Does Better Information Reduce the Gender Gap in Economics Majors?

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Women are persistently underrepresented among economics majors. For every female economics major, there are 2.9 male majors relative to their numbers as BAs in the U.S. (Goldin, 2015)[1]. Prior literature finds that women are likely to gravitate towards other disciplines when they receive a low grade in an introductory economics class (Rask and Tiefenthaler, 2008; Goldin, 2015). If such decision-making is based on incomplete information, improved information may mitigate the problem.

This study examines whether additional information provision helps reduce the gender imbalance among economics majors via a randomized-control experiment conducted in introductory economics classes at a public four-year institution, Colorado State University. Students enrolled in introductory economics classes were randomly assigned into 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.

To evaluate the treatment effect, two waves of surveys were administered to elicit students' subjective assessment of their probability of majoring in economics before and after the treatment. The panel design offers an advantage over cross-sectional analyses when individual decisions are strongly correlated with unobserved tastes and preferences. The average treatment effect from the experiment shows a 6.8 percentage points (or 54 percent) increase in female students' subjective probability of majoring in economics.

I. Research Design and Data

In the spring semester of 2016, five sections of microeconomics and three sections of macroeconomics classes were offered by six instructors.[2] Each section was supported by two teaching assistants (TAs) who taught three recitation sections each. To balance the

[1] The ratio is calculated as $\frac{\text{Male Econ Majors/Male BAs}}{\text{Female Econ Majors/Female BAs}}$ to account for the fact that women outnumber men in the number of BAs in many institutions.

[2] 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 there are no equivalent classes to serve as a comparison group for the experiments, this study excludes the honors section from the analysis.

influences from instructors and TAs across treatments, randomization of treatment was done at the recitation-level. Each of the three recitation sections taught by the same TA was randomly assigned into the full treatment, partial treatment, or control group. During the semester, three treatments were implemented, including an information intervention, nudge, 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.[3] During the semester, male and female students in both the full and partial treatment groups received an email on the general grade distribution of their class. Furthermore, women with a grade at or above the median of the grade distribution ("Median+") received an encouragement message that explicitly acknowledged their success in the class and urged them to consider majoring in economics.[4] 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"). Table 1 describes the assignment of treatments across the treatment groups.

Two waves of surveys were administered in recitation classes—one at the beginning of the semester before any treatments were administered and the other at the end of the semester after the treatments were concluded. The surveys elicited students' subjective assessment of their probability of majoring 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.[5] Students' GPA and instructor information were also obtained from the administrative records.

At the beginning of the semester, 1,593 students were enrolled in the introductory classes. Because this study focuses on undergraduate majors, I exclude 23 graduate students from the analysis. I drop 7 students who were enrolled concurrently in both

[3] The video clip is available at https://www.youtube.com/watch?v=MUuN5hvkDy0. The details of the pamphlet are provided in Appendix A1.

[4] The grade distribution includes grades at the following percentiles: 95th, 90th, 75th, 50th, 25th, and 10th. An example of the general grade distribution message refers to Appendix A2. The "nudge" message that is sent to female students with a grade at or above the median grade is in Appendix A3. Note that the message was customized for three groups: at or above 90th percentile, between 75th and 90th percentile, and between 50th and 75th percentile.

[5] Appendix A4 lists all of the questions on the survey questionnaire.

microeconomics and macroeconomics classes because they may have received different treatment assignments from the two classes. Because part of the information intervention (T_1) is implemented at the recitation-level, I further drop 33 students who went to a recitation section in which they were not enrolled and hence did not receive the intended treatments. I also drop 27 students who withdrew from the classes before the end of the semester.[6] The qualified sample consists of 1,503 undergraduate students equally distributed among the full treatment, partial treatment, and control groups. The summary statistics of student characteristics and baseline survey results by treatment group are detailed in Appendix B1. If students in the full and partial treatment groups are pooled ("Treated"), students in the Treated group are observationally similar to their counterparts in the control group with regards to their GPA and gender distribution. There are slightly more senior students in the control group (11 percent) than in the Treated group (7 percent). However, the survey responses from the baseline survey show no statistical differences between the Treated and control groups.

Among these 1,503 students, only 789 students (52.5 percent) took the first survey and 573 students (38.1 percent) took the second survey. Overall, only 443 students answered both surveys (including 185 female and 258 male students). The low response rates were driven by low recitation attendance given that the take-up rate was over 93 percent among recitation attendants.[7] Respondents have slightly higher GPAs (0.22 and 0.30 points higher in first and second wave, respectively) than non-respondents. The survey sample is reweighted by sex and grade to represent the population in the classes for estimating the average treatment effect.[8]

II. Empirical Specifications and Results

In order to control for unobserved preferences, the empirical analysis focuses on the *change* in students' subjective probability of majoring in economics across the two waves of the surveys. The subjective assessment of student i in class j on each question (Y_{ij})—such as her probability of

[6] The gender distribution of students who withdrew from the classes is identical across treatment and control groups, and the GPAs are also statistically indistinguishable among withdrawers across treatment and control groups.

[7] During the first wave of the survey, 830 students attended the recitation and 789 responded to the survey, resulting in a 95.1% take-up rate. The number of students who attended the recitation during the second wave dropped to 614, and 573 students participated in the survey, resulting in a take-up rate of 93.3%.

[8] Reweighting is implemented by sex and grade (i.e., above or below the median) to represent the class population. For instance, 63.1% of female respondents who answered both surveys have a midterm grade at or above the median, but only 51.56% of female students in the class rank above the median. Therefore, each female respondent with a midterm grade at or above the median is weighted as 51.56/63.10.

majoring in economics—changes as a function of the treatment (T_{ij}), student characteristics (X_i, such as class standing), influences from instructors and teaching assistants (Z_j, such as sex of the instructor, sex of the teaching assistant, and individual fixed effects of instructors and teaching assistants), and idiosyncratic shocks (ε_i) as specified in the equation:

$$Y_{ij} = \beta_0 + \beta_1 T_{ij} + \beta_2 X_i + \beta_3 Z_j + \varepsilon_i.$$

Because the treatments were randomly assigned, student and instructor characteristics are unrelated to the treatments, and the difference across treatments in students' changes in subjective perceptions between waves 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 this particular treatment group and 0 otherwise. To allow treatment effects to vary by gender, I estimate the equation separately for females and males.

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

The difference in the change of outcomes between the full and partial groups identifies the effect of T_3, and the difference between the partial and control groups identifies the effect of $T_1 + T_2$. Note that the effects of T_1 and T_2 cannot be separately identified unless T_1 has the same effect on all students. This assumption is strong and unlikely to hold if students who rank above the median respond to the grade distribution information positively while students below the median take it 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.

Among the 789 respondents in the first wave of the survey (264 in the control and 525 in the full and partial treatment groups), there are no statistical differences in responses to any of the survey questions across treatment groups (Appendix B1). However, notable differences across sex are present. Women came into the class with a higher GPA on average (female: 3.12, male: 2.90), but male students subjectively expected to earn a higher grade from the class (male: 3.61, female: 3.55) and ranked themselves 2.48 points higher on a ranking scale of 0-100 (0 the lowest, and 100

the highest) for their ability compared with all other college graduates with a bachelor's degree in economics (male: 66.99, female: 64.51). Female students indicated a 3.27 percentage points lower probability of majoring in economics (female: 12.63%, male: 15.9%). Compared to male students, female students predicted spending 1.38 more hours on coursework per week if they were to major in economics and having a 3.62 percentage points higher probability of finding a job immediately upon graduation with an economics degree. Female students were also 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 at the same time felt that they did have the required mathematics skills to succeed in economics. Although female and male students both agreed that female economics majors are as likely as male economics majors to succeed in the 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. Female students were also more aware of the fact that female students are not as likely as male students to major in economics (Appendix B2). Much of the gender gap persists in the second wave of the survey.

To assess how students updated their beliefs as a response to the treatments, Y_{ij} in the equation is measured as the change in the survey responses across the two waves. After receiving the information intervention, both female and male students updated their beliefs upwards in regard to future earnings associated with economics majors, but only female students in the treatment groups indicated an increase in knowledge of applicable jobs associated with economics. Most importantly, after controlling for the sex and fixed effect of instructors and teaching assistants, as well as student's sex and class standing, female students in the treatment groups show an increase in their probability of majoring in economics by 6.8 percentage points, driven primarily by students with a midterm grade above the median (Table 2).[9] Given that the average subjective probability of majoring in economics among female students at the baseline is only 12.6 percent, the magnitude of the treatment effect is equivalent to a 54 percent increase in probability. The treatment effect is not driven

[9] Unweighted average treatment effect is 7.59 percentage points increase in female students' probability of majoring in economics. The weighted sample reflect the class composition by sex and grade. The weighted result is similar to the estimated treatment effect using Heckman's two-stage selection correction by using race, Pell grant eligibility, high school GPA, and ACT composite scores in the selection equation.

by outliers, and the cumulative distribution function of the subjective probability shows a clear change of the probability distribution with the treatments (Appendix C1). Among female students with a midterm grade above the median, the change in the subjective probability of majoring in economics is 12.5 percentage points higher for those in the full treatment group and 9.07 percentage points higher for those in the partial treatment group compared with the control group.[10] It appears that the peer mentoring program may have a small positive effect, although the difference between the full and partial treatment groups is not statistically significant. This indeterminate result is likely attributable to a low take-up rate (5.35%) for the mentoring activities. There is no discernable treatment effect among male students.

To understand the mechanism of the change in female students' subjective probability of majoring in economics, I regress students' change in their probability of majoring in economics on the change in their expected grade from the class and changes in responses to all other survey questions after controlling for the sex and the fixed effect of instructors and teaching assistants as well as the student's sex and class standing. The results indicate that an increase in a student's expected grade in the class is correlated with an increase in her probability of majoring in economics. The results are consistent with findings by Goldin (2015) who finds that female students are more sensitive to grades they receive in a class. Also, an increase in a student's enjoyment of economics coursework is positively correlated with an increase in the probability of majoring in economics as found by Zafar (2013). I also find that increases in students' expected mid-career earnings and in their predicted probability that family would approve of the major are associated with an increase in female students' subjective probability of majoring in economics. Surprisingly, female students whose subjective probability of balancing work and life with an economics career increases become less likely to major in economics. Also, female students who increasingly agree with the statement that "economics courses are difficult" become more likely to major in economics. These surprising results indicate that the challenge of coursework and concerns about work-and-life balance are unlikely to be the primary reasons for the under-representation of women among economics majors.

[10] The results remain largely unchanged after controlling for students' GPA. Since 45 students do not have GPA information on records because they are exchange students or have recently transferred to CSU, the primary analyses do not include GPA as a covaraiate.

Female students whose midterm grade is above the median in the partial treatment group take 0.16 more economics courses. There is no statistically significant treatment effect on female students' probability of declaring as an economics major at the beginning of fall. It is likely to be too early to come to a conclusion regarding the treatment effects on students' *actual* major choices. Further follow-up on the students in subsequent semesters may shed more light on how the treatment effect on the change in subjective probability translates into real change in students' major decisions.

III. Conclusions

The average treatment effect of information provision on female students is substantial. The treatment effect is most pronounced among female students with a midterm grade above the median. Given the large treatment effect from a low-cost information intervention, better information on economics with nudges that target female students above the median may be a cost-effective means of reducing the gender gap among economics majors.

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Table 1. Treatment Assignments

Treatment Group		Sex	Midterm Grade	Treatments		
				T1	T2	T3
Treated	Full	Men	All	Yes	No	No
		Women	Median+	Yes	Yes	Yes
			Median–	Yes	No	Yes
	Partial	Men	All	Yes	No	No
		Women	Median+	Yes	Yes	No
			Median–	Yes	No	No
Control		Both	All	No		

Table 2. Treatment effect, Y_{ij} = ΔPr(Major in Econ)

	All	Median+	Median–
A. Female			
Treated	6.819**	10.53**	3.915
	(3.456)	(4.922)	(4.501)
N	185	116	69
B. Male			
Treated	1.612	-0.762	6.954
	(2.328)	(3.018)	(4.453)
N	258	157	101

Robust standard errors in parentheses. ***0.01, **0.05, *0.1. Analysis controls for sex and class standing of student, and sex and fixed effects of instructor, and TA. Sample weights applied.

Table 3. Treatment effect, Y_{ij} = ΔPr(Major in Econ), female only

	All	Median+	Median–
Full	7.930*	12.51*	6.177
	(4.188)	(7.236)	(4.767)
Partial	5.312	9.065*	0.768
	(4.188)	(5.088)	(6.194)
N	185	116	69

Robust standard errors in parentheses. ***0.01, **0.05, *0.1. Analysis controls for sex and class standing of student, and sex and fixed effects of instructor, and TA. Sample weights applied.