Do Mentoring, Information, and Nudge Reduce the Gender Gap in Economics Majors?

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Abstract

The gender gap in economics majors (i.e., male students are much more likely to major in economics than are their female counterparts) has remained large, despite narrowing gaps observed in many other fields. This study examines whether mentoring, the provision of additional information, and nudges help reduce the gender gap in economics majors via a randomized controlled experiment conducted in introductory economics classes at a large, public, four-year institution in the United States. The results show that the treatment effects are heterogeneous and have the most significant impact on female students with grades above the median. The treatments increase these female students' probability of majoring in economics by 5.41 – 6.27 percentage points.

Keywords: gender gap, educational economics, college major, randomized controlled trial, experiment, subjective belief.

JEL codes: A22, J16, J18

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1. Introduction

During the 2014-2015 academic year, 57 percent of bachelor's degrees were conferred to women.[1] Despite the significant improvement in female educational attainment, the gender distribution across college majors remains uneven. Economics is one of the few disciplines that have shown a persistent gender gap in the past two decades. Compared to the 18 percent of bachelor's degrees in computer and information sciences awarded to women, 19 percent in engineering, 43 percent in mathematics and statistics, and 38 percent in physical sciences and chemistry, only 31 percent of bachelor's degrees in economics were awarded to women. The gender difference in college majors has a profound impact on subsequent occupational choices and the gender wage gap (Robst, 2007; Blau and Kahn, 2017).

Prior studies have found that women are likely to gravitate towards other disciplines when they receive low grades in introductory economics classes (Rask and Tiefenthaler, 2008; Goldin, 2015) and that a substantial percentage of students would switch majors if major-specific population earnings information was perfect (Arcidiacono et al., 2012). If such decision-making is based on incomplete information, improved information may mitigate the problem. An alternative intervention, such as mentoring, is considered a viable approach to mitigate the gender gap. Blau et al. (2010) show that mentoring increases female assistant professors' success in economics.

This study examines whether mentoring, the provision of additional information, and nudges help reduce the gender imbalance in economics majors via a randomized controlled experiment conducted in introductory economics classes at Colorado State University, a large, public, four-year institution. Students enrolled in introductory economics classes were randomly assigned to

[1] Author's calculation based on 2016 U.S. Department of Education Table 318.30. Economics encompasses agricultural economics, natural resource economics, business/managerial economics, economics (general), applied economics, econometrics and quantitative economics, development economics and international development, international economics, and economics (other).

treatment and control groups. During the semester, treatments such as the provision of information on career prospects, average earnings, and grade distributions were provided to women in the treatment group. A nudging message was also sent to female students in the treatment group with a midterm grade above the median. Additionally, half of the treated female students were invited to attend mentoring activities throughout the semester. To evaluate the mechanisms of the treatment effects, two waves of surveys were administered to elicit students' subjective assessments of the probability that they would major in economics before and after the treatments.

This study contributes to the literature in three ways. First, through the experimental design, the causal effect of interventions on female students' likelihood of majoring in economics is identified. Second, this study contributes to the growing literature that uses data from subjective expectations to understand individual decision-making. Finally, the panel nature of surveys allows me to examine the potential mechanisms of treatment effects by exploiting the variation *within* individuals. My empirical results indicate that female students with a grade above the median are most susceptible to the intervention. The treatments increase these female students' probability of majoring in economics by 5.41 – 6.27 percentage points. The effects are even larger for freshmen and sophomores among these high-performing female students, who are 11.2 to 12.6 percentage points more likely to declare economics as their major within the subsequent year.

2. Background

Although the under-representation of women in science, technology, engineering, and mathematics (STEM) fields is widely reported and researched, the enduring gender inequalities in economics garner less public attention. The share of female students in colleges has increased dramatically from 39 to 57 percent over the past few decades (Goldin et al. 2006). Goldin (2015) analyzed data for U.S. college graduates in 2015, and after adjusting for the over-representation of

women in higher education, found that for every female economics major, there were 2.9 male majors.[2] The attrition among women in the economics pipeline throughout their education and career path is also substantial (Kahn, 1995; Boring, 2017). Researchers largely agree that the lack of female faculty members in disciplines or the gender differences in mathematical aptitudes and training do not explain the gender imbalance in economics (see Allgood et al., 2015 for a comprehensive review). Although simply having female role models does not necessarily increase the number of female majors in economics, an organized mentoring program targeting women might yield a different result. Blau et al. (2010) show that mentoring programs for female junior economists' increases the number of their top-tier publications, their total number of publications, and their total number of successful federal grants. However, little is known about the effectiveness of mentoring for women in the early stages (e.g., college) of the pipeline.

Evidence using data from liberal arts or selective research colleges shows that women are more sensitive to poor grades received in introductory economics classes than are men (Horvath et al., 1992; Rask and Tiefenthaler, 2008; Owen, 2010; Goldin, 2015). However, Main and Ost (2014) find that sensitivity to letter grades in introductory economics courses does not explain the gender differences in declaring economics as a major when "plus" and "minus" are used in the letter grades. The empirical results are inconclusive regarding whether gender differences in sensitivity to grades contribute to the under-representation of women in economics majors. More importantly, no prior studies have directly examined whether providing different grade information (such as percentile distributions) affects how female students interpret signals from their grades.

[2] Goldin (2015) terms this the "conversion rate" after adjusting the ratio by considering that women greatly outnumber men in many universities. The formula for the conversion rate is $\frac{\text{Male Econ/Male BA}}{\text{Female Econ/Female BA}}$.

Students choose their college major facing uncertainty about their abilities and the outcomes. Students receive new information from courses they take and may choose to persist in the major they originally choose, switch to another major, or drop out of college to maximize their expected utility among all the alternatives (Manski, 1993; Altonji, 1993; Arcidiacono, 2004; Zafar, 2011; Stinebricker and Stinebrickner, 2012; Stinebricker and Stinebrickner, 2014; Zafar, 2013).

Arcidiacono et al. (2012) find that both perceived ability and expected earnings are important determinants of college major choices for students at Duke University. They estimate that 7.8 percent of students would switch majors if they had the same expectations about the average returns for different majors but different expectations about their perceived comparative advantages across majors. Their findings suggest that imperfect information about major-specific career outcomes may lead to sub-optimal major choices. Wiswall and Zafar (2015) provided New York University students with information regarding population major-specific earnings and find that students' expectations regarding their own earnings are altered as a response to the new information, although the correction is relatively inelastic. They find that expected earnings and perceived ability are significant factors for college major choices, but heterogeneity in preferences and tastes is the dominant determinant. Zafar (2013) collected data on subjective expected major-specific outcomes of sophomores at Northwestern University. He finds that enjoying coursework is the most important determinant and largely explains the gender gap in college majors, while gender differences in self-assessed ability and future earnings explain a small portion of this gap.

This study explicitly investigates the hypotheses regarding the causes of gender imbalance in undergraduate economics, namely, whether mentoring, information intervention, and nudges affect female students' probability of majoring in economics. Specifically, I use a randomized controlled experiment to examine whether these interventions help reducing the gender gap in

economics majors. By exploiting the information from students' subject beliefs, I can investigate the potential mechanisms of the treatment effects.

3. Experiment Design and Empirical Specifications

3.1. Experiment Design

Students with heterogeneous tastes and preferences self-select into different courses and majors. Without exogenous variations, it is difficult to identify the causal effect of taking a specific course on students' decisions regarding their major. To overcome the issue of unobserved preferences that are generally correlated with students' choices and outcomes, a randomized controlled experiment was conducted in this study to identify the causal effects of interventions (including mentoring, information provisions, and "nudges") on the likelihood that female students major in economics. Because the treatments are randomly assigned, they are uncorrelated with unobserved personal characteristics or preferences and hence identify the causal effects.

In the spring semester of 2016, five sections of microeconomics and three sections of macroeconomics classes were offered by six instructors.[3] Each section was supported by two teaching assistants (TAs) who each taught three recitation sections, which were scheduled to fill a common range of recitation schedules.[4] Therefore, within the same introductory course, multiple recitation sections were offered by different TAs at the same time. If students were making their selections based on unobserved preferences for specific schedules, they still had a similar probability of being assigned into the control, partial, or full treatment groups. To ensure that students received the information treatment (i.e., a video clip viewing and information

[3] The Department of Economics offered an additional small honors section of the introductory macroeconomics class in the Spring 2016 semester to serve 24 selective honor students. Because this group of students differs from regular students in many observable ways and because there are no equivalent classes to serve as a comparison group for the experiments, this study excludes the honors section from the analysis.

[4] If the introductory courses were scheduled on Mondays and Wednesdays, the recitations sections were scheduled on Thursdays (4:00- 4:50PM, or 5:00-5:50PM) or Fridays (1:00-1:50PM). If the introductory courses were scheduled on Tuesdays and Thursdays, the recitations sections were scheduled on Fridays (1:00-1:50PM) or Mondays (4:00-4:50PM or 5:00-5:50PM).

dissemination through a pamphlet), the treatment was conducted in class. To balance the influence of instructors and TAs across treatments, the treatments were randomly assigned at the recitation level. Each of the three recitation sections taught by the same TA were randomly assigned into either the full treatment, partial treatment, or control group. During the semester, three treatments were implemented, including an information intervention, as well as nudging, and peer mentoring.

The first and primary treatment was to provide information on career prospects and the grade distribution (T_1). The career information was provided at the beginning of the semester through a video presentation and the dissemination of a pamphlet about the potential career paths and average annual earnings of economics majors.[5] Toward the end of the semester (i.e., 2 – 3 weeks before the final exam), male and female students in both the full and partial treatment groups received an email that provided information regarding the general grade distribution for their class. Simultaneously, women with a grade at or above the median of the grade distribution (Median^{+}) received an encouraging message that explicitly acknowledged their success in the class and urged them to consider majoring in economics.[6] This "nudge" was the second intervention (T_2). In addition to the information intervention, female students in the full treatment group, regardless of their grades, were invited to participate in peer mentoring activities throughout the semester (T_3). Note that since male students in the partial and full treatment groups received the same level of intervention (T_1 only), they were considered as one treated group. Because the treatments were different for male and female students, separate analyses were conducted by gender. Table 1 describes the assignment of treatments across the treatment groups.

[5] The video is available at https://www.youtube.com/watch?v=MUuN5hvkDy0. The details of the pamphlet are provided in Appendix A.
[6] The grade distribution includes grades at the following percentiles: 95th, 90th, 75th, 50th, 25th, and 10th. An example of the general grade distribution message is provided in Appendix B. The "nudge" message sent to female students with a grade at or above the median grade is provided in Appendix C. Note that the message was customized for three groups: at or above the 90th percentile, between the 75th and 90th percentiles, and between the 50th and 75th percentiles.

Two waves of surveys were administered in the recitation classes - one at the beginning of the semester before any treatments were implemented (first wave or W1) and the other at the end of the semester after the treatments concluded (second wave or W2). The surveys elicited students' subjective assessments of the probability that they would major in economics, their beliefs about future earnings associated with a bachelor's degree in economics, their perception of economics, and their likelihood of success if they were to major in economics.[7] One year later, information about the economics courses the students took and the students' major declaration were obtained from administrative records.

3.2. Empirical Specifications

3.2.1. Subsequent course-taking and major declaration

$$Y_{ijt+1} = \gamma_0 + \gamma_1 T_{ij} + \gamma_2 X_i + \gamma_3 Z_j + \zeta_i. \quad (1)$$

To analyze how these treatments affected students' actual choices, I tracked the economics courses that the students took and their major declaration in the subsequent year. I regress the outcomes Y_{ijt+1} (which includes an indicator for students who declared economics as their major, the number of economics courses taken, and an indicator for taking any additional economics courses in separate regressions) on the treatment indicator (T_{ij}), student characteristics (X_i, such as class standing, declaration of economics major upon entering the class, college GPA, high school GPA, and ACT composite score), the influence of instructors and TAs (Z_j, such as the sex of the instructor, the sex of the teaching assistant, and the individual fixed effects of instructors and TAs), and idiosyncratic shocks (ζ_i) separately for male and female students. Because the treatments were randomly assigned, the characteristics of the students and instructors are unrelated to the

[7] Appendix D lists all of the questions on the survey questionnaire.

treatments, and the difference across treatments in students' behavioral changes identifies the treatment effect.

Two measures of T_{ij} are used in the analysis: 1) T_{ij} as a composite indicator function *Treated* with the value of 1 for students in either the full or partial treatment group and 0 otherwise; and 2) T_{ij} as a vector of two dummy variables, *Full* and *Partial*, which assume a value of 1 if the student was assigned to a corresponding treatment group and 0 otherwise. To allow the treatment effects to vary by gender, I estimate the equation separately for females and males. Because male students were given one treatment level (*Treated*) only, the analysis for male students is restricted to the first measure, and the difference between the *Treated* and *Control* groups identifies the treatment effect of the information provision (T_1) for male students.

Note that the nudge (T_2) was only offered to female students whose midterm grades were at or above the median of the grade distribution for the class. Therefore, to consider the heterogeneous responses of students at or above the median grade ($Median^{+}$" = 1) and of those below the median ($Median^{+}$" = 0), I also analyze the equation separately by grade.

The difference in the change in outcomes between the *Full* and *Partial* groups identifies the effect of mentoring (T_3), and the difference between the *Partial* and *Control* groups identifies either the effect of the information intervention (T_1) or the composite effect of the information intervention and the nudge ($T_1 + T_2$), depending on whether the female student had a grade below or above the median. Note that the effects of T_1 and T_2 *cannot* be separately identified for female students whose grade is above the median, unless T_1 has the same effect on all female students, regardless of their grade (Median^{+} and Median^{-}). This assumption is unlikely to hold if students who rank above the median respond to the grade distribution information positively, whereas students below the median take this information as a negative signal. Due to the potential for

heterogeneous effects, I do not intend to disentangle the treatment effects of T_1 and T_2 for female students at or above the median.

3.2.2. Subjective measures

To examine how the treatment affects students' subjective probability of majoring in economics, I estimate the following model:

$$\Pr(EconMajor|W2)_{ij} = \beta_0 + \beta_1 \Pr(EconMajor|W1)_{ij} + \beta_2 T_{ij} + \beta_3 X_i + \beta_4 Z_j + \eta_i, \quad (2)$$

where $\Pr(EconMajor|W2)_{ij}$ is the subjective probability of majoring in economics in the W2 survey, $\Pr(EconMajor|W1)_{ij}$ is the probability of majoring in economics in the W1 survey, T_{ij} is the treatment indicator, X_i controls for the same student's characteristics, and Zj includes the instructors and TAs effects as defined in Section 3.2.1 above. Note that the coefficient β_1 has an intuitive interpretation. The closer β_1 is to 1, the stronger the student's initial belief persisted over time, and new information had only a small effect on the results of the two periods. If β_1 approaches 0, it implies a high level of uncertainty and indicates that the initial belief of the student played a small role in the posterior belief.

4. Data

4.1. Data Description

Colorado State University (CSU) is a four-year public university ranked 121st among all public and private universities nationwide for 2014-15.[8] Fall 2014 enrollment consisted of 27,086 resident students. The 4,353 freshmen admitted during the fall 2014 semester have an average 3.61 high school GPA, 24.9 ACT composite score (compared to a national average of 21), and 1,143

[8] Source: Washington Post, U.S. News and World Report https://www.washingtonpost.com/apps/g/page/local/us-news-college-ranking-trends-2015/1819/, accessed August 8, 2017.

SAT composite score (compared to a national average of 1,010).[9] Among these freshmen, approximately 55 percent are female, which is similar to the national average of 56 percent.[10] During the 2014-15 academic year, 32.8 percent of the CSU bachelor's degrees in economics were conferred to women, which is also similar to the national average of 31 percent.

At CSU, introductory microeconomics and macroeconomics classes are listed among the 21 all-university core curriculum (AUCC) courses that satisfy social and behavioral sciences credits and are therefore taken by students from a variety of disciplines. At the beginning of the spring semester in 2016, a baseline survey (W1) was administered in the recitation classes, and 896 students attended these classes. Because this study focuses on changes in the major declaration of undergraduate students, I excluded 23 graduate students from the analysis. Microeconomics is a prerequisite of the macroeconomics course, and students cannot take these courses concurrently without instructor approval. I excluded 2 students who were enrolled in both classes because they may have received different treatment assignments from the two classes. Because part of the information intervention (T_1) was implemented at the recitation level, I excluded an additional 33 students who attended a recitation section for which they were not enrolled and hence did not receive the intended treatments. I also excluded 9 students who withdrew from the classes before the end of the semester.[11]Among the remaining 829 students who attended the class during the first survey, 788 students (95.1 percent) participated in the first survey (W1). The respondents revealed their reasons for enrolling in the classes as follows: 72 percent took the class to fulfill requirements by other majors, 19 percent registered in the class to meet requirements for an

[9] The average CSU admission SAT score consists of a 574 SAT Math score and a 569 SAT Critical Reading score. The national average test scores were published on the ACT and SAT websites. ACT Profile Report – National Graduating Class 2014 http://www.act.org/content/dam/act/unsecured/documents/Natl-Scores-2014-National2014.pdf. SAT® Percentile Ranks for Males, Females, and Total Group "2014 College-Bound Seniors – Critical Reading + Mathematics" https://secure-media.collegeboard.org/digitalServices/pdf/sat/sat-percentile-ranks-composite-crit-reading-math-2014.pdf

[10]Source: CSU The Fact Book 2014-15, https://wsnet.colostate.edu/cwis36/pdf/fbk/1415/2014_15_Fact_Book.pdf, accessed October 19, 2016.

[11] The gender distribution and the GPAs of students who withdrew from the classes areindistinguishable across treatment and control groups.

economics major or minor, and only 16 percent (20 percent of males and 11 percent of females) expressed a personal interest in economics.[12] The summary statistics of student characteristics and baseline survey results by treatment group are detailed in Table A1. Students in the *Treated* group (combining partial and treated groups) are observationally similar to their counterparts in the control group regarding their class standing, gender, GPA, and ACT score, as well as their responses to all the subjective questions from the baseline survey.

However, notable differences are present across sex (Table A2). On average, women entered the class with a higher GPA (female: 3.21 and male: 3.00), but male students subjectively expected to earn a higher grade from the class (male: 3.61 and female: 3.54). Compared with all other college graduates with a bachelor's degree in economics, male students ranked themselves 2.50 points higher than did female students on a scale from 0 to 100 (0 is the lowest, and 100 is the highest) for their ability (male: 66.99; and female: 64.49). The self-reported probability that female students would major in economics was 3.29 percentage points lower than that of the male students (female: 12.6%, male: 15.9%). Compared to male students, female students predicted spending 1.32 more hours on coursework per week if they were to major in economics and predicted having a 3.65 percentage points higher probability of finding a job immediately upon graduation with an economics degree.

Female students were less likely than their male counterparts to look forward to studying economics and found economics more difficult when they entered the class. Female students believed that economics courses require too much math but concurrently felt that they possessed the required mathematics skills to succeed in economics. Although both female and male students agreed that female economics majors are as likely as male economics majors to succeed in the

[12] The reasons for students to enroll in these introductory classes are not mutually exclusive, and many students indicated multiple reasons for registering in these classes.

major and in a future career in economics, female students were much less optimistic than their male counterparts regarding their *own* probability of success in the economics major and were less certain about the types of jobs available for economics majors. Female students were also more aware of the fact that female students are not as likely as male students to major in economics (Table A2).

4.2. Attrition Bias?

Although the participation rate in the first wave of the survey was high among the 829 students who attended the class (more than 95 percent), only 450 students (54.3 percent) participated in both surveys (including 187 females and 263 males) and constitute the final sample. The attrition was driven by low attendance towards the end of the semester. Among students who attended both recitation meetings, the participation rate for the W2 survey was higher than 91 percent. Students who participated in both surveys had a slightly higher GPA (0.24 and 0.25 points higher in the control and treated groups, respectively) than those who did not participate in both surveys. If the attrition is orthogonal to treatments, reweighting the sample to represent the original sample produces unbiased estimates for the treatment effects. To examine whether attrition is random by treatments, I regress an indicator of attrition on treatments conditional on students' characteristics, including their sex, high school GPA, college GPA, ACT composite score, declaration of economics as their major upon entering the class, and class standing. Although students with low college GPAs are more likely to drop out from the sample, the coefficients on the treatment indicators are indistinguishable from zero (Table A3) – indicating that attrition is conditionally independent across treatments. To correct for the over-representation of high-performing students in the final sample, I re-weigh the sample by grade and treatment assignments to represent the

attendants in the beginning of the semester.[13]Among the 450 undergraduate students in the final sample, 152 students are in the control group, 141 are in the partial treatment group, and 157 are in the full treatment group. Because male students in the partial and full treatment groups received the same level of treatment of information provision (T_1), Table 1 reports the combination of their observations under the *Treated* group. Among these 450 students, 386 students (85.8%) had high school GPA information, 427 (94.9%) had college GPAs upon entering these classes, and 358 (79.6%) had ACT composite scores.

4.3. Selection Bias?

Typically, students enrolled in the class had considered the schedule conflicts of other classes they were taking during the same semester. The class schedules across different colleges and department are usually uncoordinated and hence create a certain randomness in terms of class schedules available for an individual student. However, given the limited choices of class schedules, one may still worry about potential self-selection into recitation classes as long as students have the latitude to choose specific sections to attend. For instance, if a group of students with similar characteristics (e.g., motivated in learning economics) enrolled in the same class so they could take it together, and these classes happened to be assigned to the *Treated* group, the treatment effect may be spurious. The direction of the bias is ambiguous since recitation sections may be assigned to the treatment or control groups. To investigate potential selection bias, Table A4 shows whether any observable student characteristics vary across treatment assignments by regressing the treatments (*Treated* in the regression analysis in Column 1, *Partial* and *Full*

[13]Weighting is implemented by treatment and grade (i.e., above or below the median) to represent the class attendants. For instance, among 286 students in the full treatment group during the first wave of the survey, 146 students (51.05%) earned a midterm grade at or above the median, and 140 (48.95%) were below the median. Conversely, among 157 students in the full treatment group who answered both waves of survey, 86 students (54.78%) scored a midterm grade above the medium and 71 students (45.22%) were below the median. Therefore, each respondent with a midterm grade at or above the median is weighted as 1.7 (=146/86) and each respondent with a grade below the median is weighted as 1.97 (=140/71). Weights are also applied following the same method for the partial treatment and control groups.

treatments in the multinomial logit regression in Column 2) on all observable student characteristics. The large *p*-values of the *F*-tests indicate that these observable student characteristics do not vary across treatments; hence, the treatment assignments appear to be random conditional on student characteristics.

5. Empirical Results

5.1. Declaration of Economics as a Major

To assess how the treatments affect students' outcomes, I tracked whether they declared economics as their major in the following year. Because the cost of switching majors increases as students progress in college, it is likely that treatment effects, if present, would be most salient among students in the lower classes (sophomores and freshmen). Table 2 presents the treatment effects separately for 1) all students across class standings, and 2) the lower classes (freshmen and sophomores) to examine whether students in the *Treated* group (including *Partial* and *Full* treatment groups) are more likely to declare economics as their major in the subsequent year. All the analyses in Table 2 control for students' class standing, their declaration of economics as their major upon entering the class, and sex and individual effects of the instructors and TAs. The results are reported separately by sex and students' grade (Median^{+} and Median^{-}). Column 1 of Table 2 shows that the treatments do not have any effect on female students' propensity to declare economics as their major on average. Conversely, the information treatment appears to reduce male students' likelihood of declaring economics as their major by 2.67 percentage points. The effect is larger (-5 percentage points) among male students in the lower classes (i.e., freshmen and sophomores). Because male students in the treated group received information about careers in the economics profession as well as the grade distribution information with no nudges, the negative effect is likely attributable to their reaction to the grade information. Similar to the findings in

Stinebrickner and Stinebrickner (2012, 2014), students were overly optimistic about their grade performance upon entering the class. The overconfidence is particularly pronounced among male students. On average, male students overestimated their grade (measured by the difference between their grade expectation from the first wave and their midterm grade) by 1.05 grade points (based on 0-4 grade points), compared to 0.929 points of overestimation by female students. Therefore, the grade distribution information may have caused them to realize how poor their actual performance was compared to their peers and hence discouraged them from majoring in economics. Although the *F*-test results in Table A4 show that student characteristics do not vary across treatments, I include students' college GPA, high school GPA, and ACT composite score as additional controls in the analysis in Column 2 to check the sensitivity of the estimates. Note that the sample size is reduced when these additional covariates are included due to the missing data for students who transferred from other colleges or enrolled in the class in their first semester at CSU. There is still no discernable treatment effect on female students after controlling for GPAs and ACT scores, but the negative treatment effect on male students becomes insignificant. The negative effect on male freshmen and sophomores remains significant, but the magnitude is reduced to – 3.3 percentage points.

To investigate whether the treatment effects are heterogeneous by students' grade, analyses were implemented separately for students above (Median^{+}) or below (Median^{-}) the median grade. Columns 3 and 4 focus on students whose grades were above the median, and Columns 5 and 6 analyze students whose grades were below the median. Compared with Columns 3 and 5, Columns 4 and 6 include students' college GPA, high school GPA, and ACT score as additional covariates. The results show that the treatment increased the probability of majoring in economics by 5.41 percentage points (or 6.27 percentage points when GPAs and ACT scores are controlled for) for

female students above the median grade (Median^{+}). This effect is larger among female freshmen and sophomores at 11.2 percentage points (or 12.6 percentage points when GPAs and ACT scores are controlled for). The treatment has no effect on female students whose grades were below the median (Median^{-}) and male students whose grades were above the median (Median^{+}). The negative treatment effect on male students seem to be driven primarily by the results of male students with grades below the median, which is plausible due to the revelation regarding their poor performance in class when they received the grade distribution information. The results show that the treatments may have substantial heterogeneous effects by sex and grade. Indeed, the difference-in-differences estimatess confirmed that the treatment has different effects for men and women whose grades were above the median. If women are similar to men and the provision of information on economics career and class grade distribution (T_1) had no effect (from the treatment effects on male students above the median), the positive treatment effects would have been a result of nudges (T_2) and partially from mentoring (T_3). This assumption may be too strong if women are more sensitive to grade information, as evident in prior studies (Horvath et al., 1992; Rask and Tiefenthaler, 2008; Owen, 2010; Goldin, 2015). Notably, both men and women below the median experienced slightly negative treatment effects, although most of the effects are imprecise and insignificant. Additionally, the treatment effects on students below the median (Median^{-}) do not appear to vary across gender.

Female students in the *Full* and *Partial* treatment groups received different levels of treatments. Compared with women in the *Partial* treatment group, female students in the *Full* treatment group received an additional mentoring intervention. To examine the effects separately, Panels A and B of Table 3 includes female students in the *Control*, *Partial* treatment, and *Full* treatment groups in one regression analysis and reports the treatment effects for the *Partial* and

Full treatment groups compared to the *Control* group. Similar to the results from Table 2, there is no observable treatment effect on average female students from Columns 1 and 2. The effects on female students above the median also become insignificant (Columns 3 and 4), but the *F*-tests show that the treatment effects are statistically indistinguishable between the *Partial* and *Full* treatment groups. The result suggests that mentoring does not appear to have any effect on female students' major outcome. This indeterminate result is likely attributable to a low participation rate (5.35%) in the mentoring activities. The treatment effects on female students below the median is negative, but the estimates are not significantly different from zero (Columns 5 and 6).

Panel B of Table 3 reports the results for female students who are freshmen or sophomores. A positive treatment effect is observed among the female freshmen and sophomores whose grades were above the median in both the *Partial* and *Full* treatment groups (Columns 3 and 4 of Panel B). The results confirm that high-performing female students in their freshmen and sophomore years are the most responsive to the treatments.

To further investigate potential heterogeneity in treatment effects across courses (microeconomics and macroeconomics), reasons for taking the course (fulfilling requirements by other majors, fulfilling economics major requirements, or personal interest in economics), and major declaration upon entering the course (economics major, business major, sciences and engineering major, liberal arts major, and undeclared) for female students above the median (Column 4 of Panels A and B), I allow these varying factors to interact with the treatment. None of the interaction terms are significantly different from zero, and the *F*-tests also fail to reject the hypothesis that all the interaction terms have zero coefficients jointly. The gender composition in economics majors in the sample changed from an initial 14.3 percent female before the treatment

to 33.3 percent female after the treatment (22.2 percent female in the control group and 41.7 percent female in the treated group).[14]

5.2. Economics Course-taking

Focusing now on the subsequent economics courses taken by students, Table 4 reports the treatment effects on the cumulative number of economics courses taken by students since the interventions. Given that the treatment effects are indistinguishable between the *Partial* and *Full* treatment groups, subsequent analyses focus on the *Treated* group (including both the partial and full treatment groups) as a whole. Since the results are similar whether GPAs and ACT scores are controlled for, Table 4 presents the treatment effects using a more rigorous specification that controls for students' academic performance (college GPA, high school GPA, and ACT score). Students who already declared economics as their major before the intervention are likely to continue taking additional economics courses regardless of whether they received the treatments. To tease out the influence from these economics majors, Columns 1, 3, and 5 include an indicator for students who already declared economics as their major when they enrolled in the introductory courses. Similar to the major declaration results, there is no discernable effect on female students' economics course-taking at the aggregate level (Column 1); however, it increases the number of economics courses taken by female students whose grades were above the median by 0.357 courses (Column 3 of Panel A). The effect is even larger among the female freshmen and sophomores above the median; the treatment causes them to take 0.681 more courses on average (Column 3 of Panel B). The results are similar using an alternative Poisson model.[15] There is no statistically significant treatment effect (Column 1 of Panel C) on male students as a whole. However, the

[14] The result that women account for 22.2 percent among the economics majors in the control group is in line with the statistics before the treatment. In fall 2015, women made up 23.95 percent of students who declared economics as their primary major.
[15] The Poisson model estimates that the treatments increase the number of additional economics courses taken by women in the Median+ group by 0.337 courses and by 0.781 courses among female freshmen and sophomores in the Median+ group.

treatment reduces the economics courses taken by male students in the lower classes by 0.351 courses on average (Column 1 of Panel D). This negative effect is driven by the negative results among male students whose grades were above the median; it reduces the courses taken by these students by 0.325 courses on average across class standings (Column 3 of Panel C) and by 0.452 courses on average among freshmen and sophomores (Column 3 of Panel D). There is no significant treatment effect on course-taking among students whose grades were below the median (Columns 5 and 6). The heterogeneous effects are most likely driven by the different treatment effects on students' major choices that varied by gender. Tables 2 and 3 show the treatment effects on economics major declaration are positive for females above the median and negative for male students; the change in students' propensity to major in economics may have resulted in the difference in their subsequent course-taking patterns.

To investigate whether this effect on course-taking extends beyond the treatment effect on the major declaration, Columns 2, 4, and 6 include an indicator for students who eventually declared economics as their major one year later. After controlling for the eventual economics major declaration, the treatment effects are drastically reduced and become insignificant for female students. However, the negative effects for male students whose grades were above the median are persistent beyond their major choices (Column 4 of Panels C and D), and the results are similar using an alternative Poisson model.[16] Although these male students performed well in the class from an objective standard, they may have perceived it negatively by their own subjective standard when they realized they did not perform as well as initially expected.

The above analyses focusing on the number of courses taken by students capture the effect on the intensive margin. To examine whether the treatment has any effect on the extensive margin, I

[16] The treatment effect is – 0.343 courses for male students above the median and – 0.37 courses for male freshmen and sophomores above the median when the declaration of economics as their major one year after the treatment is controlled for in the Poisson regression.

replace the dependent variable from the number of courses taken by students to an indicator for students who took *any* additional economics courses in the subsequent year and report the results in Table 5. The results show no treatment effects on male students, but a positive effect on female students whose grades were above the median. The treatments increase the likelihood of female students above the median to take additional economics courses by 16 percentage points (Column 3 of Panel A in Table 5) and the likelihood of female freshmen and sophomores above the median to take more economics credits by 27.1 percentage points (Column 3 of Panel B in Table 5). The results are similar in an alternative logit model, which predicts a 15.2-percentage-point increase in probability for female above the median and a 23.6-percentage-point increase in probability for female freshmen and sophomores above the median to take additional economics courses. After controlling for students' declaration of economics as their major one year later, female freshmen and sophomores above the median are still 16.5 percentage points more likely to take additional economics courses. However, this result is sensitive, and the effect disappears when an alternative logit model is used. The treatment effects on high-performing female students' increase in economics course- taking are primarily attributable to the fact that the treatments induced them to declare economics as their major.

5.3. Mechanisms of the Treatment Effects

To understand how students' subject assessment aligns with their actual behaviors, Table 6 presents the estimation of the treatment effects on students' subjective probability of majoring in economics specified in Equation (2). The results show that the subjective probability is persistent, and a student's prior belief is a stronger predictor for males than for females. For each one percentage point in the indicated probability of majoring in economics by respondents in the W1 survey, 0.717 percentage point carries through to the next wave for males, and 0.629 percentage

point carries through for females. The influence of the prior belief is less persistent among female freshman and sophomores but stronger among male students in the lower classes. This result implies that women may be more likely to update their beliefs when they receive new information throughout the course. The average treatment effect is statistically insignificant for both men and women. However, similar to the results from Table 2, the treatment effect is only discernable among female students above the median grade. The overall effect is a 10.1-percentage-point increase in the students' subjective probability of majoring in economics and a 14.63-percentage-point increase for freshmen and sophomores if the female students had a midterm grade above the median. Although the coefficients on *Treated* are negative for male students above the median, they are not significantly different from zero.

To understand the mechanisms of the change in students' probability of majoring in economics, I regress students' subjective probability of majoring in economics in the second wave (Pr(*EconMajor*|*W2*)) on their subjective probability of majoring in economics in the first wave (Pr(*EconMajor*|*W1*)), the change in their expected grade from the class, and the changes in responses to other survey questions, after controlling for students' college GPA, high school GPA, ACT composite score, economics major declaration upon entering the class, class standing, and the sex and fixed effect of instructors and TAs. The results in Table 7 indicate that an increase in a student's enjoyment of economics coursework and career are positively correlated with an increase in the probability of majoring in economics, consistent with the findings by Zafar (2013) and Wiswall and Zafar (2015).

Column 2 of Table 7 shows the analysis based on another set of subjective questions rated on a traditional Likert scale measure; students were asked to indicate their agreement with certain statements between 0 (strongly disagree) and 10 (strongly agree). Students who indicate strong

agreement with the statements "I look forward to studying economics," "I have the required math skills to succeed in economics," and "I can succeed majoring in economics" are more likely to major in economics. An increase in agreement with the statement "economics courses are difficult" results in a lower subjective probability for students to major in economics.

If these aforementioned factors are the treatment mechanisms, the treatments should have resulted in changes in these factors among the female students whose grades were above the median. Table 8 shows that the treatment increases agreement to the statement "I look forward to studying economics" among female students *above* the median (Median^{+}). Conversely, it reduces the subjective probability of course enjoyment and agreement to the statement "I look forward to studying economics" among female students *below* the median (Median^{-}). This result suggests that the intervention increases (decreases) high (low)-ability female students' subjective interest in the economics courses and led to more (fewer) economics major declarations and courses taken. For male students above the median, the treatments boost their confidence in their mathematical skills; however, the treatment does not have an effect on male students below the median. The subjective measures provide few clues regarding the mechanism for the negative effects on male students.

6. Conclusions

The treatment effect of interventions on female students with grades above the median is substantial. The treatments increase the probability of these female students majoring in economics by 5.41 – 6.27 percentage points. The effects are even larger for freshmen and sophomores among these high-performing female students, who are 11.2 – 12.6 percentage points more likely to declare economics as their major. Peer mentoring does not appear to have discernable effects on female students' declaration of economics as their major because the participation rate is negligible.

As a result, the positive treatment effect is most likely attributable to the information provision and nudges. The treatments also increase the likelihood and the number of additional economics courses taken by these female students, but the results are primarily driven by the increase in their declaration of economics as their major. Because the treatments were conducted in the recitation classes sessions, the results represent the treatment effect on the treated (those who attended the classes and hence received the treatments) rather than the average treatment effect. Nevertheless, the results still provide valuable insight given that students who actually attended economics courses were much more likely to be future majors and hence should be the targeted students for any recruitment efforts under a budget constraint. Given the large treatment effect of the low-cost interventions, better information on economics with nudges that target female students above the median may be a cost-effective means of reducing the gender gap in economics majors.

Although the research results are promising, they do not allow me to disentangle the effects of the nudge and the information intervention for the targeted high-ability women due to potential heterogeneous treatment effects of information intervention on women with varying grades or differential effects across gender. Future research that separately identifies these mechanisms would provide new information regarding the path to gender-neutral disciplines. Understanding the precise mechanisms is crucial in tackling the core problem of the under-representation of females in STEM fields and may have direct policy implications for a broader application to fields that are traditionally dominated by males. Additionally, in this field, it may be beneficial to experiment with varying degrees of intervention intensity and examine whether repeated interventions augment gains in achieving a more gender-diverse field.

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Table 1. Treatment assignments

Sex	Treatment Group		Observations	Midterm Grade	Treatments		
					T1	T2	T3
Men	Treated		175	All	No	Yes	No
	Control		88	All	No		
Women	Treated	Full	65	Median^{+}	Yes	Yes	Yes
				Median^{-}	Yes	No	Yes
		Partial	58	Median^{+}	Yes	Yes	No
				Median^{-}	Yes	No	No
	Control		64	All	No		

Table 2. Treatment effects on economics major declaration

	Dependent variable: Economics major by the end of 2017 spring semester (0/1)							
	All Grades		Median^{+}		Median^{-}		Difference-in-differences (Median^{+} − Median^{-})	
	[1]	[2]	[3]	[4]	[5]	[6]	[3] - [5]	[4] - [6]
A. Female, all class standings								
Treated group	0.00968	0.0147	0.0541*	0.0627*	-0.0487	-0.0825	0.103*	0.145*
	(0.0228)	(0.0308)	(0.0314)	(0.0359)	(0.0413)	(0.0669)	(0.0540)	(0.0775)
Controls for student college GPA, high school GPA, and ACT composite score.	N	Y	N	Y	N	Y	N	Y
Observations	187	157	119	100	68	57	187	157
B. Female, freshman and sophomore only								
Treated group	0.0240	0.0384	0.112**	0.126**	-0.115	-0.200	0.227**	0.326**
	(0.0377)	(0.0512)	(0.0547)	(0.0600)	(0.0989)	(0.157)	(0.111)	(0.158)
Controls for student college GPA, high school GPA, and ACT composite score.	N	Y	N	Y	N	Y	N	Y
Observations	136	117	90	78	46	39	136	117
C. Male, all class standings								
Treated group	-0.0267*	-0.0274	-0.00926	-0.0264	-0.0376*	-0.0398	0.0284	0.0134
	(0.0147)	(0.0163)	(0.0212)	(0.0233)	(0.0194)	(0.0329)	(0.0268)	(0.0355)
Controls for student college GPA, high school GPA, and ACT composite score.	N	Y	N	Y	N	Y	N	Y
Observations	263	184	159	113	104	71	263	184
D. Male, freshman and sophomore only								
Treated group	-0.0500***	-0.0330*	-0.0306	-0.0310	-0.0617**	-0.0528	0.0311	0.0218
	(0.0172)	(0.0166)	(0.0217)	(0.0252)	(0.0274)	(0.0423)	(0.0340)	(0.0447)
Controls for student college GPA, high school GPA, and ACT composite score.	N	Y	N	Y	N	Y	N	Y
Observations	201	156	120	93	81	63	201	156
Difference-in-differences (Female – Male) [A] – [C]	0.0364	0.0420	0.0634*	0.0891*	-0.0110	-0.0426		
	(0.0242)	(0.0368)	(0.0370)	(0.0465)	(0.0477)	(0.0724)		
Difference-in-differences (Female – Male) [B] – [D]	0.0741*	0.0714	0.143**	0.157**	-0.0531	-0.147		
	(0.0408)	(0.0538)	(0.0591)	(0.0674)	(0.0990)	(0.150)		

* p < 0.10 ** p < 0.05 *** p <0.01. Standard errors are clustered at the recitation level. Each column in each panel reports the coefficients on *Treated* from a separate regression; the panels show the different outcomes for female and male students by midterm grade. "Median^{+}" restricts the analyses to students whose midterm grade were at or above the median, and "Median^{-}" focuses on those whose midterm grades were below the median. The analysis controls for students' class standing, economics major declaration entering the class, and the sex and fixed effects of instructors and TAs. The last two columns represent the difference-in-differences estimates of the treatment effects across grades. The last two rows represent the difference-in-differences estimatess of the treatment effects across gender. Sample weights are applied.

Table 3. Treatment effects on female students' economics major declaration

	Dependent variable: Economics major by the end of 2017 spring semester (0/1)					
	All Grades		Median^{+}		Median^{-}	
	[1]	[2]	[3]	[4]	[5]	[6]
A. Female, all class standings						
Partial treated group	0.0129	0.00916	0.0434	0.0446	-0.0587	-0.107
	(0.0271)	(0.0343)	(0.0266)	(0.0337)	(0.0493)	(0.0811)
Full treated group	0.00709	0.0196	0.0684	0.0902	-0.0396	-0.0598
	(0.0223)	(0.0321)	(0.0461)	(0.0534)	(0.0355)	(0.0520)
Controls for student college GPA, high school GPA, and ACT composite score.	N	Y	N	Y	N	Y
F-test: Partial = Full (*p*-value)	0.753	0.675	0.489	0.345	0.466	0.288
Observations	187	157	119	100	68	57
B. Female, freshman and sophomore only						
Partial treated group	0.0166	0.0227	0.0977**	0.111*	-0.150	-0.243
	(0.0407)	(0.0519)	(0.0469)	(0.0559)	(0.126)	(0.183)
Full treated group	0.0314	0.0555	0.139*	0.151*	-0.0821	-0.141
	(0.0389)	(0.0546)	(0.0747)	(0.0749)	(0.0745)	(0.119)
Controls for student college GPA, high school GPA, and ACT composite score.	N	Y	N	Y	N	Y
F-test: Partial = Full (*p*-value)	0.545	0.246	0.334	0.391	0.305	0.279
Observations	136	117	90	78	46	39

* p < 0.10 ** p < 0.05 *** p <0.01. Standard errors are clustered at the recitation level. Analyses focus on female students because male students in the treatment group receive indistinguishable treatments. "Median^{+}" restricts the analyses to students whose midterm grades were at or above the median, and "Median^{-}" focuses on those whose midterm grades were below the median. All the analyses include female students from the control, partial treated, and full treated groups. The omitted reference group is the control group. The analysis controls for students' class standing, economics major declaration entering the class, and the sex and fixed effects of instructors and TAs. Sample weights are applied.

Table 4. Treatment effects on number of economics courses taken

	Dependent variable: Number of additional economics courses taken by the end of 2017 spring semester					
	All Grades		Median^{+}		Median^{-}	
	[1]	[2]	[3]	[4]	[5]	[6]
A. Female, all class standings						
Treated group	0.0468	-0.0260	0.357*	0.0827	-0.708	-0.0355
	(0.216)	(0.122)	(0.200)	(0.0892)	(0.602)	(0.172)
Control for student economics declaration by end of 2017 spring semester	N	Y	N	Y	N	Y
Observations	157	157	100	100	57	57
B. Female, freshman and sophomore only						
Treated group	0.0922	-0.110	0.681**	0.127	-1.587	0.107
	(0.364)	(0.181)	(0.332)	(0.130)	(1.387)	(0.396)
Control for student economics declaration by end of 2017 spring semester	N	Y	N	Y	N	Y
Observations	117	117	78	78	39	39
C. Male, all class standings						
Treated group	-0.210	-0.129	-0.325**	-0.233*	-0.0768	0.0218
	(0.131)	(0.124)	(0.127)	(0.124)	(0.464)	(0.409)
Control for student economics declaration by end of 2017 spring semester	N	Y	N	Y	N	Y
Observations	184	184	113	113	71	71
D. Male, freshman and sophomore only						
Treated group	-0.351**	-0.241*	-0.452**	-0.328*	-0.332	-0.214
	(0.150)	(0.136)	(0.185)	(0.161)	(0.399)	(0.324)
Control for student economics declaration by end of 2017 spring semester	N	Y	N	Y	N	Y
Observations	156	156	93	93	63	63

* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$. Standard errors are clustered at the recitation level. Each column in each panel reports the coefficients on *Treated* from a separate regression; the panels show the different outcomes for female and male students by midterm grade. "Median^{+}" restricts the analyses to students whose midterm grade were at or above the median, and "Median^{-}" focuses on those whose midterm grade were below the median. The analysis controls for students' class standing, economics major declaration entering the class, college GPA, high school GPA, and ACT composite score, and the sex and fixed effects of instructors and TAs. Sample weights are applied.

Table 5. Treatment effects on the likelihood of taking any additional economics courses

	Dependent variable: Indicator for ever taking other econ courses in a year (0/1)					
	All Grades		Median^{+}		Median^{-}	
	[1]	[2]	[3]	[4]	[5]	[6]
A. Female, all class standings						
Treated group	0.112	0.0998	0.160**	0.101	-0.107	-0.0100
	(0.0872)	(0.0771)	(0.0732)	(0.0640)	(0.188)	(0.165)
Control for student economics declaration by end of 2017 spring semester	N	Y	N	Y	N	Y
Observations	157	157	100	100	57	57
B. Female, freshman and sophomore only						
Treated group	0.163	0.129	0.271***	0.165**	-0.169	0.119
	(0.110)	(0.0938)	(0.0883)	(0.0773)	(0.402)	(0.393)
Control for student economics declaration by end of 2017 spring semester	N	Y	N	Y	N	Y
Observations	117	117	78	78	39	39
C. Male, all class standings						
Treated group	-0.0646	-0.0455	-0.0458	-0.0235	-0.0422	-0.0194
	(0.0694)	(0.0693)	(0.0700)	(0.0675)	(0.135)	(0.128)
Control for student economics declaration by end of 2017 spring semester	N	Y	N	Y	N	Y
Observations	184	184	113	113	71	71
D. Male, freshman and sophomore only						
Treated group	-0.111	-0.0891	-0.0492	-0.0249	-0.137	-0.110
	(0.0665)	(0.0672)	(0.0819)	(0.0770)	(0.112)	(0.104)
Control for student economics declaration by end of 2017 spring semester	N	Y	N	Y	N	Y
Observations	156	156	93	93	63	63

* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$. Standard errors are clustered at the recitation level. Each column in each panel reports the coefficients on *Treated* from a separate regression; the panels show the different outcomes for female and male students by midterm grade. "Median^{+}" restricts the analyses to students whose midterm grade were at or above the median, and "Median^{-}" focuses on those whose midterm grade were below the median. The analysis controls for students' class standing, economics major declaration entering the class, college GPA, high school GPA, and ACT composite score, and the sex and fixed effects of instructors and TAs. Sample weights are applied.

Table 6. Treatment effect on subjective probability of majoring in economics, by sex

Dependent variable: Probability majoring in economics, follow-up survey (Pr(*EconMajor*|W2))

	(1) All	(2) Median+	(3) Median-
A. Female, all class standings			
Probability majoring in econ, W1	0.629***	0.585***	0.630**
	(0.137)	(0.176)	(0.251)
Treated Group	5.488	10.10**	-5.806
	(3.326)	(4.708)	(4.242)
Observations	155	98	57
B. Female, freshman and sophomore			
Probability majoring in econ, W1	0.581***	0.478***	0.649**
	(0.143)	(0.160)	(0.294)
Treated Group	7.893*	14.63**	-11.54
	(4.404)	(6.501)	(10.29)
Observations	115	76	39
C. Male, all class standings			
Probability majoring in econ, W1	0.717***	0.773***	0.695***
	(0.0750)	(0.0621)	(0.163)
Treated Group	0.0634	-0.118	7.899
	(2.737)	(2.438)	(6.884)
Observations	180	111	69
D. Male, freshman and sophomore			
Probability majoring in econ, W1	0.728***	0.813***	0.707***
	(0.0922)	(0.0829)	(0.167)
Treated Group	-1.276	-2.092	7.285
	(2.894)	(3.350)	(6.899)
Observations	154	92	62

* p < 0.10 ** p < 0.05 *** p <0.01. Standard errors are clustered at the recitation level. Each column in each panel reports the coefficients on *Treated* from a separate regression; the panels show the different outcomes for female and male students by midterm grade. "Median^{+}" restricts the analyses to students whose midterm grade were at or above the median, and "Median^{-}" focuses on those whose midterm grade were below the median. The analysis controls for students' class standing, economics major declaration entering the class, college GPA, high school GPA, and ACT composite score, and the sex and fixed effects of instructors and TAs. Sample weights are applied.

Table 7. Mechanisms of the changes in students' subjective probability of majoring in economics

Dependent Variable: Pr(EconMajor|W2)

	[1]		[2]
Pr(EconMajor|W1)	0.559***	Pr(EconMajor|W1)	0.539***
	(0.0878)		(0.0850)
E(Grade)	-0.601	E(Grade)	0.531
	(1.892)		(1.571)
Pr(Graduate in 4 years)	0.0542	Look forward to studying econ	1.856***
	(0.0595)		(0.488)
Pr(GPA>3.0)	0.00968	Econ is difficult	0.915*
	(0.0537)		(0.475)
Pr(Enjoy coursework)	0.124***	Econ is boring	-0.754
	(0.0429)		(0.633)
E(Study hours per week)	0.161	Econ requires too much math	-0.622
	(0.132)		(0.674)
Pr(Family approval)	0.000191	Have math skills to succeed in econ	-1.252**
	(0.0606)		(0.584)
Pr(Find a job upon graduation)	-0.0175	Econ is too theoretical	0.479
	(0.0684)		(0.297)
Pr(Go to graduate school)	0.0142	Econ has wide career paths	0.143
	(0.0366)		(0.523)
E(Ability ranking)	-0.0809	Know what econ jobs available	0.329
	(0.0697)		(0.370)
E(Population earnings upon graduation)	-7.58e-05	I can succeed in econ	1.035***
	(8.84e-05)		(0.258)
E(Personal earnings upon graduation)	0.000103	Females as likely as males to major in econ	-0.316
	(0.000122)		(0.346)
Pr(Enjoy work at age 35)	0.170***	Females as likely as males to succeed in econ major	-0.107
	(0.0461)		(0.560)
Pr(Balance work and life at age 35)	-0.0929	Females as likely as males to succeed in econ career	-0.00642
	(0.0817)		(0.820)
E(Work hours per week)	0.0712		
	(0.146)		
E(Personal earnings at age 35)	4.24e-05		
	(6.82e-05)		
Observations	271		323

* p < 0.10 ** p < 0.05 *** p <0.01. Standard errors are clustered at the recitation level. The analysis controls for students' class standing, economics major declaration entering the class, college GPA, high school GPA, and ACT composite score, and the sex and fixed effects of instructors and TAs. Unless otherwise specified, covariates reported in the table are from the second wave of the survey. Sample weights are applied.

Table 8. Effect of *Treated* on other female subjective measures

Dependent variable:	Coefficient on *Treated*	Standard Error	Observations
A. Female students, Median^{+}			
Pr (Enjoy coursework)	-2.967	(4.792)	96
Pr (Enjoy work at age 35)	-3.425	(3.711)	95
Look forward to studying econ	0.812**	(0.333)	100
Econ is difficult	0.0597	(0.465)	99
Have math skills to succeed in econ	-0.272	(0.382)	100
I can succeed majoring in econ	0.211	(0.651)	99
B. Female students, Median^{-}			
Pr (Enjoy coursework)	-18.64*	(9.621)	56
Pr (Enjoy work at age 35)	-6.656	(9.532)	52
Look forward to studying econ	-1.655*	(0.912)	56
Econ is difficult	-0.141	(0.670)	56
Have math skills to succeed in econ	0.166	(0.418)	57
I can succeed majoring in econ	-0.747	(0.633)	54
C. Male students, Median^{+}			
Pr (Enjoy coursework)	4.25	(2.909)	111
Pr (Enjoy work at age 35)	2.515	(3.213)	109
Look forward to studying econ	-0.00225	(0.305)	112
Econ is difficult	0.311	(0.357)	112
Have math skills to succeed in econ	0.612***	(0.252)	113
I can succeed majoring in econ	-0.279	(0.334)	107
D. Male students, Median^{-}			
Pr (Enjoy coursework)	-7.484	(4.436)	69
Pr (Enjoy work at age 35)	5.551	(4.955)	68
Look forward to studying econ	0.69	(0.553)	70
Econ is difficult	0.435	(0.344)	70
Have math skills to succeed in econ	-0.474	(0.337)	70
I can succeed majoring in econ	0.298	(0.709)	68

* $p < 0.10$ ** $p < 0.05$ *** $p < 0.01$. Standard errors are clustered at the recitation level. The dependent variables are from the second wave of the survey. "Median^{+}" restricts the analyses to students whose midterm grade were at or above the median, and "Median^{-}" focuses on those whose midterm grade were below the median. The analysis controls for the student's subjective belief from the first wave, students' class standing, economics major declaration entering the class, college GPA, high school GPA, and ACT composite score, and the sex and fixed effects of instructors and TAs. Sample weights are applied.

Who We Are

The Undergraduate Women in Economics (UWE) is a nation-wide organization that focuses on shrinking the 3 to 1 men to women ratio in economics departments across the country. CSU has an even wider gender gap of 5 to 1 men to women in the program currently.

The CSU chapter of UWE strives to reach out to women not yet a part of the program in hopes of shrinking the gender gap and bringing more diversity of thought, background, and experiences to the Economics program.

What We Do

Members of UWE participate in many outreach opportunities and events that appeal to and support women that show an interest in possibly pursuing a degree in Economics. The women of UWE serve as ambassadors of the Economics school and have the opportunity to work closely with staff and department heads to improve the inclusivity and outreach towards women.

Want to be an ambassador of the Economics department? Want to share your CSU story with prospective Economics majors? Want to mentor women in Principles courses?

A Little About Econ!

Economics ranked **15 out of 129** college majors based on entry level and mid-career salary

Economics Starting Salary: **$50,100**

Economics Mid-Career Salary: **$96,700**

- According to the 2013-2014 Payscale College Salary Report

Economics majors go on to pursue a wide range of career goals! Talk to our officers to get a taste of the diversity of career options available for students with an Economics Degree!

Interested?

UWE welcomes men and women with Economics majors or minors to join the effort in combating the gender gap in Economics!

If you are interested in becoming a member of UWE and making a difference in your area of study, contact us via email at uwecoloradostate@gmail.com

Follow Us!

Facebook: CSU Undergraduate Women in Economics
Twitter: UWEcolostate
Email: uwecoloradostate@gmail.com

UNDERGRADUATE WOMEN IN ECONOMICS
Colorado State University

BE ONE OF MANY STUDENTS THAT ARE MAKING A DIFFERENCE

Colorado State University

Appendix B. Grade Distribution Message without Nudges

Dear student,

To help students enrolled in Econ 202/204 understand their standing in class, the crude grade (in % of points) percentile distribution of tasks on Canvas at this point is provided below. The grade distribution is based on the percentage points students earned in the class. Suppose the total points possible is 1000 at this point, and a student earned 850 points so far -- the student's score is 85%. Referencing to the grade distribution, this student's grade is between 90th and 95th percentiles — meaning the student does better than at least 90% of the students in the class. You may look up your current score (in %) on Canvas and refer to the grade distribution to see how relatively well you are doing comparing to your peers in the class.

If you have questions regarding how to understand the grade distribution, please feel free to let me know.

95th Percentile	90th Percentile	75th Percentile	50th Percentile	25th Percentile	10th Percentile
87.6	84.5	79.7	74.3	67.8	61.8

Appendix C. Grade Distribution Message with Nudges

Dear student,

To help students enrolled in Econ 202/204 understand their standing in class, the crude grade (in % of points) percentile distribution of tasks on Canvas at this point is provided below. According to the percentile distribution, you currently rank above the 90th (or 75th, or 50th) percentile. In other words, you **OUTPERFORM more than 90% (or 75%, or 50%)** of your classmates in the class! **Congratulation!!!** Based on your **strong performance** in class, on behalf of the Department of Economics, I'd like to encourage you to consider **majoring in economics**. If you would like to explore the opportunity or have any question about majoring in economics, please feel free to contact your instructor or myself. The grade (in % of points on Canvas) percentile distribution is as follows:

95th Percentile	90th Percentile	75th Percentile	50th Percentile	25th Percentile	10th Percentile
87.6	84.5	79.7	74.3	67.8	61.8

Appendix D. CSU UWE Survey Questionnaire

Survey Questions

I. Participant background

Q101. CSU student identification number: _____.

Q102. Sex: Female Male

Q103. Year in college:

1st 2nd 3rd 4th 5th and above Graduate Student

Q104. Current GPA:_____ or N/A

Q105. Grade in economics courses:

A A- B+ B B- C+ C D F N/A

Q106. What is the grade you expect to earn from this course?

A A- B+ B B- C+ C D F Don't know

Q107. How many economics courses (excluding this course) have you already taken in college?

Zero One Two Three Four Five or more

Q108. What is (are) your major(s)?

Economics.

_____.

Undeclared with interest in _____.

Undeclared.

Q109. What is (are) your minor(s)?

Economics.

_____.

Undeclared with interest in _____.

Undeclared.

Q110. Why are you taking this course? (check ALL that applies)

Personal interest.

To fulfill Economics major or minor requirements.

To fulfill other majors (e.g., business administration) requirements.

To fulfill general elective requirements.

Other: _____.

II. College Major

Q201. What is the percent chance (from 0 to 100%) that you will major (or continue majoring) in economics? _____%.

Q202. If you were majoring in economics, what do you think is the percent chance that you will successfully complete and earn a bachelor degree in economics in four years (from the time you started college)? _____%.

Q203. If you were majoring in economics, what do you think is the percent chance that you will graduate with a GPA of at least 3.0 (on a scale of 4) majoring in economics? _____%.

Q204. If you were majoring in economics, what do you think is the percent chance that you will enjoy the coursework in economics? _____%.

Q205. If you were majoring in economics, how many hours per week on average do you think you will need to spend on the coursework majoring in economics? _____ hours per week.

Q206. If you were majoring in economics, what do you think is the percent chance that your parents and other family members would approve if you majored in economics? _____ %.

Q207. If you were majoring in economics, what do you think is the percent chance that you could find a job (that you would accept) immediately upon graduation with a bachelor degree in economics? _____%.

Q208. If you were majoring in economics, what do you think is the percent chance that you will go to graduate school in economics some time in the future? _____%.

Q209. If you were majoring in economics, when compared to **ALL** other college graduates (at CSU, Harvard, and other universities) with a bachelor's degree in economics, what do you think you would rank in terms of ability on a ranking scale of 0-100 (0 as the lowest and 100 as the highest? _____.

Q210. What do you think is the **AVERAGE** annual starting salary of **ALL** college graduates (at CSU, Harvard, and all other universities) with a bachelor's degree in economics and work full time?
$_____.

Q211. If you received a bachelor's degree in economics and work full time, what is the annual starting salary that you believe **YOU** would earn? $_____.

Q212. Look ahead to when you will be 35 YEARS OLD. If you majored in economics, what do you think is the percent chance that you will enjoy working at the kind of jobs that will be available to you?
_____%.

Q213. Look ahead to when you will be 35 YEARS OLD. If you majored in economics, what do you think is the percent chance that you will be able to reconcile work and your social life/family at the kinds of jobs that will be available to you? _____%.

Q214. Look ahead to when you will be 35 YEARS OLD. If you majored in economics, how many hours per week on average do you think you will need to spend working at the kinds of jobs that will be available to you?
_____hours per week.

Q215. Look ahead to when you will be 35 YEARS OLD. If you majored in economics and work full-time, what do you think would be YOUR full-time annual salary in today's dollar? $_____.

III. Perception of economics:

On a scale of 0 – 10 (0 means strongly disagree, and 10 means strongly agree), indicate how much you agree with each of the following statements.

Statements	Agreement (0 – 10) 0 = strongly disagree 10 = strongly agree
Q301. I look forward to studying economics.	
Q302. Economics courses are difficult.	
Q303. Economics courses are boring.	
Q304. Economics courses require too much math.	
Q305. I have the required math skills to succeed in Economics.	
Q306. Economics is too theoretical.	
Q307. Economics is widely applicable to different career paths.	
Q308. I know what jobs I can apply to with an economics bachelor degree.	
Q309. I can succeed majoring in economics.	
Q310. Female students are as likely as male students to major in economics.	
Q311. Female economics majors are as likely as male economics majors to succeed in the major.	
Q312. Female economics majors are as likely as male economics majors to have successful careers after they graduate.	

Table A1. Summary statistics from the Survey Wave 1 by treatment

	Control	Treated	Difference
Female	0.45	0.41	-0.04
	(0.50)	(0.49)	(0.04)
	[264]	[524]	
College GPA	3.06	3.11	0.04
	(0.59)	(0.59)	(0.05)
	[248]	[498]	
High school GPA	3.54	3.59	0.04
	(0.47)	(0.43)	(0.04)
	[233]	[445]	
ACT composite score	24.50	24.36	-0.14
	(3.52)	(3.21)	(0.28)
	[212]	[410]	
Economics major	0.01	0.02	0.00
	(0.11)	(0.12)	(0.01)
	[264]	[524]	
Freshman	0.34	0.35	0.01
	(0.48)	(0.48)	(0.04)
	[264]	[524]	
Sophomore	0.35	0.41	0.05
	(0.48)	(0.49)	(0.04)
	[264]	[524]	
Junior	0.19	0.15	-0.04
	(0.40)	(0.36)	(0.03)
	[264]	[524]	
Senior	0.11	0.09	-0.02
	(0.31)	(0.28)	(0.02)
	[264]	[524]	
Year in college	1.94	1.89	-0.04
	(1.04)	(1.01)	(0.08)
	[263]	[522]	
Self-reported college GPA	3.23	3.25	0.01
	(0.51)	(0.48)	(0.04)
	[225]	[441]	
Expected grade from this course	3.57	3.59	0.02
	(0.42)	(0.45)	(0.03)
	[255]	[510]	
Probability of majoring in economics	15.45	14.03	-1.42
	(26.00)	(23.81)	(1.86)
	[261]	[520]	
Probability getting a bachelor degree in 4 years if majoring in econ	79.92	78.93	-1.00
	(28.32)	(30.51)	(2.32)
	[247]	[500]	

Probability of GPA ≥ 3 if majoring in econ	78.17	79.24	1.07
	(23.66)	(24.37)	(1.86)
	[252]	[503]	
Probability of enjoying coursework if majoring in econ	58.31	57.56	-0.75
	(27.08)	(27.53)	(2.10)
	[255]	[507]	
Expected hours per week spent on coursework if majoring in econ	13.36	14.07	0.71
	(10.37)	(10.19)	(0.80)
	[247]	[497]	
Probability of family approval if majoring in econ	85.21	85.81	0.60
	(23.65)	(24.16)	(1.85)
	[253]	[504]	
Probability of finding a job upon graduation as an econ major.	64.34	63.56	-0.78
	(23.06)	(23.99)	(1.83)
	[252]	[496]	
Probability of going to econ graduate program.	43.98	45.18	1.20
	(30.67)	(31.82)	(2.43)
	[251]	[501]	
Self-ranking (0-100) among all econ majors.	64.41	66.69	2.28
	(21.83)	(18.52)	(1.52)
	[250]	[501]	
Expected average starting salary of econ majors	53,253.85	51,314.14	-1,939.71
	(27,690.85)	(23,899.93)	(1,991.81)
	[242]	[477]	
Expected own starting salary as an econ major	55,055.50	52,987.17	-2,068.34
	(63,847.11)	(57,066.83)	(4,707.99)
	[242]	[468]	
Probability of enjoying work as an econ graduate	53.31	52.11	-1.21
	(26.91)	(27.93)	(2.13)
	[252]	[507]	
Probability of reconciling work and life as an econ graduate	66.49	65.81	-0.68
	(24.06)	(24.70)	(1.90)
	[250]	[502]	
Expected work hours per week as an econ graduate	42.56	41.96	-0.60
	(12.26)	(10.68)	(0.88)
	[243]	[493]	
Expected own salary as an econ graduate at 35 years old	80,222.17	82,340.38	2,118.21
	(47,116.23)	(60,779.32)	(4,537.69)
	[236]	[450]	
Look forward to studying econ	6.08	5.91	-0.17
	(2.54)	(2.62)	(0.20)
	[264]	[522]	
Econ is difficult	5.41	5.57	0.16
	(2.20)	(2.42)	(0.18)
	[263]	[521]	
Econ is boring	4.71	4.63	-0.08

	(2.41)	(2.44)	(0.18)
	[263]	[523]	
Econ requires too much math	2.61	2.47	-0.14
	(1.99)	(2.15)	(0.16)
	[264]	[522]	
I am mathematically ready for econ	8.84	8.79	-0.05
	(1.84)	(1.85)	(0.14)
	[264]	[522]	
Econ is too theoretical	4.35	4.17	-0.18
	(2.41)	(2.49)	(0.19)
	[261]	[519]	
Econ is widely applicable to different career paths	7.39	7.46	0.06
	(2.23)	(2.20)	(0.17)
	[264]	[523]	
I know jobs applications for econ majors	4.00	3.89	-0.12
	(2.92)	(2.85)	(0.22)
	[264]	[521]	
I can succeed majoring in econ	6.67	6.48	-0.19
	(2.58)	(2.69)	(0.20)
	[258]	[513]	
Female students are as likely as male students to major in econ	6.36	6.26	-0.10
	(3.17)	(3.19)	(0.24)
	[261]	[518]	
Female econ majors are as likely as male econ majors to succeed in the major	8.59	8.44	-0.14
	(2.18)	(2.21)	(0.17)
	[261]	[521]	
Female econ majors are as likely as male econ majors to have successful careers	8.33	8.24	-0.09
	(2.15)	(2.33)	(0.17)
	[261]	[520]	

* $p<0.10$; ** $p<0.05$, *** $p<0.01$. Standard errors are in parentheses.
Number of observations in brackets.

Table A2. Summary statistics from the Survey Wave 1 by gender

	Male	Female	Difference
College GPA	3.00	3.21	0.21***
	(0.60)	(0.55)	(0.04)
	[424]	[322]	
High school GPA	3.47	3.70	0.23***
	(0.43)	(0.43)	(0.03)
	[374]	[304]	
ACT composite score	24.37	24.44	0.07
	(3.34)	(3.29)	(0.27)
	[343]	[279]	
Economics major	0.02	0.01	-0.01
	(0.13)	(0.09)	(0.01)
	[456]	[332]	
Freshman	0.38	0.32	-0.06*
	(0.48)	(0.47)	(0.03)
	[456]	[332]	
Sophomore	0.38	0.40	0.02
	(0.49)	(0.49)	(0.04)
	[456]	[332]	
Junior	0.15	0.19	0.04
	(0.36)	(0.40)	(0.03)
	[456]	[332]	
Senior	0.10	0.09	-0.01
	(0.30)	(0.29)	(0.02)
	[456]	[332]	
Year in college	1.91	1.91	0.00
	(1.03)	(1.00)	(0.07)
	[456]	[329]	
Self-reported college GPA	3.17	3.33	0.16***
	(0.48)	(0.48)	(0.04)
	[372]	[294]	
Expected grade from this course	3.61	3.54	-0.06**
	(0.43)	(0.44)	(0.03)
	[448]	[317]	
Probability of majoring in economics	15.90	12.60	-3.29*
	(25.43)	(23.23)	(1.78)
	[450]	[331]	
Probability getting a bachelor degree in 4 years if majoring in econ	80.61	77.42	-3.19
	(28.29)	(31.65)	(2.20)
	[430]	[317]	
Probability of GPA ≥ 3 if majoring in econ	79.43	78.14	-1.29
	(23.33)	(25.18)	(1.78)
	[434]	[321]	

Probability of enjoying coursework if majoring in econ	59.21	55.91	-3.29
	(26.59)	(28.31)	(2.00)
	[439]	[323]	
Expected hours per week spent on coursework if majoring in econ	13.27	14.60	1.32*
	(9.39)	(11.27)	(0.76)
	[428]	[316]	
Probability of family approval if majoring in econ	84.71	86.83	2.11
	(25.27)	(22.09)	(1.76)
	[435]	[322]	
Probability of finding a job upon graduation as an econ major.	62.27	65.93	3.65**
	(24.64)	(22.15)	(1.75)
	[431]	[317]	
Probability of going to econ graduate program.	44.80	44.76	-0.04
	(31.19)	(31.80)	(2.32)
	[432]	[320]	
Self-ranking (0-100) among all econ majors.	66.99	64.49	-2.50*
	(19.73)	(19.59)	(1.45)
	[433]	[318]	
Expected average starting salary of econ majors	51,055.84	53,276.61	2,220.77
	(15,154.54)	(34,958.14)	(1,912.94)
	[424]	[295]	
Expected own starting salary as an econ major	55,641.71	50,981.14	-4,660.56
	(67,702.30)	(45,461.39)	(4,521.13)
	[413]	[297]	
Probability of enjoying work as an econ graduate	53.36	51.36	-2.00
	(28.28)	(26.62)	(2.02)
	[436]	[323]	
Probability of reconciling work and life as an econ graduate	65.27	67.08	1.82
	(25.15)	(23.53)	(1.81)
	[432]	[320]	
Expected work hours per week as an econ graduate	42.63	41.52	-1.11
	(11.68)	(10.56)	(0.84)
	[423]	[313]	
Expected own salary as an econ graduate at 35 years old	83,791.66	78,652.58	-5,139.08
	(44,944.24)	(69,001.33)	(4,357.93)
	[395]	[291]	
Look forward to studying econ	6.25	5.57	-0.68***
	(2.53)	(2.63)	(0.19)
	[455]	[331]	
Econ is difficult	5.28	5.85	0.57***
	(2.30)	(2.38)	(0.17)
	[454]	[330]	
Econ is boring	4.55	4.80	0.26
	(2.39)	(2.47)	(0.18)
	[455]	[331]	
Econ requires too much math	2.40	2.67	0.27*

	(2.09)	(2.11)	(0.15)
	[454]	[332]	
I am mathematically ready for econ	8.81	8.80	-0.01
	(1.92)	(1.74)	(0.13)
	[455]	[331]	
Econ is too theoretical	4.22	4.25	0.04
	(2.53)	(2.37)	(0.18)
	[453]	[327]	
Econ is widely applicable to different career paths	7.47	7.38	-0.10
	(2.13)	(2.31)	(0.16)
	[455]	[332]	
I know jobs applications for econ majors	4.07	3.73	-0.35*
	(2.84)	(2.90)	(0.21)
	[454]	[331]	
I can succeed majoring in econ	6.89	6.06	-0.84***
	(2.55)	(2.72)	(0.19)
	[446]	[325]	
Female students are as likely as male students to major in econ	6.64	5.81	-0.83***
	(3.01)	(3.35)	(0.23)
	[451]	[328]	
Female econ majors are as likely as male econ majors to succeed in the major	8.55	8.41	-0.14
	(2.11)	(2.32)	(0.16)
	[452]	[330]	
Female econ majors are as likely as male econ majors to have successful careers	8.34	8.18	-0.16
	(2.18)	(2.40)	(0.16)
	[451]	[330]	

* $p<0.10$; ** $p<0.05$, *** $p<0.01$. Standard errors are in parentheses.
Number of observations in brackets.

Table A3. Analysis of attrition bias across waves

	Dependent variable: Attrition (0/1)	
	(1)	(2)
Treated	0.0316	
	(0.0522)	
Partial treatment		0.0538
		(0.0599)
Full treatment		0.00988
		(0.0654)
Female	0.0405	0.0400
	(0.0420)	(0.0420)
College GPA	-0.154***	-0.155***
	(0.0352)	(0.0346)
High school GPA	-0.0550	-0.0558
	(0.0388)	(0.0388)
ACT composite score	0.0106	0.0105
	(0.00642)	(0.00641)
Econ major	0.0412	0.0408
	(0.219)	(0.219)
Sophomore	0.0162	0.0181
	(0.0458)	(0.0460)
Junior	0.0639	0.0685
	(0.0655)	(0.0666)
Senior	0.0474	0.0472
	(0.100)	(0.0981)
Observations	593	593

Standard errors clustered at the recitation level are in parentheses.
*** p<0.01, ** p<0.05, * p<0.1. No sample weights are applied.

Table A4. Analysis of random assignment of treatment

	(1) OLS	(2) Multinomial Logit	
	Dependent Variable		
	Treated	Partial Treatment	Full Treatment
Female	0.000271	0.00422	-0.00132
	(0.0484)	(0.248)	(0.272)
College GPA	0.0170	0.347	-0.153
	(0.0692)	(0.314)	(0.375)
High School GPA	0.0478	0.115	0.305
	(0.0718)	(0.346)	(0.350)
ACT composite score	-0.0118	-0.0598	-0.0476
	(0.00872)	(0.0463)	(0.0409)
Econ Major	-0.00852	-0.0655	-0.0317
	(0.291)	(1.551)	(1.548)
Sophomore	-0.0271	0.0562	-0.298
	(0.0854)	(0.395)	(0.487)
Junior	-0.0985	-0.418	-0.446
	(0.122)	(0.462)	(0.656)
Senior	-0.178	-0.792	-0.728
	(0.179)	(0.913)	(0.807)
Observations	341	341	
p-value of F-test/Wald test. H0: all coefficients are jointly zero.	0.807	0.745	

Standard errors clustered at the recitation level are in parentheses

*** p<0.01, ** p<0.05, * p<0.1. No sample weights are applied.