender-University				0.004	0.006*	0.006*
				(0.003)	(0.003)	(0.003)
Male publications					0.019	-0.007
					(0.086)	(0.086)
Female publications					0.106	0.072
					(0.068)	(0.077)
Institution 2		-0.031	-0.002	-0.020	0.017	0.030
		(0.051)	(0.061)	(0.060)	(0.066)	(0.074)
Institution 3		0.045	0.022	-0.007	0.006	0.044
		(0.046)	(0.054)	(0.057)	(0.076)	(0.082)
Institution 4		0.078	0.088*	0.182***	0.226***	0.252***
		(0.048)	(0.050)	(0.069)	(0.078)	(0.083)
Institution 5		0.165***	0.186***	0.078	0.091	0.091
		(0.056)	(0.061)	(0.081)	(0.094)	(0.097)
Institution 6		0.032	0.039	0.043	0.075	0.079
		(0.052)	(0.052)	(0.052)	(0.063)	(0.067)
Institution 7		0.050	0.057	-0.008	0.029	0.032
		(0.053)	(0.054)	(0.060)	(0.068)	(0.072)
Institution 8		0.026	0.016	0.038	0.085	0.111*
		(0.044)	(0.046)	(0.047)	(0.056)	(0.062)
Institution 9		-0.050	-0.036	-0.114**	-0.088	-0.090
		(0.041)	(0.044)	(0.051)	(0.057)	(0.060)
Institution 10		0.052	0.048	0.006	0.052	0.068
		(0.051)	(0.051)	(0.053)	(0.062)	(0.067)
Year FE	Y	Y	Y	Y	Y	Y
Adjusted R^2	0.053	0.237	0.235	0.277	0.280	0.269

Dependent variable is the female share of the graduating PhD class. The main independent variable is the female share of faculty at the time of admission. 140 observations consist of ten institutions over 14 years.

Table 2: Instrumental variable regressions of share students on share faculty

Dependent variable	Female faculty share	Female student share				
	(1)	(2)	(3)	(4)	(5)	(6)
	(First Stage)	(IV)	(Reduced Form)	(LIML)	(Fuller)	(Nagar)
Male exits (t-1)(A)	0.004**		0.004			
	(0.002)		(0.006)			
Male exits (t-2)(B)	0.003*		0.019***			
	(0.002)		(0.006)			
Female faculty share		2.639**		3.963**	3.443**	2.805**
		(1.318)		(1.881)	(1.586)	(1.255)
Department size	0.003***	-0.000	0.007**	-0.003	-0.002	-0.001
	(0.001)	(0.004)	(0.003)	(0.005)	(0.005)	(0.004)
Minority - Economics	-0.000	0.002**	0.003***	0.002**	0.002***	0.002***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Gender - University	0.000	0.006	0.007*	0.005	0.005	0.006
	(0.001)	(0.004)	(0.003)	(0.004)	(0.004)	(0.003)
Male publications	-0.034	0.075	0.003	0.125	0.106	0.082
	(0.024)	(0.106)	(0.087)	(0.122)	(0.109)	(0.097)
Female publications	-0.046**	0.171*	0.046	0.228**	0.206**	0.178**
	(0.019)	(0.093)	(0.068)	(0.112)	(0.099)	(0.086)
Time FE	Y	Y	Y	Y	Y	Y
Institution FE	Y	Y	Y	Y	Y	Y
Prob(A=B=0)	0.017		0.010			
AR χ^2 P-value		0.002				
Adjusted R^2	0.703	0.137	0.258			0.104

P-value of the Sargan test of overidentification is 0.02, the P-value of the Anderson LR statistic is 0.006. The P-value of the Cragg-Donald underidentification test is 0.005.
The Shea partial R^2 of the instruments is 0.072, the F-statistic is 4.24 with P-value of 0.017. 140 observations consist of ten institutions over 14 years.

Table 3: IV using simulated male exits as the instrument

Dependent variable	Exit	Female faculty share	Female student share
	(1)	(2)	(3)
	(Stage Zero)	(First Stage)	(Second Stage)
Old	0.104***		
	(0.019)		
Age	0.034***		
	(0.005)		
Old X Age	-0.003***		
	(0.001)		
Age^2	-0.043***		
	(0.005)		
Old X Age^2	0.003***		
	(0.001)		
Male exits (t-2)		1.545***	
		(0.365)	
Female Faculty Share			1.612*
			(0.873)
Department size		0.001	0.002
		(0.001)	(0.004)
Minority - Economics		-0.000	0.002***
		(0.000)	(0.001)
Gender - University		0.001	0.006
		(0.001)	(0.003)
Male publications		-0.045*	0.037
		(0.023)	(0.092)
Female publications		-0.040**	0.127
		(0.018)	(0.077)
Institution FE		Y	Y
Year FE		Y	Y
Phd institution FE	Y		
N	7786	140	140
F		14.212	2.567
Adjusted R^2	0.0362	0.727	0.266

The stage zero dependent variable is the probability that it is a person's last year at the institution (derived as the residual from regressing a dummy variable which is equal to one if it is a person's last year at the institution on institution and time fixed effects). The instrument used for the second stage is the predicted number of males who will be exiting the department the following year. The F-statistic of the instrument in the first stage is 16.4.

A Appendix

Table A.1: Percent of female faculty by institution and year

Year/Institution	1	2	3	4	5	6	7	8	9	10	Mean
1983	11.1	0.0	3.3	3.8	0.0	5.0	9.1	3.7	0.0	0.0	3.6
1984	10.7	0.0	11.1	3.8	0.0	4.8	8.7	3.6	0.0	0.0	4.3
1985	10.7	0.0	10.0	3.6	0.0	4.8	8.0	6.3	4.5	0.0	4.8
1986	12.5	0.0	8.1	3.4	0.0	4.2	6.5	5.7	4.5	5.7	5.1
1987	15.6	0.0	9.8	3.2	5.0	3.7	6.1	8.8	4.3	5.7	6.2
1988	17.1	0.0	11.4	3.1	4.8	3.2	6.1	5.6	8.0	5.7	6.5
1989	15.8	0.0	12.8	3.0	4.2	7.7	5.7	2.8	8.0	5.6	6.5
1990	17.1	4.0	14.3	5.9	6.7	5.1	2.8	2.3	7.1	4.7	7.0
1991	16.7	3.7	11.3	6.3	3.4	4.8	5.0	6.3	3.4	4.7	6.5
1992	19.0	4.0	5.8	5.9	3.1	5.4	2.6	8.2	9.7	5.0	6.9
1993	18.6	7.1	7.5	2.8	3.4	5.7	0.0	13.3	12.5	4.9	7.6
1994	18.6	7.4	5.9	5.7	3.3	8.6	5.3	14.0	13.9	5.3	8.8
1995	17.8	8.3	4.1	8.8	3.4	8.3	6.5	14.3	15.0	5.3	9.2
1996	18.6	6.9	6.5	11.1	3.3	6.1	9.7	14.6	17.1	5.3	9.9
1997	17.4	6.5	6.4	11.1	3.4	6.1	8.3	12.2	15.9	7.7	9.5
1998	17.8	10.0	7.0	11.4	3.1	6.1	5.6	13.0	17.1	7.1	9.8
1999	18.6	12.9	6.7	13.9	3.2	2.9	3.2	8.2	15.8	7.3	9.3
2000	17.8	13.8	6.1	11.4	3.4	5.7	2.9	8.2	14.0	9.5	9.3
2001	17.0	10.3	8.0	8.3	5.9	8.1	5.9	9.6	18.2	9.3	10.1
2002	17.6	6.9	8.3	8.3	7.7	12.8	5.9	9.8	19.0	9.3	10.6
2003	15.4	10.0	8.5	8.3	7.5	16.2	6.5	9.6	16.3	13.6	11.2
2004	14.5	10.3	10.9	8.3	7.1	14.3	3.6	10.0	21.4	15.6	11.6
2005	14.3	6.1	16.0	10.5	9.1	14.3	3.6	11.8	20.0	15.2	12.1
2006	11.8	6.1	17.0	12.8	8.9	12.5	3.8	12.0	18.2	15.6	11.8
2007	13.2	8.6	13.0	15.8	10.9	10.3	4.80	12.7	16.3	13.3	11.9
Mean	15.8	5.7	9.2	7.6	4.3	7.5	5.4	9.1	12.0	7.2	8.4

Table A.2: Percent of females in economics PhD graduating class by institution and year

Year/Institution	1	2	3	4	5	6	7	8	9	10	Mean
1988	23.1	4.0	16.0	12.0	16.7	22.2	20.8	20.0	13.3	35.7	18.4
1989	33.3	15.4	4.55	18.5	23.1	14.3	6.67	30.8	26.7	20.0	19.3
1990	21.9	4.55	16.7	4.76	45.5	11.1	19.0	10.0	15.8	6.25	15.6
1991	26.7	21.7	20.6	10.5	14.3	42.9	21.9	27.3	8.70	12.5	20.7
1992	23.5	9.38	26.5	14.3	14.3	0.00	14.3	7.69	15.0	8.00	13.3
1993	30.8	10.0	27.5	29.4	50.0	36.4	41.2	43.8	9.52	18.8	29.7
1994	29.4	21.9	14.7	25.0	60.0	28.6	30.0	12.5	26.3	33.3	28.2
1995	33.3	9.68	34.5	16.0	30.8	42.9	25.0	19.2	0.00	23.5	23.5
1996	26.9	20.0	17.4	31.0	30.8	13.3	21.4	23.5	7.69	21.7	21.4
1997	34.3	7.69	17.1	32.4	36.4	20.0	23.8	11.1	18.2	13.0	21.4
1998	42.9	17.2	34.3	34.8	38.9	35.3	16.7	21.4	15.8	17.2	27.4
1999	35.3	12.0	29.4	18.5	15.4	50.0	15.4	20.0	18.2	26.1	24.0
2000	17.1	15.8	22.9	28.0	35.3	10.0	11.8	38.1	18.8	16.7	21.4
2001	23.1	31.3	44.4	33.3	18.8	15.0	23.5	29.4	33.3	7.69	26.0
2002	34.9	10.7	35.1	26.1	31.8	0.00	33.3	44.4	38.9	23.8	27.9
2003	31.9	5.71	20.0	30.4	11.8	23.5	12.5	20.0	16.7	32.0	20.5
2004	36.7	12.5	9.38	38.5	40.0	9.52	33.3	29.4	21.4	41.2	27.2
2005	38.2	28.1	27.3	17.9	27.3	7.69	8.70	25.0	33.3	31.0	24.5
2006	38.1	24.3	33.3	39.3	37.5	16.7	27.3	22.2	29.0	35.3	30.3
Mean	30.6	14.8	23.8	24.2	30.4	21.0	21.4	24.0	19.3	22.3	23.2

Table A.3: OLS robustness tests: share of female PhD students

	(1)	(2)	(3)	(4)	(5)	(6)
Female faculty share	1.098***	1.130***	1.195***			
	(0.335)	(0.323)	(0.452)			
Fac share 0 - 5				1.261		
				(1.187)		
Fac share 5 - 10				1.203**		
				(0.590)		
Fac share 10 - 15				1.099***		
				(0.372)		
Fac share 15 - 20				1.484***		
				(0.518)		
Share new female fac					1.130***	
					(0.333)	
Share seasoned female fac					1.114**	
					(0.490)	
Number of female fac						0.027***
						(0.009)
Faculty share in	0.077					
female friendly fields	(0.228)					
Class size		-0.001				
		(0.002)				
Trend			0.015			
			(0.014)			
Institution specific trend			Y			
N	140	140	140	140	140	140
Adjusted R^2	0.274	0.275	0.326	0.266	0.274	0.267

Dependent variable is share of female students. All regressions include controls as in Table 1 column (5): time and institution FE, department size, male and female publications, minority students at the department and female faculty at the university level. Female faculty working at the department six years or less are considered “new,” otherwise “seasoned.”

Table A.4: Number of exits of male and female faculty by age and destination

Age X Destination	Freq	mean(age)	mean(papers)
MALES:			
Old, switch	132	28	100
Old, out	105	16	100
Young, switch	55	3.7	21
Young, out	128	4.3	20
Total	420	15	66
FEMALES:			
Old, switch	11	18	77
Old, out	17	9.3	36
Young, switch	12	3.1	10
Young, out	25	3.7	12
Total	65	7.2	29

Table A.5: OLS regressions of exits of males on female faculty share

	(1)	(2)	(3)
Dependent variable	Male exits	Young male exits	Young male exits out
Female faculty share	-3.076	-1.604	-2.188
	(4.976)	(3.017)	(2.897)
Department size	0.196***	0.081***	0.068**
	(0.048)	(0.029)	(0.028)
Minority - Economics	0.004	0.008	0.006
	(0.013)	(0.008)	(0.007)
Gender - University	0.070	0.037	0.030
	(0.052)	(0.032)	(0.030)
Male publications	0.759	-0.253	-0.374
	(1.329)	(0.806)	(0.774)
Female publications	-0.195	-0.601	-0.759
	(1.058)	(0.641)	(0.616)
Chicago	3.142***	1.421**	0.696
	(1.015)	(0.615)	(0.591)
Harvard	-0.447	0.581	0.186
	(1.167)	(0.707)	(0.679)
MIT	2.964**	1.895**	1.485**
	(1.210)	(0.733)	(0.704)
NYU	1.502	0.461	0.216
	(1.453)	(0.881)	(0.846)
Northwestern	1.785*	0.892	0.397
	(0.972)	(0.589)	(0.566)
Penn	2.007*	0.798	0.496
	(1.055)	(0.640)	(0.614)
Princeton	1.646*	0.997*	0.464
	(0.864)	(0.524)	(0.503)
UCLA	1.364	0.461	0.194
	(0.874)	(0.530)	(0.509)
Yale	0.562	-0.135	-0.258
	(0.954)	(0.578)	(0.556)
Time FE	Y	Y	Y
N	140	140	140
Adjusted R^2	0.301	0.194	0.120

Berkeley is the benchmark category for institution fixed effects.

Table A.6: IV robustness

Panel A: first stage	(1)	(2)	(3)	(4)	(5)
Male exits (t-1)	0.004**	0.004**	0.004**		
	(0.002)	(0.002)	(0.002)		
Male exits (t-2)	0.003*	0.003*	0.003*		
	(0.002)	(0.002)	(0.002)		
Young male exits out (t-1)				0.005	
				(0.003)	
Young male exits out (t-2)				0.005*	
				(0.003)	
Young male exits (t-1)					0.006**
					(0.003)
Young male exits (t-2)					0.007**
					(0.003)
Faculty share in fff*			0.150**		
			(0.062)		
Male publications			-0.023	-0.051**	-0.048*
			(0.024)	(0.025)	(0.024)
Female publications			-0.050***	-0.036*	-0.037*
			(0.019)	(0.020)	(0.019)
Minority - economics	Y		Y	Y	Y
Gender - university	Y		Y	Y	Y
N	140	140	140	140	140
Adjusted R^2	0.684	0.688	0.715	0.695	0.710

Panel B: second stage	(1)	(2)	(3)	(4)	(5)
Female faculty share	2.853**	2.713*	2.894*	3.502*	2.115*
	(1.410)	(1.443)	(1.579)	(1.825)	(1.087)
Male publications			0.067	0.108	0.056
			(0.105)	(0.125)	(0.098)
Female publications			0.189*	0.208*	0.149*
			(0.107)	(0.113)	(0.084)
Minority - economics	0.002**		0.002**	0.002**	0.002***
	(0.001)		(0.001)	(0.001)	(0.001)
Gender - university	0.003		0.005	0.005	0.006
	(0.004)		(0.004)	(0.004)	(0.004)
Faculty share in fff*			-0.237		
			(0.371)		
N	140	140	140	140	140
Adjusted R^2	0.051	0.055	0.084	-0.072	0.219

Dependent variable of first stage is share of female faculty. Dependent variable of second stage is share of female students. All regressions are estimated by IV and include time and institution fixed effects and department size.
* Faculty share in female friendly fields (fff)

Table A.7: IV robustness using predicted male exits as the instrument

	(1)	(2)
Panel A: stage 0. Dependent variable is male exit.	OLS	Probit
Old	0.104***	1.464***
	(0.019)	(0.226)
Age	0.034***	0.392***
	(0.005)	(0.066)
Old X Age	-0.003***	-0.503***
	(0.001)	(0.068)
Age^2	-0.043***	-0.034***
	(0.005)	(0.008)
Old X Age^2	0.003***	0.036***
	(0.001)	(0.008)
Year FE		Y
Institution FE		Y
Phd Institution FE	Y	Y
N	7786	7641
Adjustd / Pseudo R^2	0.036	0.124
Panel B: 1st stage. Dependent variable is female faculty share.		
Male exits (t-1)	0.421	
	(0.549)	
Male exits (t-2)	1.229**	1.011***
	(0.551)	(0.243)
N	140	140
Adjustd R^2	0.726	0.726
PanelC: 2nd stage. Dependent variable is female student share.		
Female Faculty Share	1.529*	1.679*
	(0.857)	(0.888)
N	140	140
Adjustd R^2	0.270	0.261

Both first and second stage include: department size, minority students in economics, female students at the university, male publications, female publications, institution and year fixed effects.