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Grade Sensitivity and the Economics Major at a Women's College †

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Women who receive lower grades in introductory economics courses are less likely to major in economics than men with similar grades, one of many explanations for the gender gap in economics (e.g., Rask and Tiefenthaler 2008, Ahlstrom and Asarta 2019). Even so, the partial correlations between grades and major choice could reflect the effects of correlated but unobserved variables, such as precollege math skills or preferences. Thus, Owen (2010) and Main and Ost (2014) compared the major choices of putatively similar students just above and below letter-grade cutoffs. The point estimates suggest that women are more grade sensitive than men, but some confidence intervals include zero.[1]

This paper reports precise discontinuity estimates using ten years of data at Wellesley College, a highly selective liberal arts college that admits only women. Students just above letter-grade cutoffs are 18 percentage points more likely to major in economics than students just below, with larger differences among students receiving financial aid. We discuss potential mechanisms for these effects.

I. Empirical Strategy

A. *Economics at Wellesley College*

Thirty-nine percent of women took at least one course in micro- or macroeconomic principles between fall 2004 and spring 2014, usually in their first or second year. Both are prerequisites to advanced requirements such as econometrics and calculus-based microeconomics. Students must declare a major by their fourth semester.

Given the timing, students are likely to use introductory course experiences and performance—including letter grades—to update beliefs about major-specific abilities (e.g., Stinebrickner and Stinebrickner 2014). The modal grade in principles courses is a B+ (25 percent), and there is little grade compression at the top of the grading scale (see Table A1 in the online Appendix). Students with higher grades are far more likely to major in economics (64 percent among students who receive an A versus 29 percent among those who receive a B−). However, students with higher grades also have higher levels of precollege math skills and greater interest in the major at the time of application. They also, perhaps, differ in unobserved ways that affect major choice, providing a motivation for limiting comparisons to similar students just above and below the letter-grade cutoffs.

B. *Data and Estimation*

Between fall 2004 and spring 2014, instructors awarded 4,723 grades in micro- and macroeconomic principles courses to 2,999 students. (This sample excludes a small number of nontraditional students who transferred into Wellesley College with substantial college

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[1] Near the A/B letter-grade cutoff, Owen (2010) found that women with higher grades in an introductory economics course have a higher probability (by 16 percentage points) of majoring in economics, although men do not. The effects at the B/C cutoff were not statistically distinguishable from zero, although the 95 percent confidence interval includes effects as large as 14 percentage points for women. Near the A/B cutoff, Main and Ost (2014) found that effects for both men and women were not statistically distinguishable from zero, although the confidence interval is consistent with effects as large as 20 percentage points for women.

credits, although none of the estimates are sensitive to their exclusion.) We gathered grading spreadsheets that include 57 percent of these grades, henceforth referred to as the discontinuity sample. Students in the full and discontinuity samples have similar precollege attributes on average (see Table A2 in the online Appendix).

The spreadsheets record weighted averages of all course assessments, expressed as percentages. In all cases, a cumulative final exam accounts for at least one-third of the weighted average. Define S_{ijk} as the final score of student i, taught by instructor j in semester k. Instructors order students by values of S_{ijk} and choose letter-grade cutoffs. The spreadsheets do not report exact cutoffs corresponding to the letter grades, and so we imputed them. Define z_{jk}^{s} as the letter-grade cutoff s for instructor j in term k, where $s = 1$ denotes the A/A− cutoff, $s = 2$ denotes the A−/B+ cutoff, and so on. We impute each z_{jk}^{s} as the midpoint between two values of S_{ijk}: that of the highest A− (or B+, B, etc.) in a semester-by-instructor group and the next highest value. For example, suppose that the highest A− within a term-by-instructor group is 90.2 percent. If the next highest value within the cell is 90.4 percent, then $z_{jk}^{1} = 90.3$.

We then assigned observations to mutually exclusive groups, also indexed by s. For example, we assigned all As to $s = 1$. Observations for an A− were assigned to $s = 1$ if scores exceeded $\left(z_{jk}^{1} + z_{jk}^{2}\right)/2$, the midpoint of the A/A− and A−/B+ cutoffs. If scores fell below the midpoint, then observations were assigned to $s = 2$. We followed a similar procedure for lower scores.

This facilitates a linear spline regression in a stacked sample of observations:

$$O_{ijk}^{s} = \alpha + \beta G_{ijk}^{s} + \theta\left(S_{ijk}^{s} - z_{jk}^{s}\right) + \mu\left(G_{ijk}^{s} \times \left(S_{ijk}^{s} - z_{jk}^{s}\right)\right) + \varepsilon_{ijk}^{s},$$

where O_{ijk}^{s} is the outcome of student i near letter-grade cutoff s, having taken a course with instructor j in semester k. Define $G_{ijk}^{s} = \mathbf{1}\left\{S_{ijk}^{s} - z_{jk}^{s} \geq 0\right\}$, equal to one if a student's centered score exceeds zero. Thus, β is the magnitude of the discontinuity in the dependent variable at centered letter-grade cutoffs.

Figure 1 reports "first-stage" estimates using grade points in principles courses as the

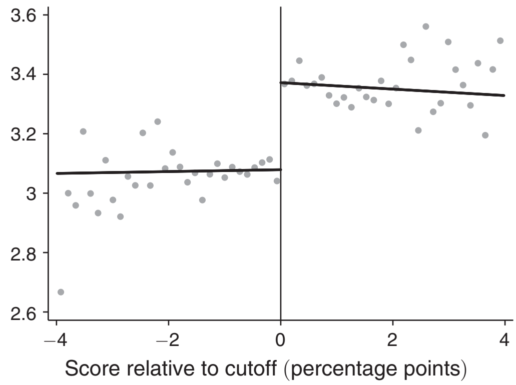

FIGURE 1. GRADE POINTS IN PRINCIPLES COURSES AT LETTER-GRADE CUTOFFS

Notes: The discontinuity sample includes 2,479 observations that are within 4 percentage points of letter-grade cutoffs. Circles indicate unadjusted means of course grade points, taken within 30 evenly spaced bins on each side of the cutoff. The solid lines are fitted values from linear regressions estimated separately on each side of the cutoff, applying triangular weights.

dependent variable (where an A is 4.0, an A− is 3.67, and so on). It employs a bandwidth of 4 percentage points around letter-grade cutoffs, which includes 92 percent of the discontinuity sample. As expected, there is a sharp increase in grade points near the cutoff, representing about one-third of a letter grade. In Table 1, the first row reports the corresponding coefficient (0.29) and standard error (0.03). The estimate is robust to the inclusion of covariates as well as the use of a smaller, data-driven bandwidth. We interpret the discontinuity design as sharp rather than fuzzy, since instructors do not systematically defy the rank ordering of final scores when awarding letter grades.

C. *Threats to Internal Validity*

For estimates to have a causal interpretation, the relationship between S_{ijk}^{s} and students' potential outcomes must be continuous near the cutoffs. The assumption might be violated if instructors precisely manipulate the assignment variable, most plausibly by altering students' final percentage scores or strategically choosing letter-grade cutoffs so as to (nonrandomly) ensure that particular students receive higher or lower grades. It is implausible that students could precisely target

TABLE 1— DISCONTINUITIES IN STUDENT OUTCOMES AT LETTER-GRADE CUTOFFS

	Bandwidth		
	4 percentage points		Data driven
Grade points in principles course (3.07)	0.293 (0.034) 2,479	0.308 (0.006) 2,479	0.323 (0.008) 1,538
Nonprinciples GPA in same semester (3.35)	0.004 (0.028) 2,472	0.009 (0.026) 2,472	−0.030 (0.037) 1,658
Cumulative GPA (3.37)	0.001 (0.023) 2,479	0.006 (0.018) 2,479	−0.029 (0.027) 1,516
Economics major (0.36)	0.179 (0.038) 2,377	0.175 (0.037) 2,377	0.218 (0.062) 1,381
Double major (0.30)	0.105 (0.037) 2,377	0.113 (0.038) 2,377	0.152 (0.054) 1,660
Other social science major (0.35)	−0.036 (0.037) 2,377	−0.067 (0.036) 2,377	−0.057 (0.052) 1,655
Humanities major (0.30)	0.018 (0.035) 2,377	0.028 (0.036) 2,377	0.015 (0.060) 1,376
Math or science major (0.25)	−0.046 (0.033) 2,377	−0.022 (0.033) 2,377	−0.025 (0.053) 1,366
Did not graduate (0.04)	0.002 (0.018) 2,479	0.003 (0.018) 2,479	0.021 (0.033) 1,394
Controls	No	Yes	Yes

Notes: Cells in the first column report estimates of β from equation (1), applying triangular weights within a bandwidth of 4 percentage points. Robust standard errors, clustered by student, are in parentheses. The final row indicates controls for semester-by-instructor-by-cutoff fixed effects (δ_{jk}^{s}); the precollege variables in panel A of Table A2 in the online Appendix; and dummy variables indicating missing values of these controls. The data-driven bandwidth is mean-squared-error optimal (Calonico, Cattaneo, and Titiunik 2014). The number in parentheses next to the variable name is the mean of the dependent variable to the left of cutoffs (within 4 percentage points of the cutoff).

a final exam score (and hence a course weighted average) that falls very near cutoffs, if only because instructors do not announce fixed cutoffs (e.g., 90 percent, 80 percent, etc.).

We find no evidence of asymmetrical bunching of scores around cutoffs (see Figure A1 in the online Appendix). Online Appendix Figure A2 and Table A3 show no evidence of discontinuities in eight precollege variables, including measures of quantitative skills and major preferences. Finally, the results are not sensitive to the exclusion of potentially "contaminated" observations within 0.5 percentage points of letter-grade cutoffs (see online Appendix Table A4).

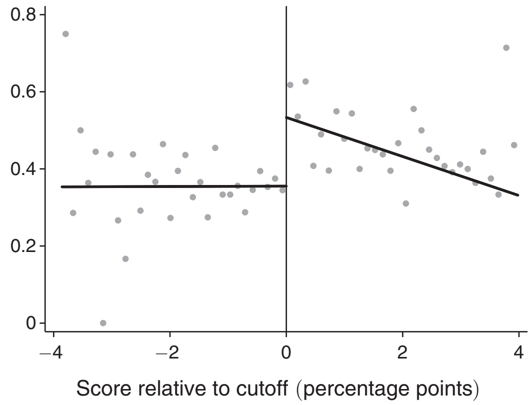

FIGURE 2. ECONOMICS MAJOR CHOICE AT LETTER-GRADE CUTOFFS

Notes: The discontinuity sample includes 2,377 observations that are within 4 percentage points of letter-grade cutoffs. See the notes to Figure 1 for additional details.

II. Results

Figure 2 illustrates the main results for choice of the economics major. Near the cutoff, there is a sharp jump in the proportion of students who graduate with an economics degree. Across three specifications in Table 1, the magnitude of the effect is 18 percentage points or more, an increase of roughly 50 percent over the proportion of economics majors to the left of the cutoff.[2] There is sample attrition in the major variable because 4 percent of principles students in the discontinuity sample did not graduate from the college (largely due to transferring elsewhere). However, Table 1 shows no evidence of a discontinuity in the probability that students did not graduate.

[2] The coefficients are still significant at 1 percent after adjusting for multiple comparisons across 27 estimates in Table 1 (Benjamini and Hochberg 1995).

Table 1 further suggests that additional economics majors mainly result from students adding a second major, although point estimates also suggest small declines in the probability of choosing a science or social science major. Finally, there is no evidence of effects on students' other grades, whether in the same semester as the principles course or at the time of graduation.

The previous estimates represent weighted effects across two courses—micro- and macroeconomics principles—and across multiple letter-grade cutoffs. Table A5 in the online Appendix shows that point estimates are positive for both courses and for all cutoffs; we cannot reject the null hypothesis of equality at 10 percent.

Table 2 assesses whether the effects on major choice are moderated by students' precollege quantitative skills, precollege preferences for the economics major, financial aid status, and status as an underrepresented minority. Students receiving any financial aid—a household income proxy—are 14 percentage points more grade sensitive than students with no financial aid (a difference that is statistically significant at 10 percent).

Point estimates further show that students with no precollege preference for economics are 12 percentage points more grade sensitive than students without such as major preference, although the difference is not statistically significant at 10 percent. Table A6 in the online Appendix reveals no heterogeneity for other dependent variables.

Table 2—Heterogeneity by Student Attributes

	Grade points in principles course	Economics major
Panel A. Quantitative reasoning (QR) assessment		
Lower QR score	0.312	0.166
	(0.007)	(0.049)
Higher QR score	0.304	0.186
	(0.007)	(0.048)
p-value	0.34	0.75
Panel B. Preference for economics major		
Economics preference	0.316	0.080
	(0.016)	(0.084)
No economics preference	0.306	0.197
	(0.006)	(0.042)
p-value	0.56	0.21
Panel C. Receipt of financial aid		
Any financial aid	0.307	0.228
	(0.008)	(0.047)
No financial aid	0.310	0.088
	(0.008)	(0.062)
p-value	0.78	0.07
Panel D. Underrepresented minority (URM)		
URM	0.316	0.187
	(0.019)	(0.146)
Non-URM	0.310	0.171
	(0.006)	(0.039)
p-value	0.77	0.91

Notes: For each moderating variable (e.g., two categories of quantitative reasoning scores in panel A), we calculate dummy variables indicating both categories. We fully interact the dummies with G^s_{ijk} in equation (1) and report these coefficients in the tables. In addition, we fully interact the dummies with the continuous measures of the assignment variable in equation (1) so that estimated slopes are allowed to vary by each category of the moderator. All regressions include the additional controls described in the notes of Table 1. Robust standard errors, clustered by student, are in parentheses. The *p*-values correspond to a test of the null that the coefficients are jointly equal.

III. Interpretations and Conclusions

Otherwise similar women are 18 percentage points more likely to choose an economics major when they receive a higher letter grade, with larger effects among students receiving financial aid. What can explain this pronounced grade sensitivity at Wellesley College and the broader finding in the literature that women are more grade sensitive than men?[3] Researchers have speculated that grade sensitivity is the direct or indirect result of exposure to male students or instructors in predominantly male fields of study (e.g., Ost 2010; Kugler, Tinsley, and Ukaneva 2017). However, Wellesley College only admits women, and the effects were not smaller in principles courses led by female instructors (see Table A5 in the online Appendix).

[3] A simple but implausible explanation for the large effects is that instructors use letter grades as a signal when giving advice to students about subsequent course work and major choice. Instructors have full information about students' final scores and their proximity to cutoffs. Thus, advice given over the semester (or afterward) should not differ markedly for students close to letter-grade cutoffs.

Rask and Tiefenthaler (2008) hypothesize that women are more sensitive to grades because they have weaker preferences for economics course work or careers (also see Goldin 2015). In partial support of this, our point estimates suggest that women are more responsive to grades when they do not express a precollege preference for economics.

Finally, men and women may simply respond differently to noisy feedback such as grades. Grades communicate major-specific abilities to students, but they also reflect an element of luck. In lab experiments, Shastry, Shurchkov, and Xia (2020) found that women were more likely than men to attribute negative feedback to a lack of ability (versus luck) regardless of their actual ability. One implication is that women who receive a lower grade in an introductory course are less likely to choose the major.

The evidence suggests two avenues for research. The first is to understand how preferences are shaped before and during college. If preferences reflect a misunderstanding of the content of majors and careers, then informational interventions (e.g., Li 2018; Bayer, Bhanot, and Lozano 2019) might alter preferences and diminish grade sensitivity as a by-product. The second avenue is to test interventions that provide more nuanced information on ability than letter grades. For example, instructors could provide students with more feedback on their absolute or relative course performance or simply targeted nudges of encouragement (Li 2018).

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