College Major Restrictions and Student Stratification

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Many selective universities restrict access to high-demand majors using grade minimums and competitive internal applications. Difference-in-difference estimation around the implementation of 24 major restrictions at three universities since the 1970s shows that the restrictions are binding and differentially impact underrepresented minority (URM) students and students with absolute (not comparative) academic disadvantage, generating within-school socioeconomic stratification. A case study of Economics majors suggests that these effects are largely explained by URM and low-income students' lower pre-college academic opportunity and measured preparedness, which lead to poor performance in introductory classes. The same universities that intentionally admit and recruit disadvantaged applicants to promote economic mobility appear to prevent many of those students from earning their most-lucrative degrees.

1 Introduction

Undergraduate major selection has substantial long-run labor market implications: students earn higher post-graduate wages if they obtain 'high-return' professional degrees or degrees in their preferred field of study.[1] Underrepresented minority (URM) and lower-income university students are underrepresented in many high-earning fields like computer science and economics, which likely exacerbates income inequality. Meanwhile, many universities 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 policy brief analyzes whether and how major restrictions contribute to the socioeconomic stratification of university students across fields of study.

Prior studies of major selection have largely focused on student preferences; indeed, a recent survey does not mention major restrictions in its discussion of the 'supply side' of college major choice.[2] However, major

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[1] See Deming and Noray (2018) and Andrews, Imberman, and Lovenheim (2017) on the former and Kirkeboen, Leuven, and Mogstad (2016) and Daly and Le Maire (2019) on the latter.

[2] See Arcidiacono, Hotz, and Kang (2012); Zafar (2013); Kinsler and Pavan (2015); Wiswall and Zafar (2015, 2017). Altonji, Arcidiacono, and Maurel (2016) mention major restrictions as a potential source of identifying variation to estimate major-specific returns, though their proposed approach is not implemented in the present brief. Stange (2015), Andrews and Stange (2016), and Denning and Turley (2017) discuss major-specific price discrimination and incentive payments, which are important – though presently less-common – supply-side contributors to major choice. Stinebrickner and Stinebrickner (2014) show that even students at a small private university without major restrictions are over-optimistic about their likelihood of earning STEM majors, though they attribute major switching to demand-side factors. Rask (2010) argues that low grades in STEM courses explain a small portion of lower persistence in STEM courses (see also Butcher, McEwan, and Weerapana (2014)).

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: 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, in addition to 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.
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

restrictions are widely implemented at selective public universities in 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).[3] Half of these schools restrict their computer science majors – typically to students who earn high 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.[4]

This brief analyzes the impact of major restrictions using a new dataset of demographic and course records for the 700,000 students who enrolled between 1975 and 2018 at three selective public universities: UC Berkeley, UC Davis, and UC Santa Barbara. It employs a difference-in-difference design to estimate the effect of the 24 new major restrictions imposed by the universities during the period. It then examines Economics as a case study, comparing students' course performance and persistence

[3]Wage statistics as reported by Altonji, Blom, and Meghir (2012).

[4]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. Thinly-stretched resources from 'over-enrollment' could negatively-impact educational quality (Bound and Turner, 2007; Bound, Lovenheim, and Turner, 2010), in part by through increased class sizes (Bettinger and Long, 2017).

by socioeconomic characteristics at two universities, one of which had a minimum grade restriction.

The results described below show that major restrictions lead to an 18% decline in the number of students declaring that major on average. URM students and students with low SAT scores are much more likely to exit restricted majors than their peers. Major restrictions impede major choice for students with *absolute* academic disadvantage, not comparative disadvantage in the field; the students who exit restricted majors earned similarly-low first-quarter grades across all disciplines, not just in the restricted field. The case study shows that URM and lower-income students become less likely to earn degrees in a restricted field because of their lower average grades in introductory courses, which is explained in part by their lower SAT scores and more-limited prior access to related AP and IB high school courses. This evidence implies that major restrictions inefficiently limit student choice on the basis of students' pre-enrollment educational opportunity.

This brief presents the first evidence that popular policies implemented by many selective universities – major restrictions based on introductory course performance – magnify socioeconomic stratification.[5] Indeed, the same universities that intentionally admit and recruit disadvantaged applicants in order to promote economic mobility appear to prevent many those students from earning the schools' most-lucrative degrees. Major restrictions likely have substantive implications for impacted students' postgraduate outcomes: Kirkeboen, Leuven, and Mogstad (2016) show evidence of large postgraduate wage declines among students prohibited from earning degrees in their preferred discipline.[6]

This brief also presents new evidence on how university policies mediate science and engineering (STEM) degree attainment in the US.[7] Half of the major restrictions imposed by the three universities discussed below were imposed in STEM fields, and major restrictions generally impose a previously-unreported ceiling on STEM major growth in many fields at many universities, particularly discouraging URM and less-relatively-prepared students from earning high-demand STEM majors.

Finally, this brief documents an important determinant of student major selection that was previously undiscussed in the large academic literature on major choice.[8] While that literature has largely focused on the demand-side of major choice – particularly students' preferences and subjective expectations – this brief describes a widely-implemented supply-side policy that substantially limits many students' access to high-average-wage majors. It also documents an important source of selection bias in the estimation of major-specific returns; majors (like engineering and nursing) that many universities restrict are likely to yield substantially upwardly-biased estimates of major-specific returns unless researchers apply statistical corrections that account for substantial access restrictions, especially for relatively-disadvantaged students.[9]

The increasing prevalence of major restrictions at public universities – and the resulting socioeconomic stratification of their students – is in part a consequence of shrinking educational resources following declines in public support for higher education (Douglass and Bleemer, 2018). But at least three low-cost alternative policies are available 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'.[10] Any of these policies would likely mitigate the inequities fostered by the present major restrictions.

The next section discusses the data used in this brief, while Section 3 presents the empirical methodology used to estimate the average effect of major restriction implementation on the characteristics of declared majors. Section 4 presents more-detailed analysis of two universities' economics departments as a case study of a major restriction's impact on disadvantaged students, and the final section provides concluding remarks.

2 Data

The detailed student enrollment database analyzed in this brief was collected as part of the UC ClioMetric History Project (Bleemer, 2018). The sample includes all undergraduate students who first enrolled at each of

[5] A large academic literature studies socioeconomic stratification across (Chetty et al., 2017; Arcidiacono, Kinsler, and Ransom, 2019a,b; Markovits, 2019) and within (Clewell and Campbell, 2002; Summers and Hrabowski, 2006; Tsui, 2007; Schultz et al., 2011) universities.

[6] Griffith (2010) shows that students with lower measured preparedness are less likely to earn STEM majors, while Arcidiacono, Aucejo, and Hotz (2016) and Bleemer (2019) come to different conclusions about whether enrollment at more-selective universities under affirmative action decreases URM students' STEM degree attainment.

[7] See National Academies (2007); Wang (2013); Sjoquist and Winters (2015a,b); Castleman, Long, and Mabel (2018).

[8] See Altonji, Blom, and Meghir (2012) and Altonji, Arcidiacono, and Maurel (2016) for surveys.

[9] E.g. see Carnevale, Cheah, and Hanson (2015). In his study of the contribution of sample selection bias to cross-major differences in mean wages, Arcidiacono (2004) argues in favor of "large differences in preferences that high ability individuals have for the more lucrative fields". These could be demand-side preferences, but also appear to reflect supply-side access to lucrative restricted majors.

[10] See Johnson and Turner (2009) for a discussion of efficient resource allocation across academic departments, Bettinger and Long (2010) for evidence on the impact of teaching-oriented faculty on student major choice, and Abeysekera and Dawson (2015) for a survey of evidence on flipped classroom pedagogy.

Table 2: *Fifty Years of Major Restrictions at Three Universities*

	Years				Years		
Major	First	Last	Rule	Major	First	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	-	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	-	3
Electrical Eng.	1986	-	3	Fin. Math. and Stat.	2005	-	2.5

Note: 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, while * 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. 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

three University of California campuses in the observed sample period: UC Berkeley (1975 to 2016), UC Davis (1980 to 2018), and UC Santa Barbara (1986 to 2018).[11] UC comprises California's ten public research universities, and the three observed campuses are among the nation's 15 most-selective public universities and enroll more than 80,000 undergraduates. The data include first year of enrollment, gender, ethnicity, and California residency; underrepresented minorities (URM) are defined to include Black, Hispanic, and Native American students. For students who enrolled after 1993, the data include SAT score, high school GPA, family income, and (for California-resident freshmen) high school.

Table 2 shows all majors at the three 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 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. Berkeley and Davis's Computer Science departments have implemented restrictions twice.

One possibly-important effect of major restrictions is to stratify students by their university course performance, with higher-performing students permitted to enroll in

[11] Ethnicity is observed after 1975 (B), 1987 (SB), or 1990 (D).

restricted fields of study. Student grade point averages (GPAs) are often used to measure university course performance, but GPA is biased by differences in grading standards across academic disciplines. Figure 1 displays average course GPAs by division at UC Berkeley throughout the sample period, showing large and growing gaps in average grades by discipline: Science and Engineering courses had average grades about 0.2 GPA points below the Humanities in 1970, but the gap had grown to almost 0.4 GPA points by the mid-2010s. The distributional shape of available grades may also differ by discipline.

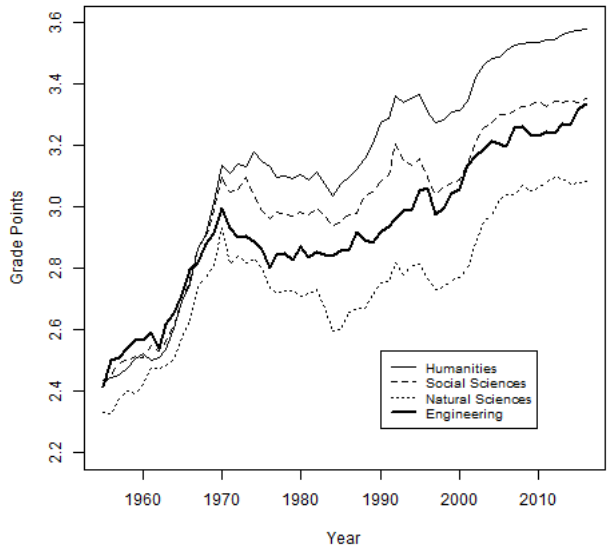
In order to abstract away from cross-field differences in grade availability, a new "Normed GPA" measure is calculated as follows:

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

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.

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.[12]

Figure 1: *Average UC Berkeley Grades by Discipline over Time*



Note: Average grade points earned by students in Humanities, Social Science, Natural Science, and Engineering courses at UC Berkeley annually from 1955 to 2016. Source: UC ClioMetric History Project Student Database

[12]California Department of Education course-level school information available at http://www.cde.ca.gov/ds/sd/df/filesassign.asp.

Table 3 presents descriptive statistics of the majors offered at each of the three UC campuses. Each campus offered an average of 65 majors in each year of the sample period, with an annual average of 94 students per major (s.d. 115). The average major was 53 percent female and 20 percent URM. There were 24 newly-imposed major restrictions during the period covered by the data – with 7-10 at each of the three campuses – and 20 restrictions imposed in the period when ethnicity is observed. The total sample includes about 700,000 students who enrolled in 6,700 major-cohort pairs.

Table 3's last column shows characteristics of majors soon to implement major restrictions. Those majors are twice the size of average majors, averaging 190 annual students, and only 14 percent of their students are URM.

3 Event Study Analysis

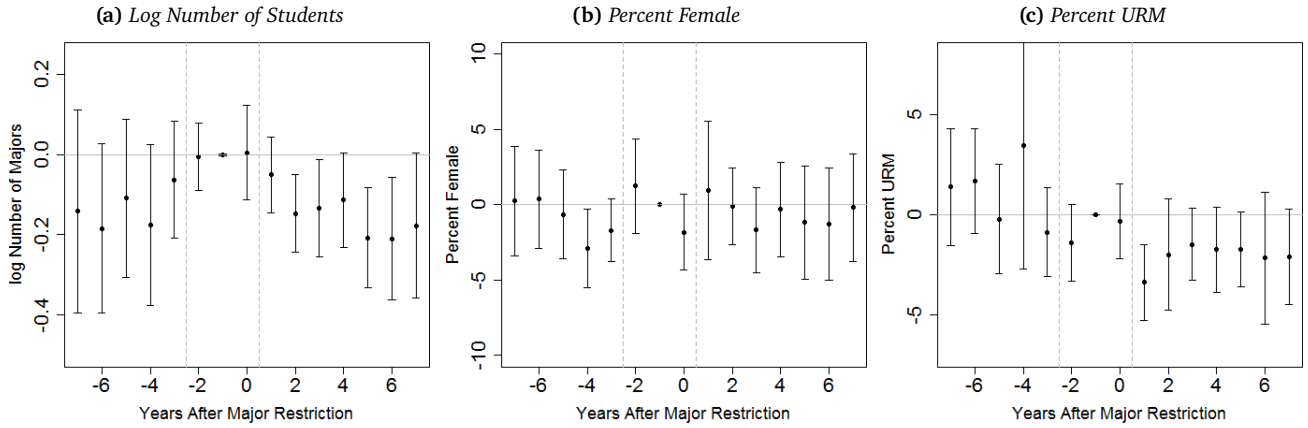
This brief implements an event study difference-in-difference design to estimate the impact of imposing a major restriction on the major's student composition. Each newly-imposed major restriction in the sample period – either a selective internal application or an

Table 3: *Descriptive Statistics of UC Campus Majors*

	All	UCB	UCD	UCSB	3 Years Prior to Major Restrict.
Number of Departments	65 [15]	74 [5]	69 [15]	47 [4]	
# of Students	94 [115]	95 [112]	77 [98]	122 [142]	190 [147]
% Female	53 [22]	52 [21]	56 [22]	54 [23]	53 [21]
% URM	20 [17]	18 [17]	20 [15]	24 [20]	14 [7]
Sample Size, Overall					
Events	24	7	10	7	
Major-Years	6,737	2,902	2,479	1,356	
Sample Size, Observe Demographics					
Events	20	7	7	6	
Major-Years	6,073	2,902	1,899	1,272	

Note: Descriptive statistics of the average number of departments at each covered university, average number of students per department, and average percent of female and URM students across departments, for all departments and for departments three years prior to instituting major restrictions. Standard deviations in brackets. Events indicate number of new observable major restrictions (see Table 2) and major-year observations, in the full sample and in the sample where student demographic characteristics (like ethnicity) are observed. Source: UC ClioMetric History Project Student Database

Figure 2: *Department Event Study: Student Characteristics*



Note: 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. 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 ClioMetric History Project Student Database

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 than four years (prohibiting estimation of longer-run effects) are omitted. Using the resulting 24 events, models of the following form are estimated over the unbalanced panel of all majors in all available years at the three campuses:

$$Y_{cmy} = \alpha_{cm} + \gamma_{cy} + \sum_{t=-7}^{8} \beta_t \mathbb{1}\{y + t = PM_{cm}\} + \epsilon_{cmy} \quad (2)$$

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, and PM_{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.

3.1 Event Study Results

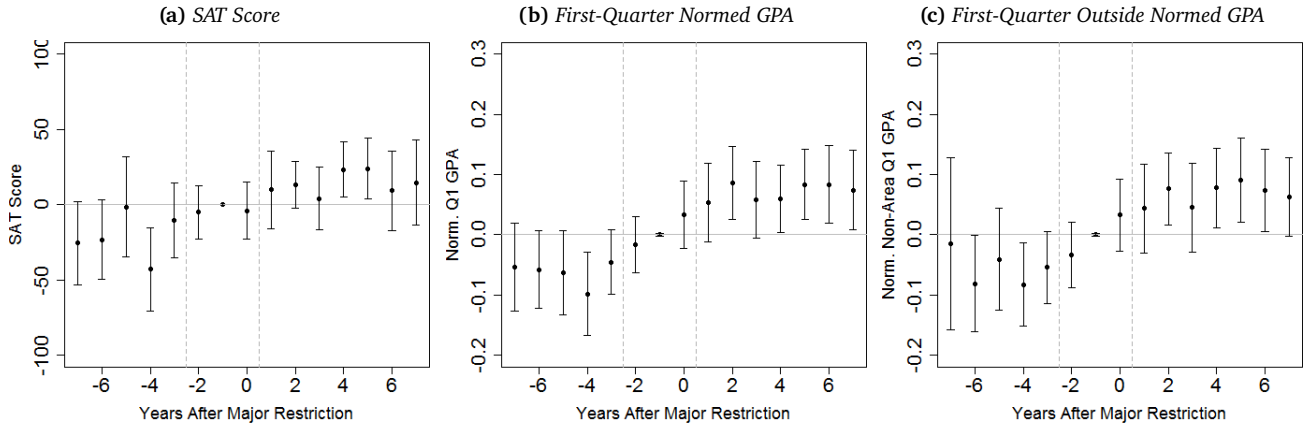
Panel (a) of Figure 2 shows β estimates from Equation 2 for the log number of students who declare newly-restricted majors before and after the imposition of the restrictions. The estimates suggest that major restrictions are put into place about three years after a majors begin growing relative to other fields, with average (statistically-insignificant) growth of about 15 log points. However, major restriction imposition more than undoes this short-run growth, with immediate enrollment declines of about 20 percentage points (> 0.2 log points) that persist for at least seven years.

What were the characteristics of the students denied from the major as a result of newly-implemented major restrictions? The middle panel of Figure 2 shows that the proportion of female students in newly-restricted majors remained unchanged, but that the average proportion of URM students sharply declined by 2-4 percentage points. Given the 18 percentage point decline in all major declarations, this implies that URM students were about 15 percentage points more likely to exit the major as a result of the restriction than non-URM students.[13]

How did major restrictions differentially impact students with different levels of measured academic ap-

[13]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.

Figure 3: *Department Event Study: Student Characteristics*



Note: 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. 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 above in Equation 1; "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 ClioMetric History Project Student Database and UC Corporate Student System

titude? The left panel of Figure 3 shows that newly-restricted majors' enrollees had higher average SAT scores by almost 40 points (on the 2400 scale), with the increase occurring over the three-year transitional period of the new restriction. This suggests that students pushed out of the major by the restriction 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 3 unsurprisingly shows that major restrictions yield students with higher average first-quarter normed GPAs; after all, most of the relevant restrictions explicitly exclude students with poor performance in specific introductory courses. However, Panel (c) shows a near-identical effect when only unrelated courses in other disciplines are used to calculate students' normed GPA.[14] This implies that students pushed out of restricted majors had average normed first-quarter GPAs about 0.9 z-scores lower than the major's average, even when their GPA is calculated using only courses outside the major's discipline. The similarity between Figures (b) and (c) suggests that major restrictions do not ultimately target students based on their *comparative* advantages – that is, students with particular academic strengths in that specific field – but instead target students whose academic performance is generally stronger across fields (*absolute* advantage).

These evidence, summarized in Table 4, suggest that major restrictions sharply reduce the number of students who declare the restricted major, with URM students far more likely to exit the major than non-URM students. The restrictions appear to select students with general academic advantages as opposed to students with advantages specific to the field of study. The next section provides greater detail about a specific major restriction – imposed by the Department of Economics at UC Santa Barbara – in order to provide some insight into why the restrictions function in this manner.

4 Mechanism Analysis: A Case Study of Economics

To shed light on how major restrictions influence the majors that students enter, we compare entry into the economics majors at UCSB and UC Davis between 2010 and 2016.[15] These majors provide a useful case study for several reasons:

1. UC Davis and UC Santa Barbara were similarly-selective institutions; both were ranked between 38 and 42 in every annual US News & World Report national university ranking in the period.

[14] 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.

[15] UC Berkeley's economics major is omitted because Berkeley's semester schedule (instead of UCSB and Davis's quarter schedules) yields a different lower-division economics curriculum, with introductory micro- and macroeconomics combined into a single course. This prohibits direct comparison with the other campuses.

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

	Log Num. of Students	Percent Female	Percent URM	Percent CC Transfers	SAT Score	Q1 Normed GPA[1] All	Q1 Normed GPA[1] Outside Area
Before Major Restriction	-0.10	-0.44	0.79	-0.08	-21.31	-0.06	-0.06
	(0.09)	(1.07)	(0.98)	(0.02)	(14.80)	(0.03)	(0.03)
Transition Years	-0.00	-0.20	-0.93	-0.02	-10.82	0.03	0.03
	(0.04)	(1.47)	(0.78)	(0.02)	(8.29)	(0.03)	(0.03)
After Major Restriction	-0.18	-0.48	-2.73	-0.02	16.28	0.10	0.09
	(0.06)	(1.64)	(0.83)	(0.02)	(7.64)	(0.03)	(0.03)
Campus-Major FE	X	X	X	X	X	X	X
Campus-Year FE	X	X	X	X	X	X	X
Observations	6737	6073	6073	5970	4198	6042	6042
R^2	0.88	0.86	0.85	0.69	0.87	0.67	0.58
Δ (Post-Pre)[2]	-0.09	-0.04	-3.52	0.06	37.59	0.16	0.15
	(0.08)	(1.46)	(0.75)	(0.02)	(16.44)	(0.03)	(0.03)

Note: Event study β estimates of the measured characteristics of 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 3-7 years prior to initial restriction implementation; "Transition" includes the year of implementation and two years earlier; and "After" includes 1-5 years following implementation. β_{-1} is omitted. Students can be included in more than one major estimate (e.g. as double-majors). [1]First-quarter normed GPA is defined above in Equation 1; "Outside Area" 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. [2] The difference between "After" and "Before" Major Restriction β coefficients, with standard error in parentheses.

Source: UC ClioMetric History Project Student Database and UC Corporate Student System

2. Each campus had a similarly-structured progression of introductory courses that students were required to take prior to major declaration: two quarters of calculus, introductory micro- and macroeconomics (Economics 1 and 2), and one or two additional courses depending upon students' chosen track.
3. All economics tracks at Santa Barbara had a 2.85 grade point average restriction (over 3-5 introductory economics courses), while the Davis economics major was unrestricted.[16]
4. The Santa Barbara restrictions (and Davis's non-restriction) did not change in the sample period.
5. Despite UCSB's restriction, the economics majors at each school graduated more students than any other major in the period, suggesting substantial demand.

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:

$$Y_{iyctu} = \alpha_{ctu} + \gamma_{yu} + (\beta_c + \beta_{c,SB}\mathbb{1}_{SB})X_{iyu} + \epsilon_{iyctu} \quad (3)$$

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.[17] Cohort and course-term fixed effects are included for each campus, and standard errors are clustered by high school. Propensity weights ensure that the Davis and Santa Barbara student samples are balanced on observed covariates, including the full set of covariates described above as well as California county fixed effects.[18]

Our preferred interpretation of these models is that between-campus differences students' propensity to declare the major mainly reflect the effect of UCSB's economics major restriction. The first two regression

[16]UC Davis'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 UC Davis. While Davis'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 (available from the authors).

[17]These characteristics include 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.

[18]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.

Table 5: *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)
Miss. Income	4.40	6.55	2.15	4.76	2.26	-2.50	3.06	-1.21
	(1.83)	(1.92)	(2.62)	(1.87)	(1.90)	(2.64)	(1.07)	(1.47)
Out-of-State	-4.50	-4.30	0.20	-4.74	0.69	5.43	4.34	-2.45
	(2.30)	(2.58)	(3.41)	(2.43)	(2.63)	(3.52)	(1.52)	(2.06)
International	0.96	-0.23	-1.19	0.26	5.64	5.38	17.02	14.09
	(1.79)	(2.22)	(2.62)	(2.06)	(2.22)	(2.78)	(5.45)	(3.15)
CA Private HS				4.07	-0.59	-4.66	1.35	1.66
				(1.85)	(1.83)	(2.44)	(1.13)	(1.42)
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 FEs		X			X		X	
Campus-Cohort FEs		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: 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 ~ 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

models presented in Table 5 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.[19]

The first model includes only demographic and socioeconomic characteristics as covariates, directly testing whether UCSB's major restriction induces social stratification. The baseline Davis 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.[20] They reveal a significant relative preference for the subject among Asian students, but not among URM students. There is some evidence that preference for economics increases with income; the high-income students who do not report family income statistics are much more likely than average to declare the major.[21]

At Santa Barbara, by comparison, Asian students who took ECON 1 are not significantly more likely to declare an Economics major, while URM students are 10 percentage points less likely to declare an economics major. The magnitude of this URM difference is appreciable relative to an average declaration propensity of 26.4 percent at UCSB.[22] The difference between the campuses in URM students' propensity to declare an economics major is similarly large and highly statistically significant. Income also appears to have stronger effects on enrollment at Santa Barbara. This is consistent with the major restriction muting student preferences, and doing so in a way that stratifies students on race and income.

The second regression model in Table 5 includes academic opportunity preparation covariates. In contrast to the previous results, racial differences *between similarly prepared students* are much smaller, though URM students remain somewhat less likely to declare an economics major at UCSB than at Davis, by 3.1 (s.e. 2.0) percentage points.[23] 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 Davis, ECON 1 students with higher SAT scores and high school GPAs are less likely to select an economics major, while the precise opposite is true at UCSB. This suggests that economics tends not to be the top choice of the best prepared (ECON 1) students, but that the major restriction systematically prevents the least prepared from declaring at UCSB.[24] Second, while exposure to economics in high school does not predict major declaration at Davis, it certainly does so at UCSB. This suggests that the restriction does not only induce selection on prior general preparation, but on prior exposure to economics. Unless prior exposure is correlated with the benefits derivable from economics training, this suggests that selection is inefficient.

The final model in Table 5 examines 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 Davis in three respects. First, Asian, male and richer students are more likely to take ECON 1 at Davis, while URM 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 take ECON 1 at Davis, while those who attended private school are not. In contrast, high SATs and high school GPAs are not associated with taking ECON 1 at UCSB, and private high-school attendance is. 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, perhaps because students who feel they are less likely to qualify for the major do not attempt it. Finally, students who have taken AP Micro and are therefore eligible to opt out of ECON 1 tend to do so at Davis, but not at UCSB, where the major restriction only considers ECON 1 grades from courses taken at UCSB.

The results presented in Table 5 reveal more positive selection and self-selection into the economics majors at UCSB than at Davis, that selection is on prior academic preparation and exposure to economics in high school, and that this selection results in stratification on race and income. Our preferred interpretation is that the greater observed positive selection at UCSB arises due to the majors' GPA cap. While alternative explanations are feasible, Table 6 shows further student patterns bolstering our interpretation.

[19] Economics major declaration includes both Economics and Economics & Accounting at UCSB and both Economics and Managerial Economics at UC Davis.

[20] By "preference" here, we mean simply students' relative desire to complete different majors given their own aptitudes, inclinations and personal circumstances.

[21] The coefficient on missing income has been adjusted to reflect the difference in outcome propensity between the non-reporting and a student with a family income at the mean reported level.

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

[23] In fact, only SAT score (not HS GPA or courses) partially absorbs URM students' lower likelihood of major declaration at UCSB. If SAT scores are poorer predictors of URM students' academic performance than they are for non-URM students Vars and Bowen (1998), then the URM student effect would be over-absorbed in this context. Indeed, interacting SAT score with URM status estimates a sharply negative coefficient for URM students at UCSB and yields a baseline URM coefficient (at mean SAT) of -4.5 (s.e. 2.2) percentage points.

[24] 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.

Table 6: *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)
Miss. Income	-0.09	0.08	-0.07	0.09	-0.01	0.04	-0.02	0.01	-0.01
	(0.05)	(0.07)	(0.06)	(0.07)	(0.05)	(0.05)	(0.02)	(0.03)	(0.05)
Out-of-State	-0.08	0.33	0.02	0.17	-0.00	-0.10	0.10	0.11	0.25
	(0.07)	(0.09)	(0.07)	(0.09)	(0.07)	(0.07)	(0.04)	(0.05)	(0.07)
International	0.42	0.32	0.46	0.07	0.02	-0.12	0.48	0.40	0.41
	(0.05)	(0.06)	(0.07)	(0.08)	(0.06)	(0.06)	(0.06)	(0.04)	(0.08)
CA Private HS	-0.07	0.13	-0.02	0.02	-0.01	-0.08	0.02	0.01	0.01
	(0.04)	(0.06)	(0.06)	(0.06)	(0.04)	(0.05)	(0.03)	(0.03)	(0.05)
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 FEs	X	X	X	X	X	X	X	X	X
Campus-Cohort FEs	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: 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 ClioMetric History Project Student Database, UC Corporate Student System, and California Department of Education

4.1 Robustness

One alternative explanation for the patterns described above is that quantitative aptitude covaries with prior preparation to a greater degree among UCSB students. If this were the case, and students' course and major choices responded 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 6 – which model ECON 1 students' performance in the first two calculus courses – show that this is not the case for quantitative skills. The baseline (Davis) 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 Davis 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 Davis, and the URM grade penalty is smaller at UCSB than at Davis. This implies that UCSB provides somewhat more-lenient grades in its introductory courses, but its binding major restriction nevertheless discourages disadvantaged and lower-preparation students from earning the major.

The final three columns of Table 6 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 Davis, 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. URM 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 Davis and Santa Barbara.

5 Conclusion

UC Berkeley, UC Davis, and UC Santa Barbara have imposed 39 significant policies restricting students' major choice in the past 50 years, in line with similar behavior at selective public universities across the country. These restrictions, most of which require students to earn high grades in specific introductory courses before being permitted to declare a major, tend to decrease the number of students in the major by about 20 percent, with URM students about 15 percentage points more likely to exit the major than non-URM students. Despite only targeting relevant coursework, the restrictions push out students with *absolutely* poorer early university performance, not students who perform poorly in the targeted courses.

Major restrictions' systematic stratification of students by pre-enrollment characteristics can be explained by the close correlation between introductory course performance and prior student opportunity and preparation. Underrepresented minority students, lower-income students, and students whose high schools did not offer related advanced courses earn substantially lower grades in introductory courses and become less likely to persist in restricted majors.

Like most public universities, each UC campus has explicit undergraduate admissions policies in place targeting disadvantaged applicants and encouraging their enrollment. Major restrictions systematically restrict those applicants' access to many fields of study, including most of the campuses' most-lucrative majors as well as many STEM fields. Future analysis will leverage linked wage records to document the long-run labor market effects of major restriction policies for impacted students.

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