Women's Colleges and Economics Major Choice:

Evidence from Wellesley College Applicants

Kristin F. Butcher, Patrick J. McEwan, and Akila Weerapana

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Women's colleges and economics major choice:
Evidence from Wellesley College applicants*

Kristin F. Butcher
Federal Reserve Bank of Chicago, Wellesley College, and NBER

Patrick J. McEwan
Wellesley College

Akila Weerapana
Wellesley College

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Abstract: Many observers argue that diversity in Economics and STEM fields is critical, not simply because of egalitarian goals, but because who is in a field may shape what is studied by it. If increasing the rate of majoring in mathematically-intensive fields among women is a worthy goal, then understanding whether women's colleges causally affect that choice is important. Among all admitted applicants to Wellesley College, enrollees are 7.2 percentage points (94%) more likely to receive an Economics degree than non-enrollees (a plausible lower bound given negative selection into enrollment on math skills and major preferences). Overall, 3.2 percentage points—or 44% of the difference between enrollees and non-enrollees—is explained by college exposure to female instructors and students, consistent with a wider role for women's colleges in increasing female participation in Economics.

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1. Introduction

In U.S. colleges and universities, men are over twice as likely as women to major in Economics.[1] The pattern holds among schools with the highest mathematics SATs, within public and private schools, and regardless of the highest degree offered (see Table 1). Similar gaps are evident in mathematically-intensive STEM fields (Kahn and Ginther, 2017). Such persistent gender gaps in Economics and STEM may hold important consequences for economic growth and gender equity.[2]

These concerns have motivated research in coeducational settings on the determinants of women's success in mathematically-intensive fields. For example, experiments have shown that exposure to female role models in Economics or STEM courses can increase the likelihood that women pursue STEM fields.[3] At the same time, the proportion of female classmates has mixed effects on women's outcomes, with some positive effects seen in STEM programs and negative effects in business school settings.[4]

This paper focuses on the comparatively under-studied setting of single-sex colleges and universities. Women's colleges regulate the gender of classroom peers and peer mentors, and

[1] See Dynan and Rouse (1997); Bayer and Rouse (2016); Avilova and Goldin (2018); Buckles (2019); and Lundberg and Stern (2019).

[2] Hsieh et al. (2019) find that convergence in the occupational distribution across men and women explains up to 40% of growth in GDP per capita since the 1960s. Mathematically-intensive fields of study increase male and female wages, even after controlling for individuals' occupations (Altonji et al., 2016; Zafar, 2013), and gender gaps in fields of study account for over half of the male-female wage gap in the United States (Brown and Corcoran, 1997; Altonji et al., 2016; Sloane, Hurst, & Black, 2021).

[3] Porter and Serra (2020) and Breda et al. (2021) show that transitory exposure to female role models in Economics or STEM courses—entwined with the provision of information about careers—increases the probability that women pursue similar undergraduate specializations. At the U.S. Air Force Academy, high-achieving women exposed to female instructors in the first year were far more likely to choose STEM majors and careers (Carrell et al., 2010; Mansour et al., 2020). Similarly, South Korean students exposed to female math teachers in middle schools increased their subsequent engagement with STEM fields (Lim and Meer, 2020).

[4] Random assignment to single-sex classrooms increased women's classroom performance in economics (Booth et al., 2018) and mathematics (Eisenkopf et al., 2015), while female peer mentors improved retention of women in an engineering program (Dennehy and Dasgupta, 2017). However, more female peers in gender-mixed settings of business schools had either zero effects on outcomes (Oosterbeek and van Ewijk, 2014) or negative effects on women's propensity to choose male-dominated majors (Zölitz and Feld, 2021).

their alumnae networks provide ready access to role models, many working in male-dominated fields. Less obviously, students at women's colleges are more likely to be exposed to female instructors, both in Economics and college-wide. Among the top 200 schools (by math SAT scores) that offer Economics degrees, the enrollment-weighted proportion of female faculty in Economics is 23% at coeducational schools and 43% at six women's colleges, including Barnard, Bryn Mawr, Mount Holyoke, Scripps, Smith, and Wellesley (see Figure 1).[5]

In secondary schools, causal evidence finds some beneficial effects of single-sex schools in Trinidad and Tobago and South Korea.[6] There is less evidence in higher education, with the important exceptions of Calkins et al. (2021) and Billger (2002).[7] The evidence from both these papers suggests a large role for single-sex institutions in explaining gender differences in major choice. The descriptive evidence in Table 1 shows that women at single-sex colleges and universities are more likely to receive undergraduate degrees in Economics than women (but not men) at coeducational schools.

There are major hurdles to interpreting descriptive comparisons as a causal relationship (Jackson, 2012; Calkins et al., 2021). First, there is non-random selection in application, admission, and enrollment decisions, which threatens the causal interpretation of descriptive comparisons. A plausible concern is that women's colleges enroll women who are predisposed—by virtue of their abilities or preferences—to choose Economics or another mathematically-intensive major. Second, women's colleges are often selective, private liberal arts colleges. They

[5] The female proportion of Economics faculty between 2009 and 2018—including tenure-track and non-tenure-track faculty—is from the CSWEP survey. The female proportion of college-wide faculty between 2009 and 2018—including all full-time instructional staff—is from IPEDs surveys. See Appendix A for details.
[6] See, for example, Jackson (2012), Lee et al. (2014), and Park, Behrman, and Choi (2013).
[7] Calkins et al. (2021) use an event study design using differences in the timing of co-educational conversion across comparable schools to identify the effect of single-sex education on women's major choices. Billger (2002) uses a difference-in-differences strategy to examine what happens to women's major choice when one formerly women's college transitioned to being co-educational, and finds that women become less likely to major in male-dominated fields when men are admitted.

may be effective in attracting women into mathematically-intensive majors for reasons other than gender, such as an emphasis on teaching.

We address these concerns with a novel data set that includes 15 cohorts of Wellesley College admittees between Fall 1999 and Fall 2013, merged to degree and major data from the National Student Clearinghouse (NSC). By focusing only on admitted students, we avoid many issues associated with non-random selection in a student's decision to apply and a college's decision to admit. Conditional on admittance, the dataset allows us to tackle the challenge posed by non-random selection in enrollment decisions in several ways.

First, we have data on intended majors for all students, which allows us to control for differences in pre-college interest between enrollees and non-enrollees. Second, we have an applicant quality rating made by the admissions board, which captures differences in an applicant profile that are usually unobservable to the researcher—such as admissions essays, high school transcripts, and recommendations—but that may be correlated with a predisposition to major in a mathematically-intensive field. Third, we have information on whether an applicant is the sister, daughter, niece, and/or grandchild of a Wellesley alumna. Legacy connections may be particularly informative about applicant's pre-college preferences for a single-sex education or mathematically-intensive majors. Fourth, we link applicants to administrative data from their high schools, including proxies of school quality and prior exposure to single-sex schools, as well as high school fixed effects to control for unobserved school and neighborhood attributes.

Students who initially enroll at Wellesley College are 6.2 percentage points more likely to major in Economics, relative to 7.7% among students who were admitted to Wellesley, but did not initially enroll. This represents an increase of 81% relative to non-enrollees. In our preferred specification, where we control for a full set of observables about applicants, including test score data, admissions ratings, pre-college major interests, legacy connections, and high school variables, we find that enrollment at Wellesley College increases the probability of majoring in Economics by 7.2 percentage points, a 94% increase relative to non-enrollees.

This larger effect is because Wellesley enrollees have lower levels of variables that are positively associated with the choice of mathematically-intensive majors, such as math SAT scores and pre-college major preferences. In other words, selection on observables makes Wellesley enrollees *less* inclined to choose an Economics major than applicants who turned down Wellesley admission.[8] The increased probability of choosing Economics at Wellesley does not reduce the likelihood of majoring in mathematically-intensive STEM fields. Nor does it appear that Economics is mainly a substitute for mathematically-intensive business majors that are not offered at Wellesley. The effect is smaller but still robustly observed among students who are under-represented in Economics, including students with lower math SAT scores, under-represented minority students, and students without a pre-college preference for Economics or STEM. Even among admitted students who say they intend to major in Economics, enrolling at Wellesley increases the probability of graduating with an Economics major by 94%. Finally, enrollment at Wellesley College doubles the small probabilities of completing graduate work in Economics and receiving an award or honorable mention in the National Science Foundation Graduate Fellowship in Economics.

If we invoke the untestable, but reasonable, assumption that selection-on-observables and selection-on-unobservables operate in the same direction (Altonji, Elder, and Taber, 2005), then the inclusion of unobserved variables would further increase the coefficient estimate on

[8] Non-enrollees graduated from a range of highly-selective colleges and universities, including 50% from Amherst, Barnard, Brown, Chicago, Cornell, Dartmouth, Duke, Georgetown, Harvard, MIT, Northwestern, Pennsylvania, Princeton, Smith, Stanford, Williams, and Yale.

enrollment. In that case the estimated effect is a lower bound to the true effect (Altonji et al., 2005; Oster, 2019). Of course, the threat to internal validity remains: what if students who choose to enroll at Wellesley have an unobserved taste for majoring in Economics or other mathematically-intensive fields that work in the *opposite* direction to selection on observables? We discuss this in the empirical section below, and argue that the richness of our observed variables weighs against this possibility.

If not student selection, then what are the remaining channels that could explain this effect? We examine what happens to the estimated Wellesley effect when we further control for attributes that Wellesley shares with peer institutions that non-enrollees choose to attend (including many selective women's and/or liberal arts colleges). We control for attributes along two dimensions: (1) gender-related college attributes, such as being a women's college and having more equal gender representation among faculty in Economics and across the college; and (2) non-gender related college attributes, such as being a liberal arts college that prioritizes teaching, or having high-achieving peer groups.

Since these attributes are correlated, we use an empirical decomposition from Gelbach (2016) that allows us to determine how much of the "Wellesley effect" can be attributed to features of Wellesley that are shared by (some) other institutions and how much is an unexplained or Wellesley-specific effect. We find that about 44% of the positive effect of Wellesley enrollment on the likelihood of majoring in Economics is explained by gender-related college variables, including being a women's college and the proportion of female peers and instructors. Non-gender-related variables explain less, around 15% of the gap. Collectively, these factors explain about 60%—or 4.3 percentage points of the 7.2 percentage points in our preferred specification—of the higher major rates observed among Wellesley-enrollees. Forty percent of the gap (2.9 percentage points) is a Wellesley-specific effect.

Many observers argue that diversity in Economics and STEM fields is critical, not simply because of egalitarian goals, but because who is in a field may shape what is studied by it (May, McGarvey, and Whaples, 2014; Pugatch and Schroeder, 2020; Wolfers, 2018). If increasing the rate of majoring in mathematically-intensive fields among women is a worthy goal, then understanding whether women's colleges causally affect that choice is important. The evidence here suggests they do. While more research is needed to understand what affects the choices of under-represented groups, these findings point the way toward the importance of gender-related interactions with students and faculty.

2. Empirical Strategy

This paper analyzes 15 cohorts of admitted applicants to Wellesley College between Fall 1999 and Fall 2013, matched to subsequent degree and major data from the National Student Clearinghouse (NSC).[9] We limit the sample to U.S. citizens because they are much more likely to appear in the NSC data. In addition, we limit the sample to the regular admission and early evaluation applicant pools, since neither type of admission binds the enrollment decisions of applicants. Appendix A provides details on the construction of the estimation sample.

Overall, we obtained NSC degree and major data for 15,390 of 17,217 applicants in our preferred sample of admitted applicants (see Figure 2). This includes 99.9% of those who

[9] The NSC matches applicant data to degree attainment data using applicants' names and birthdates, and typically covers over 90% of enrollment at selective colleges and universities (Dynarski, Hemelt, and Hyman, 2015). NSC coverage depends on whether students graduate from college, on whether colleges submit data, on matching errors, and on the suppression of student-level records under the Family Educational Rights and Privacy Act (FERPA).

initially enrolled at Wellesley College, and 83.5% of those who did not. (We later compare the means of pre-college variables between matched and unmatched students.)

We use the NSC data to construct dummy dependent variables that capture the range of mathematically-intensive majors offered at American colleges and universities. Our focus is on Economics, but we also want to assess whether potential gains in Economics reflect losses from other STEM majors at Wellesley, or whether students choose Economics as a substitute for mathematically-intensive majors not offered at Wellesley. Thus, we define dependent variables that include: (1) mathematically-intensive business majors; (2) mathematics, statistics, the physical sciences, and computing; (3) engineering; (4) biological and biomedical sciences; and (5) all other STEM majors. The categories are guided by the Department of Homeland Security's list of officially-designated STEM majors, and the accompanying Classification of Instructional Program (CIP) codes (DHS, 2016). Table A1 describes the CIP codes used for each category of mathematically-intensive majors.[10]

We estimate variants of equation (1):

$$O_{itjk} = \alpha + \beta E_{itjk} + \delta_{tj} + \theta_k + \lambda X_{itjk} + \varepsilon_{itjk}, \quad (1)$$

where O_{itjk} is a dummy variable indicating Economics major choice for admitted applicant *i* in cohort *t* (from Fall 1999 to Fall 2013). In addition, *j* indexes the two largest applicant groups in each cohort, regular admissions and a non-binding early evaluation pool, while *k* indexes discrete

[10] Our typology departs in three ways from DHS (2016), in order to ensure that Wellesley College is not unduly favored. First, we use a four-digit CIP code (4506) to indicate economics majors, rather than a STEM-eligible six-digit code for Econometrics and Quantitative Economics (450603). Wellesley College began reporting Economics majors with the STEM code in Spring 2017, the final year of our degree data, although the required courses did not change. However, not all colleges and universities necessarily use the STEM-eligible code, even when they require similar courses. Second, we identify an expanded list of mathematically-intensive business majors that includes finance and business economics, in addition to the STEM-eligible codes for management science. All are plausible substitutes for Economics at colleges and universities with business programs. Third, we conservatively omit the six-digit CIP code for a popular STEM-eligible major at Wellesley (Media Arts and Sciences) that nonetheless requires only three computer science courses.

values of a global quality rating by College admissions board. The rating is the sum of three individual evaluations conducted by board members, using a consistent evaluation rubric.

E_{ijk} is a dummy variable indicating initial enrollment at Wellesley College, and β is the average effect of initial enrollment. Note that enrollment is highly, but not perfectly, correlated with graduation from Wellesley College. In our estimation sample, 95.1% of initial enrollees graduated from Wellesley College, as did 1.5% of those who did not initially enroll (see Figure 2). This is due to post-enrollment transfers to and from Wellesley College.

Enrollment is correlated with many determinants of major choice. Thus, we include applicant-group-by-cohort fixed effects (δ_{tj}) in order to capture unobserved differences across these groups in their unobserved skills and preferences. We further include fixed effects (θ_k) for 31 discrete values of the admissions board rating. The quality ratings proxy application variables not directly measured in our dataset, such as the quality of high school transcripts, essays, and recommendations.

Finally, the X_{itjk} are applicant-specific covariates that measure pre-college skills, socioeconomic status, and preferences for majors and single-sex education. These include quadratics in ACT and SAT scores, as well as dummy variables indicating (1) major preferences; (2) race and ethnicity, home language, and first-generation college status; and (3) whether an applicant is the sister, daughter, niece, and/or grandchild of a Wellesley alumna.[11] The variables also include high school attributes obtained from merged administrative data (see Appendix A for a description). These include the proportion of high school students eligible for free-and-reduced-lunch—a proxy of local incomes and peer attributes—and whether applicants' high

[11] There are 64 dummies indicating preferred majors; these are not mutually-exclusive since applicants can identify up to two preferred majors. There are 9 mutually-exclusive race-and-ethnicity dummy variables, and 13 mutually-exclusive home language dummy variables.

schools are charter, magnet, or private. Among private schools, we identify which are independent, Catholic, another religious affiliation, and single-sex. We also report a specification with high school fixed effects, which controls for unobserved high school and neighborhood variables.

In equation (1), $\hat{\beta}$ is the estimate of the average enrollment effect. Further denote $\tilde{\beta}$ as the estimate from a specification with E_{ijk} and no other control variables. Our estimates will show that $\hat{\beta} > \tilde{\beta}$. That is, a full set of applicant and high school controls *increases* the magnitude of the estimate. As we will show, Wellesley enrollees have lower levels of variables that are positively associated with the choice of mathematically-intensive majors, such as math SAT scores and pre-college major preferences.

Suppose that selection-on-observables and selection-on-unobservables operate in the same direction (Altonji, Elder, and Taber, 2005). That is, the inclusion of unobserved variables would further increase the coefficient estimate on enrollment. If so, $\hat{\beta}$ is a lower bound to the true effect (Altonji et al., 2005; Oster, 2019). This would be uninformative if $\hat{\beta}$ were small or negative, but it is substantially larger than zero for Economics. (In contrast, the lower bounds for other STEM majors are often closer to zero and therefore less informative.)

There is the possibility that selection-on-unobservables and selection-on-observables work in opposite directions. This would mean that although women who choose to enroll at Wellesley have, for example, lower math SAT scores and lower pre-college preferences for Economics than those who choose to enroll elsewhere, they have unobservable characteristics that make them *more* likely to choose mathematically-intensive majors (e.g., they have a "taste" for defying gender norms as evidenced both by choosing a women's college and choosing a field of study in which women are under-represented). We find this unlikely given the richness of our observed controls. Since we have data on Wellesley's admissions committee ranking of each candidate, high-school exposure to single-sex education, and students' pre-college major preferences and legacy connections, unobserved variables would need to be things that had not yet manifested in students' pre-college attributes, behaviors, and outcomes. Further, we estimate a very large effect of attending Wellesley on the probability of graduating with an Economics major, effectively a doubling. It is difficult to think of unobservables—given the richness of observed variables—that would lead to bias of this size in our estimates if the true "Wellesley effect" were zero (or negative).

In addition to a plausible lower bound, one can estimate an upper bound by invoking an untestable but reasonable assumption, namely that selection-on-observables and selection-on-unobservables are equal (Altonji et al., 2005; Oster, 2019). That is, the portion of major choice explained by observed variables has the same relationship to enrollment as the portion explained by unobserved variables. In this context, equal selection seems conservative given the richness of the observed covariates.[12] While we report these upper bounds, our interpretations emphasize the conservative lower bounds.

We report heteroskedasticity-robust standard errors that are clustered by the college or university from which the applicant graduated. Cluster-robust standard errors are too small—and lead to over-rejection of the null hypothesis—when the number of treated clusters is small and/or when cluster size is substantially imbalanced (Conley and Taber, 2011; MacKinnon and Webb, 2017a,b). Both issues are relevant, since we estimate the effect of initial enrollment in a single

[12] One must further make an assumption about the proportion of variance in the dependent variable that is explained by the full set of observed and unobserved controls. The maximum is 1, but this tends to dramatically inflate bounds, and it is high in most empirical settings due to measurement error or other idiosyncratic variation in the dependent variable (Oster, 2019). We adopt a benchmark of $min(1, 1.5R^2)$, where R^2 is obtained from a regression with a full set of controls. Using estimates from randomized experiments, Oster (2019) shows that 86% of bound estimates are within 2.8 standard errors of the experimental estimate with an assumption of $min(1, 1.5R^2)$. An assumption of $min(1, 1.25R^2)$ increases this to 91%, while an assumption of 1 decreases it to 37%.

college, and Wellesley College graduates account for 39% of the sample. There are 437 other colleges and universities represented in the sample, with a mean of 21 students per cluster and a range of 1 to 472.

An alternative is the restricted wild cluster bootstrap (i.e., with the null imposed) described by Cameron et al. (2008). MacKinnon and Webb (2017a,b) show that it tends to under-reject the null in applications with a single treated cluster. In contrast, the unrestricted wild cluster bootstrap—without imposing the null—tends to over-reject. We report cluster-robust standard errors as well as p-values for both variants of the wild cluster bootstrap, and base conclusions on instances of substantial agreement.

3. Results

A. Descriptive Statistics

Table 2 reports the mean differences in applicant variables between Wellesley enrollees and students who do not enroll at Wellesley. The starkest result is that ACT and SAT test scores are lower among Wellesley enrollees, by 33% to 36% of a standard deviation compared to non-enrollees. All three approaches to inference suggest that the differences are statistically different from zero. These results are consistent with the selectivity of colleges and universities ultimately chosen by non-enrollees. Half of the comparison group received degrees from 17 highly-selective colleges and universities: Amherst, Barnard, Brown, Chicago, Cornell, Dartmouth, Duke, Georgetown, Harvard, MIT, Northwestern, Pennsylvania, Princeton, Smith, Stanford, Williams, and Yale. We do not observe the choice sets of admitted applicants, but the descriptive data imply that admitted applicants with the highest test scores are more likely to also gain admission to highly-selective colleges and universities.

Enrollees are also less likely to indicate a preference for Economics and STEM majors on their applications, although the differences are largest and only statistically different from zero for STEM majors. As a proxy of preferences for single-sex education, we measure legacy affiliations with Wellesley College and graduation from a single-sex high school. The percentage of enrollees with Wellesley College relatives is higher for sisters, but very similar for mothers. A similar percentage of enrollees and non-enrollees attended a single-sex high school (and were also similarly likely to have attended private or charter high schools). These patterns are robustly observed in a sample that omits students with missing NSC data.[13]

B. Effects on Major Choice

In Table 3, column (1) shows that Wellesley College enrollees are 6.2 percentage points more likely to major in Economics, relative to a comparison-group mean of 7.7%. The estimate increases to 7.2 percentage points with a full set of applicant and high school controls. The estimates are statistically different from zero across all approaches to inference. As explained in section 2, the estimate is a lower bound if selection-on-observables and selection-on-unobservables operate in the same direction. The estimated upper bound is 7.7 percentage points (Oster, 2019).[14]

[13] Recall that 0.01% and 16.5% of the initial Wellesley enrollees and non-enrollees, respectively, were not matched to NSC degree and major data. Among non-enrollees, the means of observed variables are similar between missing and non-missing observations (see Table A2). We also re-calculated the comparisons in Table 2, but including missing observations in the calculation of mean differences. As before, test scores are still 32% to 35% of a standard deviation lower among enrollees, and other differences are similar to those in Table 2. These similarities between missing and non-missing observations in the comparison group suggests that missingness is not a straightforward proxy for dropping out of college. A more likely explanation is that many NSC records are privacy-blocked, even at selective institutions in the comparison group. The NSC provides an aggregate matching report which cannot be matched to individual data. More than half of unmatched records among admitted Wellesley applicants are privacy-blocked. These include, for example, all degree records from Columbia University (which enrolls the fifth-highest number of admitted Wellesley applicants).

[14] This assumes equal selection and a maximum R^2 of 0.21 (=0.14×1.5).

Column (3) adds high school fixed effects in order to control for unobserved variables shared across applicants from the same high school, including high school quality and neighborhood attributes. This increased the estimates of lower and upper bounds, respectively, to 7.9 and 9.0 percentage points. These are not strictly comparable to the estimates in other columns because the fixed-effects sample does not include 13% of applicants from high schools with only one applicant. However, it is instructive that the smallest estimate of 7.2 percentage points still represents a 94% increase in the probability of majoring in Economics, relative to non-enrollees.

One interpretation of this coefficient is that it represents "new" Economics majors who would otherwise not have chosen a mathematically-intensive major. Another interpretation is that Economics majors at Wellesley College would have chosen a different mathematically-intensive major in Business or STEM, had they not enrolled at Wellesley College. Table 3 shows that Wellesley enrollees are indeed less likely to choose a mathematically-intensive business major—not offered at Wellesley College—but the magnitude (–1.5 percentage points) is still modest in comparison to the Economics coefficient.[15]

Table 3 also shows that enrollees are no less likely to choose *any* STEM major (excluding Economics and Business). There are large effects on mathematics, physical sciences, and computing-related majors (from 3.8 to 5.2 percentage points), but these are offset within the STEM category by the negative effects on choice of engineering majors, which are not offered at Wellesley. We cannot rule out that some Economics majors were drawn from STEM fields, but the coefficient magnitudes still imply a considerable effect on drawing "new" majors into Economics. We further note that the evidence does not conclusively demonstrate a zero effect of

[15] As a referee pointed out, it is possible that students would have chosen another business major instead of Economics. Our main point in this paper is that such business majors are not mathematically-intensive to the same degree as an Economics major.

the probability of choosing any STEM major, since the upper bound is consistent with effects as large as 2.8 to 3.6 percentage points.

C. Heterogeneity of Effects

Table B1 reports effects within subsamples defined by several variables, including mathematics SAT scores (above and below 700), under-represented minority (URM) status, and pre-college preferences for Economics and single-sex schooling.[16] On average, 4.8% of non-enrollees with lower math SATs major in Economics, while 10% of higher-scoring non-enrollees do so. Relative to these proportions, enrollment at Wellesley College nearly doubles the probability that both groups choose an Economics major. A similar pattern is evident in samples defined by URM status. Among non-enrollees, URM students are less likely than non-URM students to major in Economics (5.2% versus 8.2%, respectively). Relative to non-enrollees, enrollment at Wellesley increases the probability that both URM and non-URM students choose Economics by more than 70%. The coefficients in the subsamples of lower-math and URM students imply that Wellesley enrollment raises the probability of majoring in Economics to the average levels of non-enrollees in the higher-math and non-URM samples, respectively.

Table B1 also reports estimates within subsamples defined by pre-college preferences for Economics and other majors. Among non-enrollees with an Economics preference, 29.6% choose to major in Economics. Wellesley enrollees are 28 percentage points (or 94%) more likely to major in Economics. Only 5.6% of non-enrollees who do not declare a preference in either STEM or economics go on to major in economics, though Wellesley enrollment doubles

[16] Our definition of under-represented minority includes students who self-identify as African-American, Latinx, and/or Native American.

this probability. Thus, the Wellesley effect is robustly observed whether or not students have a strong pre-college interest in the discipline.

It is possible that the effects of single-sex schools are concentrated among students with a stronger preference for such schools (Jackson, 2012). We assess this by estimating effects in samples of students with plausibly stronger or weaker preferences. The estimated effect on enrolling in Economics is slightly larger in the small sample of applicants who attended single-sex high schools (10.5 percentage points), though the effect is still large among applicants who attended coeducational high schools (7.1 percentage points). Effects are also similar regardless of whether applicants have a close relative who attended Wellesley College, and regardless of whether they applied via the early evaluation or regular admission (assuming that early evaluation applicants reveal a stronger preference for Wellesley College).

D. Effects on Graduate Outcomes

If enrollment at Wellesley increases the probability of majoring in Economics, then it may also increase the chances of pursuing graduate study in the same field. In the estimation sample, 72% of students who eventually receive any graduate degree in Economics also have an undergraduate major in the field. We assess whether Wellesley enrollees were more likely to receive an M.A. degree or higher in fields defined by the same CIP codes used to categorize undergraduate majors (see Table 4).[17]

Only 0.27% of non-enrollees complete a graduate degree in Economics, but Wellesley enrollment more than doubles the probability by 0.32 percentage points. This lower-bound

[17] We use the NSC data to identify students with graduate degrees in our undergraduate estimation sample. If students are not observed to receive graduate degrees, we assume that they did not. However, the latter group may include students whose data is privacy-blocked or otherwise unmatched.

estimate is statistically distinguishable from zero at conventional levels. Coefficients on other fields of study have a mix of positive and negative signs, and are generally not statistically different from zero for both variants of the wild cluster bootstrap.

Table 4 further assesses whether enrollees were more likely to receive an award or honorable mention in the National Science Foundation Graduate Fellowship. NSF Fellowship data are a useful way to corroborate the previous results, since the awards are publicly available and can be readily matched to the estimation sample by name and undergraduate institution (see Appendix A). Naturally, this is rare among non-enrollees: 0.05% received an NSF award in Economics. Wellesley enrollment more than doubles this probability (by 0.12 percentage points), although the coefficient is not statistically significant using both variants of the wild cluster bootstrap.

4. What Can Explain the Wellesley Effect?

A. Potential Causal Channels

Table 3 showed that enrollment at Wellesley College increased the probability of majoring in Economics by 7.2 percentage points, conditional on a rich set of applicant variables. The effect is consistent with at least three causal channels unrelated to students. First, it may reflect the influence of gender-related college attributes, notably the presence of female peers and instructors. The introduction reviewed a broad literature in coeducational and, to lesser extent, in single-sex settings that examines these causal links (e.g., Porter and Serra, 2020; Calkins et al., 2021). On the one hand, the mere presence of female instructors or peers may provide positive role models or diminish stereotype threat, among other passive, gender-related causal mechanisms.[18] On the other hand, female instructors or peers may directly influence students

[18] Inzlicht and Ben-Zeev (2000) and Sekaquaptewa and Thompson (2003) show that female performance in mathematics declines when women complete tasks in the presence of men perhaps because it causes women to view

through interactions inside and outside of the classroom, perhaps by using a different style of classroom instruction or otherwise provide greater instructional support to female students.[19] More generally, female instructors or peers may exhibit less gender bias in their classroom interactions with female students.[20]

Second, the Wellesley effect may reflect the influence of non-gender-related college attributes that are shared with liberal arts colleges, whether single-sex or not. For example, liberal arts colleges emphasize teaching in tenure and promotion, which is empirically associated with more time allocated to teaching tasks (Allgood and Walstad, 2013). Relatedly, liberal arts colleges may provide more individualized advice and information about majors and careers. This may be particularly effective if women misperceive economics courses and careers as entirely focused on finance or business (Avilova and Goldin, 2018; Buckles, 2019). Research suggests there is a small, but positive, effect of providing information to women on Economics major choice.[21] Finally, selective colleges and universities may simply admit higher-ability peers which could have independent effects on the choice of mathematically-intensive majors such as Economics.

Third, the Wellesley effect may be the result of institutional factors that are unique to Wellesley College, rather than broader categories of women's and/or liberal arts colleges. One

themselves through the lens of a negative stereotype. Porter and Serra (2020) show that the presence of female role models might encourage or inspire women to pursue similar paths.

[19] We thank an anonymous referee for this observation.

[20] Paredes et al. (2020) measured gender attitudes among Chilean Economics students. They were more gender-biased than students in other fields upon entry. The gap increased over time, especially for male students, but the gap was attenuated when students were exposed to more female instructors and peers. Wu (2020) shows that women are described with derogatory and sexualized language in an anonymous online forum for nominally professional economists.

[21] Bayer, Bhanot, and Lozano (2019) found that randomly sent emails with an encouragement to take economics courses and additional information about the types of research conducted by economists had modest but imprecisely-estimated effects on the likelihood of taking additional courses. Li (2018) evaluated a treatment that provided information about careers and earnings in economics along with targeted encouragement of women with above-median scores in economics. The combined intervention had large effects on the probability that women with higher grades chose a major in economics.

plausible explanation is a unique anti-grade-inflation policy that was implemented in Fall 2004, and therefore affected many cohorts in our dataset (Butcher, McEwan, and Weerapana, 2014). The policy lowered average grades in the humanities and non-Economics social sciences, relative to grades in Economics and STEM. Its principal effect was to modestly increase students' choices of courses and majors in the latter departments (Butcher et al., 2014). One interpretation is that students responded to signals of their relative abilities across majors. If women and men draw different conclusions from the same signals of ability, then the provision of additional information about ability may influence how women update beliefs about their major-specific abilities. This is consistent with literature showing that the major decisions of women are especially sensitive to relative grades.[22]

B. Decomposition of the Wellesley Effect

Table 5 reports an empirical decomposition of the estimated effect of enrolling at Wellesley College, using methods in Gelbach (2016). Column (1) repeats the estimate of 0.072 from the preferred specification in Table 3, which includes detailed applicant controls. The estimate in column (2) adds controls for gender-related and non-gender-related college variables described in Table 6. The estimated effect of enrolling at Wellesley on majoring in Economics declines to 0.029 once college-related variables are held constant. The magnitude of the reduction (–0.043) implies that 60% of the Wellesley effect is "explained" by institutional covariates.

[22] An observational literature shows that women at coeducational schools who receive lower grades in introductory economics courses are less likely to major in economics than men with similar grades (Rask and Tiefenthaler, 2008; Goldin, 2015). Antman et al. (2020) randomly provided students with information about their location in the grade distribution, and found that it reduced grade sensitivities among women at a large coeducational university. At Wellesley College, a regression-discontinuity design showed that women just above letter-grade cutoffs in introductory economics courses are much more likely to major in Economics (McEwan, Rogers, and Weerapana, 2021), suggesting that grades are important signals used to update beliefs about major-specific abilities. Related theory also suggests that closing the difference in mean grades across departments might also close gaps in major choice (Ahn et al., 2019).

Column (3) in Table 5 further decomposes this change of –0.043 between gender-related and non-gender-related college variables, as described in the following paragraphs.[23] Gender-related college variables include an indicator of women's colleges, the proportion of female students, and the proportion of female faculty in the Economics Department and college-wide (see panel A in Table 6). The variables capture the varied effects of exposure to female classmates, mentors, and instructors. We do not claim to identify specific causal mechanisms, since the variables are collinear and potentially consistent with other, unobserved causal pathways described in the previous section.

Collectively, the gender-related college variables are responsible for –0.032 of the reduction, which is 44% of the estimated gap of 7.2 percentage points between Wellesley enrollees and non-enrollees. We can separately interpret the contribution of individual variables, although the collinearity of gender-related variables suggests some caution in interpreting the results. The women's college indicator explains –0.014 of the change. Stated differently, the effect of Wellesley enrollment on majoring in Economics is attenuated by 19% when enrollees are compared to non-enrollees who went to women's colleges, all else equal. Overall, 9% of non-enrollees went to another women's college (see Table 6), including Agnes Scott, Barnard, Bryn Mawr, Mount Holyoke, Scripps, Smith, Spelman, and others.

The set of gender-related variables also includes the proportion of peers who are women, and the proportion of faculty—overall and in Economics—that are women. These variables explain

[23] The explained portion of a college covariate is obtained by multiplying two estimates: (1) the coefficient on the college covariate from the fully-specified regression in column (2) of Table 5, and (2) the mean difference in the college covariate between enrollees and non-enrollees, conditional on the covariates already included in the base regression in column (1) of Table 5. The latter is obtained by regressing the covariate on an enrollment indicator, while controlling for covariates in the base specification (which are, in this case, all the applicant and high school variables included in the base specification). The explained portion for a group of college covariates is obtained by summing the individual contribution of each variable. Gelbach (2016) further describes formulas for obtaining the standard errors of the components of the decomposition, which are reported in column (3) of Table 5.

0.019 of the change in the enrollment coefficient, which is 26% of the estimated gap. Figure 3 illustrates how gender-related institutional features vary among non-enrollees in the comparison group, relative to the mean among Wellesley enrollees. For non-enrollees at co-educational institutions, the fraction female among the students is fairly tightly clustered around 0.5 (the small spike in the histogram at 1 is due to other women's colleges among non-Wellesley-enrollees). The percent of female faculty, both overall and in Economics specifically, is also substantially higher for Wellesley enrollees.[24]

Non-gender-related college variables include the public/private status of the college, its focus on undergraduate versus graduate education, and the presence of higher- or lower-performing peers of any gender, as proxied by math SAT scores (see panel B in Table 6). Together, these variables account for –0.011 or which is 15% of the estimated gap. Unlike the gender-related variables, this component of the decomposition is not statistically distinguishable from zero. Table 6 shows that 28% of non-enrollees graduated from private liberal arts college (including Amherst, Barnard, Smith, and Williams). However, Wellesley enrollees are actually exposed to peers with modestly lower math SAT scores.

Overall, 60% of the Wellesley effect on Economics major choice is explained by attributes that are shared with other institutions. The remaining 0.029, or 40%, of the effect is Wellesley-specific or, at least, cannot be explained by the observed controls. Are there Wellesley attributes, beyond its being a women's college and selective liberal arts college, that encourage women to major in Economics? We can indirectly assess whether the anti-grade-inflation policy at Wellesley College—implemented in Fall 2004—is responsible for this unexplained effect

[24] An anonymous referee pointed out that ideally, we would also want control for variation in exposure to female faculty in introductory Economics courses, but we do not have access to this data on institutions in the comparison group.

(Butcher et al., 2014). Since most introductory courses are taken in the first two years, and the deadline for major declaration is in the second year, the major choices of cohorts entering between Fall 1999 and Fall 2002 were not affected by the policy. Table B1 shows that the enrollment effect is 6.2 percentage points among earlier cohorts and 7.4 percentage points among later cohorts. The large effect among earlier cohorts suggests that anti-grade-inflation policy is not by itself responsible for the unexplained component of the Wellesley effect. However, the modest difference of 1.2 percentage points suggests that it may play some role, consistent with earlier research (Butcher et al., 2014).

Another hypothesis is that the Economics curriculum at Wellesley is less mathematically-rigorous than schools in the comparison group, including other women's colleges. However, the major is not different in its basic structure and mathematical requirements from its peer institutions, since it requires calculus-based intermediate theory, and two courses in statistics and econometrics. Upper-level electives call upon these pre-requisites in theory and econometrics, and span the usual subfields of economics. Thus, other unobserved attributes of Wellesley College may be responsible for the unexplained effect.[25]

In summary, we find that 3.2 percentage points (or 44%) of the large Wellesley enrollment effect on Economics major choice is explained by gender-related variables shared with institutions in the comparison group. This provides support for the potential importance of gender environments in affecting the major choices of women. However, we are cautious in arguing that these results might be directly applied to coeducational settings by, for example, increasing the percentage of female students or instructors. On the one hand, these variables are

[25] One possibility is that Economics is a relatively popular major, with at least 15% of students, which may influence major choices via information or interactions with peers. On the other hand, the popularity of the major may simply be an outcome that results from the effects of unmeasured variables.

collinear, and may also be correlated with unobserved colleges attributes that are responsible for increasing Economics major choice. On the other hand, the variation in female peers is relatively narrow among coeducational institutions compared to single-sex environments (see Figure 3), and our data are not well-suited to identifying the impact of college or classroom gender composition across wider ranges of these variables.

5. Conclusion

Enrolling at Wellesley College increases the probability of majoring in Economics by at least 7.2 percentage points, a near-doubling of the probability in the comparison group of non-enrollees. The effect is smaller but still robustly observed among students who are under-represented in Economics, including students with lower math SAT scores, under-represented minority students, and students without a pre-college preference for Economics. The effect is also large even when students do not have a stronger revealed preference for single-sex schooling and/or Wellesley College. We do not find that the effect can be easily explained by the poaching of students from other STEM majors, or that Economics majors reflect a one-for-one substitution for mathematically-intensive business majors not offered at Wellesley College.

A decomposition exercise suggests that a substantial portion (44%) of the large Wellesley effect is explained by the fact that Wellesley College is a women's college and because Wellesley enrollees are more likely to be exposed to female peers and instructors, both college-wide and in Economics. Although the decomposition suggests some importance for both student and faculty gender, it is possible that gender-related variables are capturing the influence of unobserved variables in women's colleges, such as career-related information delivered by women. Our results are broadly consistent with quasi-experimental evidence on women's colleges that began admitting men (Calkins et al., 2021), as well as recent experiments finding large effects of exposure to female role models and instructors (e.g., Carrell, Page, and West, 2010; Porter and Serra, 2020). Thus, our results may have wider implications for understanding potential solutions to gender gaps in Economics and other fields, although some caution is warranted in extrapolating these results to coeducational settings. There are also obvious parallels to the important role of Historically Black Colleges and Universities in training black students to enter professional fields (Price and Viceisza, 2023; Edmonds, 2022; Gasman et al, 2017).

We find that Wellesley's anti-grade-inflation policy could play a modest role in explaining the Wellesley effect on Economics major choice, since the effect is 1.2 percentage points larger among cohorts exposed to the policy. This is consistent with theoretical predictions (Ahn et al., 2019) and previous quasi-experimental research on the policy itself (Butcher et al., 2014). However, this paper cannot fully explain the 40% of the Wellesley effect that is unexplained by gender-related or non-gender-related college covariates.

When Henry and Pauline Durant founded Wellesley College in 1870, the former proclaimed that "women can do the work. I give them the chance." Even as most educational institutions have become coeducational, there seems to be a measurable legacy of "giving women a chance" at this institution. We hope this work will spark interest in understanding how other women's colleges, Historically Black Colleges and Universities, and related programs at coeducational institutions, might play key roles in increasing diversity and inclusion across mathematically-intensive disciplines such as Economics.

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Table 1: Economics degrees by gender and school type, 2009-2018

	Coeducational schools			Women's colleges	
	Economics degree (%)		N	Economics degree (%)	N
	Men	Women		Women	
Panel A: Top 200 schools (by math SAT) that offer undergraduate Economics					
PhD, public	5.8	2.4	49	–	
PhD, private	9.4	4.3	53	–	
MA, public	2.5	0.9	6	–	
MA, private	4.6	1.5	13	–	
BA, public	17.9	6.5	1	–	
BA, private	14.9	5.6	72	10.2	6
Total	7.2	3.0	194	10.2	6
Panel B: All schools that offer undergraduate Economics					
PhD, public	4.0	1.5	140	–	
PhD, private	7.9	3.6	70	–	
MA, public	1.9	0.5	171	–	
MA, private	2.3	0.7	147	1.9	5
BA, public	2.2	0.7	23	–	
BA, private	9.1	3.3	194	8.1	13
Total	4.0	1.5	745	6.4	18

Source: IPEDS data files and authors' calculations.
Notes: For each college or university with any undergraduate degrees in Economics during the time period, we calculate the percent of men and women who received an Economics degree. Each cell reports the mean percentage across colleges and universities, weighted by total enrollment.

Table 2: Applicant and high school variables in the estimation sample

	Non-enrollees		Mean difference: enrollees – non-enrollees			
	Mean	S.D.	Mean difference	S.E.	p-value (RWCB)	p-value (UWCB)
Panel A: Applicant variables						
Math SAT	701.8	64.6	-22.9	2.7	<0.001	<0.001
Verbal SAT	716.3	63.4	-21.5	2.4	<0.001	<0.001
Writing SAT	723.0	61.5	-20.8	2.2	<0.001	<0.001
ACT	30.8	2.9	-1.0	0.1	<0.001	<0.001
First-generation college student (1/0)	0.106	0.308	0.020	0.007	0.427	0.019
Under-represented minority (1/0)	0.170	0.376	-0.019	0.008	0.106	0.044
Major preferences:						
Economics (1/0)	0.087	0.282	-0.011	0.006	0.173	0.057
Biological sciences (1/0)	0.267	0.442	-0.042	0.010	0.029	<0.001
Math, physical, computing (1/0)	0.160	0.367	-0.036	0.010	0.043	<0.001
Other STEM (1/0)	0.055	0.227	-0.005	0.003	0.506	0.231
Alumna(e) relative(s):						
Sister (1/0)	0.022	0.148	0.011	0.002	0.003	<0.001
Mother (1/0)	0.040	0.196	0.006	0.004	0.143	0.295
Aunt (1/0)	0.024	0.154	0.006	0.002	0.070	0.005
Grandmother or higher (1/0)	0.024	0.154	0.004	0.003	0.156	0.253
Panel B: High school variables						
Public charter school (1/0)	0.011	0.106	-0.003	0.001	0.173	0.040
Public magnet school (1/0)	0.069	0.253	-0.009	0.005	0.164	0.047
Private non-religious (1/0)	0.235	0.424	-0.016	0.010	0.632	0.258
Private Catholic (1/0)	0.058	0.233	-0.002	0.004	0.593	0.607
Private religious, other (1/0)	0.047	0.212	-0.001	0.002	0.780	0.745
Private single-sex (1/0)	0.051	0.220	-0.005	0.003	0.413	0.132
Proportion free/reduced lunch	0.203	0.234	0.005	0.005	0.562	0.344

Notes: The sample includes 15,390 admitted applicants with NSC degree and major data. Variables in panel A are from Wellesley College administrative data. Variables in panel B are from national datasets described in Appendix A. For each mean difference, we report the heteroskedasticity-robust standard error, as well as p-values for restricted and unrestricted variants of the wild cluster bootstrap-t.

Table 3: Enrollment at Wellesley College and undergraduate major choice

	(1)	(2)	(3)
Economics [0.077]	0.062**	0.072**	0.079**
	(0.007)	(0.007)	(0.007)
R^2	0.01	0.14	0.28
p-value [R,U]	[0.017,0.000]	[0.001,0.000]	[0.000,0.000]
Bound		0.077	0.090
Business (math-intensive) [0.016]	-0.015**	-0.015**	-0.015**
	(0.005)	(0.005)	(0.005)
R^2	0.01	0.04	0.19
p-value [R,U]	[0.122,0.000]	[0.097,0.000]	[0.114,0.000]
Bound		-0.015	-0.014
Any STEM (except Economics and Business)	-0.054**	-0.002	-0.003
[0.327]	(0.020)	(0.011)	(0.012)
R^2	0.00	0.29	0.41
p-value [R,U]	[0.100,0.003]	[0.816,0.847]	[0.841,0.831]
Bound		0.028	0.036
Biological and biomedical sciences [0.157]	-0.024**	-0.001	-0.003
	(0.009)	(0.006)	(0.007)
R^2	0.00	0.21	0.35
p-value [R,U]	[0.126,0.012]	[0.870,0.870]	[0.616,0.667]
Bound		0.013	0.012
Math, Physical, Computing [0.089]	0.015*	0.038**	0.043**
	(0.007)	(0.007)	(0.007)
R^2	0.00	0.17	0.31
p-value [R,U]	[0.270,0.054]	[0.016,0.000]	[0.016,0.000]
Bound		0.052	0.063
Engineering [0.043]	-0.042**	-0.037**	-0.037**
	(0.009)	(0.007)	(0.007)
R^2	0.02	0.07	0.23
p-value [R,U]	[0.025,0.000]	[0.011,0.000]	[0.009,0.000]
Bound		-0.032	-0.032
Other STEM [0.044]	-0.005	-0.002	-0.005
	(0.006)	(0.005)	(0.005)
R^2	0.00	0.04	0.20
p-value [R,U]	[0.527,0.485]	[0.674,0.684]	[0.425,0.318]
Bound		-0.001	-0.006
Controls	N	Y	Y
High school fixed effects	N	N	Y

Notes: Each cell reports the coefficient on enrollment from a separate regression. Additional controls in column (2) include those described in equation (1), as well as dummy variables indicating missing values. Standard errors are in parentheses, clustered by the college or university where the degree was received. ** indicates significance at 1%, and * at 5%. The p-values are from the restricted (with null imposed) and unrestricted wild cluster bootstrap-t, respectively. The bounds in columns (2) and (3) are calculated relative to the baseline specification in column (1); see the text for a description of other assumptions. In the first column, the number in brackets is the mean of the dependent variable in the comparison group of non-enrollees. The sample size for specifications in columns (1) and (2) is 15,390. In column (3), the sample size is 13,405, since observations from unique high schools are excluded.

Table 4: Enrollment at Wellesley College and graduate outcomes

	MA or higher degree	NSF Graduate Fellowship (award or honorable mention)
Economics	0.0032**	0.0012**
	(0.0004)	(0.0003)
R^2	0.01	0.01
p-value [R,U]	[0.001,0.000]	[0.199,0.000]
Non-enrollee mean	0.0027	0.0005
Bound	0.0036	0.0016
Business (math-intensive)	-0.0010	---
	(0.0008)	
R^2	0.02	
p-value [R,U]	[0.282,0.229]	
Non-enrollee mean	0.0046	
Bound	-0.0010	
Biological and biomedical	-0.0052**	0.0039**
sciences	(0.0017)	(0.0010)
R^2	0.03	0.02
p-value [R,U]	[0.049,0.004]	[0.199,0.000]
Non-enrollee mean	0.0220	0.0067
Bound	-0.0038	0.0056
Math, Physical, Computing	0.0029	-0.0001
	(0.0019)	(0.0009)
R^2	0.04	0.04
p-value [R,U]	[0.421,0.135]	[0.912,0.896]
Non-enrollee mean	0.0192	0.0072
Bound	0.0053	0.0015
Engineering	-0.0066**	-0.0012
	(0.0022)	(0.0008)
R^2	0.04	0.01
p-value [R,U]	[0.088,0.004]	[0.454,0.204]
Non-enrollee mean	0.0146	0.0036
Bound	-0.0044	-0.0005
Other STEM	-0.0014	-0.0006
	(0.0012)	(0.0007)
R^2	0.01	0.01
p-value [R,U]	[0.222,0.249]	[0.409,0.359]
Non-enrollee mean	0.0083	0.0036
Bound	-0.0015	0.0001

Notes: Each cell reports the coefficient on enrollment from a separate regression. All regressions include the variables in equation (1), as well as dummy variables indicating missing values. Standard errors are in parentheses, clustered by the college or university where the degree was received. ** indicates significance at 1%, and * at 5%. The p-values are from the restricted (with null imposed) and unrestricted wild cluster bootstrap-t, respectively. Bounds are calculated relative to a specification that only controls for enrollment; see the text for a description of other assumptions. The sample size for all specifications is 15,390.

Table 5: Decomposition of the Wellesley enrollment effect on Economics major choice

	(1)	(2)	(3): (2) – (1)
Initial enrollment at Wellesley	0.072**	0.029**	-0.043**
	(0.007)	(0.007)	(0.008)
p-value [R,U]	[0.001,0.000]	[0.029,0.000]	
Applicant controls	Y	Y	
College controls: gender-related	N	Y	-0.032**
			(0.012)
Women's college (1/0)	N	Y	-0.014
Proportion female students	N	Y	-0.002
Proportion female faculty:			
Economics	N	Y	-0.010
Campus-wide	N	Y	-0.007
College controls: non-gender-related	N	Y	-0.011
			(0.009)

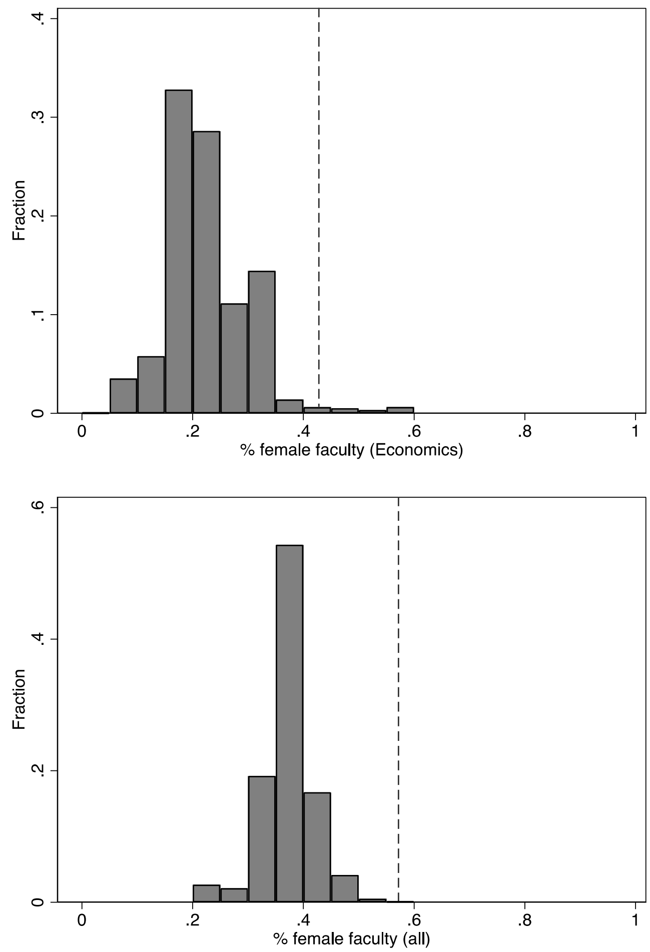
Notes: For details on the decomposition and standard errors, see the text and Gelbach (2016). ** indicates statistical significance at 1%, and * at 5%. The applicant variables include those in Table 2, as well as dummy variables indicating missing values of covariates. The college-related variables are the same as Table 6, in addition to dummy variables indicating missing values of covariates.

Table 6: Variables from degree-awarding college and universities

	Non-enrollees		Mean difference: enrollees – non-enrollees			
	Mean	S.D.	Difference	S.E.	p-value (RWCB)	p-value (UWCB)
<u>Panel A: Gender-related</u>						
Women's college (1/0)	0.090	0.286	0.863	0.047	<0.001	<0.001
Proportion female students	0.557	0.146	0.421	0.023	<0.001	<0.001
Proportion female faculty:						
Economics	0.208	0.299	0.252	0.015	<0.001	<0.001
Campus-wide	0.377	0.086	0.195	0.012	<0.001	<0.001
<u>Panel B: Non-gender-related</u>						
PhD, public (1/0)	0.133	0.340	-0.122	0.032	0.132	0.001
PhD, private (1/0)	0.566	0.496	-0.541	0.063	0.002	<0.001
MA, public (1/0)	0.010	0.100	-0.007	0.004	0.748	0.172
MA, private (1/0)	0.011	0.104	-0.010	0.002	0.229	<0.001
BA, public (1/0)	0.002	0.045	-0.002	0.001	0.369	0.046
BA, private (1/0)	0.278	0.448	0.682	0.059	<0.001	<0.001
SAT verbal (25^{th} percentile)	633.2	54.7	9.5	5.9	0.432	0.159
SAT verbal (75^{th} percentile)	732.4	48.8	7.4	5.5	0.465	0.224
SAT math (25^{th} percentile)	646.8	55.3	-9.9	5.8	0.201	0.113
SAT math (75^{th} percentile)	741.7	48.9	-11.9	5.2	0.130	0.043

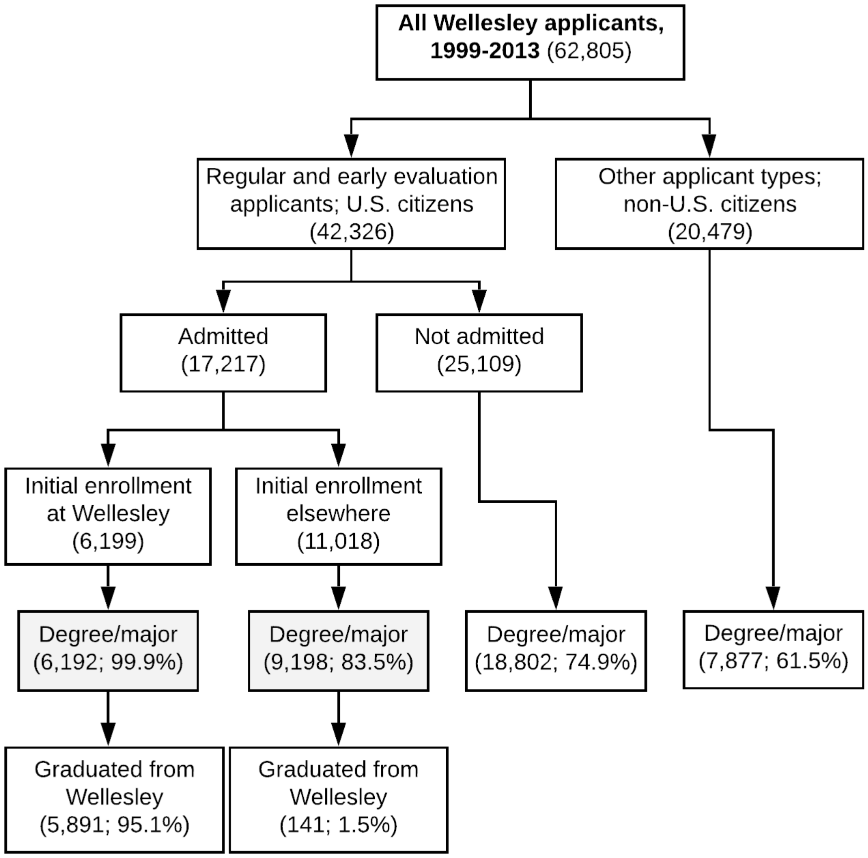
Notes: The sample includes 15,390 admitted applicants (see the text and Table 2). Variables in panel A and B are from IPEDs, except for the proportion of female Economics faculty which is drawn from the annual CSWEP survey (see Appendix A). College and university categories are based on the 2000 Carnegie classification. For each mean difference, we report the heteroskedasticity-robust standard error, as well as p-values for restricted and unrestricted variants of the wild cluster bootstrap-t.

Figure 1: Percent female faculty in top 200 coeducational and women's colleges and universities (by math SAT) that offer undergraduate Economics, 2009-2018



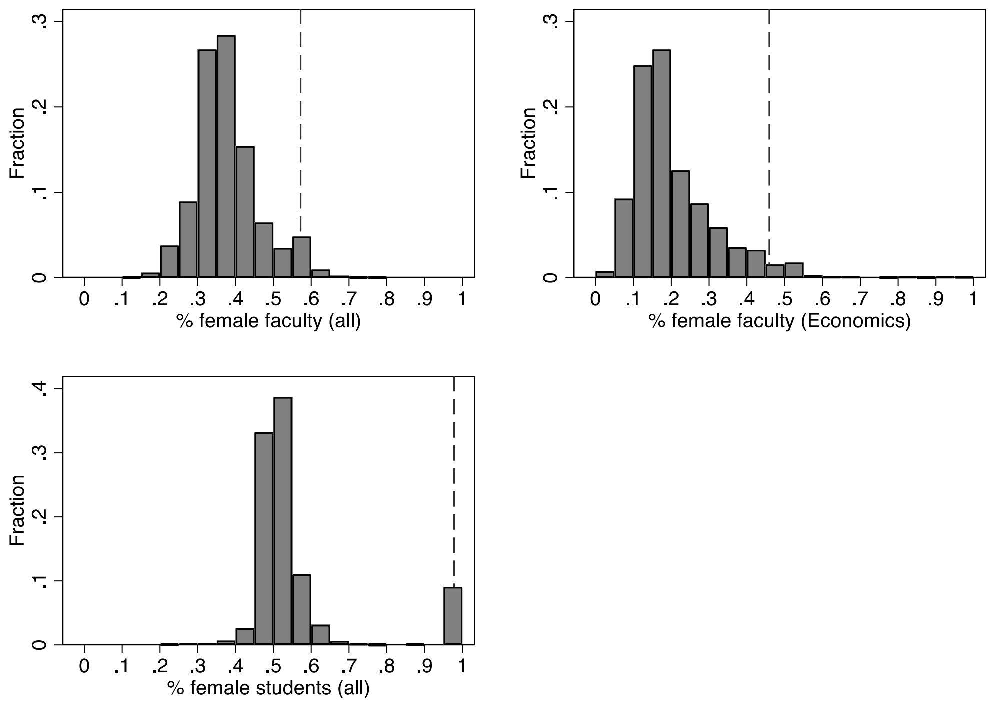
Sources: CSWEP panel dataset, IPEDS data files, and authors' calculations.
Notes: For each college or university with any undergraduate degrees in Economics during the time period, we calculate the mean percent of female faculty—in Economics or college-wide—during the selected years. The dotted line refers to the mean of six single-sex, private liberal arts colleges, including Wellesley College (weighted by total enrollments). The histogram refers to coeducational colleges and universities with non-missing data (N=145 in the top panel, and N=193 in the bottom panel), also weighted by total enrollments.

Figure 2: Wellesley College applicant data, Fall 1999 to Fall 2013



Notes: Other applicant types include early decision applicants and transfer. The availability of degree and major data implies that a Classification of Instructional Program code was available or imputed for a record (see Appendix A for details). The two shaded boxes indicate this paper's estimation sample.

Figure 3: Exposure to female faculty and students



Sources: CSWEP panel dataset, IPEDS data files, and authors' calculations.
Notes: For each student observation in the estimation sample, we calculated potential exposure to female students and faculty as the four-year mean of data from their college of graduation. Data in the lower-left and upper-left panels are from IPEDs surveys. Data in the upper-right panel is from the CSWEP survey. See Appendix A for details. The dotted line refers to the mean of initial enrollees at Wellesley College. The histogram describes non-enrollees.

Appendix A: Data

A. Wellesley College applicants, 1999-2013

There were 62,805 applicants for Fall admission between 1999 and 2013 (see Figure 2). Of these, 42,326 were U.S. citizens and applied through regular admissions or early evaluation. In both groups, admission does not obligate the applicant to enroll at Wellesley College. We exclude all other applicants, including early decision applicants who are required to enroll if admitted, as well as other applicants who may have already completed some college elsewhere (e.g., transfer and Davis Scholar applicants). We further limit this paper's sample to the 17,217 applicants who received offers of admission. The estimation sample includes 15,390 applicants for whom we could also identify degree and major data from the National Student Clearinghouse.

B. National Student Clearinghouse data

In September 2017, we submitted the full applicant dataset for matching to the StudentTracker service of the National Student Clearinghouse. To identify applicants' degree(s) and major(s), we used the following procedure in the full applicant sample:

- We kept all observations that recorded a graduation event. This excluded records with privacy-related blocks, with matching errors, or for whom only enrollment episodes were reported.
- We kept observations with non-missing string values of the degree title, which we coded into bachelor's degrees, graduate degrees (of any kind), and other degrees or certificates.
- In the remaining sample, we identified the first (and usually only) college or university that awarded a bachelor's degree to a student. We identified the six-digit Classification of Instructional Program (CIP) code(s) for the major(s) in this college or university.
- We imputed missing CIP codes using college-reported string descriptions of the majors. First, we identified non-missing, exactly-matching string major descriptions within colleges, and imputed missing CIP codes using non-missing CIP codes in the same string group. Second, we identified the modal CIP code in sample-wide groups defined by non-missing, exactly-matching major strings, and imputed this CIP for missing observations in the same string group. Note that all applicants were used to impute missing CIP codes, even if they were not included in the estimation sample.
- We used CIP codes to generate the dependent variables, as described in Table A1.
- Finally, we used non-missing major strings and keyword matches (e.g., "Economics") to impute remaining missing values of the dependent variables. We used keywords from descriptions of the CIP codes at https://nces.ed.gov/ipeds/cipcode/.

C. NSF Graduate Fellowships

We downloaded spreadsheets of NSF Graduate Research Fellowship awardees and honorable mentions (from 2002 to 2020).[1] We matched by the strings of first name, last name, and undergraduate institution using the Stata command matchit.[2] We hand-verified all exact and close matches.

[1] https://www.research.gov/grfp/AwardeeList.do?method=loadAwardeeList

[2] https://ideas.repec.org/c/boc/bocode/s457992.html

D. High School Data

We extracted public high school variables from the 2013 Common Core of Data (https://nces.ed.gov/ccd/), and private school variables from the Private School Universe Surveys in 2005, 2007, 2009, 2011, 2013, and 2015 (https://nces.ed.gov/surveys/pss/), using multiple rounds because of non-reporting. In the latter case, we used the most recent non-missing observation for each private school code (with the exception of free-and-reduced price lunch, which was only available in 2015). We linked the variables to the Wellesley dataset using the College Board's high school CEEB codes. Because CEEB codes are not available in the Common Core or Private School Surveys, we created a cross-walk between the CEEB codes in our admitted applicant dataset and the high school codes used in the national datasets. Specifically, we matched school names and cities using the Stata command matchit, and then hand-verified exact and close matches.

D. College and University Data

We created a college-level panel of variables from the Integrated Postsecondary Education Data System (https://nces.ed.gov/ipeds/) for each year from 2000 and 2017, including the proportion of female full-time instructional faculty. For each Spring graduation year—and being attentive to the timing of Fall and Spring IPEDs surveys—we constructed an average of non-missing observations in that academic year and the three prior ones, in order to proxy exposure for a typical graduate. We merged these to Wellesley College applicants with non-missing bachelor's degree data, using the graduation year and college codes that are shared across NSC and IPEDS datasets. We also created a college-level panel of a single variable—proportion of tenure-track and non-tenure-track female faculty in Economics—using the restricted-use panel dataset of the Committee on the Status of Women in the Economics Profession (CSWEP) (https://www.icpsr.umich.edu/web/ICPSR/studies/37118). We constructed 4-year averages as with the IPEDs data, and merged the exposure proxy to Wellesley College applicants.

Table A1: Mathematically-intensive and/or STEM majors

Binary dependent variable	Classification of Instructional Program (CIP) code(s)
Economics[a]	4506
Business (math-intensive)[b]	5206 (Business/Managerial Economics), 5208 (Finance and Financial Management Services), 5213 (Management Sciences and Quantitative Methods)
Mathematics, Statistics, Physical Sciences, Computing[c]	Mathematics and Statistics (27), Physical Sciences (40), Computing[c]
Engineering	14
Biological and Biomedical Sciences	26
Other STEM	Other officially designated CIP codes not referenced above.

Notes: A full list of 2010 CIP codes are available at https://nces.ed.gov/ipeds/cipcode/browse.aspx?y=56. DHS (2016) lists officially-designated STEM codes.

[a] Within the four-digit economics CIP code (4506), only 450603 (Econometrics and Quantitative Economics) is officially designated as STEM.
[b] Among four-digit business CIP codes, only 5213 is officially designated as STEM.
[c] "Computing" includes 24 six-digit CIP codes (all with a two-digit code of 11) that are officially designated as STEM, including Computer Science. One six-digit code is excluded (110899), corresponding to the Media Arts and Sciences major at Wellesley College.

Table A2: Descriptive statistics for applicant and high school variables

	Degree and major data *available* in NSC						Degree and major data *missing* in NSC					
	Enrollees			Non-enrollees			Enrollees			Non-enrollees		
	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N	Mean	S.D.	N
<u>Panel A: Applicant variables</u>												
Mathematics SAT	678.9	66.50	5,586	701.8	64.63	8,454	664	88.49	5	698.6	67.14	1,620
Verbal SAT	694.8	67.20	5,587	716.3	63.36	8,454	706	53.67	5	715.7	65.42	1,620
Writing SAT	702.2	63.25	2,686	723.0	61.53	4,240	736.7	101.2	3	717.1	64.77	954
ACT	29.86	3.035	2,042	30.82	2.873	2,826	32.50	3.536	2	30.78	2.922	583
First generation (1/0)	0.126	0.331	6,192	0.106	0.308	9,198	0.286	0.488	7	0.125	0.330	1,820
Under-represented minority (1/0)	0.152	0.359	6,192	0.170	0.376	9,198	0.286	0.488	7	0.198	0.399	1,820
Alumna(e) relative(s):												
Sister (1/0)	0.034	0.181	6,192	0.022	0.148	9,198	0.143	0.378	7	0.015	0.121	1,820
Mother (1/0)	0.046	0.210	6,192	0.040	0.196	9,198	0.143	0.378	7	0.037	0.188	1,820
Aunt (1/0)	0.030	0.171	6,192	0.025	0.154	9,198	0	0	7	0.021	0.145	1,820
Grandmother or higher (1/0)	0.028	0.165	6,192	0.024	0.154	9,198	0.143	0.378	7	0.023	0.148	1,820
Application major preferences												
Economics (1/0)	0.076	0.265	6,192	0.087	0.282	9,198	0	0	7	0.069	0.254	1,820
Biological sciences (1/0)	0.225	0.418	6,192	0.267	0.442	9,198	0.143	0.378	7	0.280	0.449	1,820
Math, physical, computer (1/0)	0.124	0.329	6,192	0.160	0.367	9,198	0	0	7	0.157	0.364	1,820
Other STEM (1/0)	0.050	0.218	6,192	0.055	0.227	9,198	0.143	0.378	7	0.065	0.247	1,820
<u>Panel B: High school variables</u>												
Public charter (1/0)	0.009	0.094	5,622	0.011	0.106	8,393	0	0	6	0.014	0.118	1,618
Public magnet (1/0)	0.060	0.237	5,622	0.069	0.253	8,393	0	0	6	0.063	0.243	1,618
Private non-religious (1/0)	0.219	0.414	5,622	0.235	0.424	8,393	0.167	0.408	6	0.256	0.436	1,618
Private Catholic (1/0)	0.056	0.229	5,622	0.058	0.233	8,393	0	0	6	0.064	0.245	1,618
Private other religious (1/0)	0.047	0.211	5,622	0.047	0.212	8,393	0.167	0.408	6	0.046	0.210	1,618
Single-sex (1/0)	0.046	0.210	5,622	0.051	0.220	8,393	0	0	6	0.059	0.235	1,618
Proportion free-and-reduced lunch	0.208	0.231	5,070	0.203	0.234	7,558	0.312	0.375	6	0.213	0.247	1,433

Appendix B

Table B1: Heterogeneity of effects on Economics major choice

	<700 math	≥700 math	Not URM	URM
Economics	0.049**	0.093**	0.077**	0.038**
	(0.005)	(0.011)	(0.008)	(0.006)
R^2	0.13	0.16	0.15	0.13
p-value [R,U]	[0.000,0.000]	[0.019,0.000]	[0.000,0.000]	[0.004,0.000]
Non-enrollee mean	0.048	0.100	0.082	0.052
Bound	0.050	0.089	0.083	0.045
N	6,828	7,212	12,882	2,508

	Economics preference	Any STEM preference	Neither Economics nor STEM preference	
Economics	0.277**	0.053**	0.062**	
	(0.032)	(0.008)	(0.007)	
R^2	0.20	0.12	0.08	
p-value [R,U]	[0.003,0.000]	[0.019,0.000]	[0.003,0.000]	
Non-enrollee mean	0.296	0.068	0.056	
Bound	0.294	0.058	0.065	
N	1,270	6,157	8,281	

	Single-sex high school	Non-single-sex high school	Any Wellesley College relative	No Wellesley College relative
Economics	0.105**	0.071**	0.077**	0.072**
	(0.021)	(0.007)	(0.013)	(0.007)
R^2	0.33	0.14	0.23	0.14
p-value [R,U]	[0.127,0.000]	[0.001,0.000]	[0.055,0.000]	[0.001,0.000]
Non-enrollee mean	0.047	0.078	0.059	0.078
Bound	0.138	0.077	0.090	0.077
N	688	14,702	1,532	13,858

	Applicant group		Years of Fall enrollment	
	Early evaluation	Regular admission	1999-2002	2003-2013
Economics	0.071**	0.072**	0.062**	0.074**
	(0.009)	(0.006)	(0.009)	(0.007)
R^2	0.14	0.16	0.17	0.14
p-value [R,U]	[0.005,0.000]	[0.000,0.000]	[0.004,0.000]	[0.001,0.000]
Non-enrollee mean	0.083	0.070	0.070	0.079
Bound	0.078	0.079	0.062	0.082
N	7,911	7,479	4,083	11,307

Notes: Each cell reports the coefficient on enrollment from a separate regression in the sample denoted in the header; all regressions include dummy variables for δ_j and θ_k, and application and high school variables. Standard errors are in parentheses, clustered by the college or university where the degree was received. ** indicates significance at 1%, and * at 5%. The p-values are from the restricted (with null imposed) and unrestricted wild cluster bootstrap-t, respectively. The bounds are calculated relative to a specification that only controls for enrollment; see text for a description of other assumptions.