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Will Studying Economics Make You Rich? A Regression Discontinuity Analysis of the Returns to College Major[†]

By Zachary Bleemer and Aashish Mehta*

We investigate the wage return to studying economics by leveraging a policy that prevented students with low introductory grades from declaring a major. Students who barely met the grade point average threshold to major in economics earned $22,000 (46 percent) higher annual early-career wages than they would have with their second-choice majors. Access to the economics major shifts students' preferences toward business/finance careers, and about half of the wage return is explained by economics majors working in higher-paying industries. The causal return to majoring in economics is very similar to observational earnings differences in nationally representative data. (*JEL* A22, I26, J24, J31)

Forty-year-old US workers with undergraduate degrees in economics earned median wages of $90,000 in 2018. By comparison, those who had majored in other social sciences earned median wages of $65,000, and college graduates with any major other than economics earned $66,000. Relative to workers with lower-wage majors, the observational premiums earned by workers with high-wage majors like engineering, nursing, and economics are similar in size to the wage gap between college graduates and nongraduates (Altonji, Blom, and Meghir 2012). These gaps have motivated a large literature examining the determinants of students' major choices (Zafar 2013; Stange 2015; Arcidiacono, Aucejo, and Hotz 2016; Wiswall and Zafar 2018; Patnaik et al. 2020). However, average wage differences between majors do not necessarily reflect the causal effect of choosing one

* Bleemer: University of California, Berkeley (email: bleemer@berkeley.edu); Mehta: University of California, Santa Barbara (email: asmeht@ucsb.edu). David Deming was coeditor for this article. Thanks to Joseph Altonji, David Card, Carlos Dobkin, Laura Giuliano, Hilary Hoynes, Peter Kuhn, Enrico Moretti, Jesse Rothstein, Christopher Walters, Matt Wiswall, Basit Zafar, and seminar participants at UC Berkeley for helpful comments; to the UC Santa Cruz Office of the Registrar and the UC Berkeley Center for Studies in Higher Education for help in obtaining the data used in this study; and to Alia Roca-Lezra and Dan Ma for excellent research assistance. This study was granted exemption by UC Berkeley's Office for Protection of Human Subjects. Bleemer was employed by the University of California in a research capacity while conducting this study and acknowledges financial support from the National Academy of Education/Spencer Dissertation Fellowship and UC Berkeley's Center for Studies in Higher Education. Both authors hold undergraduate degrees in economics. See Bleemer and Mehta (2022) for the code and public data used in this study. Any errors that remain are our own.

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major over another. This study directly analyzes the treatment effects of earning an undergraduate degree in the popular high-earning field of economics.[1]

Estimating the causal effects of earning specific college majors is challenged by students' nonrandom assortment across majors: most students self-select their college major, and many universities and departments use admissions and grade requirements to restrict entry into certain majors. As a result, observational wage differences across majors may reflect selection bias. We overcome this challenge by using a regression discontinuity (RD) design that exploits a fuzzy discontinuity in economics major access at a large, moderately selective public university (Angrist and Lavy 1999).[2] We implement this design to estimate the effect of studying economics on students' early-career earnings and industries as well as how the major's effect on earnings is mediated by changes in students' other educational outcomes, career preferences, and early-career industries. We then characterize and estimate the biases that arise when using observational average wage difference between economics and other majors as a proxy for the treatment effect of majoring in economics.

The specific case we analyze is the economics department at the University of California, Santa Cruz (UCSC). UCSC Economics imposed a grade point average (GPA) restriction policy in 2008: students with a GPA below 2.8 in Economics 1 and 2 were generally prevented from declaring an economics major.[3] Students who just met the GPA threshold were 36 percentage points more likely to declare the economics major than those who just failed to meet it. Most of these students would have otherwise earned degrees in other social sciences. Students just above the threshold who majored in economics were surprisingly representative of UCSC economics majors on observables; for example, their average SAT score was at the forty-first percentile of economics majors.

Comparing the major choices and average wages of above- and below-threshold students shows that majoring in economics caused a $22,000 (46 percent) increase in the annual early-career wages of barely above-threshold students. It did so without otherwise impacting their educational investment—as measured by course-adjusted average grades and weekly hours spent studying—or outcomes like degree attainment and graduate school enrollment. The effect is nearly identical for male and female students, may be larger for underrepresented minority students, and appears to grow as workers age (between ages 23 and 28). About half of the wage effect can be explained by the effect of majoring in economics on students' industry of employment: relative to students who did not qualify for the major, economics majors became more interested in business and finance careers and were more likely to find employment in higher-wage economics-related industries like finance, insurance, and real estate (FIRE) and accounting. Most of the barely above-threshold

[1] Economics is a particularly popular major at highly selective universities. The 2020 federal College Scorecard shows that economics was the most-earned major at 11 of the top 20 highest-ranked American universities (as ranked by *US News and World Report*) and was among the top 5 majors at 34 of the 50 highest-ranked universities.

[2] This design was recommended (but not implemented) by both Altonji, Blom, and Meghir (2012) and Altonji, Arcidiacono, and Maurel (2016).

[3] Like many universities, UCSC has multiple "tracks" for its economics major. Students just above the GPA threshold mostly chose its "business management economics" (BME) track, in which about one-third of required courses are taken in business- and finance-related subdisciplines.

economics majors would have otherwise earned degrees in lower-earning fields like psychology and sociology, and differences in either OLS-estimated average wages by major (with or without controls) or median wages by major (estimated at the university, state, or national level) slightly *underestimate* the estimated local average treatment effect. This suggests that the net magnitude of selection bias and treatment effect heterogeneity is small in this context.[4]

Our data include comprehensive 2000–2014 UCSC student and course records linked to biannual administrative student surveys, National Student Clearinghouse (NSC) educational outcomes, and annual California unemployment insurance (UI) employment records. These highly detailed records allow us to test several alternative explanations for above-threshold students' higher postgraduate earnings. We show that detailed student characteristics are smooth across the GPA threshold and that grade distributions in economics courses remained unchanged in the period. There is no evidence of students bunching above the threshold, as might be expected if threshold-crossing was somehow manipulated. We also show that wages were smooth across the grade threshold prior to the policy's implementation but slightly discontinuous during an interstitial period with a less binding major restriction policy, generating similar (but noisier) instrumental variable estimates to the main specification. While our main empirical strategy estimates linear RD models with standard errors clustered by GPA (Lee and Card 2008), we confirm the estimates using a number of other specifications, including "honest RD" estimates following Kolesár and Rothe (2018).[5]

A small number of previous studies have analyzed major-specific returns in other countries by exploiting centralized field-specific enrollment assignment rules (Kirkeboen, Leuven, and Mogstad 2016; Hastings, Neilson, and Zimmerman 2014; Daly and Le Maire 2021). However, the external validity of those estimates in the United States may be limited: American universities offer a broader core liberal arts curriculum, permit students to choose their majors years after their initial enrollment, and provide students with more discretion over their courses, all of which could narrow field-specific returns.[6] A large literature has employed selection-on-observables methods and structural estimation to identify major-specific returns (James et al. 1989; Rumberger and Thomas 1993; Black, Sanders, and Taylor 2003; Arcidiacono 2004; Hamermesh and Donald 2008), generally arguing that selection bias explains a substantial portion of US wage variation across majors.

This study's reduced-form RD design provides unusually transparent evidence of postsecondary education's heterogeneous and persistent role in shaping students' labor market outcomes. Our estimated early-career wage return to economics rivals the baseline return to a college degree, implying that major choice is a

[4] Our results mirror the well-known finding that causal estimates of the return to schooling slightly exceed the mean differences recovered from OLS (Angrist and Keueger 1991; Card 1999), with our study focusing on heterogeneity in the return to schooling.

[5] Because of the small number (20) of discrete GPAs available to students, these latter estimates are likely conservative.

[6] The only known quasi-experimental study to previously identify heterogeneous returns by college major in the United States is by Andrews, Imberman, and Lovenheim (2017), who analyze the return to majoring in business by exploiting a GPA threshold policy at several University of Texas campuses. Their suggestive finding of a large wage return to business majors closely parallels our own estimates with regard to economics.

first-order heterogeneity component in the return to higher education.[7] A related literature has used quasi-experimental research designs to highlight university selectivity as another important dimension of heterogeneous university treatment effects (Hoekstra 2009; Zimmerman 2014; Cohodes and Goodman 2014; Bleemer 2021, 2022). However, even students who are quasi-randomly switched to enrolling at universities with 25 percentage points higher graduation rates—a large increase in selectivity—receive an early-career wage return 30 percent smaller than the return to majoring in economics at UC Santa Cruz (Bleemer 2021).[8] These findings imply that widespread but understudied university policies that shape student major choice—like GPA restrictions, variable tuition, and grade inflation—have important long-run efficiency and social mobility ramifications.[9]

While prior studies have documented that students select majors partly based on career preferences (Wiswall and Zafar 2018), we present quasi-experimental evidence that major choice causally affects students' career preferences and industry of employment. The correlation between college graduates' majors and their occupations and industries of employment is notably weak: fewer than 60 percent of most majors' students work in the top *10* highest-employment (5-digit) occupations for that major (Altonji, Blom, and Meghir 2012).[10] Nevertheless, majoring in economics causes students to report a stronger preference for business and finance careers prior to labor market entry—likely in part as a result of perceived job availability—and to be more likely to ultimately work in related industries like FIRE and accounting. These changed industry preferences could reflect the fact that knowledge and skills acquired in the economics major may be particularly useful in these industries, providing students with industry-specific human capital (Altonji, Kahn, and Speer 2014; Kinsler and Pavan 2015).

I. Background

The University of California, Santa Cruz is a moderately selective public research university in northern California. In 2010, UCSC admitted 64 percent of freshman applicants, resulting in a 3,290-student class largely split between White (38 percent), Asian (27 percent), and Hispanic (24 percent) students. Nearly all (98 percent) of its

[7] One reason for the economics major's large return is the relatively low return to economics majors' second-choice social science fields, highlighting the importance of counterfactual student choices in measuring educational returns (Kirkeboen, Leuven, and Mogstad 2016).

[8] As in nearly all previous studies on the return to education and university selectivity, we are unable to distinguish whether the observed returns result from changes in human capital or signaling. We discuss this further in Section V. Other recent papers on heterogeneous university returns by university quality include Sekhri (2020) and Canaan and Mouganie (2018).

[9] The close correspondence between observational and causal estimates of major-specific returns also suggests the potential for private pecuniary gains resulting from providing students with locally relevant information about average wages by majors, which has been shown to increase students' enrollment in high-wage majors (Berger 1988; Beffy, Fougre, and Maurel 2012; Hastings, Neilson, and Zimmerman 2015; Wiswall and Zafar 2015). See Bleemer and Mehta (2021) on GPA restrictions, Andrews and Stange (2019) on variable tuition, and Ahn et al. (2019) on grade inflation. Policies encouraging economics major choice (e.g., Porter and Serra 2020) are particularly likely to provide students with substantial pecuniary returns.

[10] A substantial academic literature studies how university policies shift students toward science and engineering majors (Sjoquist and Winters 2015; Denning and Turley 2017; Castleman, Long, and Mabel 2018), though none directly investigate whether this actually bolsters the STEM labor force.

students were California residents. In many ways, UCSC is relatively representative of the average US university; among four-year US universities in the 2010 Integrated Postsecondary Education Data System database (weighted by enrollment), UCSC is at the forty-second percentile in admissions rate, the fifty-ninth percentile in average student SAT scores, the forty-second percentile in middle-income students' average net price of attendance, and the fifty-third percentile in student-to-faculty ratio.[11] The UCSC Department of Economics had 25 ladder-rank faculty and 7 lecturers in 2010 and taught 8,800 student enrollments that academic year, implying that each faculty member taught an average of 91 students per quarter, among the highest loads at the university.[12]

The UCSC Economics Department's 2003 GPA restriction was the university's first policy limiting enrolled students' access to a particular college major (Bleemer and Mehta 2021). The restriction was first recorded in UCSC's 2003 course catalog, which stated that students with a GPA in Economics 1 and 2 (*EGPA*) below 2.8 would only be allowed to declare the major "at the discretion of the department." If students retook one of the courses, only the initial grade was used to calculate *EGPA*. This policy hardly changed de jure over the following ten years, though the 2012 course catalog is the first to note that for students with below-2.8 *EGPA*s, "appeals are rarely granted." Starting in 2013, calculus grades were added to the *EGPA* calculation.

However, the department's "discretion" left substantial room for year-over-year de facto differences in below-2.8 students' access to the major.[13] The difference in the probability of majoring in economics above and below the *EGPA* threshold remained small (below 15 percentage points) until the 2008 entering cohort and then ranged from 25 to 60 percentage points until 2012.[14] As a result, this study focuses on these latter five cohorts of freshman UCSC students.

II. Data

The student database analyzed in this study (University of California ClioMetric History Project (UC-CHP) 2020) was collected from the UCSC Office of the Registrar as part of the UC ClioMetric History Project (Bleemer 2018). The sample covers all freshman-admit students who first enrolled at UCSC between 1999 and 2014.[15] For each student, we observe gender, ethnicity, cohort year, (pre-enrollment) home address, California residency status, high school, and SAT score as well as

[11] Calculations from the Integrated Postsecondary Education Data System. Average SAT calculated as the summed averages of the twenty-fifth and seventy-fifth percentiles of each SAT test component. Average net price defined over federal financial aid recipients with family incomes between $48,000 and $75,000.

[12] Altonji and Zimmerman (2019) show that economics and business degrees have below-average educational costs.

[13] Online Appendix Figure A-1 shows 2000–2014 UCSC students' likelihood of majoring in economics by *EGPA* for each cohort.

[14] This change was likely driven by increased demand after the 2007–2008 financial crisis; see online Appendix Figure A-2.

[15] Community college transfer students are omitted from our analysis because they followed a different admission rule into the economics major.

UCSC course enrollments and grades.[16] The *EGPA* running variable is calculated by averaging students' GPAs in Economics 1 and 2, using their earliest letter grades if they retook either course.

These student records are linked by name and birth date to the NSC StudentTracker database (NSC 2019), which contains undergraduate and graduate enrollment and degree attainment records for nearly all American colleges and universities, and by social security number to employment records from the California Employment Development Department (EDD 2019), which include annual wages and six-digit North American Industry Classification System (NAICS) industry code.[17] We proxy family income by the mean adjusted gross income in the student's home zip code in their first year of enrollment (IRS 2018).[18]

UCSC students are also linked to survey responses from the biannual UC Undergraduate Experience Survey (UCUES), conducted online in the spring of even-numbered years (Student Experience in the Research University (SERU) 2019). The second/third and third/fourth year response rates among the 2008–2012 students in the main sample were 29 and 28 percent, with the response rates and respondent characteristics smooth across the GPA threshold.[19] Among the survey's many questions are responses about number of hours per week spent studying and students' intended careers.[20]

Non-economics majors are categorized into four disciplines: humanities, social sciences, natural sciences, and engineering. Combining the three tracks of the economics major—economics, BME, and global economics—it was the second-most-popular major at UCSC for the 2008–2012 cohorts (11.7 percent of students), below psychology (12.9 percent) but ahead of environmental studies (6.1 percent) and sociology (6.0 percent).

Table 1 presents descriptive statistics for 2008–2012 UCSC freshman-admit students. Relative to the full sample of 15,400 UCSC students, the 3,053 students who complete Economics 1 and 2 are more likely to be male and Asian and come from slightly higher-income neighborhoods. Of those students, the 55 percent who actually declare the economics major are 41 percent female (compared to 56 percent across UCSC) and 44 percent Asian (compared to 27 percent) and have similar average SAT scores to the average UCSC student (1716 out of 2400).

[16] ACT test scores (submitted by 4 percent of applicants instead of SAT scores) and SAT scores on a 1600 point basis are converted to 2400-point SAT scores using standard concordance tables.

[17] NSC match quality is near complete but missing for some students who opt out of coverage. For example, 97 percent of UCSC undergraduate degrees awarded to the 2008–2012 cohorts appear in NSC (see Appendix C of Bleemer 2021). EDD NAICS code reflects the industry of employment from the year's latest nonmissing quarter (US Census Bureau 2017). EDD employment records exclude out-of-state, federal, and self-employment. All EDD-related analysis was originally conducted for the purpose of institutional research (see Bleemer and Mehta 2020).

[18] Income statistics are from the IRS Statistics of Income (SOI). Wage and income statistics are winsorized at the top and bottom 2 percent and CPI inflation adjusted to 2019 (BLS 2019).

[19] See online Appendix Figure A-3. UCUES data were provided by the SERU Consortium at UC Berkeley's Center for Studies in Higher Education and linked by student ID.

[20] Full questions and responses are provided in the survey Appendix.

TABLE 1—DESCRIPTIVE STATISTICS OF 2008–2012 UCSC ENROLLMENT COHORTS

	Freshman students	Econ 1 and 2 enrollees	Economics majors	Near-threshold economics majors	(SE)
Female (percent)	55.7	41.3	40.9	35.6	(7.3)
White (percent)	40.8	32.4	32.8	27.9	(6.5)
Asian (percent)	26.5	41.4	43.7	41.1	(8.1)
Hispanic (percent)	24.3	19.2	16.7	18.3	(7.1)
Black (percent)	2.9	1.9	1.7	6.2	(1.8)
CA resident (percent)	97.1	97.4	97.2	99.7	(2.5)
SAT score (2400 scale)	1720	1697	1716	1667	(14)
Mean zip code inc. ($)	92,060	95,819	99,477	86,770	(7,309)
Number of students	15,423	3,053	1,689		

Notes: This table presents mean demographic and socioeconomic statistics for 2008–2012 UCSC freshman-admit students, those who take Economics 1 and Economics 2, and those who then declare the economics major. The final columns present the average characteristics of the students who majored in economics because of their barely above-threshold *EGPA*s, estimated following equation (1) by treating the interaction between each characteristic and economics major indicator as the outcome (Abadie 2002). Mean zip code income measures the mean adjusted gross income of tax filers in the student's home zip code in the year they graduated high school.

Source: UC-CHP student database and IRS SOI

III. Empirical Design

We identify the relationship between economics major choice (the treatment) and resulting outcomes (Y) by exploiting a discrete fuzzy grade discontinuity in economics major access (Hahn, Todd, and van der Klaauw 2001). Figure 1 shows the first-stage estimate of the impact of meeting the 2.8 GPA threshold on economics major choice for the 2008–2012 cohorts. Above-threshold students were about 36 percentage points more likely to declare the economics major. Some below-threshold students were nevertheless able to declare the major—"at the discretion of the department"—and about 20 percent of above-threshold students chose not to declare the major. Each bubble is scaled by the proportion of students who earned that *EGPA*; because the *EGPA* is calculated over only 2 letter grades, students could earn only 14 common or 6 uncommon *EGPA*s.

Let $Y_i(1)$ denote the outcome that UCSC student i would experience if they majored in economics, and let $Y_i(0)$ denote the outcome they would experience if they did not. Outcomes of interest include (for example) postgraduation earnings, industry of employment, study time, and graduate school attendance. Let C be the group of policy compliers: the subset of students who major in economics if they are above the GPA threshold but do not if they are below it. The effect of the major on policy compliers whose *EGPA* was near the threshold (the local average treatment effect) is given as

$$(1) \qquad LATE_{RD}(Y) \equiv \lim_{EGPA \downarrow 2.8} E\left[Y_i(1) | EGPA, i \in C\right] - \lim_{EGPA \uparrow 2.8} E\left[Y_i(0) | EGPA, i \in C\right]$$

so long as $E\left[Y_i(1) | EGPA, i \in C\right]$ and $E\left[Y_i(0) | EGPA, i \in C\right]$ are smooth at $EGPA = 2.8$.

We test several implications of this smoothness assumption. First, we find that the empirical grade distribution does not spike at or near the 2.8 *EGPA* threshold and

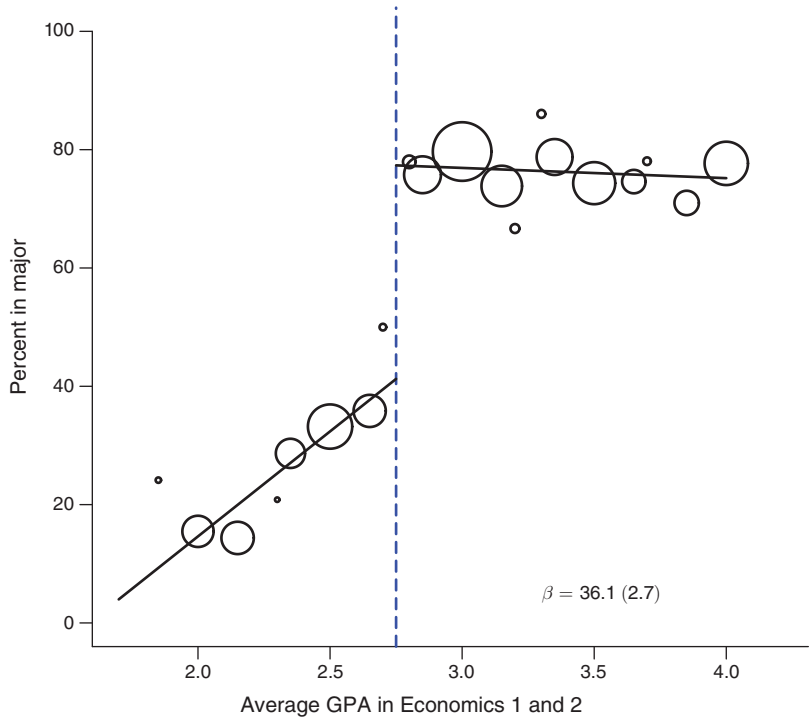

FIGURE 1. THE EFFECT OF THE UCSC ECONOMICS GPA THRESHOLD ON MAJORING IN ECONOMICS

Notes: Each circle represents the percent of economics majors (*y*-axis) among 2008–2012 UCSC students who earned a given *EGPA* in Economics 1 and 2 (*x*-axis). The size of each circle corresponds to the proportion of students who earned that *EGPA*. *EGPA*s below 1.8 are omitted, leaving 2,839 students in the sample. Fit lines and beta estimate (at the 2.8 GPA threshold) from linear RD specification; standard error (clustered by *EGPA*) in parentheses.

Source: UC-CHP student database

that the 2008–2012 distribution is highly similar to the 2003–2007 grade distribution, years when the *EGPA* threshold was loosely enforced.[21] This pattern implies that students did not manipulate their course grades to meet the GPA threshold. Second, we find that detailed student socioeconomic characteristics are smooth across the GPA threshold, as is a one-dimensional summary of student characteristics generated by flexibly predicting each student's 2017–2018 average wages by socioeconomic observables. This indicates that effects estimated across the threshold are unlikely to be driven by anything other than qualification for the major.[22] Finally, as a placebo test, we find that economics major selection and early-career wages are smooth across the 2.8 *EGPA* threshold in 2000-2002, before the GPA restriction was introduced.[23]

[21] See online Appendix Figure A-4. Both distributions share the same shape as the 2000–2002 grade distribution (prior to the *EGPA* restriction's implementation), though average *EGPA*s trended downward over time. Students' Economics 2 grades are smooth across the threshold.

[22] See online Appendix Figure A-5. Predicted wages are estimated by OLS on the 2017–2018 wages of 2008–2012 UCSC students who did not complete Economics 1 and 2. Predicted wages are imputed only for students with observed 2017–2018 wages to match our main labor market estimation sample.

[23] See online Appendix Figure A-6. We also exploit the small increase in economics major choice across the less binding 2003–2007 GPA threshold to noisily replicate the instrumental variable wage results in the main

Our baseline specification for estimating equation (1) is linear in the running variable (*EGPA*) on either side of the threshold and clusters standard errors by the 20 observed *EGPA*s above 1.8 (Lee and Card 2008). We also check that our results are robust to using a number of alternative specifications. These include (i) allowing quadratic running variable terms, (ii) adding demographic controls and high school fixed effects, (iii) narrowing the bandwidth to 0.5 *EGPA* points on either side of the threshold, and (iv) estimating "honest" local linear RD coefficients with optimal bandwidth and triangular kernel following Kolesár and Rothe (2018).[24] We note below the rare occasions in which any of the alternative specifications result in coefficients that differ substantially or statistically from those presented in the figures.[25]

The last columns of Table 1 present estimated characteristics of the students who majored in economics as a result of their barely above-threshold *EGPA*s (estimated following Abadie 2002). These students' observable characteristics are surprisingly similar to those of the average UCSC economics student: 36 percent are female, 41 percent are Asian, and essentially all of them are California residents. Despite their low introductory course grades, there is no indication that they were much less prepared for success than other economics majors: their mean SAT score is at the forty-first percentile of all economics majors, while the mean income of their zip codes of residence is at the forty-eighth percentile of their economics peers.[26] The representativeness on observables of our above-threshold policy compliers suggests that our estimated local average treatment effects may be similar to the average treatment effect of majoring in economics at UCSC.

IV. Baseline Return to the Economics Major

Figure 2 shows that 2008–2012 UCSC students with above-threshold *EGPA*s had far higher early-career wages than their below-threshold peers.[27] Measuring average California wages in 2017 and 2018—when students in the sample were 23 to 28 years old—above-threshold students earned about $8,000 higher wages than below-threshold students, with a standard error of $1,900.[28] Given that they were also 36 percentage points more likely to major in economics, the IV estimator suggests that students who just met the GPA threshold earned higher early-career wages by about $22,000 if they declared the economics major, rising from $37,000 to over $59,000. Measuring wages in log dollars provides a similar 0.58 log dollar

specification below (first-stage 6.2 percentage points (2.9 SE), IV $32,500 ($19,600)).

[24] The small number of running variable values suggests that these last estimates will be conservative. Online Appendix Tables A-1 to A-4 present regression coefficients from these alternative specifications for all main results.

[25] All OLS and IV regressions are estimated using the *felm* function in the *lfe* R package, version 2.8-5. Honest local linear regressions are estimated by the *RDHonest* R package, version 0.3.2.

[26] This absence of significant positive selection may result from the substantial noise in introductory course grades, which reflect a host of professor, teaching assistant, and extracurricular determinants (e.g., Sacerdote 2001; Fairlie, Hoffmann, and Oreopoulos 2014). A linear regression of *EGPA* on high school fixed effects and gender-ethnicity indicators interacted with SAT score, mean zip code GPA, and cohort provides an adjusted R^2 of only 0.15.

[27] Impacted students mostly graduated between 2012 and 2016, so their early-career earnings and industries were not shaped by a postgraduate recession (Altonji, Kahn, and Speer 2016).

[28] Students with earnings in only one of the two averaged years are assigned their observed year's wages; students with no observed wages in either year are dropped. Some RD specifications provide somewhat larger wage return estimates.

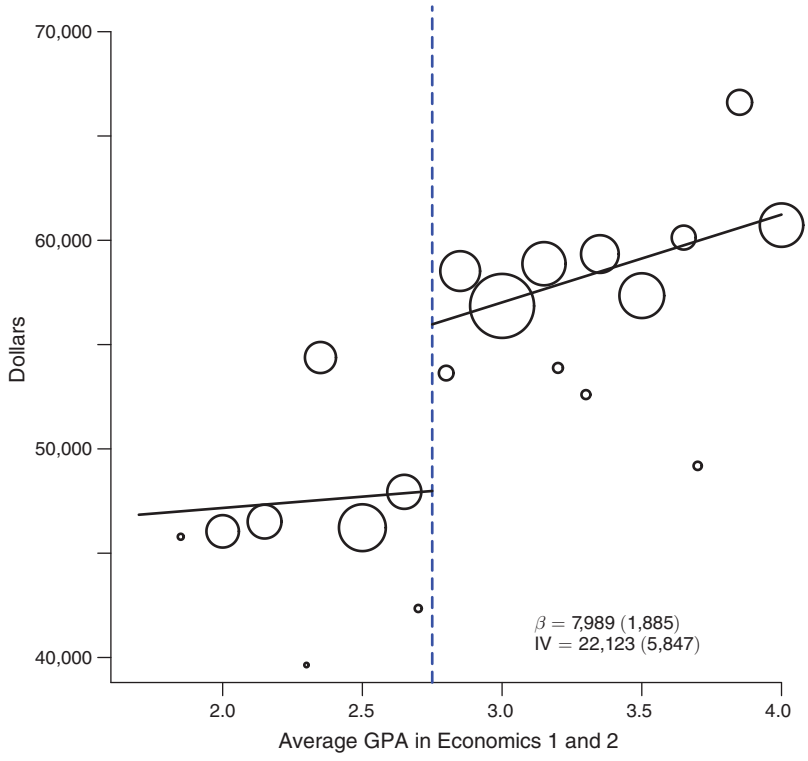

FIGURE 2. THE EFFECT OF THE UCSC ECONOMICS GPA THRESHOLD ON ANNUAL WAGES

Notes: Each circle represents the mean 2017–2018 wages (y-axis) among 2008–2012 UCSC students who earned a given *EGPA* in Economics 1 and 2 (x-axis). The size of each circle corresponds to the proportion of students who earned that *EGPA*. 2017–2018 wages are the mean EDD-covered California wages in those years, omitting zeroes. Wages are CPI adjusted to 2018 and winsorized at 2 percent above and below. *EGPA*s below 1.8 are omitted, leaving 2,446 students with observed wages. Fit lines and beta estimate (at the 2.8 GPA threshold) from linear RD specification and instrumental variable specification (with majoring in economics as the endogenous variable); standard errors (clustered by *EGPA*) in parentheses.

Sources: UC-CHP student database and CA Employment Development Department

estimated treatment effect, though that estimate is statistically noisy in the Kolesár and Rothe (2018) specification.

The estimated returns to majoring in economics are nearly identical when estimated separately by student gender: $21,700 (SE $8,800) for men, $22,600 ($5,700) for women. The unexpectedly high observed earnings of students with $EGPA = 2.35$ visible in Figure 2 obtains only for male students, driving those estimates' higher standard errors. The return is also similar in magnitude among underrepresented minority (Black, Hispanic, and Native American) students: $27,600 ($13,500).[29]

[29] See online Appendix Figure A-7. California wages are observed for 80–90 percent of the sample, likely the result of nearly all UCSC freshman students being California residents. There is some evidence that students' likelihood of 2017–2018 California employment rises at the GPA threshold, though the estimates are not robust across different specifications; see online Appendix Figure A-9.

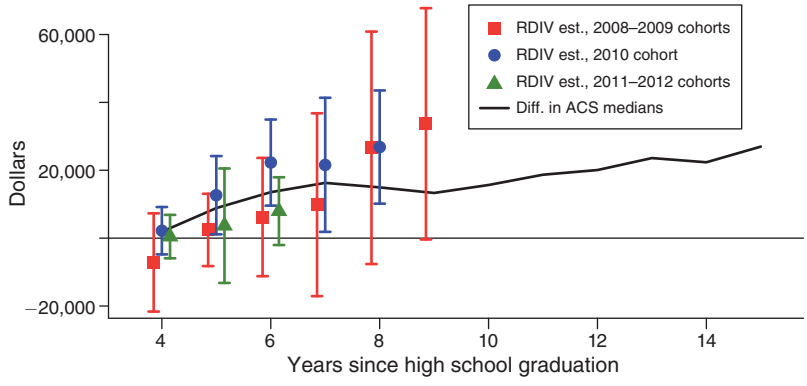

FIGURE 3. ESTIMATED WAGE RETURN TO ECONOMICS MAJOR BY AGE

Notes: This figure shows RD instrumental variable β estimates at the 2.8 GPA threshold of the effect of majoring in economics on earnings in each of 4–9 years after high school graduation, splitting the sample into the 2008–2009, 2010, and 2011–2012 UCSC incoming-class cohorts. The bars show 95 percent confidence intervals from standard errors clustered by *EGPA*. The black line shows the difference between the national median wages of economics majors and those of college graduates with majors in barely above-threshold UCSC students' second-choice majors, as measured in the ACS; see online Appendix Figure A-8. Wages are CPI adjusted to 2018 and winsorized at 2 percent above and below.

Sources: UC-CHP student database, CA Employment Development Department, and ACS (Ruggles et al. 2020)

These estimates do not appear to be solely driven by college graduates' first employment after graduation. Figure 3 presents estimates of the annual wage return to majoring in economics four to nine years after graduating high school for three partitions of our baseline sample: the 2008–2009 cohorts, 2010 cohort, and 2011–2012 cohorts. It shows suggestive evidence that the wage return grows larger as workers age from 23 to 28, though the small number of cohorts challenges separate identification of age and cohort effects. Online Appendix Figure A-8 contextualizes this finding by using American Community Survey (ACS) wage data (Ruggles et al. 2020) to visualize the median wages of US economics majors annually from ages 22 to 62 along with the weighted median wages of US college graduates who earned the second-choice majors that UCSC's policy-complying economics majors would have earned if economics had been unavailable (discussed further below). The relative observational return to economics increases with age in workers' twenties and thirties and remains large throughout workers' careers, resulting in a $536,000 observational net present value of majoring in economics.[30]

[30] The observational wage return to economics shrinks (though remains large) after age 50, possibly reflecting informational obsolescence (Deming and Noray 2020).

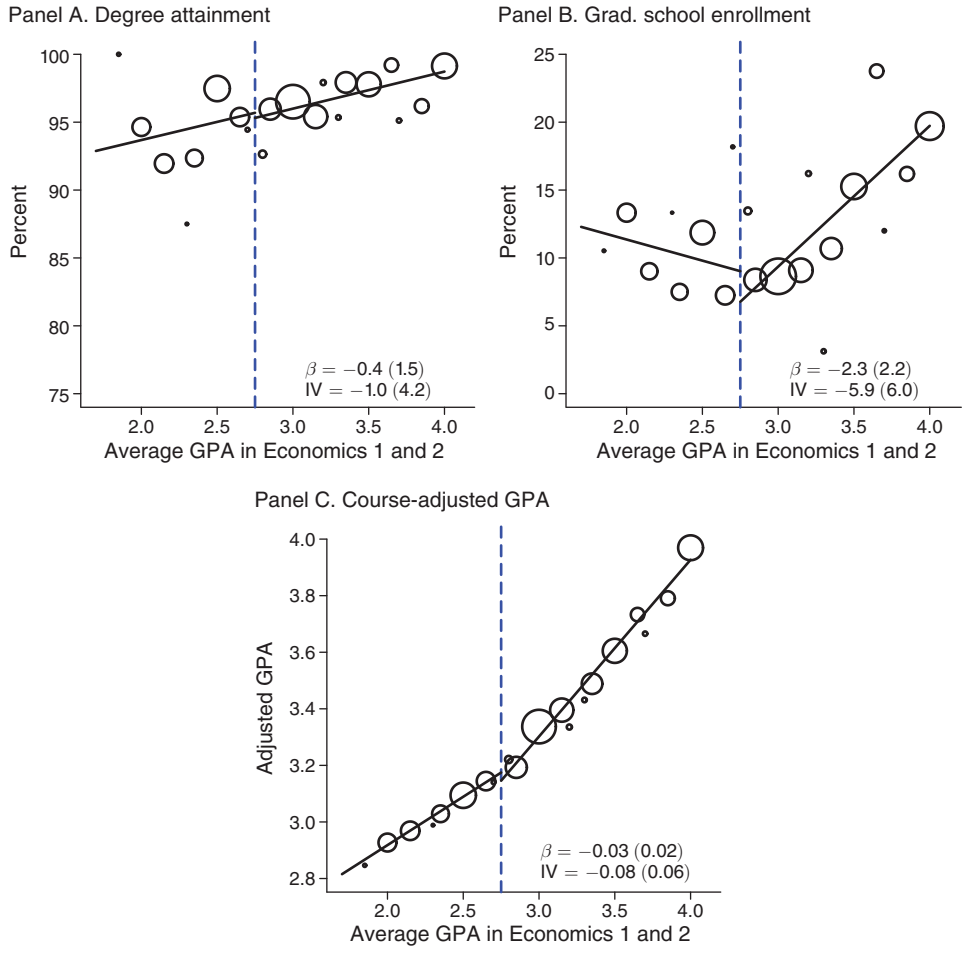

Figure 4. The Effect of Economics Major Access on Education and Attainment

Note: Each circle represents the mean educational outcome (y-axis) among 2008–2012 UCSC students who earned a given *EGPA* in Economics 1 and 2 (x-axis). The size of each circle corresponds to the proportion of students who earned that *EGPA*. Undergraduate degree attainment is measured in 2018. Graduate school enrollment indicates enrollment at a four-year university after undergraduate degree attainment within seven years of UCSC matriculation. Course-adjusted college GPA is calculated as the mean of the differences between students' grades and each course's fixed effect from a two-way student-course fixed effect model (see online Appendix Figure A-10). *EGPA*s below 1.8 are omitted, leaving 2,839 students in the sample. Fit lines and beta estimate (at the 2.8 GPA threshold) from linear RD specification and instrumental variable specification (with majoring in economics as the endogenous variable); standard error (clustered by *EGPA*) in parentheses.

Sources: UC-CHP student database and NSC

V. Why do Economics Majors Earn Higher Salaries?

A. *Educational Performance, Resources, and Attainment*

Figure 4 shows how the characteristics of UCSC students' postsecondary educations differed as a result of being provided access to the economics major. Panels A and B show that access to the economics major does not change students' likelihood of earning a college degree or enrolling in a graduate degree program (within seven

years of matriculating).[31] Above-threshold students also have similar time to degree as below-threshold students. Economics major access does not provide students with smaller class sizes; if anything, average class sizes grow larger.[32] It does not lead students to earn higher or lower grades when adjusted for course difficulty (panel C), nor does it change the weekly amount of time students report studying outside of class.[33]

Instead, the primary estimable difference in students' postsecondary educations is the content of that education. Barely above-threshold economics majors completed 13 more economics courses than nonmajors, for a total of 17 economics courses on average. This caused the economics majors to take nine fewer courses in other social sciences and about four fewer courses across other disciplines. About seven of the additional economics courses were in traditional economics subdisciplines, while almost six were in subdisciplines related to business, finance, and accounting also offered by UCSC's economics department. Access to the economics major did not change the number of mathematics and statistics courses that students completed, but they did complete an average of two additional courses in quantitative methodology.[34]

If there was no signal value of economics degree attainment, then these estimates would imply a wage elasticity of economics course taking of about 0.3.[35] However, this estimate is likely upwardly biased by the potentially high signal value of economics degrees relative to students' second-choice majors. We are unable to directly distinguish between the degree's signal value and the value of additional human capital accumulation in this setting.[36]

B. *Employment by Industry*

Majoring in economics causally impacts the industries in which students are employed in their early careers. This could reflect either industry-specific human capital formation or changes in students' preferences across industries. Panel A of Figure 5 suggests that part of the effect arises from student preferences: survey

[31] Near-threshold students had a 96 percent bachelor's attainment rate—including degrees earned at other institutions by 2018—compared to 94 percent across the 2008–2012 UCSC freshman cohorts.

[32] For plots showing estimates for additional educational outcomes like time to degree and class size, see online Appendix Figure A-10.

[33] Above-threshold students earn slightly lower unadjusted GPAs than below-threshold students as a result of relatively lower grading standards in UCSC's economics department; see online Appendix Figure A-10.

[34] Quantitative methodology courses include any course that mentions "statistics," "econometrics," "psychometrics" or "quantitative/math/research/information methods" in its title. See online Appendix Figures A-11 and A-12.

[35] Arteaga (2018) finds that in the setting of a Colombian university, a policy change that resulted in a 15 percent reduction in course taking among economics majors caused a 16 percent decline in students' early-career wages, implying a unit wage elasticity of economics course taking. It is unsurprising that we estimate a lower elasticity given that (i) below-threshold UCSC students excluded from the economics major took other courses instead of economics courses, whereas the Colombian students graduated having completed fewer aggregate courses, and (ii) below-threshold UCSC students earned a different college major instead, which could change the signal value of their degree.

[36] One potential strategy to directly estimate the signal value of UCSC's economics degree would be to compare the wages of economics majors and nonmajors who took comparable numbers of economics courses. Unfortunately, as at many US public universities, many UCSC economics courses were formally or informally restricted to economics majors. Online Appendix Figure A-13 shows that there is essentially no overlap between the distribution of economics courses completed by 2008-2012 UCSC economics majors and nonmajors, thwarting that design.

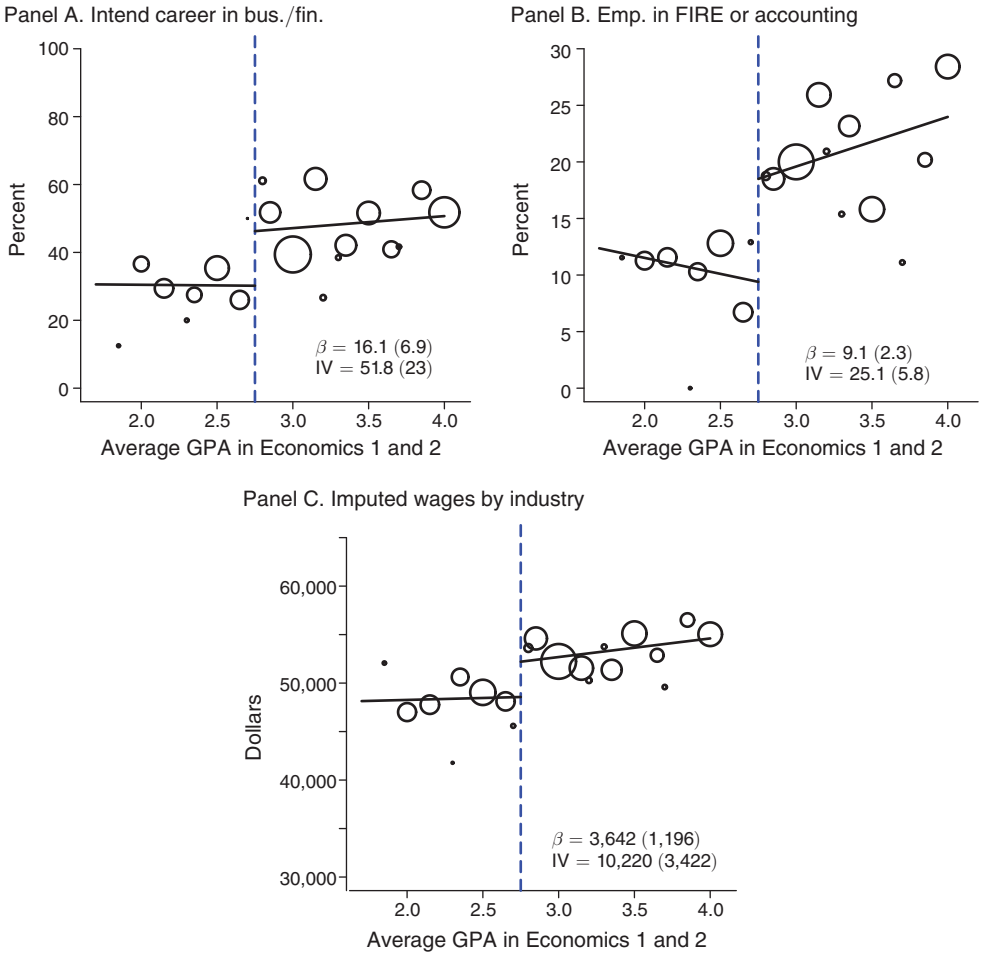

FIGURE 5. EFFECT OF ECONOMICS MAJOR ACCESS ON INDUSTRY PREFERENCES AND EMPLOYMENT

Notes: Each circle represents the mean outcome measure (y-axis) among 2008–2012 UCSC students who earned a given *EGPA* in Economics 1 and 2 (x-axis). The size of each circle corresponds to the proportion of students who earned that *EGPA*. Intended career in business/finance indicates selecting "Business, finance-related professions" on a survey asking "Career hope to eventually have after education complete" (see the online survey Appendix) among the 834 in-sample second- and third-year UCUES respondents. Employment in FIRE and accounting indicates 2017 or 2018 employment in the FIRE (NAICS codes 52 and 531) or accounting (541211) industries; see online Appendix Figure A-5. Imputed wages by industry (six-digit NAICS) are calculated as the mean 2017–2018 wages of all 2008–2012 freshman-admit UCSC students. Imputed wages are CPI adjusted to 2018 and winsorized at 2 percent above and below. Fit lines and beta estimate (at the 2.8 GPA threshold) from linear RD specifications and instrumental variable specifications (with majoring in economics as the endogenous variable); standard error (clustered by *EGPA*) in parentheses. Six 2012 sophomore respondents were omitted from estimation; see online Appendix Figure A-14.

Sources: UC-CHP student database, SERU database, and CA Employment Development Department

responses from students' sophomore and junior spring quarters (prior to labor market entry) show that barely above-threshold economics majors became more than 50 percentage points more likely to report an interest in a business or finance career than nonmajors, though this could in part reflect increased employment opportunity in those industries.[37] Panel B shows that economics major access increases students' early-career likelihood of working in the most impacted FIRE and accounting industries by 25 percentage points, split two-thirds/one-third between the two. Economics majors became 17 percentage points less likely to work in the education, health-care, and social assistance industries in 2017–2018.[38]

Panel C of Figure 5 shows the effect of majoring in economics on the average wages earned in students' industries of employment. Industries are defined by six-digit NAICS codes, and industry mean wages are measured using the 2017–2018 wages of all 2008–2012 UCSC students. Barely above-threshold economics majors work in industries with higher mean wages by about $10,000, implying that just under half of the $22,000 wage return to majoring in economics can be explained by economics majors working in higher-paying industries.[39]

VI. Average Wage-by-Major Statistics

Differences in the average wages earned by college graduates with different majors are often presented as useful for students' major selection (Carnevale, Cheah, and Hanson 2015; US Department of Education 2019), but they could be misleading as a result of self-selection into majors. To examine this concern empirically, this section compares the causal return to majoring in economics at UCSC to observational differences in wages by major estimated using data from various reference populations (e.g., all UCSC graduates or college graduates in California).

Denote the average wage of college graduates in reference population R who completed major m by $\tilde{w}_m^R$. Among students at UCSC who have taken Econ 1 and 2, let m_i be student i's chosen major, $w_i(m)$ be the latent wages they would have earned if they had selected major m, and $w_i = w_i(m_i)$ be their observed wage given that they chose m_i. The variable T is the treatment major (economics). Let P_m^0 be the probability of choosing non-economics major m for the barely below-threshold students who would have earned economics majors if their *EGPA*s had been slightly higher (that is, below-threshold policy compliers), P_m^R be the probability of a

[37] First-year career-intention survey responses (prior to majoring in economics) are smooth across the threshold. We examine sophomore and junior responses because those students have (likely) already declared the economics major but have not yet been hired into postgraduate employment. Six 2012 sophomore respondents—economics majors with 2.7 *EGPA*s—are omitted from estimation as outliers; see online Appendix Figure A-14.

[38] See online Appendix Table A-5, which shows estimated changes for each two-digit NAICS code. Accounting—in which UCSC Economics offers several courses—is the most-impacted six-digit NAICS code outside of FIRE industries.

[39] This conclusion is supported by a $15,400 estimated IV wage coefficient in the presence of 6-digit-NAICS industry fixed effects, though that estimate is statistically noisy (SE $8,000). If industries are partitioned into just 3 groups—FIRE, accounting, and all other industries combined—the 2 can explain only a $2,300 (IV) wage increase at the threshold. Mean industry wages calculated using earlier UCSC cohorts and 2009–2010 wages provide nearly identical estimates, suggesting that this information *could* have been partly known by students. NAICS codes with fewer than ten observed workers are omitted.

student in R selecting m conditional on not selecting economics, and $\bar{w}_m^0$ and $\bar{w}_m^1$ be the expected latent wages in major m of UCSC policy compliers just below and above the GPA threshold. We can then estimate equation (1) in our sample of UCSC Econ 1 and 2 takers either using each student's observed wage as the dependent variable or replacing it with the $\tilde{w}_m^R$ of their chosen major. These regressions yield estimates, respectively, of

$$LATE_{RD}(w) = \bar{w}_T^1 - \sum_{m \neq T} P_m^0 \bar{w}_m^0, \tag{2}$$

$$LATE_{RD}(\tilde{w}_m^R) = \tilde{w}_T^R - \sum_{m \neq T} P_m^0 \tilde{w}_m^R. \tag{3}$$

These equations show that wage-by-major statistics from R can be used to predict the treatment effect of earning an economics major for barely above-threshold UCSC students if they are similar to policy compliers' latent wages by major near the GPA threshold.

Figure 6 shows the average early-career wages by major for barely above-threshold economics majors' 10 most common second-choice majors—led by psychology (20 percent), environmental studies (14 percent), and "technology and information management" (12 percent)—and for UCSC's 3 economics tracks.[40] Average wages by major ($\tilde{w}_m^R$) are calculated in three ways: by linear regression of UCSC students' early-career wages on major dummies with and without detailed student controls and by the median wages of all early-career college graduates in California.[41] The figure also shows estimates of $LATE_{RD}(\tilde{w}_m^R)$ for each set of average wage statistics as the difference between two dashed horizontal lines. These are estimates of equation (3), which implicitly weights the average wage in each counterfactual major by the likelihood that a below-threshold policy complier would select it. They are juxtaposed at the far right with the causally identified return to majoring in economics, as estimated following equation (2).[42]

At UCSC and across the state, economics majors have substantially higher average wages than college graduates who earned the observed counterfactual majors.[43] Using either OLS estimates or median wages, the difference between the average wages of economics majors and the weighted-average wage among the counterfactual majors *underestimates* the causally estimated return to majoring in economics by up to 21 percent.

[40] Above-threshold policy compliers are more likely to choose the BME track than the average economics major. The fraction of economics majors on the BME track only increases slightly and statistically insignificantly across the GPA threshold (10.5 percentage points, SE 6.1), suggesting that the large share of policy compliers on that track largely results from local student demand, not department policy. See online Appendix Figure A-15.

[41] National wage-by-major medians display a similar pattern; see online Appendix Table A-6. California and US statistics are from the ACS (Ruggles et al. 2020). See online Appendix Table A-7 for a UCSC-ACS major crosswalk.

[42] The imputed wage estimates partition students by their *set* of majors to calculate averages, whereas the major-specific estimates assign multi-major students to their higher-earning major; see online Appendix Figure A-16. Estimates of below- and above-threshold UCSC policy compliers' imputed and actual wages follow Abadie (2002).

[43] BME majors have somewhat higher average wages than other economics majors at UCSC, but not elsewhere. UCSC's high-wage technology and information management major includes the economics department's core course sequence as required courses.

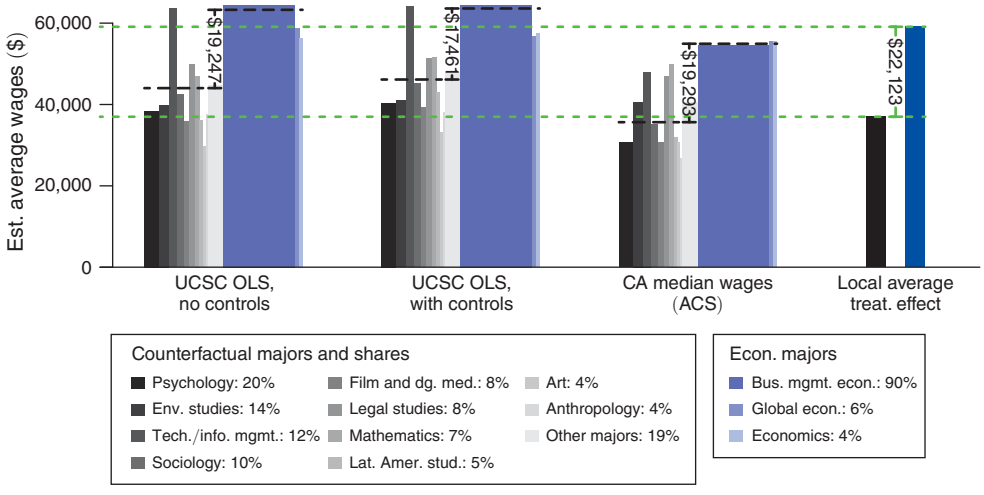

FIGURE 6. AVERAGE WAGE DIFFERENCES BETWEEN ECONOMICS AND COUNTERFACTUAL MAJORS

Notes: This figure shows average early-career 2017–2018 wages by major of UCSC students (estimated by OLS, with and without control variables) and all California college graduates (ACS medians) for UCSC's three economics tracks and for the ten most common counterfactual majors earned by below-threshold UCSC policy compliers, juxtaposed with the causally identified local average treatment effect on early-career wages for below- and above-threshold UCSC policy compliers (following Abadie 2002). The black dotted lines show the average wages of the majors chosen by below- and above-threshold policy compliers, calculated by assigning each 2008–2012 UCSC student to their corresponding majors' average wage—leave-one-out in the UCSC no-controls sample—and using the linear RD IV model on the resulting imputed wages. Counterfactual major shares are estimated by the linear RD IV model predicting an indicator for earning that major; the shares sum to over 100 percent because below-threshold policy compliers earn more multiple majors. Bar widths are proportional to the major shares. UCSC statistics from 2008–2012 UCSC students matched to 2017–2018 wages; California statistics calculated from age 23–28 2017–2018 ACS respondents. OLS coefficients from regressions of wages on major indicators with or without covariates (gender-ethnicity, SAT score, zip code average adjusted gross income, cohort year, and high school fixed effects), partitioning students by their highest-earning major. See online Appendix Figure A-7 for UCSC-ACS major mapping. Wages and wage-by-major averages are CPI adjusted to 2018 and winsorized at 2 percent above and below.

Sources: UC-CHP student database, CA Employment Development Department, and ACS (Ruggles et al. 2020)

Why might wage-by-major estimates differ from the treatment effect of majoring in economics? To see the possible sources of bias, note that linear regression of observed wages on treatment in population R estimates $\beta^R_{OLS}(w) \equiv \tilde{w}^R_T - \sum_{m \neq T} P^R_m \tilde{w}^R_m$ and that it is generically true in a Rubin causal model that

$$\beta^R_{OLS}(w) = \overbrace{E\big(w_i(T)\,|\,m_i = T\big) - E\big(w_i(\sim T)\,|\,m_i = T\big)}^{\text{Average Treatment Effect on Treated in } R\ (ToT^R)} + \underbrace{\Big[E\big(w_i(\sim T)\,|\,m_i = T\big) - E\big(w_i(\sim T)\,|\,m_i \neq T\big)\Big]}_{\text{Selection Bias}}. \tag{4}$$

Equation (4) shows that OLS overestimates economics majors' true wage gains if those selecting economics would have earned more in non-economics majors than those who did not select economics—due to, e.g., stronger prior quantitative

training or stronger preferences for high wages. Combining equations (2), (3), and (4) yields

$$(5)\quad LATE_{RD}\left(\tilde{w}_m^R\right) - LATE_{RD}(w) = \underbrace{\left[LATE_{RD}\left(\tilde{w}_m^R\right) - \beta_{OLS}^R(w)\right]}_{\text{Counterfactual Major Correction}} + \underbrace{\left[ToT^R - LATE_{RD}(w)\right]}_{\text{Treatment Effect Heterogeneity}} + \left[\text{Selection Bias}\right].$$

Equation (5) decomposes the difference between the observational difference in average wages by major in population R and our estimated treatment effect of majoring in economics at UCSC. The counterfactual major correction is positive whenever the majors selected by below-threshold UCSC policy compliers are systematically higher-earning than those selected by non-economics majors in R—as is clear from comparing the definition of $\beta_{OLS}^R(w)$ to equation (3). The treatment effect heterogeneity term is positive whenever economics majors in R have larger latent treatment effects than those of policy compliers near the GPA threshold. Selection bias is positive when economics majors in R would have earned higher wages in non-economics majors than nonmajors in R.

The left-hand side of equation (5) is negative and small when R consists of all UCSC graduates, and the counterfactual major correction is very small. This implies that the treatment effect heterogeneity and selection bias terms must roughly cancel each other out.[44] Figure 6 shows this clearly. Above-threshold policy compliers have lower average earnings than the average UCSC students on their economics tracks, but their wages would have been even lower—to an even greater degree than the difference in average wages by major—if they'd earned their second-choice majors instead.[45,46] Combined with the fact that selection bias resulting from observable characteristics is positive ($\$19,247 - \$17,461 > 0$), this suggests that $ToT^{UCSC} < \beta_{OLS}^{UCSC} < LATE_{RD}(w)$: the average economics major earned a return smaller than the observational wage difference, while students who were barely unable to declare the economics major may have earned a return larger than the observational wage difference.

Together, these results suggest that OLS and wage-by-major medians well approximate, and in fact slightly underestimate, the causal effect of majoring in economics identified by our instrumental variable design.

[44] With all UCSC graduates as R, we estimate $LATE_{RD}(\tilde{w}_m^R) = \$19,427$ (Figure 6), $LATE_{RD}(w) = \$22,123$ (Figure 6), and $\beta_{OLS}^R(w) = \$20,039$ (online Appendix Table A-6). The LHS is then −$2,876, the counterfactual major correction is −$792, and the heterogeneity and selection terms sum to −$2,084, which is less than 10 percent of the estimated treatment effect by magnitude.

[45] This is consistent with students having comparative advantage in their preferred major (Kirkeboen, Leuven and Mogstad 2016), one dimension of treatment effect heterogeneity.

[46] Using the CPI-adjusted 2009–2010 wage-by-major medians of earlier UCSC cohorts to impute the 2008–2012 cohorts' wages yields $LATE_{RD}(\tilde{w}_m^R)$ estimates that are strikingly similar to the true local average treatment effect (online Appendix Figure A-17), suggesting that those effects are relatively stable over time.

VII. Conclusion

The UCSC Economics Department's 2008–2012 binding major restriction policy provides an unusual opportunity to transparently identify the personal early-career wage return to earning an economics major in college. We show that the wage return to economic education is very high relative to education in students' second-choice social science disciplines, causing a 46 percent increase in mid-twenties earnings despite no change in educational investment or degree attainment. About half of the observed effect can be attributed to economics majors' specialization in particular high-wage industries, in part reflecting changes in students' reported preferences across professions. Mirroring a similar finding from studies of the return to additional years of education (Card 1999), we show that major-specific OLS estimates and differences in median wages by major both slightly underestimate the observed wage return to economics. For reference, a comparison between the national median wages of college graduates with economics degrees and those of graduates with degrees in UCSC economics students' second-choice majors suggests that majoring in economics raises the net present value of a student's college education by $536,000, with the early-career annual wage difference widening over time.

These findings imply that students' major choices could have financial implications roughly as large as their decision to enroll in college (Autor 2014), highlighting the centrality of heterogeneity in the private returns to higher education. They also point to students' college major choice as a key decision point where policymakers can intervene to substantially impact youths' long-run labor market outcomes.[47] Finally, these findings illuminate the relationship between major-specific returns and industrial composition, suggesting an important role for preferences and industry-specific human capital acquisition in postsecondary education.

These findings come with four caveats. First, our results are estimated for students at a moderately selective public university—at the sixtieth percentile of the university average SAT distribution—where nearly all students eventually earn a bachelor's degree (at UCSC or elsewhere); the findings may not be representative of the average university student. Second, our analysis is restricted to students who already choose to take introductory economics courses and may not extend to other students. Third, there are many US states (unlike California) where economics majors do not earn above-average early-career wages, suggesting an important role for local labor demand in shaping major-specific returns.[48] Finally, higher education's broad public and nonpecuniary returns imply that wage returns are insufficient in themselves for drawing conclusions about the efficiency of educational policies (e.g., see McMahon 2009).

[47] Indeed, Bleemer and Mehta (2021) show that GPA-based major restrictions regressively shape students' major choices, tending to decrease disadvantaged students' access to universities' high-demand majors.

[48] For example, in the 15 states where industries' employment shares among college graduates are least similar to California's, 2017–2018 ACS statistics show that economics majors do not have higher median wages than other college graduates and earn lower wages than nonmajors in most two-digit industries. See online Appendix Figure A-18.

Survey Appendix

We analyze students' responses to two UCUES survey questions. The first question asks, "How many hours: -Studying and other academic activities outside of class," and respondents are provided 8 radio-button alternatives: "0; 1–5; 6–10; 11–15; 16–20; 21–25; 26–30; More than 30." We code each range to its mean and code "More than 30" to 35.

The second question asks, "Career hope to eventually have after education complete." Students' available responses are "Agricultural/agribusiness; Artistic, creative professions; Business, finance-related professions; Civil service/government; Education; Engineering, computer programming; Law; Medicine, health-related professions; Military; Psychology, helping professions; Researcher, scientist; I have no idea whatsoever; Other." Our analysis uses an indicator for whether the student selected the third response, "Business, finance-related professions."

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