Major restrictions, socioeconomic stratification, and student success

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Executive Summary

Like many other public research universities, most UC campuses restrict access to high-demand majors using grade minimums and competitive internal applications, with some current policies dating back to the 1970s. This topic brief examines three questions:

1. On average, what is the impact of major restriction policies on the number and characteristics of students who declare restricted majors?
2. If major restriction policies *do* change the characteristics of students who declare restricted majors, then *how* do they do so; what mechanisms explain their effects?
3. What are the long-run impacts of major restrictions for students who are unable to earn their preferred major?

This brief analyzes these questions using three different research designs. First, it presents difference-in-difference estimation around the initial implementation of 26 major restrictions at four campuses since the 1970s to show that, on average, the restrictions lead to substantial enrollment declines in impacted majors. As an unintended consequence, **major restrictions disproportionately restrict entry by students from underrepresented groups (URG) and students with low test scores**. Moreover, the students who earn restricted majors aren't those who perform particularly well in that specific field of study, but instead are students who have generally-higher grades in all of their courses.

The brief follows this quantitative analysis with a case study of two campuses' economics majors, one with a restriction, the other without. Comparing the major choices of introductory economics students at the two campuses, it shows that lower-income and URG students are disproportionately discouraged from declaring the major at the restricted campus. This can be largely explained by those students' lower pre-college academic opportunity and measured preparedness: **students with lower SAT scores and without access to high school AP and IB courses tend to earn lower grades in introductory courses, leading many of them to be restricted out of their preferred major**.

Finally, this brief compares the post-graduate wages of on-the-bubble students on either side of one major restriction. Students with grades just above the GPA threshold are much more likely to be allowed into their preferred major than students just below the threshold. The brief shows that **below-threshold students, unable to earn their preferred major, end up with substantially lower early-career wages** in lower-paying industries, though their degree attainment and graduate enrollment remain unchanged.

In short, major restriction policies contribute to within-campus socioeconomic stratification and prevent many students – particularly those already disadvantaged – from earning their preferred degrees and postgraduate careers. The brief provides a short discussion of alternative policies available to campuses.

Introduction

University of California students from underrepresented groups (URG) and lower-income families are underrepresented in many high-earning and high-demand fields of study like computer science and economics.[2] Meanwhile, many campuses impose restrictions – like minimum GPA requirements and competitive internal applications – on which fields of study are available to enrolled students, with restrictions particularly prevalent in high-demand fields. This topic brief analyzes the prevalence, operation, and effects of major restrictions in the UC system.

Typically arising as a result of surges in student demand for particular college majors (with additional pressure from general enrollment growth and state disinvestment), **major restrictions have become widely implemented at selective public universities across the United States**. Table 1 shows the restrictions imposed on five of the highest-wage college majors at the 25 top-ranked US public universities (according to US News & World Report). These universities enroll about 750,000 undergraduates, or half of all students at top-100 American universities (and 7 percent of all American undergraduates). Half of these schools restrict their computer science majors – typically to students who earn minimum grades (minimum 2.5-3.75 GPAs) in introductory computer science courses – while 10 have restricted economics majors. Only two schools do not restrict their finance majors, and only Georgia Tech does not restrict Mechanical Engineering. Every university with a Nursing school restricts entry to that major.[3]

This brief analyzes the impact of major restrictions using a newly-created dataset of demographic and course records for the 800,000 students who enrolled between 1975 and 2018 at four UC campuses: Berkeley (UCB), Davis (UCD), Santa Barbara (UCSB), and Santa Cruz (UCSC).[4] It employs three research designs – difference-in-difference, propensity score matching, and regression discontinuity – to illuminate the impact of major restrictions on UC student choices and outcomes over the past 50 years.

The results below are split into three sections. The first analyzes how enrollment in each restricted major changed in the years immediately following the initial implementation of the restriction, compared to enrollment in earlier years (and relative to other majors at the campus). Most of the 29 major restrictions imposed since 1970 came about after years of enrollment growth in those programs, and the average restriction not only ends that growth, but also causes an immediate and persistent 10 percent enrollment decline in the impacted major. The enrollment decline is particularly severe among URG students; the proportion of URG students in impacted majors falls by about 15 percent. Interestingly, major restrictions impede major choice for students with absolute academic disadvantage, not field-specific comparative disadvantage; the students who exit restricted majors earn low first-quarter grades across *all* disciplines, not just in the restricted field. This implies that major restrictions act to restrict access away from generally less-prepared students, not students who merely lack academic strengths in the specific area of study.

The second section of results analyzes the specific mechanisms that explain how major restrictions act to restrict access to disadvantaged students. It focuses on a case study of two otherwise-similar

Table 1: Binding major restrictions at the top 25 US&WR ranked public universities, Fall 2019

Univ.	Undergrad. Students	Computer Science	Economics	Finance	Mechanical Engineering	Nursing
Cornell	14,907	2.5	2.7	3.3; A	2.5; A	*
UCLA	31,002	3.5; A	2.5	3.3	3.5; A	HS
UC Berkeley	30,853	3.3	3.0	A	3.0; A	*
Virginia	16,655	-	-	A	2.5	A
Michigan	29,821	-	-	A	A	A
UC Santa Barbara	22,186	3.2	2.85	2.85	A	*
UNC–Chapel Hill	18,862	-	-	3.0; A	*	A
UC Irvine	29,307	3.0	2.5	3.0; A	3	A
Georgia Tech	15,573	-	-	-	-	*
Florida	35,247	-	3.0	3.0	2.8	3.3
William and Mary	6,285	-	-	2.5; A	*	*
UC Davis	30,145	3	-	*	2.8	*
UC San Diego	28,587	3.3; A	2.5	*	A	*
Georgia	28,848	-	A	A	A	*
UI–Urbana-Champaign	33,955	3.75; A	-	A	3.75; A	*
UT–Austin	40,492	A	-	3.25; A	3.0; A	3.0; A
UW–Madison	32,196	-	-	2.75; A	A	2.75; A
Ohio State	45,946	3.2	-	3.0; A	3.4	A
Purdue	31,006	-	2.75	-	3.2; A	2.75
Rutgers	35,641	-	-	A	A	HS
Penn. State–Univ. Park	40,835	HS	-	3.2	HS	HS
Washington	31,331	A	A	2.5; A	A	2.8; A
Connecticut	19,241	3.0; A	-	A	3.0; A	3.0; A
UMD–College Park	29,868	-	-	A	2.7	3.0; A
Clemson	19,402	-	-	-	HS	A
Texas A&M	53,065	2.75; A	3.0	3.5; A	3.5; A	A

Note: This figure shows that GPA thresholds and other major restrictions are in widespread use at selective public research universities. It presents the Fall 2019 minimum major admissions requirements for enrolled students at the top 25 public universities as ranked by US News and World Report in 2019, plus Cornell University (which is part-public). A number indicates the minimum GPA required in department-specified courses for current students to declare the major, omitting restrictions of C+ or lower. Chosen majors are the top-earning majors reported in Altonji, Blom, and Meghir (2012) averaged between male and female students, Table 3, omitting Electrical Engineering due to its similarity with Computer Science. Finance includes Business Administration, Business Economics, and Economics and Accounting majors when otherwise unavailable. Restrictions on overall GPA are omitted.
HS: Students must be directly admitted from high school to the major (with elevated admissions standards). **A**: Students must submit a successful internal application after initial enrollment in order to earn the major. *: Major is unavailable.

Source: University and department websites and US News & World Report, August 2019

economics departments: UCSB, which requires majors to earn a 2.85 GPA in 3-5 introductory courses, and UCD, which has no grade requirements for prospective majors. The results show that URG and lower-income students are substantially less likely to earn the economics major at UCSB than they are at UCD. This gap is largely explained by those students having poorer prior academic opportunity and lower measured academic preparedness. All else equal, students whose high schools offered AP Macro and Micro are more likely to major in economics at UCSB, but not at UCD.[5] URG, lower-income, and female students are also less likely to ever enroll in an introductory economics course at UCSB relative to UCD. The results suggest that between-campus differences in students' propensity to declare the economics major mainly reflect the effect of UCSB's

economics major restriction, illustrating how major restrictions can substantially limit URG and lower-income students' access to restricted majors.

The third section of results analyzes a different case study to estimate the impact of major restrictions on the labor market outcomes of impacted students. It analyzes UCSC's economics major restriction between 2008 and 2012, when students generally had to earn a 2.8 GPA in their first two economics courses in order to be allowed into the major. A comparison of the students just above and just below that threshold – whether or not they ultimately declare the economics major – shows that students below 2.8 were no less likely to graduate, on time or otherwise, but ended up earning lower post-graduate California wages by more than $20,000 per year. About half of the earnings gap can be explained by industry changes, with below-threshold students far less likely to find jobs in finance, insurance, or accounting. Access to the restricted economics major would have been extremely valuable to the low-GPA students who had already taken the field's two introductory courses but who were unable to earn it because of the major restriction.

The increasing prevalence of major restrictions at UC -- and the resulting socioeconomic stratification of its students – is in part a consequence of shrinking educational resources following declines in public support for higher education. But at least three second-best policies might be considered in place of major restrictions: (1) high-demand majors could be expanded with teaching-oriented lecturers; (2) majors' capacity constraints could be relaxed (in the long run) by increased efficiency in instructional resource allocation across academic departments; or (3) class sizes could rise in tandem with pedagogical innovations like 'flipped classrooms', or campuses could further rely on college-level high school courses like those offered by UC Scout. While these policies could mitigate the inequities fostered by the present major restrictions, more research is necessary to understand these policies' likely pedagogical effects and to compare their costs and benefits.

Data

The detailed student enrollment and course database analyzed in this brief was collected as part of the UC ClioMetric History Project, a joint project of UCOP's Institutional Research and Academic Planning group and UC Berkeley's Center for Studies in Higher Education. The data include all freshman students who enrolled at each of four UC campuses in the observed sample period: UCB (1975 to 2016), UCD (1980 to 2018), UCSB (1986 to 2018), and UCSC (1975 to 2018).[6] They include enrollment year, gender, ethnicity, and California residency; underrepresented groups (URG) are defined to include Black, Hispanic, and Native American students. For students who enrolled after 1993, the data are augmented with application records including SAT score, high school GPA, family income, and (for California residents) high school.

Table 2 shows all majors at the four UC campuses that have had major restrictions since the 1970s. Each restriction's first year is defined as the year prior to the major restriction first appearing in the school's course catalog, since that entering cohort is typically the first that would face the new binding major requirement. For major restrictions that are no longer implemented, a `Last Year' is

Table 2: Fifty years of major restrictions at four UC campuses

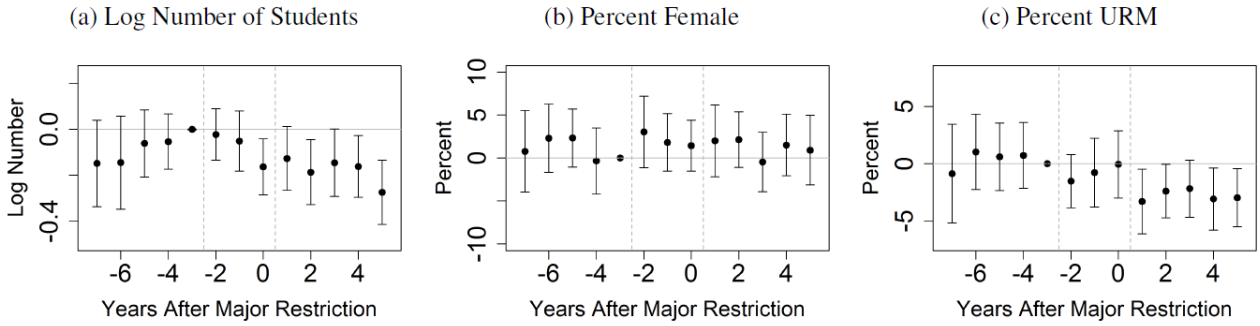
Major	Years First	Years Last	Rule	Major	Years First	Years Last	Rule
UC Berkeley							
Business°	1970	-	A	Art	1993	-	A/3.3
Economics	1976	-	3.0	Psychology	2003	-	3.2
Computer Science	1979	2007	3.0	Public Health	2004	-	A/2.7
Political Economy	1980	2004	3.0-3.2	Oper. Research†	2005	-	3.2
Media Studies†	1980	-	A/3.2	Env. Econ. & Pol.	2009	-	2.7
Biochemistry*	1988	1989	2.7	Computer Science*	2013	-	3.0-3.3
UC Davis							
Statistics°	1982	2004	3.0	Communication	2001	2013	2.5
Land. Architecture°	1986	-	A	Human Dev.	2001	-	2.5
Psychology	1989	-	2.5	Managerial Econ.	2001	2011	2.8
Int. Relations	1992	2013	2.5	Biotechnology	2007	-	2.5
Computer Science	1997	2004	2.75	Design*	2011	2013	2.6
Exercise Science*	1997	2000	2.5	Mechanical Eng.*	2011	2014	2.8
Vit. and Enology	1998	-	2.5	Computer Science*	2016	-	3.0
Ferment. Science*	1998	2000	2.5				
UC Santa Barbara							
Computer Science°	<1983	2014	A/3.2	Political Science	1988	-	2.6
Communication°†	1983	-	2.5-3.0	Biology	1996	-	‡
Economics°	1984	-	2.7-2.85	Law and Society	1997	2006	2.5
Psychology°	1985	-	2.5-2.75	Biopsychology	2001	-	2.7-2.75
Mathematics°	1985	-	2.5	Computer Eng.	2003	2013	3
Electrical Eng.°	1986	1996	3	Fin. Math. and Stat.	2005	-	2.5
UC Santa Cruz							
Economics	2002	-	2.8	Biochem. and Mol. Bio.	2011	-	2.5
Physics	2008	-	2.7	Cognitive Science†	2011	-	2.5
Psychology	2011	-	2.7	Applied Linguistics*	2016	-	2.7
Chemistry	2011	-	2.5				

Note: This figure shows the large number and wide variety of major restrictions ever imposed by four UC campuses. Eligible major restrictions include GPA requirements for specified courses exceeding a C+ (2.3) or an internal competitive application. Does not include majors that are open to admits to a specific college but closed to admits to different colleges, like most Engineering majors; in any case, those policies have little changed in this period. † indicates that the major has had restrictions since within two years of its creation; * indicates that the restriction only lasted (or has only lasted) for a small number of years, either of which lead the major to be omitted from analysis below; and ⋆ indicates that the major was implemented prior to the beginning of our data. The reported years are one year prior to the first or last year in which the restriction is mentioned in the campus's course catalog. **A**: Students must submit a successful internal application after initial enrollment in order to earn the major. ‡ UCSB Biology implements a complex and highly-stratified major restriction that requires several course-catalog pages to explain (with dozens of alternative paths leading to different major specialties), though ultimately never requires GPA performance over 2.0 in any course.

Source: University Course Catalogs

also recorded, again referring to the final cohort that likely faced the restriction. Restrictions with GPA caps at or below 2.3 (a C+ average in the requisite courses) are omitted, both because of their prevalence and because they are unlikely to bind in most cases. Each campus has imposed about 12 restricted majors over the past 50 years, though Davis's restrictions tend to be more-numerous and shorter-lived than those at other campuses. Santa Cruz has imposed fewer restrictions, in part because it did not mandate letter grades in all courses until 2001. Berkeley and Davis's Computer Science departments have implemented restrictions twice.

Figure 1: Department event study around restrictions' initial implementation: student demographics



Note: This figure shows that major restrictions lead to 10-20% declines in major declaration, leading to a 3 percentage point decline in the share of URG students in the major. Event study β estimates of demographic characteristics of students who declare restricted majors before and after the implementation of the restriction, relative to other majors in that campus-year. Outcomes are averages by declared major and cohort-year, defined by students' first year of enrollment. Bars show 95-percent confidence intervals. β_{-1} is omitted, and standard errors are clustered by campus-major. Students can be included in more than one major estimate (e.g. as double-majors). Source: UC Corporate Student Database and UC-CHP Database

For reference: each campus offered an average of 67 majors in each year of the sample period, with an annual average of 86 students per major. The total sample includes about 800,000 students who enrolled in 6,300 major-cohort pairs. The majors that implement major restrictions tended to be about twice the size of the average major, with 190 annual students on average.

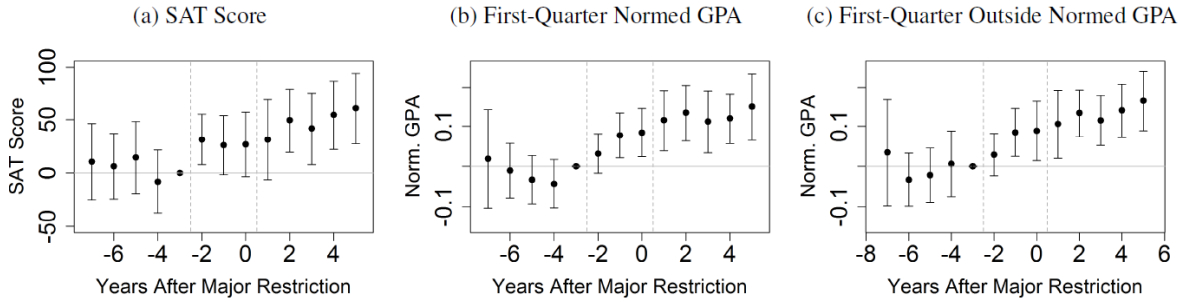
One possibly important effect of major restrictions is to stratify students by their university course performance, with higher-performing students permitted to enroll in restricted fields of study. Student grades (GPAs) are often used to measure university course performance, but GPA is biased by differences in grading standards across academic disciplines. In order to abstract away from cross-field differences in grade availability, a new "Normed GPA" measure is calculated to measure students who consistently out-perform their peers in their chosen courses of enrollment.[7]

Public California high schools are linked by CDS code to 1997-2016 California Department of Education school records to identify AP and IB course availability.[8]

Result 1: Major restrictions cause a decline in URG and lower-testing students' representation in restricted majors.

The first set of results implement an event study difference-in-difference design to estimate the impact of imposing a major restriction on the major's student composition. Each newly-imposed restriction in the sample period – either a selective internal application or an average introductory course grade threshold exceeding C+ (2.3) – is considered an `event'. Restrictions that were imposed within two years of the major's creation (prohibiting pre-period estimation) or for fewer

Figure 2: Department event study around restrictions' initial implementation: student academic preparation



Note: This figure shows that major restrictions lead majors to be filled with higher-testing and higher-grade students. Even though major restrictions focus on grades in preparatory courses, they yield student bodies with generally-higher grades, not students with a particular strength in that field. Event study β estimates of the measured aptitude of students who declare restricted majors before and after the implementation of the restriction, relative to other majors in that campus-year. Outcomes are averages by declared major and cohort-year, defined by students' first year of enrollment. Bars show 95-percent confidence intervals. β_{-1} is omitted, and standard errors are clustered by campus-major. Students can be included in more than one major estimate (e.g. as double-majors). Normed GPA is defined in the Appendix; "Outside Normed GPA" is calculated only using first-quarter courses taken outside the major's division (Humanities, Social Sciences, Natural Sciences, Engineering, and Professional) and excluding Mathematics and Statistics courses. Source: UC Corporate Student Database and UC-CHP Database

than four years (prohibiting estimation of longer-run effects) are omitted. Using the resulting 26 events, the results below employ linear regression analysis to estimate how each department's enrollment responds when a restriction is implemented (relative to other majors at that campus), presenting cohort-by-cohort estimates in the years before and after each restriction 'event'.[9]

Panel (a) of Figure 1 shows the average impact of imposing a major restriction on the log number of students who declare newly-restricted majors before and after the imposition of the restrictions. The estimates suggest that major restrictions are put into place about five years after a major begins growing relative to other fields. Imposing the restriction causes an immediate enrollment decline of about 10 percentage points, with longer-run enrollment stabilizing around 20 percent below peak enrollment, despite the observed increased student demand in that major.

Which students were denied from these majors as a result of newly-implemented major restrictions? The next two panels of Figure 1 shows that the proportion of female students in newly-restricted majors remained unchanged, but that the average proportion of URG students sharply declined by 2-3 percentage points relative to other majors at the campus. Given the 10 percentage point decline in all major declarations, this implies that URG students were 20-25 percentage points more likely to exit the major as a result of the restriction than non-URG students.[10]

How did major restrictions differentially impact students with different levels of measured academic aptitude? The left panel of Figure 2 shows that newly-restricted majors' enrollees had higher average SAT scores by about 20-30 points (on the 2400 scale) among *all* students, with the increase occurring over the restrictions' three-year transitional period. This suggests that the

roughly 10% of students unable to earn the major had an average SAT score more than 200 points (or 2/3 of a nationwide standard deviation) lower than the average student declaring the major.

Panel (b) of Figure 2 shows that major restrictions yield students whose normed GPAs averaged across all their first-quarter courses were higher. This includes courses required to qualify for the major. Panel (c) shows a near-identical effect when only unrelated courses in other disciplines are used to calculate students' first-quarter normed GPA.[11] These results imply that students unable to get into restricted majors had average normed first-quarter GPAs about 1.2 standard deviations lower than the major's average, even when their GPA is calculated using only courses outside the major's discipline. The similarity between Panels (b) and (c) suggests that major restrictions do not ultimately affect students based on their comparative advantages – that is, students with particular academic strengths in that specific field – but instead affect students whose academic performance is generally stronger both in that field and across *all* fields (absolute advantage).

These results indicate that major restrictions sharply reduce the number of students declaring the major (as often intended), with URG students far more likely to exit the major than non-URG students. The restrictions typically appear to select students with general academic advantages rather than students who only have advantages specific to the restricted field.

Result 2: Major restrictions' effect can be explained by disadvantaged students' limited prior opportunity and observed preparation.

To shed light on how major restrictions influence the majors that students enter, we compare entry into the economics majors at UCSB and UCD between 2010 and 2016. These majors provide a useful case study for several reasons:

1. Each campus had a similarly-structured progression of introductory courses that students were required to take prior to major declaration.[12]
2. UCSB Economics had a 2.85 GPA restriction, while the UCD major was unrestricted.
3. The UCSB restrictions (and UCD's non-restriction) did not change in the sample period.
4. Economics was the most-popular major at both schools, suggesting substantial demand.

The results in Table 3 compare differences in course enrollment and major declaration at the two campuses for students with different demographic and socioeconomic characteristics, different access to high school economics courses, and different measured academic preparedness (SAT scores and HS GPA).[13] The comparisons are estimated using linear regression analysis.[14]

Between-campus differences in students' propensity to declare the major likely mainly reflect the effect of UCSB's economics major restriction. The first two regression models presented in Table 3 examine which of the students who enrolled in ECON 1 eventually declared economics majors, where ECON 1 enrollment is a signal of students' potential interest in majoring in economics.[15]

The first model (occupying the first 3 columns) includes only demographic and socioeconomic characteristics as covariates, directly testing whether UCSB's major restriction induces social stratification. The baseline UCD estimates, where any student is permitted to declare an economics major after passing the introductory courses, reveal how "preferences" for the major differ by race and income.[16] They reveal a significant relative preference for the subject among Asian students, but not among URG students.

Among students who completed ECON 1 at UCSB, by comparison, URG students are 10 percentage points *less* likely to become economics majors than white students. The magnitude of this URG difference is appreciable relative to an average declaration propensity of 26.4 percent at UCSB.[17] The difference between the campuses in URG students' propensity to declare an economics major is similarly large. Lower-income students are also less likely to declare the economics major at UCSB after taking ECON 1, compared to UCD. This is consistent with the major restriction muting student preferences in a way that stratifies students on race and income.

The second regression model in Table 3 (the next three columns) includes academic preparation and opportunity. In contrast to the previous results, racial differences between similarly-prepared students are much smaller, though URG students remain somewhat less likely to declare an economics major at UCSB than at UCD. This suggests that the primary stratifying effect of the major restriction is to induce selection on the basis of prior preparation.

The other coefficients in this regression confirm that impression. At UCD, ECON 1 students with higher SAT scores and high school GPAs are less likely to select an economics major, while the opposite is true at UCSB. This suggests that economics tends not to be the top choice of the best prepared (ECON 1) UCD students, but that the major restriction systematically prevents the least-prepared from declaring at UCSB.[18] Second, while exposure to economics in high school does not predict major declaration at UCD, it certainly does so at UCSB. This suggests that the restriction not only induces selection on prior general preparation, but on prior exposure to economics.

The final model in Table 3 examines major selection (conditional on prior opportunity and preparation) on a different margin – enrollment in a student's first economics course. The UCSB outcomes differ significantly from those at UCD in two respects. First, Asian, male, and higher-income students are more likely to take ECON 1 at UCD, while URG students are less likely to do so. These patterns are more muted at UCSB, again suggesting that the major restriction mutes preferences. Second, students with lower SAT scores and high-school GPAs are more likely to take ECON 1 at UCD, while high SATs and high school GPAs are not associated with taking ECON 1 at UCSB. Each of these results are consistent with the major restriction inducing significant positive self-selection into the first course in the major based on prior preparation. This could be because students who feel they are less likely to qualify for the major do not attempt it.

The results presented in Table 3 reveal (1) more positive selection and self-selection into the economics majors at UCSB than at UCD, (2) that selection can be explained largely by prior academic preparation and likely exposure to economics in high school, and (3) this selection results in fewer URG and lower-income students enrolling in restricted majors. These trends likely arise

Table 3: 2010-2016 economics major enrollment propensities at UC Davis and UCSB

Dep. Var:	Earn Economics Major, Conditional on ECON 1						Enroll in ECON 1	
	Davis	UCSB	Diff.	Davis	UCSB	Diff.	Davis	Diff.
Female	-8.68	-5.84	2.85	-8.57	-5.94	2.63	-9.09	-4.49
	(1.25)	(1.30)	(1.55)	(1.24)	(1.27)	(1.54)	(0.56)	(0.88)
Asian	6.06	3.07	-2.99	5.69	4.11	-1.58	6.90	-0.18
	(1.22)	(1.47)	(1.92)	(1.21)	(1.37)	(1.80)	(0.79)	(1.02)
URM	0.60	-10.07	-10.68	-0.84	-3.92	-3.08	-7.00	3.56
	(1.40)	(1.40)	(1.93)	(1.45)	(1.41)	(1.96)	(0.72)	(0.97)
Log Fam. Inc.	0.64	1.96	1.32	0.86	0.28	-0.58	0.83	-0.29
	(0.45)	(0.43)	(0.61)	(0.49)	(0.40)	(0.62)	(0.24)	(0.34)
High School Offered[1]:								
AP Macro				0.34	4.76	4.42	-1.23	-0.27
				(1.96)	(2.04)	(2.82)	(1.18)	(1.51)
AP Micro				1.49	4.25	2.76	-5.25	4.18
				(2.81)	(2.95)	(4.16)	(1.26)	(2.06)
IB Economics				-4.37	2.96	7.34	0.27	-0.75
				(3.07)	(4.04)	(5.24)	(2.07)	(3.74)
SAT Score[2]				-1.78	6.96	9.55	-1.12	1.45
				(0.55)	(0.56)	(0.83)	(0.37)	(0.49)
HS GPA[2]				-1.44	5.47	7.42	-2.59	0.85
				(0.66)	(0.53)	(0.86)	(0.41)	(0.50)
Course-Term FE		X			X		X	
Campus-Cohort FE		X			X		X	
Residency FE		X			X		X	
R^2		0.02			0.04		0.06	
Observations		16,974			16,974		62,512	
Mean of Y	32.2	26.4	-	32.2	26.4	-	29.0	

Note: This table shows that URG and lower-income students at UCSB –which had a major restriction – were less likely to declare the economics major than those at UCD – which did not have a restriction – among students who completed an introductory economics course. This effect can largely be explained by those students' lower prior academic opportunity (to take AP and IB courses in high school) and measured academic preparedness (SAT scores and HS GPA). The major restriction also discouraged female and less academically prepared students from ever enrolling in an introductory economics course. Propensity-score-weighted WLS regression models among 2010-2016 freshman-applicant Santa Barbara and Davis students of economics major declaration and ECON 1 enrollment on student characteristics. Major declaration models conditional on having earned a grade in ECON 1. Main effects estimated for Davis and Santa Barbara; 'Diff' estimated as the difference between Santa Barbara and Davis. Standard errors clustered by high school in parentheses. Inverse propensity score weights estimated using full set of listed covariates as well as high school CA county indicators. Family income is missing for the $\sim$ 13 percent of students who did not apply for financial aid; estimates relative to the mean observed log income. [1]High school course offerings only available for public CA high schools. [2]Normalized to mean 0, s.d. 1.

Source: UC ClioMetric History Project Student Database, UC Corporate Student System, and California Department of Education

due to UCSB's major restriction. Appendix 3 provides several additional robustness checks testing plausible alternative hypotheses. In sum, this evidence strongly suggests that major restrictions inhibit URG students, lower-income students, and students from lower-preparation high schools from selecting majors as a result of those students' poorer prior opportunities and preparation.

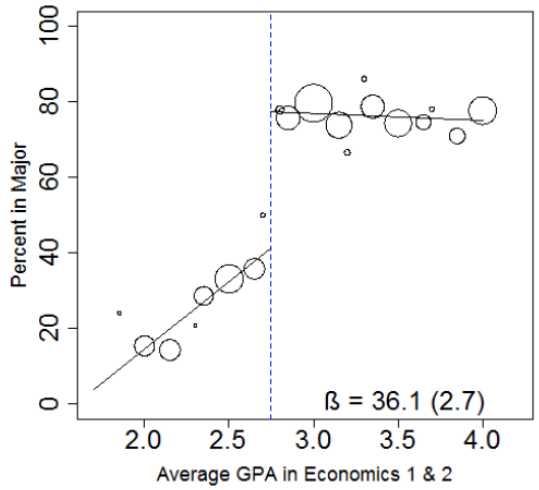
Result 3: Students restricted from lucrative majors are excluded from substantial labor market returns.

This last results section analyzes whether, in addition to restricting disadvantaged students' intellectual choices, low-GPA students' exclusion from restricted majors has ramifications for those students' longer-run educational or labor market opportunities. Several recent academic studies have shown that barring students from earning degrees in their preferred fields leads them to lower early-career earnings, but these low-GPA students may have actually benefited from being barred from fields of study in which they would have had a difficult time producing high-quality work in challenging upper-division courses.[19] In order to directly test the effect of restricting students' major choice using a UC GPA restriction, we choose a case study and compare the longer-run outcomes of students just above and below a particularly-restrictive GPA restriction.

Between 2008 and 2012, the UC Santa Cruz Department of Economics maintained a relatively strict major restriction on its economics majors. Prospective majors had to complete two introductory courses, Economics 1 and 2, with an average GPA of 2.8. Some students with grades below that threshold were given a second chance to earn higher grades in other courses (or retake the introductory courses), allowing some below-threshold students into the economics major. However, a large number of students were excluded from the economics major. Figure 3 shows students' likelihood of declaring the economics major for each GPA level in the department's introductory courses. It shows that about 80 percent students just above the 2.8 restriction threshold ended up declaring the economics major, while only about 45 percent of students just below the threshold did so. This gap does not appear in previous years or at other campuses, suggesting that the major restriction caused a large number of students to earn other majors instead of economics.

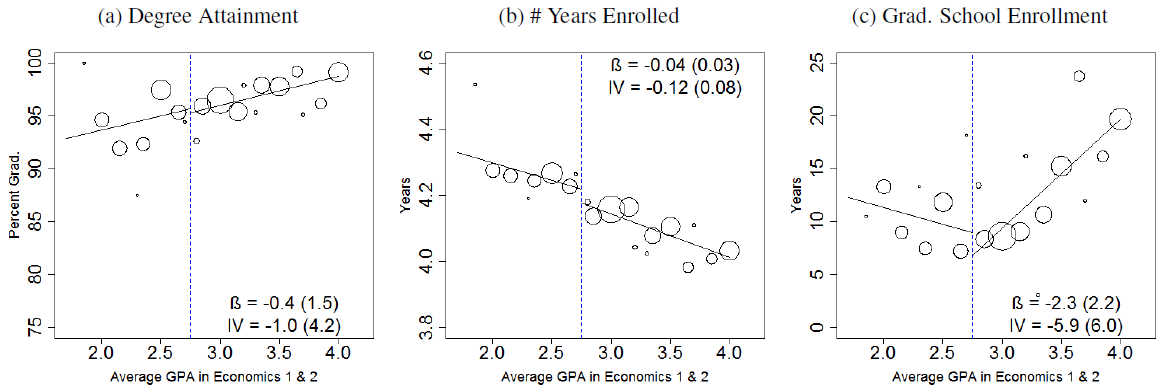
This setting, then, allows direct estimation of the GPA restriction's impact on student outcomes. Consider, for example, the claim that major restrictions may aid impacted students by dissuading them from continuing in a field of study for which they are unprepared. If this were the case, then perhaps students just below the major restriction threshold – who ended up choosing majors other than economics – would be less likely to drop out before earning a degree,

Figure 3: 2008-2012 UCSC economics major declaration



Note: This figure shows that 2008-2012 UCSC students with introductory economics grades below the department's GPA restriction were much less likely to declare a major in economics. Each circle represents the proportion of UCSC students who declared the economics major (y axis) among those who earned a given GPA in Economics 1 and 2 (x axis). The size of the circle corresponds to the proportion of economics students who earned that GPA. GPAs below 1.8 are omitted. Fit lines and beta estimate (at the 2.8 restriction threshold) from linear regression discontinuity specification; standard error (clustered by GPA) in parentheses. Source: UC-CHP Database and UC Corporate Student System

Figure 4: Educational outcomes of prospective UCSC economics students



Note: This figure shows that below-threshold students had similar educational outcomes to above-threshold students; being pushed out of the economics major did not impact their degree attainment, time to degree, or graduate school enrollment. Each circle represents the percent of UCSC students who earned a Bachelor's degree, number of years enrolled as an undergraduate, and percent who enrolled in a graduate degree within 7 years of high school graduation (y axis) among those who earned a given GPA in Economics 1 and 2 (x axis). The size of the circle corresponds to the proportion of economics students who earned that GPA. GPAs below 1.8 are omitted. Fit lines and beta estimate (at the 2.8 restriction threshold) from linear regression discontinuity specification and instrumental variable specification (with Economics major declaration as the endogenous variable); standard error (clustered by $EGPA$) in parentheses. For students who transfer away from UCSC, degrees and years-to-degree are measured in National Student Clearinghouse enrollment and degree records. Source: UC-CHP Database, UC Corporate Student System, and National Student Clearinghouse

or would earn their degree in fewer years. Figure 4 shows that neither of these is the case; below-threshold students have similar graduation rates and years-to-degree statistics as above-threshold students, despite their being unable to earn the economics major. Panel (c) also shows no change in graduate school enrollment over the following years, suggesting that access to the economics major for below-threshold students had no observable effect on any educational outcome.

However, Figure 5 shows that below-threshold students were significantly impacted in another way. The figure shows that mean 2017-2018 California wages of students on either side of the restriction threshold differ substantially: above-threshold students earn about $55,000 per year in their mid-20s, while below-threshold students earn closer to $47,000. The difference is highly statistically significant; it cannot have resulted from chance alone. The below-threshold students are lower-earning because they are less likely to be able to earn economics majors; conditional on majoring in economics, students' earnings are smooth at the threshold. Moreover, this gap actually masks an even larger effect the students who *would have* earned economics majors at Santa Cruz except for the fact that they were below the restriction threshold. Using instrumental variable regression analysis, the income gap for such students (denoted "IV" in the figure) is more than $22,000 per year in foregone earnings as a result of their being unable to earn the economics major.

One reason that low-GPA students likely desire to be economics majors is that the major could be an important steppingstone toward their desired career. When these students are unable to earn economics degrees, this also impacts their career opportunities in many industries. Figure 6 shows

that these industry ramifications play a big role in the wage differences at UCSC's economics restriction threshold. Students below the threshold, unable to be economics majors, are far less likely to be employed in the finance, insurance, real estate (FIRE), or accounting industries in 2018 than students just above the threshold, with the latter much more likely to earn restricted economics degrees. In general, they work in industries with lower average wages (for early-career UCSC workers) by about $10,000, explaining about half of the full wage effect of being restricted out of their preferred economics major by UCSC's major restriction policy.

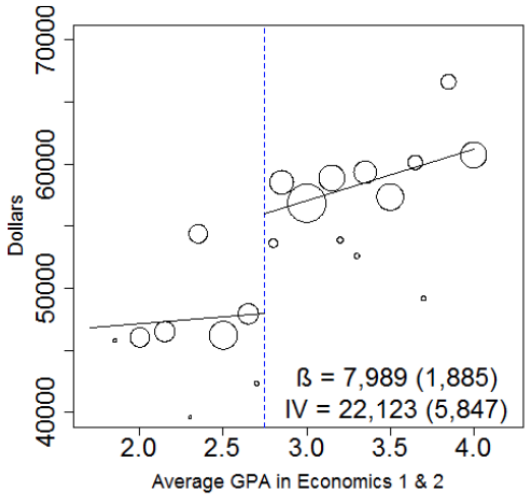
This case study shows that, in one notably-binding case, major restrictions neither help nor harm graduation outcomes, but can cause substantial long-run labor market deterioration for students unable to earn their preferred major.

Conclusion

Major restrictions policies using introductory course grades have become a popular administrative tool at American public universities as they face a combination of substantial enrollment growth, state disinvestment, and surging student demand for certain college majors. The four campuses analyzed in this topic brief have implemented 45 substantial major restrictions since 1970, when Berkeley's Haas School of Business implemented UC's first known restriction for already-enrolled students. These restrictions do not include further restrictions used by many campuses' engineering majors, which severely restrict access to students not directly admitted to their programs from community college or high school.

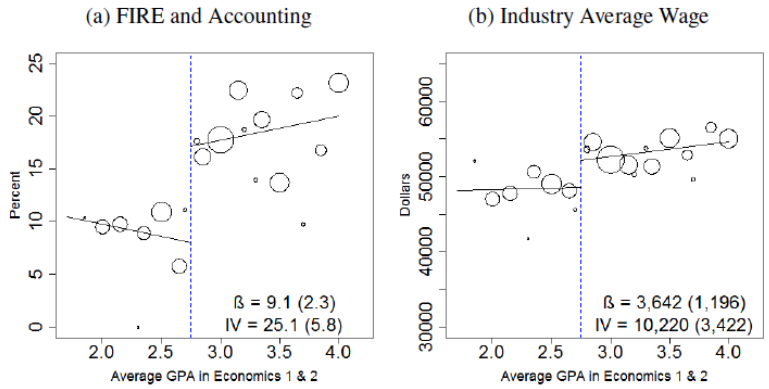
This brief documents three facts about the function and impact of UC's major restriction policies. First, it shows that on average, major restrictions cause enrollment declines that are particularly severe among URG and lower-testing students. Despite targeting grades in related introductory courses, major restrictions *de facto* impact students with lower academic preparedness in general, not students who happen to

Figure 5: 2017-2018 wages of prospective UCSC economics students



Note: This figure shows that below-threshold students had *far* lower early-career earnings than above-threshold students as a result of being unable to earn a degree in economics. Each circle represents the mean 2017-2018 annual wages of UCSC students (y axis) among those who earned a given GPA in Economics 1 and 2 (x axis). The size of the circle corresponds to the proportion of economics students who earned that GPA. GPAs below 1.8 are omitted. Fit lines and beta estimate (at the 2.8 restriction threshold) from linear regression discontinuity specification and instrumental variable specification (with Economics major declaration as the endogenous variable); standard error (clustered by $EGPA$) in parentheses. Wages are winsorized at 2% above and below. Source: UC-CHP Database, UC Corporate Student System, and Employment Development Department

Figure 6: 2017-2018 industries of employment of prospective UCSC economics students



Note: This figure shows that below-threshold students were much less likely to work in the high-paying finance, insurance, and real estate (FIRE) and accounting industries, and in general were employed in industries with lower average wages. Each circle represents the mean 2017-2018 percent of UCSC students employed in the stated industry or the average wage of the industry in which they were employed (y axis) among those who earned a given GPA in Economics 1 and 2 (x axis). The size of the circle corresponds to the proportion of economics students who earned that GPA. FIRE includes the finance, insurance, and real estate industries (NAICS 52 and 531); accounting is NAICS code 541211. Imputed wages by industry (6-digit NAICS) are calculated as the mean 2017-2018 wages of all 2008-2012 freshman-admit UCSC students. GPAs below 1.8 are omitted. Fit lines and beta estimate (at the 2.8 restriction threshold) from linear regression discontinuity specification; standard error (clustered by GPA) in parentheses. IV estimates instrument economics major declaration with an above-threshold indicator. Missing employment is omitted. Source: UC-CHP Database, UC Corporate Student System, and Employment Development Department

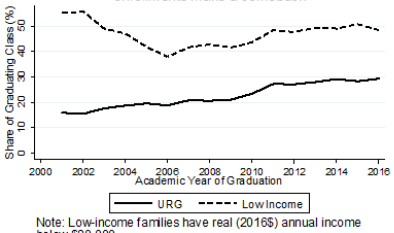
perform particularly poorly in the restricted major's courses. Second, it shows that major restrictions' effects on students can be largely explained by students' prior academic opportunity and preparation: the students who lose access to restricted majors are those who were admitted to UC despite their high schools' lower access to AP and IB courses and despite their lower measured test scores. Indeed, UC appears to intentionally admit and recruit disadvantaged applicants to promote economic mobility only to ultimately prevent many of those students from the opportunity of earning the university's most-lucrative high-demand degrees, though those students still receive the many other benefits of UC enrollment. Finally, it shows that there are real long-run implications of losing access to restricted majors: in the case study of UC Santa Cruz's Department of Economics, students who are restricted from earning the economics major as a result of low introductory grades are caused to earn more than $20,000 lower wages in their mid-20s as a result of earning alternative majors instead, partly because they are much less likely to earn employment in FIRE and accounting.

Major restrictions are one policy that can be implemented to manage surging student demand for particular undergraduate majors, but they are far from the only policy. Relatively low-cost alternatives include: (1) high-demand majors could be expanded with teaching-oriented lecturers; (2) majors' capacity constraints could be relaxed (in the long run) by increased efficiency in instructional resource allocation across academic departments; or (3) class sizes could rise in tandem with pedagogical innovations like "flipped classrooms". Further study is necessary to facilitate careful weighing the relative costs and benefits of these alternative policies.

Appendix 1: UC's Growing Stratification across Majors

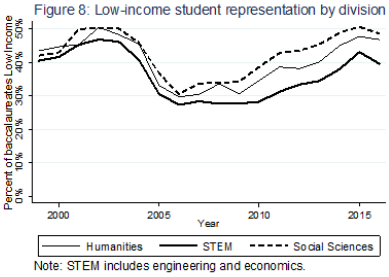
We use UCSB as a case study to visualize changes in lower- and higher-income UC students' major choices over time. The fraction of UCSB students from lower-income families (that is, students with annual family income below $80,000) rose from 16% to 28% between 1998 and 2016, while the fraction that come from under-represented backgrounds also rose substantially after the 2008 financial crisis (Figure 7). This was accompanied by a widening gap in student representation by income between STEM majors and the rest (Figure 8). This was not caused by growing gaps in SAT scores between disadvantaged and other students (Figure 9). Grading is more lenient in those majors that serve the largest numbers of URG and low-income students, suggesting that stratification by major restrictions has pedagogical consequences (Figure 10). In short, there is good reason to ask whether increasingly-prevalent policies like major restrictions have contributed to this growing student stratification across UC majors over time.

Figure 7: URG enrollment takes off, while low-income enrollments make a comeback



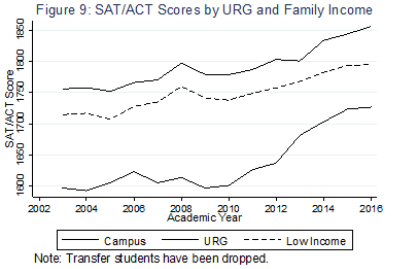
Note: Low-income families have real (2016$) annual income below $80,000.

Figure 8: Low-income student representation by division



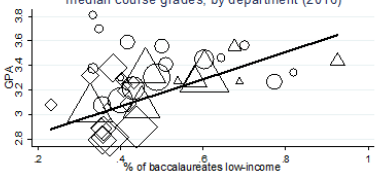
Note: STEM includes engineering and economics.

Figure 9: SAT/ACT Scores by URG and Family Income



Note: Transfer students have been dropped.

Figure 10: Low-income student representation & median course grades, by department (2016)



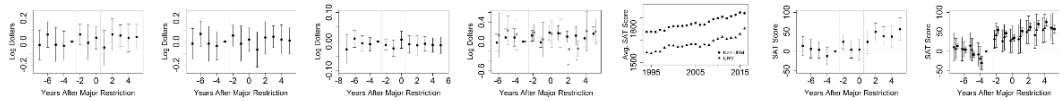
Note: STEM includes engineering majors and economics. Best fit line is weighted by the number of students in majors offered by each department.

Appendix 2: Additional figures for Result 1

Table 4 summarizes the effect of implementing a major restriction on majors' student composition. It collapses the linear regressions estimated to produce Figures 1 and 2 into three difference-in-

Figure 10: Additional Major Restriction Findings

(a) Average Wages (b) Avg V-Added (c) Dept. Level (d) Student Level (e) Avg. SATs (f) SAT with FE (g) SAT with Rob.



Note: This figure presents a series of additional results rejecting potential efficiency gains of major restriction policies using the event study analysis. Panels (a) and (b) show that major restrictions do not measurably increase implementing departments' wage value-added to students. Panels (c) and (d) show that major restrictions neither (c) screened for students with above-average value-added in the restricted major nor (d) differentially led URM students toward majors where they achieved stronger match effects in wage terms. Panel (c) shows that UC URM students' SAT scores have declined over the past 30 years, suggesting that increasing stratification is not driven by negative selection among URM students, and Panels (f) and (g) show that Figure 2(a) is robust to the inclusion of major-year fixed effects and stacked event study designs following Sun and Abraham (2021). See Bleemer and Mehta (2021), Figs 10, II-1, A-9, and A-10 for details on value-added and match quality estimation and SAT robustness exercises. Panel (e) shows the average SAT score at UC Berkeley, UC Davis, UC Santa Cruz, and UC Santa Barbara by freshman cohort and URM status from 1994-2016, equally weighting each campus in each series. Source: UC Corporate Student Warehouse and the CA Employment Development Department.

Table 4: Summary of Difference-in-Difference Estimates around Major Restriction Implementation

	Log Num. of Students	SAT Score	GPA FE	Percent URM	Avg. Zip AGI $	Avg. Zip AGI Log $	First Term $nGPA$[1] In Disc.	First Term $nGPA$[1] Out of Disc.	Average Wage[2] No Cov.	Average Wage[2] GPA Cov.
4-7 Years Before Restriction	-0.10 (0.07)	5.3 (14.3)	-0.03 (0.02)	0.43 (1.14)	102 (1,575)	0.00 (0.01)	-0.02 (0.03)	-0.00 (0.03)	-0.01 (0.04)	-0.00 (0.04)
Transition Years	-0.09 (0.05)	27.2 (13.0)	0.07 (0.02)	-0.63 (1.19)	1,598 (1,454)	0.02 (0.01)	0.07 (0.02)	0.07 (0.03)	0.03 (0.05)	0.02 (0.05)
1-5 Years After Restriction	-0.18 (0.06)	45.4 (15.8)	0.12 (0.03)	-2.56 (1.13)	4,385 (1,738)	0.04 (0.02)	0.13 (0.03)	0.13 (0.03)	0.02 (0.05)	0.00 (0.05)
Fixed Effects	X	X	X	X	X	X	X	X	X	X
Observations	4,963	3,648	4,962	4,905	3,856	3,856	4,811	4,726	3,330	3,297
$\bar{Y}$	4.2	1820	3.5	19.7	99,373	11.4	0.1	0.0		
Δ (Post-Pre)[3]	-0.08 (0.08)	40.1 (12.7)	0.15 (0.03)	-2.99 (0.86)	4,283 (1,701)	0.04 (0.02)	0.15 (0.03)	0.14 (0.03)	0.03 (0.04)	0.00 (0.04)
M.C. p-value[4]	[0.336]	[0.001]	[0.000]	[0.025]	[0.014]	[0.020]	[0.000]	[0.000]	[0.520]	[0.916]

Note: This table presents regression coefficients mirroring the results presented in Figures 1 and 2, showing that major restrictions are binding, especially for URG students and students with low SAT scores and overall first-quarter grades. Staggered difference-in-difference β estimates of the measured characteristics of freshman students who declare restricted majors before and after the implementation of the restriction, relative to other majors in that campus-year. Standard errors clustered by campus-major in parentheses. Outcomes are averages by declared major and cohort-year, defined by students' first year of enrollment. "Before" indicates 4-7 years before initial restriction implementation; "Transition" includes the year of implementation and two years earlier; and "After" includes 1-5 years following implementation. β_{-3} is omitted. Students can be included in more than one major's average if they have declared multiple majors. GPA fixed effect is the student effect from a two-way fixed effect model of grades on students and course-terms. Average local household income is measured as the CPI-adjusted mean adjusted gross income of tax-filing households in the student's Zip code in their first year of enrollment. [1]See definition of first-term $nGPA$; in-discipline courses include those taken in the major's discipline (Humanities, Social Sciences, Natural Sciences, Engineering, and Professional) plus Mathematics and Statistics courses, while out-of-discipline courses include all remaining courses. [2]Value-added fixed effects from linear regressions of wages on major-year fixed effects (stacking students with multiple majors) with either no covariates (left) or controlling for students' GPA fixed effect interacted with gender and their ethnicity (right), where year is freshman students' first year of enrollment and wages are measured 10 years later. [3]The difference between "After" and "Before" Major Restriction β coefficients, with standard error in parentheses. [4]An exact p-value on Δ (Post-Pre) from 1,000 Monte Carlo draws of placebo major restrictions, to account for mechanical correlations as students move between departments in general equilibrium.

Source: UC-CHP Database and UC Corporate Student System

difference coefficients of interest (all estimated relative to implementing majors one year prior to initial implementation): "before major restriction" measures 3-7 years prior to implementation, "transition years" measure 2 years prior to implementation and the year of implementation, and "after major restriction" measures 1-5 years following implementation. The last row of Table 4 presents the difference between the "before" and "after" major restriction coefficients, summarizing the impact of the restriction abstracting away from the specific year in which the restriction was first enforced. These coefficients are discussed in greater detail in the main text.

Figure 10 presents additional results that confirm and extend many of the presented findings in Result 1. Panel (e) shows that the average academic preparation of URM UC students has been rising since the 1990s, rejecting the idea that URM STEM enrollment might be falling due to declining preparation. Panels (a) to (d) present evidence rejecting the hypothesis that major restrictions provide academic benefits to admitted or pushed-out students, using statistical techniques described in Bleemer and Mehta (2021). Finally, the last two panels show that the results shown in Figure 1(b) are robust to alternative specifications, again discussed in that study.

Appendix 3: Additional figures for Result 2

Table 5 presents a series of robustness checks analyzing whether alternative explanations for the results presented in Table 3 withstand empirical scrutiny. One alternative explanation for the

Table 5: Robustness Table: Other Aspects of Economics Major Qualification at Davis and Santa Barbara

	Grade in Calc. I		Grade in Calc. II		Difference in:		UCSB-only determinants of:		
	UCD	Diff.	UCD	Diff.	ECON 1 Grade	ECON 2 Grade	ECON 1 Grade	ECON 2 Grade	ECON 10A Grade
Female	0.06	-0.05	0.12	-0.03	0.09	-0.01	-0.14	-0.13	-0.03
	(0.03)	(0.04)	(0.03)	(0.05)	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)
Asian	0.17	-0.07	0.21	-0.14	-0.06	-0.15	0.02	-0.04	0.01
	(0.03)	(0.05)	(0.03)	(0.05)	(0.03)	(0.04)	(0.02)	(0.02)	(0.04)
URM	-0.11	-0.05	-0.17	-0.05	0.09	0.06	-0.11	-0.12	-0.12
	(0.04)	(0.06)	(0.04)	(0.06)	(0.04)	(0.04)	(0.02)	(0.02)	(0.04)
Log Fam. Inc.	0.02	-0.01	0.00	0.02	-0.02	0.00	0.01	0.02	0.01
	(0.01)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
High School Offered[1]:									
AP Macro	0.02	0.04	0.03	0.06	0.06	0.13	0.07	0.13	0.06
	(0.05)	(0.07)	(0.05)	(0.07)	(0.05)	(0.05)	(0.03)	(0.04)	(0.05)
AP Micro	-0.00	0.06	-0.08	0.12	0.19	0.08	0.06	0.04	0.02
	(0.07)	(0.10)	(0.08)	(0.09)	(0.07)	(0.07)	(0.04)	(0.05)	(0.07)
IB Economics	-0.08	-0.07	0.03	0.09	0.03	0.09	0.09	0.15	0.13
	(0.13)	(0.18)	(0.14)	(0.13)	(0.08)	(0.12)	(0.05)	(0.08)	(0.12)
SAT Score[2]	0.24	0.03	0.21	-0.04	-0.08	-0.01	0.23	0.27	0.19
	(0.01)	(0.03)	(0.02)	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	(0.02)
HS GPA[2]	0.16	0.01	0.17	0.04	-0.03	-0.03	0.14	0.15	0.16
	(0.02)	(0.02)	(0.02)	(0.03)	(0.02)	(0.02)	(0.01)	(0.01)	(0.02)
Course-Term FE	X	X	X	X	X	X	X	X	X
Campus-Cohort FE	X	X	X	X	X	X	X	X	X
Residency FE	X	X	X	X	X	X	X	X	X
R^2	0.16		0.11		0.21	0.18	0.18	0.18	0.08
Observations	10,168		11,554		16,974	13,884	7,829	6,216	3,565
Mean of Y	2.89		2.75		2.61	2.58	2.56	2.55	2.76

Note: This figure presents linear regression estimates showing that differences in course performance or the correlation between prior preparation and quantitative abilities at the two campuses cannot explain the observed effects presented in Table 3. Propensity-score-weighted WLS regression models among 2010-2016 freshman-applicant Santa Barbara and Davis students of grades earned in first and second quarters of calculus, ECON 1 and 2, and the subsequent ECON 10A course at Santa Barbara on student characteristics. Mathematics grades are conditional on ECON 1 enrollment. Main effects estimated for Davis and Santa Barbara; 'Diff' estimated as the difference between Santa Barbara and Davis. Standard errors clustered by high school in parentheses. Inverse propensity score weights estimated using full set of listed covariates as well as high school CA county indicators. Family income is missing for the ~ 13 percent of students who did not apply for financial aid; estimates relative to the mean observed log income. Calculus I and II courses are MATH 2A/B, 3A/B, or 34A/B at UCSB and 16A/B and 21A/B at Davis, respectively. [1]High school course offerings only available for public CA high schools. [2]Normalized to mean 0, s.d. 1.

Source: UC-CHP Database, UC Corporate Student System, and California Department of Education

patterns described above is that quantitative preparation covaries with prior preparation to a greater degree among UCSB students. If this were the case, and students' course and major choices reacted to it, this could explain the higher degree of selection on prior preparation and economics experience at UCSB. However, the first two models presented in Table 5 – which model ECON 1 students' performance in the first two calculus courses – show that this is not the case for quantitative skills. The baseline (UCD) coefficients do confirm significant variation in math-preparation with observables, including prior preparation: higher SAT scores, high school GPAs and family incomes predict better mathematical performance, as do being Asian and female, while URM students had worse math grades. However, there is almost no evidence of a stronger

relationship between student characteristics and math performance at UCSB than at UCD in either of the first two calculus courses.

Another alternative explanation for the observed patterns is that UCSB might provide lower grades to less-prepared students in its introductory courses, discouraging those students using 'soft' restrictions rather than relying on its grade minimum. The next two columns in Table 6 show that in fact, the opposite is the case: higher SAT scores are associated with smaller ECON 1 grade gains at UCSB than at UCD, and the URM grade penalty is smaller at UCSB than at UCD.

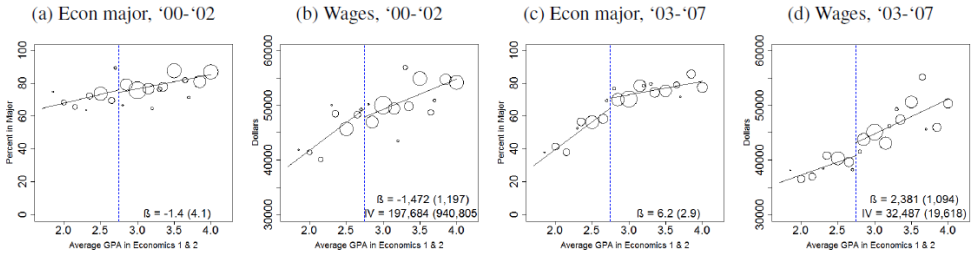
The final three columns of Table 5 illuminate how UCSB's major restriction – which selects on socioeconomic status, prior academic opportunity, and measured academic preparation – generates larger racial and income gaps in major declaration. The key insight is that while racial grade gaps are less pronounced at UCSB than at UCD, the grade restriction makes any grade gap more consequential at UCSB. UCSB students with higher high school GPAs and SAT scores obtain much higher grades in ECON 1, 2 and 10A, and those who have taken IB or AP economics perform much better in ECON 1 and 2. URG students also obtain lower grades in these threshold courses than their equally prepared counterparts, clarifying why prior preparation does not fully explain URM students' lower likelihood of economics major declaration.

These results confirm major restriction filtering as the obvious interpretation for differences in the stratifying role of ethnicity, exposure to economics, and prior preparation between UCD and UCSB.

Appendix 4: Additional figures for Result 3

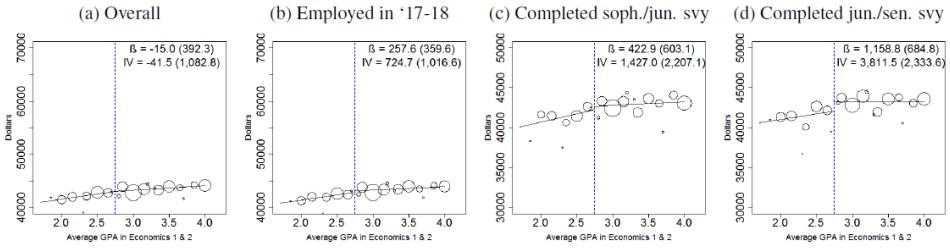
Figure 11 conducts a placebo exercise to test whether there's anything special about UCSC's 2.8 GPA threshold (other than the economics major restriction threshold at that value) that could

Figure 11: Placebo tests: major choices and wages with no restriction or a less-binding restriction



Note: This figure presents two placebo tests showing (a-b) that major choice and wages were smooth across the 2000-2002 2.8 GPA threshold (prior to the policy's initial implementation) and (c-d) both slightly discontinuous in 2003-2007 (during the policy's less-binding phase), generating a similar (but noisy) instrumental variable estimate of the impact of economics major choice on early-career wages. Each circle represents the proportion of economics majors or mean annual wages of UCSC students (y axis) among those who earned a given GPA in Economics 1 and 2 (x axis), restricted to the 2000-2002 or 2003-2007 UCSC cohorts. The size of the circle corresponds to the proportion of students who earned that GPA. GPAs below 1.8 are omitted. UCSC did not restrict the economics department to the 2000-2002, and only maintained a loosely-binding major restriction for the 2003-2007 cohorts. Wages are presented for each cohort when they were approximately the same age as in the main analysis: 2008-2009 for '00-'02 and 2012-2013 for '03-'07. 2008-2009 and 2012-2013 wages are the mean in EDD-observed California wages in those years; individuals with no wages in one year are assigned the other year's wages, and those with no observed wages in either are omitted. Wages are CPI-adjusted to 2018 and winsorized at 2% above and below. Fit lines and beta estimate (at the 2.8 restriction threshold) from linear regression discontinuity specification and instrumental variable specification (with Economics major declaration as the endogenous variable); standard error (clustered by GPA) in parentheses. Source: The UC-CHP Database and the CA Employment Development Department.

Figure 12: Baseline balance on observables of prospective UCSC economics students



Note: This figure presents baseline balance statistics showing that the above-threshold and below-threshold students do not differ on socioeconomic background, providing additional evidence that any longer-run differences must result from their different major choices. Note: Each circle represents the mean predicted wage by demographics (y axis) among 2008-2012 UCSC students who earned a given $EGPA$ in Economics 1 and 2 (x axis). The size of the circle corresponds to the proportion of students who earned that $EGPA$. "Major in economics" indicates declaring any of UCSC's three economics major tracks: economics, global economics, or business management economics. "Predicted Wages by Demographics" estimates each student's predicted wages by a linear regression (among 2008-2012 UCSC students outside the main sample) of 2017-2018 wages on gender-ethnicity indicators, residency status, and third-order polynomials in SAT score and mean Zip Code income. Predicted wages are presented (a) overall, (b) restricted to students with observed 2017-2018 wages, or (c-d) for students who responded to their $2^{nd}/3^{rd}$ year or $3^{rd}/4^{th}$ year annual student experience survey. Wages are CPI-adjusted to 2018 and winsorized at 2% above and below. $EGPA$s below 1.8 are omitted, leaving 2,839 students in the sample (2,446 with observed wages). Fit lines and beta estimate (at the 2.8 restriction threshold) from linear regression discontinuity specification and instrumental variable specification (with Economics major declaration as the endogenous variable); standard error (clustered by $EGPA$) in parentheses.

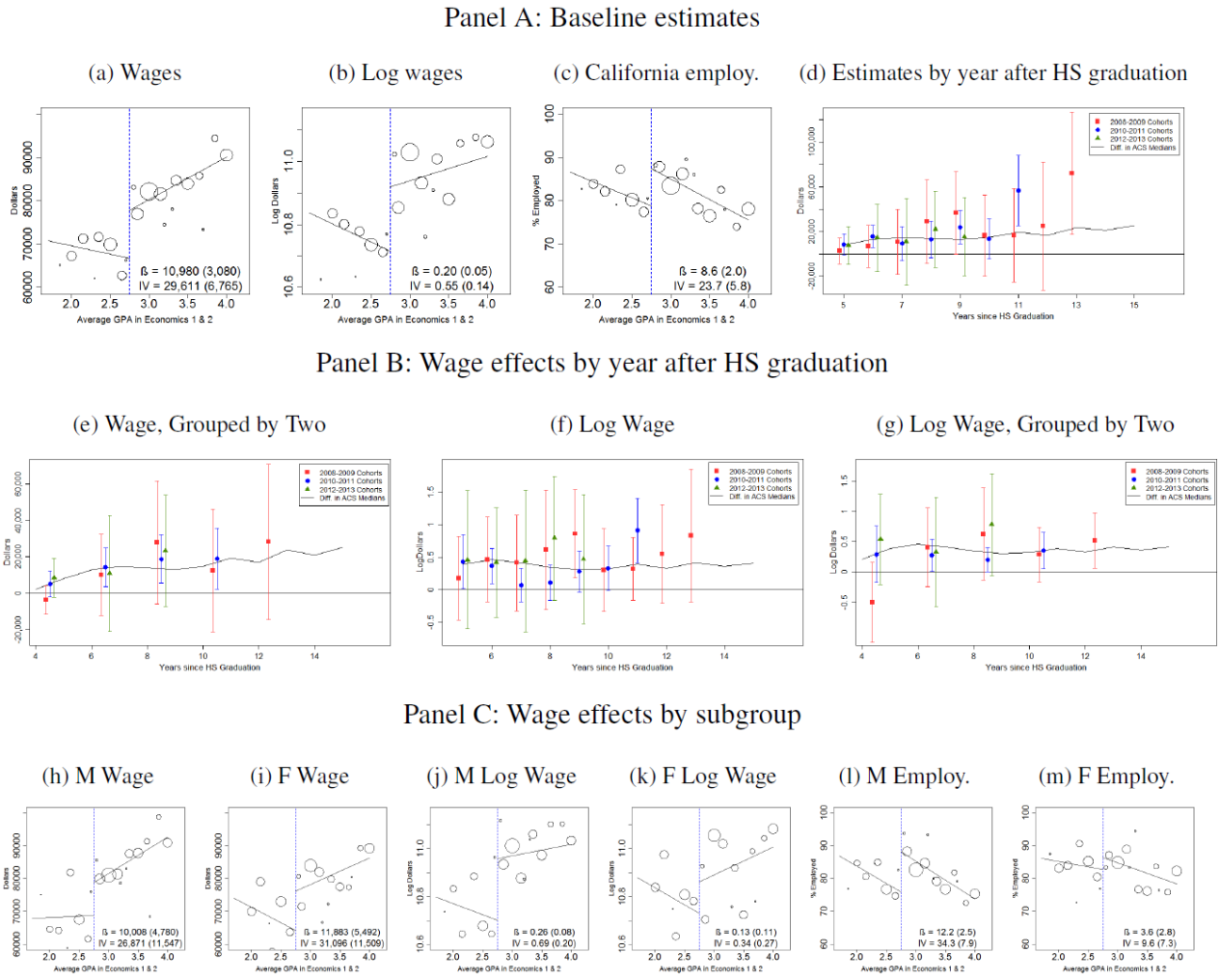
explain the large earnings gap among 2008-2012 cohorts. It presents wage estimates for the the 2000-2002 cohorts, who did not face a restriction, and the 2003-2007 cohorts, who faced a much less-binding major restriction at UC Santa Cruz. The graphs show that major declaration and wages don't change at the 2000-2002 threshold, as expected. Below-threshold 2003-2007 students were hardly less-likely to earn economics majors than above-threshold students, and there are similarly small differences in their longer-run 2012-2013 wages. This provides additional evidence that the 2008-2012 restriction was the main cause for impacted students' substantially lower wages.

Figure 12 plots baseline balance statistics for various groups of 2008-2012 UCSC students above and below the threshold. The baseline statistic is calculated by predicting a student's earnings by their demographic and socioeconomic characteristics, and then plotting those statistics for each economics GPA. The figure shows that these "predicted wages by demographics" do not change at the 2.8 GPA threshold for any of the selected samples. This provides additional evidence that above-threshold students' higher earnings are because of their major choice, not their background.

Figure 13 presents a series of robustness checks of the wage estimates presented in Figure 5. It shows that below-threshold students had lower wages and log wages, measured overall, for men, or for women. It shows that male CA employment rose at the threshold by 2021, suggesting labor participation effects. It also shows that the wage return to economics major access grows as the students age, suggesting that the lifetime effect could be even larger than the observed estimates.

Table 6 presents the cross-industry dynamics of above- and below-threshold UCSC students. It shows that the two industries that above-threshold students become most increasingly likely to work in are finance, insurance, and real estate (FIRE) and accounting, explaining why those are the industries presented in Figure 6. These industries generally employ a disproportionate

Figure 13: Detailed estimates of postgraduate wages of UC Santa Cruz students



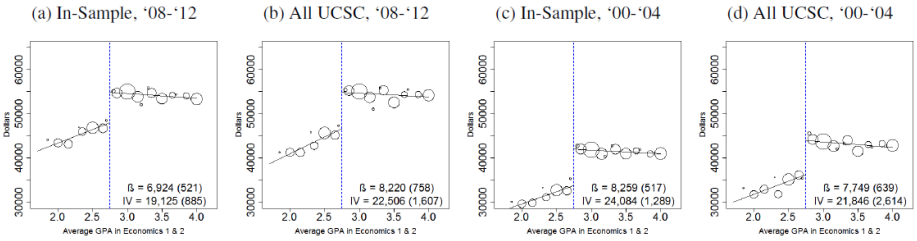
Note: This figure presents a series of robustness checks of the finding in Figure 5. The results are the same when estimated in logs and for men and women; California employment rises for men at the threshold; and it appears that the wage effect if anything grows in age (as would be expected). Each circle represents the mean (2020-2021) annual wages, the mean log wages, and the mean proportion employed in California of UCSC students (y axis) among those who earned a given GPA in Economics 1 and 2 (x axis). The size of the circle corresponds to the proportion of economics students who earned that GPA. Wages are measured as the mean between EDD-observed 2020 and 2021 California wages, where individuals with no wages in one year are assigned the other year's wages and no wages in both periods are marked as not employed and excluded. Panel B and A(d) show regression discontinuity instrumental variable β estimates at the 2.8 GPA threshold (with Economics major declaration as the endogenous variable) of the effect of economics major choice on earnings in each of 5-13 years after high school graduation (or by 2 years), splitting the sample into the '08-09, '10-11, and '12-13 UCSC incoming-class cohorts (with separate models estimated for each cohort group and age) and estimated where data are available. The bars show 95% confidence intervals from standard errors clustered by GPA. GPAs below 1.8 are omitted. Wages are CPI-adjusted to 2021 and winsorized at 2% above and below. Fit lines and beta estimate (at the 2.8 restriction threshold) from linear regression discontinuity specification and instrumental variable specification (with Economics major declaration as the endogenous variable); standard error (clustered by GPA) in parentheses. Source: The UC-CHP Database and the CA Employment Development Department.

Table 6: Changes in 2017-18 Industry

Two-Digit NAICS Industry	Marginal Share (IV β)	(s.e.)	Share of Econ. Maj.	Share of All UCSC Work.
FIRE	17.2	(5.4)	14.0	4.9
Accounting	9.3	(2.8)	10.8	1.6
Professional Services	5.7	(10.0)	32.6	20.5
Public Administration	4.2	(4.3)	4.2	5.3
Construction	4.0	(2.3)	2.0	1.3
Transportation	4.0	(2.9)	2.2	1.6
Management Firms	3.5	(1.5)	0.5	0.3
Agriculture	2.1	(2.3)	1.6	1.2
Manufacturing	1.8	(6.0)	7.6	6.5
Utilities	1.2	(1.3)	0.6	0.3
Admin. Support	0.5	(4.3)	10.9	10.2
Rental/Leasing	0.0	(1.3)	0.7	0.5
Arts and Entertainment	-0.7	(3.7)	2.4	4.3
Other Services	-1.0	(2.8)	2.0	4.8
Information	-1.3	(10.0)	9.9	7.2
Accomodation and Food	-4.1	(2.9)	5.3	8.4
Retail Trade	-5.1	(8.8)	8.2	9.9
Education	-8.1	(4.0)	6.6	19.5
Wholesale Trade	-8.5	(6.6)	5.2	3.3
Healthcare and Social Assist.	-8.6	(3.4)	4.6	15.1

Note: This table shows the two-digit-NAICS industries of 2017-2018 employment most impacted across the 2008-2012 UCSC economics access threshold, with workers flowing most into FIRE and out of education, healthcare and social assistance, and (noisily) wholesale trade, along with the worker shares at UCSC for economics majors and all college graduates. Columns one and two show estimates from instrumental variable regression discontinuity specifications of indicators for 2017 or 2018 employment in each two-digit NAICS industry on economics major choice (instrumented by the 2.8 GPA threshold; standard error (clustered by GPA) in parentheses. The remaining columns show the proportion of 2008-2012 UCSC students employed (in 2017-2018) in each industry, overall and among economics majors. The following NAICS codes are combined for similarity: 52/531 (FIRE), 31/32/33 (Manufacturing), 44/45 (Retail Trade), and 48/49 Transportation. Accounting (541211, or 5412 in the ACS) is separated out from professional services. Employment industry is the reported NAICS code of an individual's highest-paying position in the year's fourth quarter. Sources: The UC-CHP Database, the CA Employment Development Department, and the American Community Survey.

Figure 14: Median wages in the 2008-2012 UCSC cohorts' Chosen Majors, imputed from different samples



Note: This figure shows that when wages are imputed for each student by the median wages of similar-age workers with their same major choice – among the 2008-2012 main UCSC sample and among all 2008-2012 UCSC students – the imputed wages increase across the access threshold by $6,700 to $8,200, similar (or slightly smaller) magnitude to the true change in students' early-career wages. Each circle represents the imputed wages associated with students' chosen majors (y axis) among 2008-2012 UCSC students who earned a given $EGPA$ in Economics 1 and 2 (x axis). The size of the circle corresponds to the proportion of students who earned that $EGPA$. Wage-by-major medians are calculated using 2017-2018 wages for four groups: (a) 2008-2012 freshman-admit UCSC students who completed Economics 1 and 2; (b) all 2008-2012 freshman-admit UCSC students; (c) 2000-2004 freshman-admit UCSC students who completed Economics 1 and 2; and (d) all 2000-2004 freshman-admit UCSC students. Students with double majors are characterized by that double-major (irrespective of order) in both data sets, with independent wage medians for each major pair. ACS medians are weighted by sample weights. Wages are CPI-adjusted to 2018 and winsorized at 2% above and below. $EGPA$s below 1.8 are omitted, leaving 2,839 students. Fit lines and beta estimate (at the 2.8 restriction threshold) from linear regression discontinuity specification and instrumental variable specification (with Economics major declaration as the endogenous variable); standard error (clustered by $EGPA$) in parentheses. Source: UC-CHP Database, UC Corporate Student System, and Employment Development Department

number of UCSC economics majors. The industries that economics majors became most decreasingly likely to work in were education, healthcare and social assistance, and wholesale trade.

Table 7: Counterfactual major choice and average wages by major

Major	% of Grads UCSC	US	Δ Among Comp. (%)	UCSC OLS Coef. No Cont.	Controls	Median Wages UCSC	CA	US
Psychology	12.9	6.4	-20.4 (4.3)	-26,088 (1,146)	-24,160 (1,253)	33,875	30,661	30,000
Environmental Studies	6.1	0.8	-14.1 (6.8)	-24,602 (1,473)	-23,561 (1,609)	38,135	40,606	33,915
Tech. & Info. Mgmt.	1.2	0.2	-11.6 (1.5)	3,410 (2,682)	1,183 (2,698)	61,672	48,000	49,871
Sociology	6.0	1.7	-9.8 (2.4)	-22,014 (1,341)	-19,316 (1,543)	37,024	35,055	32,000
Film and Dig. Media	3.4	0.7	-8.0 (2.7)	-28,599 (1,638)	-25,241 (1,845)	30,685	30,594	28,617
Legal Studies	2.6	0.2	-7.7 (1.8)	-14,636 (1,897)	-13,140 (2,054)	42,500	46,828	34,749
Mathematics	2.0	1.4	-6.5 (3.0)	-17,446 (2,256)	-12,911 (2,590)	44,577	50,000	38,899
Latin Amer. Studies	2.0	0.7	-5.1 (1.2)	-28,369 (2,846)	-21,465 (3,160)	35,112	32,007	30,661
Art	3.6	1.0	-3.9 (1.5)	-34,687 (1,809)	-31,265 (1,932)	25,641	30,661	28,000
Anthropology	4.7	0.7	-3.6 (1.8)	-26,810 (1,556)	-26,426 (1,854)	32,032	26,711	25,551
...								
Economics	3.4	2.4	4.0 (8.9)	-8,071 (1,623)	-7,085 (1,737)	50,317	55,560	50,000
Global Economics	0.9		5.9 (1.7)	-5,848 (2,947)	-7,788 (3,085)	53,689	55,560	
Bus. Mgmt. Economics	7.1	0.2	90.1 (8.2)	-	-	61,872	54,538	48,025
Weighted Sum by UCSC Major Shares				20,039	18,073	21,287	17,436	15,385
RD IV Estimate on Imputed Wages by Majors				19,247	17,461	22,171	19,293	18,794

Note: This table shows that economics has higher average wages than the most-popular alternative majors that below-threshold UCSC students chose instead, and that these average wage-by-major differences are a good proxy for the effect on below-threshold students' wages. This table presents shares and average wages by major among 2008-2012 UCSC students (in 2017-2018) and 2017-2018 ACS respondents (age 23-28), along with estimates of the difference between the average wages of majors chosen by above-threshold compliers and average wages of their counterfactual majors. Columns 1 and 2 present the proportion of students who choose each major in each sample. The third column shows the change in major choice at the access threshold estimated using the linear RD IV specification described in the text; majors are ordered by this column, with those outside the top ten (and bottom three) omitted from the table. OLS coefficients from a linear regression of wages on major dummies with or without covariates (gender-ethnicity, cohort year, and high school), partitioning students by major (choosing higher-earning major among in-sample single majors for multi-major students) and omitting Business Management Economics. Median wages calculated by higher-earning major for UCSC sample and full ACS sample. "**Weighted Sum Using UCSC Major Shares**" shows the difference between the weighted sum of Econ wage values by the share of UCSC students in that major (using highest-earning majors) and that of non-Econ wage values. "**RD IV Estimate on Imputed Wages**" assigns each 2008-2012 UCSC student to their corresponding majors' average wage – now partitioning students by their set of majors (not their higher-earning major), and in the UCSC no-controls sample using leave-one-out averages – and estimates the linear RD IV model on the resulting imputed wages. The ACS does not have separate major categories for Economics and Global Economics; see the appendix for UCSC-ACS major mapping. Wages are CPI-adjusted to 2018 and winsorized at 2% above and below. Sources: The UC-CHP Database, the CA Employment Development Department, and the American Community Survey

Table 7 shows the majors that UCSC students flowed into and out of across the 2.8 GPA threshold, with students generally flowing from other social sciences like psychology into UCSC's three economics tracks. It also shows the average wages of each major (measured in several ways), noting that economics majors have higher average wages than most of the majors they would have otherwise enrolled in. In fact, average wages by major is shown to be a useful proxy for the actual wage difference shown in Figure 5: the difference in average wages is about $20,000, compared

Table 8: Robustness of the wage-related estimates to alternative specifications

	Major in Economics	Predicted Wages by Demographics All	Emp. 17-18	UCUES	2020-2021 Wages	2020-2021 Log Wages	2020-2021 CA Employ.
Baseline	36.1	-15.0	998.9	-15.0	10,980	0.20	8.6
	(2.7)	(392.3)	(733.9)	(392.3)	(3,080)	(0.05)	(2.0)
Quadratic Run. Var.	31.8	-114.6	405.9	-114.6	19,279	0.29	14.0
	(5.5)	(661.4)	(839.2)	(661.4)	(3,216)	(0.09)	(2.4)
Detailed Covariates	35.2	-288.1	-159.4	-288.1	11,616	0.22	8.6
	(4.4)	(258.2)	(504.8)	(258.2)	(2,578)	(0.08)	(3.0)
Narrow Bandwidth	37.5	-346.2	-766.2	-346.2	16,748	0.24	11.3
	(4.3)	(821.1)	(951.6)	(821.1)	(3,692)	(0.09)	(2.3)
"Honest" Local Lin.	29.4	554.3	2,590.3	554.3	19,394	0.17	11.3
	(7.9)	(1,047.5)	(2,357.2)	(1,047.5)	(8,044)	(0.17)	(6.7)

Note: This table shows that the major choice and wage results presented in this brief are highly robust to alternative regression specifications. Regression discontinuity specifications estimating the reduced-form effect of economics major access on major choice and labor market outcomes for 2008-2012 UCSC students who completed Economics 1 and 2. Baseline specification is the beta coefficient from a regression discontinuity OLS model linear in the running variable (Econ GPA). The second specification includes quadratic terms in the running variable on either side of the threshold. The third specification includes linear running variable terms along with gender-ethnicity indicators, cohort indicators, and high school indicators. The fourth specification includes linear running variable terms but restricts the sample to within 0.5 GPA points of the threshold, resulting in 10 available GPAs. The fifth specification estimates "honest" local linear RD coefficients with optimal bandwidth, triangular kernel, and an assumed constant bound on the second derivative of the conditional expectation function following Kolesar and Rothe (2018). See the respective tables and figures above for detailed variable descriptions. GPAs below 1.8 are omitted, leaving 2,839 students in the sample (2,446 with observed wages). All standard errors are clustered by the 20 available GPAs earned by students in Economics 1 and 2.

Sources: The UC-CHP Database and the CA Employment Development Department

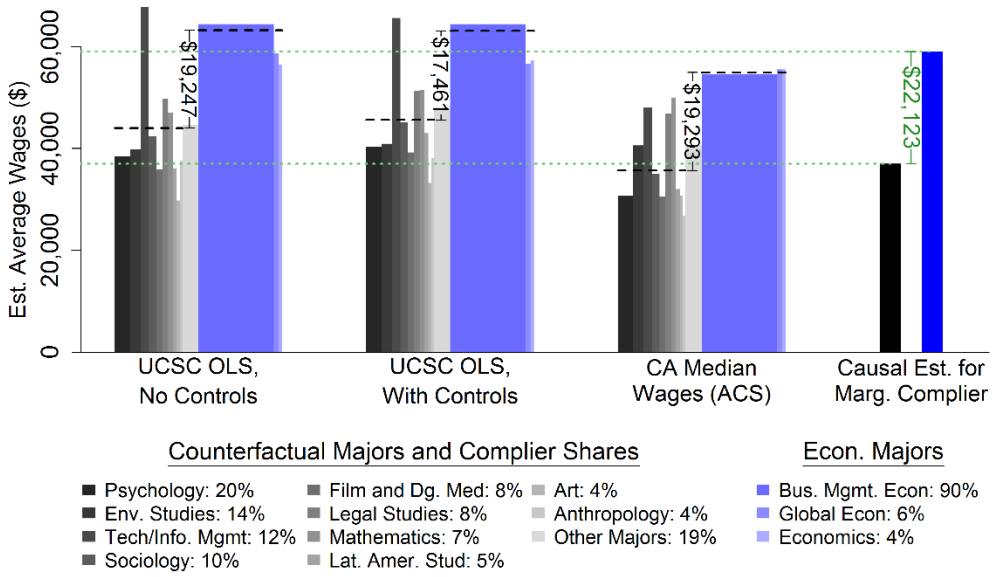
Table 9: Robustness of the educational, industry-specific, and major-specific estimates to alternative specifications

	Degree Attain.	Years Enr.	Grad. Deg. Enr.	FIRE and Account.	FIRE	Account.	Imp. By Ind.	Wages Imputed by Major UCSC OLS Coef. No Cont.	Controls	UCSC Med.
Baseline	-0.4	0.00	-2.3	9.1	6.3	3.4	3,937	7,178	5,579	8,065
	(1.5)	(0.05)	(2.2)	(2.3)	(2.3)	(1.1)	(1,166)	(547)	(1,333)	(599)
Quadratic Run. Var.	-3.8	-0.07	-2.8	11.4	10.0	3.2	6,431	7,731	7,491	8,100
	(2.1)	(0.08)	(4.1)	(3.2)	(2.9)	(1.7)	(1,473)	(715)	(1,475)	(996)
Detailed Covariates	-1.6	-0.06	-2.5	9.6	7.1	2.4	3,471	6,693	1,778	7,727
	(1.9)	(0.05)	(4.8)	(3.7)	(4.0)	(1.3)	(1,604)	(823)	(2,123)	(830)
Narrow Bandwidth	-2.6	-0.09	-1.4	6.8	4.3	3.6	7,374	8,156	8,111	9,106
	(2.0)	(0.06)	(3.8)	(2.9)	(2.5)	(1.5)	(1,053)	(674)	(1,360)	(861)
"Honest" Local Lin.	1.3	0.07	1.3	11.0	8.9	5.1	9,498	8,072	6,873	8,404
	(3.6)	(0.13)	(6.2)	(5.3)	(5.2)	(3.6)	(3,387)	(1,894)	(2,269)	(1,753)

Note: This table shows that the educational, industry-specific, and major-specific results presented in this brief are highly robust to alternative regression specifications. Regression discontinuity specifications estimating the effect of being eligible to declare the economics major on educational and labor market outcomes for 2008-2012 UCSC students who completed Economics 1 and 2. Baseline specification is the beta coefficient from a regression discontinuity OLS model linear in the running variable (Econ GPA). The second specification includes quadratic terms in the running variable on either side of the threshold. The third specification includes linear running variable terms along with gender-ethnicity indicators, cohort indicators, and high school indicators. The fourth specification includes linear running variable terms but restricts the sample to within 0.5 GPA points of the threshold, resulting in 10 available GPAs. The fifth specification estimates "honest" local linear RD coefficients with optimal bandwidth, triangular kernel, and an assumed constant bound on the second derivative of the conditional expectation function following (Kolesar and Rothe, 2018). See the respective tables and figures above for detailed variable descriptions. All standard errors are clustered by the 20 available GPAs earned by students in Economics 1 and 2, with the sample restricted to GPAs above 1.8. Source: UC-CHP Database, UC Corporate Student System, National Student Clearinghouse, and Employment Development Department

to the true wage change of $22,000. These estimates are confirmed in Figure 14, which presents

Figure 15: Observational Average Wage Differences between Economics and Counterfactual Majors



Note: This figure visualizes the evidence presented in Table 7 that wage-by-major averages well-approximate the causal wage effect of majoring in economics. 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 (estimated by weighted medians in the American Community Survey) for UCSC's three economics tracks and for the ten most-common counterfactual majors earned by marginally below-threshold UCSC compliers, juxtaposed with the causally-identified average early-career wages of below- and above-threshold UCSC compliers (following Abadie, 2002). The black dotted lines show the average wages of the majors chosen by below- and above-threshold compliers (using each set of wage-by-major statistics), calculated by assigning each 2008-2012 UCSC student to their corresponding majors' average wage – partitioning students by their *set* of majors, and in the UCSC no-controls sample using leave-one-out averages – and using the linear RD IV model on the resulting imputed wages to estimate complier wages. The complier shares are estimated by the linear RD IV model predicting an indicator for earning that major (standard errors available in Table **??**); the counterfactual major shares sum to greater than 100% because above-threshold compliers are less likely to earn multiple majors than below-threshold compliers. Bar widths correspond to these complier shares, rescaled to sum to 1. UCSC statistics from 2008-2012 UCSC students matched to 2017-2018 wages; California statistics calculated from age 23-28 ACS respondents in 2017-2018. OLS coefficients from linear regressions of wages on major dummies with or without covariates (gender-ethnicity, SAT score, Zip code average AGI, cohort year, and high school fixed effects), partitioning students by major (choosing the higher-earning major among in-sample single majors for multi-major students) and omitting BME; estimated coefficients are then summed with the approximate average earnings of in-sample single-major BME majors for comparability with actual earnings. Median wages are also calculated by respondents' higher-earning major. The ACS does not have separate major categories for Economics and Global Economics. Wages and wage-by-major averages are CPI-adjusted to 2018 and winsorized at 2% above and below. Sources: The UC-CHP Student Database, the CA Employment Development Department, and the American Community Survey.

figure versions of the bottom row of Table 7 (for the presented sample and for a group of earlier students, showing similar results). Figure 15 visualizes these comparisons.

Finally, Tables 8 and 9 present robustness checks of all of the results discussed above, estimating the regression discontinuity models using the baseline linear regression method but also using four other standard methods. In general, the results are very similar.

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[2] Appendix 1 presents evidence of this social stratification across majors by race and family income, using UCSB as a case study.

[3] Grade restrictions of C+ (2.3) or below are excluded, as they are generally put in place to prevent students who cannot pass upper-division courses from beginning technical majors, not to manage demand among students capable of passing introductory courses. Major restrictions are generally justified by either capacity constraints resulting from temporary over-demand – though many remain in place for decades – or on the pedagogical grounds that lower-performing (but passing) students cannot succeed in challenging fields of study.

[4] Comparable data are presently unavailable for the Irvine, Merced, San Diego, and UCLA campuses. UC Riverside hardly makes use of major restrictions, and so is omitted from the analysis.

[5] UC Davis permits some students with high AP scores to skip their introductory courses, while UCSB does not. In total, 18 percent of UC Davis freshman-admit 2010-2016 economics majors do not complete Economics 1A at UCD, compared to 3% of UCSB students who do not complete Economics 1. This 15 percentage point difference may generate a small degree of sample selection bias in the results presented in the second Results section, with the introductory UC Davis students somewhat negatively selected relative to UCSB students.

[6] Ethnicity is observed after 1975 (UCB), 1987 (UCSB), or 1990 (UCD and UCSC).

[7] Normed GPA is defined as:

$$nGPA_i = \frac{1}{|C_i|}\sum_{c \in C_i} \frac{GPA_{ic} - \overline{GPA}_c}{sd(GPA)_c}$$

where student i's GPA is defined as the average number of standard deviations by which their grade was greater or less than the average grade in each course they completed (set C_i). Students with high Normed GPAs are students who consistently out-performed their peers in their chosen courses of enrollment. Estimates are similar but smaller if raw GPA is used instead of normed GPA.

[8] CDE course-level school information available at http://www.cde.ca.gov/ds/sd/df/filesassign.asp.

[9] Models of the following form are estimated over the unbalanced panel of all majors in all available years at the four campuses:

$$Y_{cmy} = \alpha_{cm} + \gamma_{cy} + \zeta_{d_m y} + \sum_{t=-8}^{50} \beta_t \mathbb{1}\{y = R_{cm} + t\} + \epsilon_{cmy}$$

where Y_{cmy} is an outcome (like log number of students) for campus c's major m in cohort year y, α_{cm} and γ_{cy} are campus-major and campus-cohort fixed effects, $\zeta_{d_m y}$ are discipline-year fixed effects (grouping majors into five disciplines), and R_{cm} is the first cohort-year that faced major m's restriction at c. For example, $Y_{UCB,Econ,1990}$ could represent the log number of 1990-cohort students (that is, students whose first year of enrollment was 1990) who declared an economics major (whether or not they ultimately earned a degree) at UC Berkeley. Standard errors are clustered by campus-major.

Year of first implementation is noisily measured for major restrictions; course catalogs typically do not specify which cohort will be the first to face the major restriction, and timing of restrictions' catalog inclusion may differ by campus or department. As a result, β_{-1} is set to 0 but care should be taken to not over-interpret β_0 or β_{-2}; the discussion below will highlight changes in further pre- and post-periods.

[10] For example, imagine a 100-student major with 15 URG students imposed a GPA restriction. On average, this leads to a 10% decline in enrollment – to 90 students – and a 3% decline in URG, to 12%. This means that 11 students will by URG and 79 students won't be. The percent of non-URG students who exited the major is 6/85=7%; for URG, it's 27%. In other words, URG students were 20 percentage points more likely to exit the major than non-URG students, on average.

This and similar estimates below of the characteristics of major restriction `compliers' – that is, students who would have declared the major if not for the restriction – require assuming that the major restriction did not impact the likelihood of major declaration of students who would otherwise have not declared the major. If the major restriction immediately encouraged positively-selected students to declare that major (perhaps believing that the restriction would increase the major's educational quality or postgraduate return), then these estimates could be overestimates of the true effect.

[11] Mathematics and Statistics courses are omitted from all majors' "Outside Normed GPA", since those courses are often required by (and included in the restriction GPA calculations of) majors in nearly all disciplines.

[12] Economics major declaration includes both Economics and Economics & Accounting at UCSB and both Economics and Managerial Economics at UCD. UCD's Managerial Economics track, like many business-oriented economics majors, had a 2.8 GPA major restriction prior to 2013. That track catered to almost half of the students in economics-

based majors at UCD. While UCD's 'partial' major restriction could attenuate the results discussed below, the coefficient estimates are similar (but less-precise) if the sample is split prior to 2014 and models are re-estimated separately in both periods.

[13] AP and IB economics course exposure at public high schools from the CDE: https://www.cde.ca.gov/ds/sd/df/filesassign.asp

[14] As a result, we examine differences in students' course grades, course enrollment, and major declaration at each campus $u \in \{D, SB\}$ using a series of linear regression models:

$$Y_{iyctu} = \alpha_{ctu} + \gamma_{yu} + (\beta_c + \beta_{c,SB}\mathbb{1}_{SB})X_i + \epsilon_{iyctu}$$

where each outcome Y_{iyctu} for student i in cohort y who completed course c in term t is modeled as a function of students' demographic, socioeconomic, high school opportunity, and academic preparedness characteristics: gender, ethnicity, log parental income, SAT score, high school GPA, California residency, California public school enrollment, and the presence of AP and IB economics for students from public CA high schools. Male and white students are the omitted groups. An indicator for missing income marks students who did not apply for federal, state, or institutional financial aid, usually connoting high income or wealth. Cohort and course-term fixed effects are included for each campus, and standard errors are clustered by high school.

Propensity weights ensure that the UCD and UCSB student samples are balanced on observed covariates, including the full set of covariates described above as well as California county fixed effects. In particular, each observation is weighed by the student's inverse likelihood of enrolling at that campus, recovering the average treatment effect for students at both campuses.

[15] By ECON 1, this section refers to Economics 1 at UCSB and Economics 1A at UCD.

[16] In this context, "preferences" refer to students' relative desire to complete different majors given their own aptitudes, inclinations and personal circumstances.

[17] Major declaration propensity among plausibly-interested students is significantly lower at UCSB (26.4%) than it is at UCD (32.2%). This difference is similar in magnitude to the effects of major restrictions on major size reported in the previous section.

[18] The major restriction may also make the economics major more-appealing to highly-prepared students for other reasons by shrinking class sizes (and increasing peer academic aptitude) or improving the major's signal quality.

[19] See Kirkeboen, Leuven, and Mogstad (2016) and Daly and Le Maire (2019).