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Affirmative action and its race-neutral alternatives ☆

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ABSTRACT

As affirmative action loses political feasibility, many universities have implemented race-neutral alternatives like top percent policies and holistic review to increase enrollment among disadvantaged students. I study these policies' application, admission, and enrollment effects using University of California administrative data. UC's affirmative action and top percent policies increased underrepresented minority (URM) enrollment by over 20 percent and less than 4 percent, respectively. Holistic review increases implementing campuses' URM enrollment by about 7 percent. Top percent policies and holistic review have negligible effects on lower-income enrollment, while race-based affirmative action modestly increased enrollment among very low-income students. These findings highlight that the most common race-neutral alternatives to affirmative action increase Black and Hispanic enrollment far less than affirmative action itself and reveal that none of these policies substantially affect universities' socioeconomic composition.

> *The University seeks to enroll, on each of its campuses, a student body that, beyond meeting the University's eligibility requirements, demonstrates high academic achievement or exceptional personal talent, and that encompasses the broad diversity of cultural, racial, geographic, and socioeconomic backgrounds characteristic of California.*
>
> *~Regents of the University of California Policy 2102, 1988–2022*

1. Introduction

Access to selective universities provides an important socioeconomic mobility pipeline for lower-income and otherwise-disadvantaged students in the United States (Chetty et al., 2020; Bleemer, 2022). Selective universities have been providing underrepresented minority (URM) students with targeted admission advantages since the 1960s, but a growing number of laws and court decisions have prohibited race-based affirmative action in universities' admission decisions. As a result, many universities have implemented alternative 'access-oriented' admission policies designed to bolster their enrollment of URM and other disadvantaged students.

This study estimates the university- and system-level enrollment effects of affirmative action and its two most common race-neutral alternatives: "top percent" policies and holistic review. Top percent policies guarantee admission to the top *x* percent of each high school's graduates, exploiting cross-school stratification to boost enrollment among disadvantaged graduates from low-performing high schools. Holistic review eliminates universities' use of fixed weights over the wide variety of admission criteria used to judge applicants, providing evaluative flexibility designed to benefit applicants whose academic preparation was hindered by limited pre-college opportunity. Most selective private and many public universities implement holistic review (Coleman and Keith, 2018), and top percent policies are employed by four of the nation's largest public university systems.

While several previous studies have estimated the URM enrollment effects of affirmative action and top percent policies (e.g. Long, 2004; Howell, 2010; Backes, 2012), data limitations have challenged the separate identification of each policy's effects –

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especially because multiple policy changes are often implemented in quick succession – and prohibited estimation of how these policies shape universities' socioeconomic composition.[1] I construct a novel administrative database covering in-state freshman applicants to the nine undergraduate University of California (UC) campuses between 1994 and 2021, a period with significant admission policy variation over time and between campuses, and supplement those data with records covering all high-GPA high school graduates and SAT-takers in the state. Employing a series of difference-in-difference and regression discontinuity research designs, I identify the effects of affirmative action, two top percent policies, and holistic review on the racial and socioeconomic composition of enrollment at each UC campus. I then investigate the relative degree to which changes in application behavior and admission decisions contribute to each policy's observed enrollment effects.

I find that each policy provides observable admission advantages to URM students, but that affirmative action has an order of magnitude greater effect on URM enrollment than UC's top percent policies, the current version of which has no measurable enrollment effect at all. Holistic review has about one-third the URM enrollment effect of affirmative action at each implementing campus. Top percent policies and holistic review have negligible effects on universities' net enrollment of below-median or very low-income students, defined respectively as students with parental incomes below 100% or 50% of the median California household, and race-based affirmative action's effect on universities' socioeconomic composition is relatively modest.

I begin by estimating the net admission and enrollment effects of affirmative action using a difference-in-difference design that compares academically-similar students before and after racial admission preferences were banned by California ballot proposition in 1998. Affirmative action substantially increased URM admission across all UC campuses, but its net URM enrollment effects were concentrated at the more-selective UC campuses because of an enrollment cascade by selectivity (Conrad and Sharpe, 1996; Bleemer, 2022): campuses gained URM students from less-selective campuses and lost others to more-selective campuses. Single-difference enrollment comparisons before and after 1998 show that affirmative action increased URM UC enrollment overall and at the more-selective campuses by about 20 and 60 percent, respectively, with about two-thirds of those gains accounted for by the policy's effects on admission and yield rates.[2] Affirmative action decreased lower-income students' average admission advantages at UC's more-selective campuses, but shifts in applicant behavior contributed to the policy's increasing enrollment among very low-income students by 7 percent (and among below-median students by 2 percent).

Three years after affirmative action's termination, the University of California implemented its first iteration of a top percent policy called Eligibility in the Local Context. The 2001–2011 ELC policy provided substantial admission advantages to the top 4 percent of graduates from each California high school. Students received letters informing them of their eligibility a few months prior to UC's application deadline, so the policy increased UC enrollment through both an application channel (by encouraging new UC applications among some high school students) and an admission channel. Using a regression discontinuity design and linear extrapolations across the sharp GPA eligibility discontinuity, I find that the 4% ELC policy increased gross URM and lower-income enrollment by about 4 and 3 percent, respectively, with the application and admission channels each contributing about half of the total effect. Those estimates are an upper bound on the policy's net effect, since some of those students likely crowded out other URM and lower-income students.[3] Those students largely attended UC's four middle-selective campuses, where they increased URM enrollment by up to 9 percent and both below-median and low-income enrollment by up to 6 percent.

The ELC policy was nominally expanded to the top 9% of California high school graduates in 2012. However, UC stopped directly informing high school students of their ELC eligibility, shutting down the application channel, and only the least-selective campus (Merced) continued to provide admission advantages to eligible applicants. Regression discontinuity estimates at the eligibility threshold (and at each other percentile threshold) show no evidence of substantive admission or enrollment effects at other campuses, and there is no measurable enrollment effect at Merced.

Six UC campuses implemented undergraduate holistic review between 2002 and 2012. Staggered difference-in-difference estimates around each implementation suggest that holistic review increased URM enrollment at the implementing campus by about 7 percent, though many of those students would have otherwise enrolled at other UC campuses; the policy's net effect on URM UC enrollment was no larger than half its campus-specific magnitude. Estimates for lower-income applicants are noisier, but if anything suggest that holistic review generated small *declines* in lower-income admission and enrollment.

Studies of access-oriented admission policies have recently been galvanized by evidence that they may promote socioeconomic mobility without net efficiency costs (Dale and Krueger, 2014; Black et al., 2023; Bleemer, 2021; Bleemer, 2022). I focus on the California setting, where these policies' effectiveness is likely magnified relative to states with weaker institutional interests in promoting student diversity (e.g. Atkinson and Pelfrey, 2004). Nevertheless, I still find both (1) a large gap between the net URM enrollment effects of affirmative action and its two most common race-neutral policy alternatives and (2) only modest effects on lower-income enrollment across all three policies.[4] The limited available evidence on "test-optional" or "test-blind" policies – another race-neutral access-oriented admission policy, implemented by UC in 2021 – also suggests relatively small treatment effects (Belasco et al., 2015; Saboe and Terrizzi, 2019), leaving few well-tested options for increasing URM enrollment absent affirmative action.[5] Several studies document that race-neutral alter-

[1] Long and Bateman (2020) show that states that implement affirmative action bans have lower URM college enrollment in the long run, net their other access-oriented admission policies.

[2] Several studies have uncovered evidence that affirmative action impacts URM students' application decisions (Antonovics and Backes, 2013; Chade et al., 2014), which the presented estimates suggest could explain as much as one-third of the observed enrollment effects. Antonovics and Sander (2013) and Mello (2022) study affirmative action's effect on yield rates: that is, matriculation rates conditional on admission. Bagde et al. (2016) show that a caste-based affirmative action policy in India increases low-caste enrollment.

[3] Using a limited sample of secondary school records, Long (2004) sharply underestimates the number of URM students admitted to UC by the 4% ELC policy. Several other studies similarly underestimate the impact of the 4% ELC policy by focusing on generally non-participating campuses (Berkeley and UCLA) or on early years prior to the policy's largest effects (Long, 2007; Kidder and Gandara, 2015; Zwick, 2017), while Carnevale et al. (2014) present a simulation exercise that substantially overestimates top percent policies' enrollment effects.

[4] Several studies have estimated the enrollment effects of affirmative action bans using cross-state variation (Cortes, 2010; Backes, 2012; Hinrichs, 2012; Blume and Long, 2014; Long and Bateman, 2020), which identifies the combined effect of ending affirmative action and subsequent admission policies (like top percent policies in TX and CA). Kapor (2020) uses a structural model to estimate a 1.7 percent net URM enrollment effect of Texas Top Ten at the UT system.

[5] Arcidiacono et al. (2019) use a simulation design to argue that eliminating legacy and athlete preferences at Harvard University would increase URM admission by 4 percent. Antonovics and Backes (2014) and Long and Tienda (2008) argue that California and Texas universities achieved small compositional changes by shifting the weights they employed across application criteria; holistic review eliminates such weights altogether. Bennett (2022) finds evidence of larger URM enrollment effects – perhaps 10 percent – from test-optional admission policies.

natives to affirmative action tend to admit relatively lower-testing students (Chan and Eyster, 2003; Fryer and Loury, 2008), but these 'efficiency' concerns may be second-order if feasible policies only minimally affect URM enrollment.[6] This is the first known study to use quasi-experimental research designs to estimate the effect of access-oriented admission policies on U.S. universities' economic composition, despite substantial policy interest in "class-based affirmative action" (e.g. Kahlenberg, 1996; Xiang and Rubin, 2015).[7]

This study also contributes to a broader literature on socioeconomic stratification and the relative effects of race-conscious and race-neutral interventions, in part by highlighting reduced-form policy effects by family income in addition to ethnicity. A closely-related strand of that literature investigates the enrollment effects of race-neutral high school admission policies, another setting with possible equity-efficiency trade-offs (Dobbie and Fryer, 2011; Barrow et al., 2020) and growing evidence on the compositional effects of feasible allocation policies (e.g. Cestau et al., 2017; Ellison and Pathak, 2021).[8]

Section 2 provides background information on the University of California system and its predominant admission policies over the past 25 years. Section 3 discusses the data used in this study. Sections 4 to 6 develop respective research designs to analyze the URM admission and enrollment effects of UC's three major access-oriented admission policies: affirmative action, top percent policies, and holistic review. Section 7 extends these research designs to estimate the lower-income enrollment effects of each policy. Section 8 concludes.

2. Background

The University of California system enrolls over 200,000 undergraduate students at nine campuses: the *more-selective* Berkeley and UCLA campuses; the *selective* San Diego, Davis, Irvine, and Santa Barbara campuses; and the *less-selective* Santa Cruz, Riverside, and Merced campuses. Mirroring other selective U.S. universities, underrepresented minority (URM: Black, Hispanic, and Native American) and lower-income students have been persistently underrepresented at most UC campuses. Admission to each UC campus was broadly available to qualified California high school graduates until growing demand and limited growth necessitated selective admissions in the 1960s. Since then, each campus has generally admitted students through independent admission procedures, but the central UC administrative office has also instituted a number of system-wide policies designed to promote URM and lower-income enrollment (Douglass, 2007).

Race-based affirmative action provided direct admission advantages to URM applicants at every UC campus until it was banned by Proposition 209, which has prohibited racial and ethnic admission preferences since the Fall 1998 cohort. In the years since Prop 209, UC has implemented two primary "race-blind" admission policies intended to increase disadvantaged students' UC enrollment.[9] First, the 2001 Eligibility in the Local Context program provided admission advantages to the top four percent of graduates from each California high school. UC determined ELC eligibility using a special ELC grade point average (GPA) calculated over specified sophomore- and junior-year courses and directly informed high school seniors of their ELC eligibility a few months before the University's application deadline.[10] Campuses were informed which of their applicants were ELC-eligible but generally maintained autonomy over whether to admit those students (which remained feasible because most campuses guaranteed admission to eligible students).

By 2002, all UC campuses were making their baseline admission decisions using "comprehensive review": campuses scored applicants on a fixed set of (objective and subjective) applicant criteria and "evaluat[ed] students' academic achievements in light of the opportunities available to them". But starting that year, UC Berkeley went a step further, implementing "holistic review," an access-oriented policy in which "a trained evaluator or set of evaluators craft a single score for the applicant based upon a combination of the criteria," without fixed weights between criteria, so that "no single factor plays a deciding role in how an applicant is evaluated" (BOARS, 2012; UCOP, 2013). While holistic review did not add any additional fields to the UC application, this practice brought Berkeley closer in line with the many selective private universities already implementing holistic review (Coleman and Keith, 2018). UCLA implemented holistic review in 2007.

The early 2010s brought a new wave of UC admission reforms. ELC eligibility was expanded to the top nine percent of graduates from each California high school in 2012, but students were no longer informed of their eligibility prior to applying to UC and campuses adjusted their ELC admission advantages.[11] Campuses were also provided each ELC-eligible applicant's percentile rank, from one to nine, and thus could theoretically provide admission advantages to any percentile of applicants. Four additional campuses implemented holistic review: San Diego (2011), Irvine (2011), Davis (2012), and Santa Cruz (2012). This flurry of policy changes was followed by a period of relative policy stasis that persisted until 2020, when admission was upended by the covid-19 pandemic and the cessation of standardized testing.

3. Data

This study primarily analyzes an administrative University of California application database collected by the UC Office of the President (Bleemer, 2023). It includes one record for each freshman California-resident applicant to any UC campus between 1994 and

[6] Given recent disagreement over whether returns to university selectivity are increasing or decreasing by SAT (Dillon and Smith, 2020; Bleemer, 2021; Bleemer, 2022), the 'efficiency' ramifications of admitting lower-SAT students are ambiguous.

[7] Bertrand et al. (2010) and Francis and Tannuri-Pianto (2012) show that affirmative action policies in India and Brazil also increased lower-income enrollment. Alon and Malamud (2014) show that an Israeli class-based affirmative action policy increased targeted students' likelihood of admission and enrollment.

[8] Other strands investigate the stratification ramifications of race-neutral labor (e.g. Derenoncourt and Montialoux, 2021), crime (e.g. Rose, 2021), and post-enrollment university (e.g. Bleemer and Mehta, 2021; Bleemer and Mehta, 2022) policies, among many recent examples.

[9] UC attempted school-specific outreach programs between 1998 and 2001 to increase enrollment from majority-URM high schools, but those programs wound down with little evidence of enrollment effects (University of California, 2003). Atkinson and Pelfrey (2004) discuss a third major access-oriented UC admission policy – the Dual Admissions Program, which would have strengthened UC's transfer pathway from community colleges – but it was never implemented, and its successor (the 2004 Guaranteed Transfer Option) was aborted in its first year (Kurlaender and Grodsky, 2013).

[10] The relevant courses were two years of English and Mathematics, one year of History, Lab Science, and Non-English Language, and four other UC-approved courses (Atkinson and Pelfrey, 2004). ELC GPAs were then weighted, with students receiving an additional GPA point for each honors-designated course in their junior year, and rounded to the nearest hundredth.

[11] In order to decrease administrative costs, UC also stopped calculating special ELC GPAs. Instead, UC determined top students' ELC eligibility using ELC GPAs provided by their high schools and re-estimating each school's (never-released) eligibility threshold every three years.

2021.[12] Each record contains self-reported demographic characteristics (gender and 15-category ethnicity); parental income, occupation, and education; and home Zip code and most-recently-attended high school. Applicant's SAT and ACT scores are converted to a single 2400-scale score using a standard concordance, which is included along with applicants' weighted high school GPA and SAT II subject test scores. Finally, each record indicates which campuses the applicant applied to, was admitted to, and enrolled at (if any).

The data also include applicants' ELC GPAs and ELC eligibility since 2003 and their within-school ELC percentile rank (from one to nine) since 2012. I do not directly observe the high-school-specific ELC thresholds used to determine ELC eligibility or ELC-eligible students' percentile rank, an important input into the regression discontinuities below. Instead, I approximate each threshold by the average threshold that minimizes within-school eligibility classification error, though choosing thresholds just below the lowest-GPA ELC-eligible applicant's GPA provides highly-similar results.[13]

I also collect two supplemental datasets to study the application effects of the 2001–2011 ELC policy. The first covers all 2001–2011 California high school graduates in the top 10 percent of their class, collected by the University of California to determine students' ELC eligibility. These data include students' relative ELC GPA *rank* within their high-school-year but not students' ELC GPA itself, along with their ELC eligibility and which UC campuses the students apply to (if they apply to any). The second covers all SAT-takers in the state of California, including students' SAT scores and responses to a mandatory pre-test survey that solicited students' race and family income. Appendix A details how these datasets are linked together.

I define two sets of lower-income UC students: 'below-median' students have reported parental incomes below the California household median in the year that they applied to UC, while 'very low-income' students with parental incomes below *half* the household median. About 14 percent of freshman California-resident UC applicants fail to report their parent's income on their UC application, so I approximate them using models that predict reported parental incomes by the other detailed characteristics on students' applications; see Appendix A for details.

3.1. Descriptive statistics

The University of California had a total of 2,232,223 freshman California-resident applicants in the sample period. Fig. 1(a) shows that the share of URM students at UC's more-selective campuses sharply declined after the end of their affirmative action policies in 1998.[14] URM enrollment shares trended upward across UC campuses over the subsequent years as a result of both policy changes and the increasing share of URM students among UC-eligible graduates of public California high schools, which nearly doubled between 1994 and 2021.[15]

In order to abstract from compositional changes in the UC applicant pool, I estimate URM applicants' average annual admission advantage at each UC campus by estimating the following OLS regression for each UC campus (c) over 1994–2020 applicants:

$$Admit_i^c = \alpha_y^c + \beta_y^c URM_i + \gamma^c X_{iy} + \epsilon_{iy}^c \quad (1)$$

where y indexes applicant i's application year and URM_i indicates whether i is URM.[16] Pre-college academic opportunity and preparation is absorbed by interactions between cohort and both SAT score and high school GPA (X_{iy}). I interpret β_y^c as the average increased likelihood with which URM applicants are admitted to c than academically-comparable non-URM applicants.

Fig. 1(b) reports time trends in $\beta_y^c / \overline{Admit_y^c}$ – that is, the *relative* (percent) URM admission advantage at c, normalized by c's baseline admission likelihood in y – for each group of UC campuses. URM applicants' relative admission advantage was over 100 percent at the more-selective universities in the 1990s – implying that URM students were more than twice as likely to be admitted as academically-comparable non-URM students on average – but admission advantages sharply declined after Prop 209 at the more-selective and selective campuses. Other than a short-lived decline at the selective campuses after the start of the 9% ELC policy, however, URM applicants' average advantage has been generally stable throughout the 2000s and 2010s.[17] Both panels (a) and (b) show some evidence of small URM increases after campuses adopt holistic review policies, indicated by short dotted lines.

Fig. 2 similarly summarizes trends in lower-income applicants' admission and enrollment at UC.[18] Below-median students made up about one-third of UC students in the mid-1990s but have grown to over half of enrollees at the less-selective UCs since 2010. Below-median applicants receive similar admission advantages to URM applicants across the UC system when compared to academically-comparable higher-income applicants, but these admission advantages did not meaningfully change in the years when UC implemented or ended major access-oriented admission policies. The one exception is a small decline in below-median students' admission advantage and enrollment at the selective UC campuses following the end of the 4% ELC policy. These trends look similar when comparing very low-income students (with parental incomes below half the California household median) to their higher-income peers (Appendix Fig. A-2).

4. Affirmative action

I estimate the effect of affirmative action on URM UC applicants' admission and enrollment using a difference-in-difference design around the 1998 termination of that policy:

$$Y_{iyc} = \alpha_{h_i} + \beta_{1c} NoAA_y + \beta_{2c} URM_i + \beta_{3c} NoAA_y * URM_i + \gamma_c X_{iy} + \epsilon_{iyc} \quad (2)$$

where Y_{iyc} indicates whether individual i applied to UC campus c in year y, was admitted to that campus, or ultimately enrolled at that campus. The sample is restricted to 1995–2000, three years before and after the implementation of Prop 209. The application model is estimated by OLS over the full population of UC freshman

[12] The University of California (and its most-selective Berkeley and UCLA campuses) only enrolled a small share of non-resident students in the sample period, rising from 5 (7) percent in 1994 to 16 (22) percent in 2021. These students were typically admitted under different admission practices and are omitted from the present analysis. About one-third of new UC students each year are transfers from California community colleges. Those students are more relatively more likely to be URM, but transfers' enrollment share is unchanged overall and at the most-selective UC campuses across the study period; those students are also omitted from the present analysis.

[13] The estimated thresholds yield Type 1 and 2 error rates of 1.3 and 2.8 percent. See Bleemer (2021) for details.

[14] Hispanic students comprised a large and growing share of URM UC applicants throughout the study period, rising from 73 percent in 1994 to 84 percent in 2021.

[15] UC eligibility requires completing 15 college-preparatory courses with a B average and no grade below a C. Data from the California Department of Education; see Appendix A.

[16] 2021 applicants are omitted because UC stopped collecting SAT scores on their application.

[17] The remaining URM admission advantage following Prop 209 visualizes policymakers' limitations in constraining race-based admission advantages (Yagan, 2016), with campuses providing advantages to students using observable characteristics correlated with race (Chan and Eyster, 2003). The 2020 rise in the more-selective campuses' URM admission advantage was driven by UC Berkeley.

[18] The correlation between URM and below-median (very low-income) indicators is 0.28 (0.20) among UC applicants and 0.27 (0.19) among UC students.

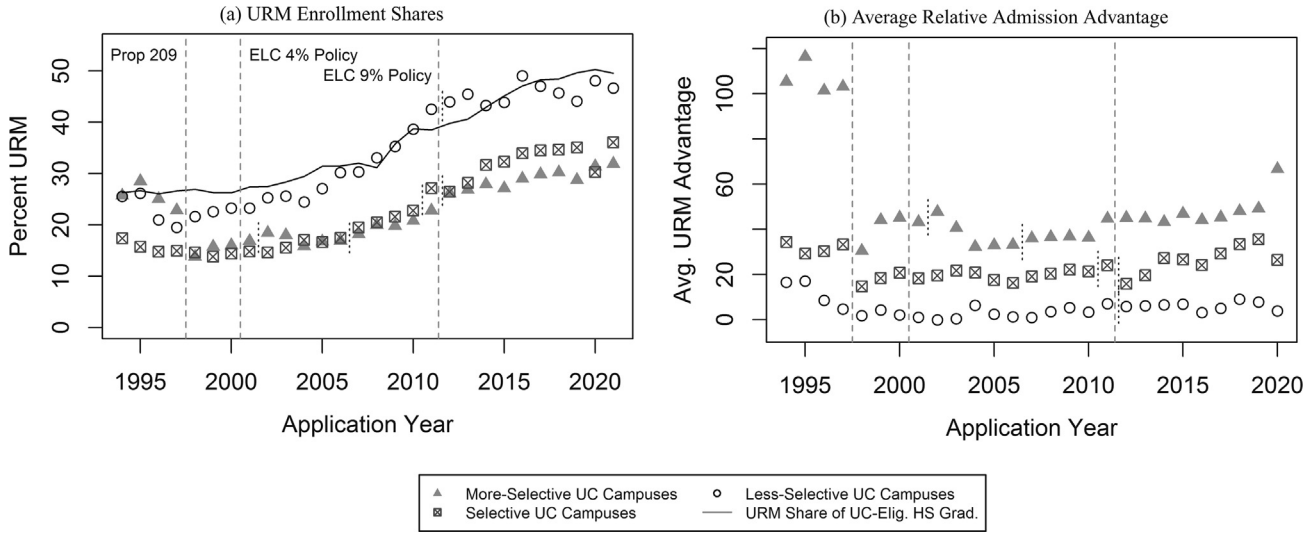

Fig. 1. URM admission and enrollment at the University of California. *Note:* Average URM enrollment share and average URM relative admission advantage at more-selective (Berkeley and UCLA), selective (San Diego, Irvine, Davis, and Santa Barbara), and less-selective (Santa Cruz, Riverside, and Merced after 2005) UC campuses among California-resident freshman applicants. Admission advantage reflects the increased percent likelihood with which each URM applicant is admitted to a UC campus (conditional on application) compared to an academically-similar non-URM applicant; it is estimated by campus conditional on SAT score and high school GPA with annually-varying coefficients (Eq. (1)), normalized to percent units by the overall campus admission rate that year, and then averaged across campuses within group. Short dotted lines indicate when campuses adopted holistic review: Berkeley (2002), UCLA (2007), San Diego (2011), Irvine (2011), Davis (2012), and Santa Cruz (2012). URM share of high school graduates restricted to public California high school students who satisfactorily completed an approved college-preparatory curriculum. Source: UC Corporate Student System and the California Department of Education.

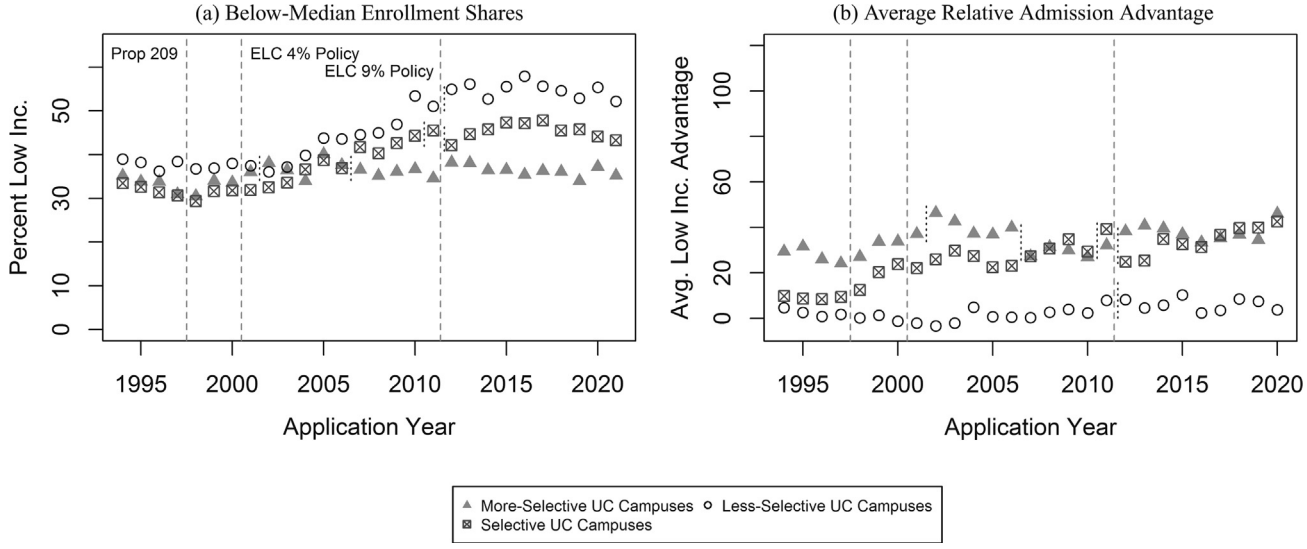

Fig. 2. Lower-income admission and enrollment at the University of California. *Note:* Average below-median enrollment share and average below-median relative admission advantage at more-selective (Berkeley and UCLA), selective (San Diego, Irvine, Davis, and Santa Barbara), and less-selective (Santa Cruz, Riverside, and Merced after 2005) UC campuses among California-resident freshman applicants. Admission advantage reflects the increased percent likelihood with which each URM applicant is admitted to a UC campus (conditional on application) compared to an academically-similar non-URM applicant; it is estimated by campus conditional on SAT score and high school GPA with annually-varying coefficients (Eq. (1)), normalized to percent units by the overall campus admission rate that year, and then averaged across campuses within group. Short dotted lines indicate when campuses adopted holistic review: Berkeley (2002), UCLA (2007), San Diego (2011), Irvine (2011), Davis (2012), and Santa Cruz (2012). 'Below-median' is defined as having family income below the California household median in the application year; see Appendix A for details. Source: UC Corporate Student System and the California Department of Education.

California-resident applicants, while estimation of the admission and enrollment models is restricted to applicants to each campus. Each campus and outcome is estimated independently. The coefficients of interest are β_2, the degree to which URM students were more likely to have Y_{iyc} under affirmative action, and β_3, the change in that likelihood after the policy's termination (indicated by $NoAA_y$). High school fixed effects α_{h_i} (for i's school h_i) and the detailed academic covariates in X_{iy}, including SAT scores and high school GPA, absorb spurious cross-school application variation and other bias arising from shifts in UC application behavior.[19] Standard errors are robust.

[19] Applicants' two SAT components and three available SAT II scores are included as separate covariates, along with an indicator for whether the student submitted a Math 1 or Math 2 SAT II score and indicators for which third SAT II score was submitted. Covariates are winsorized at the top and bottom 1%. These academic covariates are substantially finer-grained than those used by (e.g. Antonovics and Backes, 2014) in their related estimation.

Table 1
The impact of Proposition 209 on URM UC admission and enrollment.

Campus:	UCB	UCLA	UCSD	UCSB	UCI	UCD	UCSC	UCR	Total
Panel A: Application conditional on any UC application (%)									
URM	11.2	9.0	−3.5	−6.0	−9.4	−4.6	−2.8	−7.1	
	(0.3)	(0.3)	(0.3)	(0.3)	(0.3)	(0.3)	(0.3)	(0.3)	
URM × Prop. 209	−1.9	−3.8	1.1	0.7	0.0	1.2	0.2	4.7	
	(0.4)	(0.4)	(0.4)	(0.4)	(0.4)	(0.4)	(0.4)	(0.4)	
$\overline{Y}$	45.0	54.8	50.2	42.5	36.2	38.5	24.2	24.6	
Number of Obs.	299,295	299,295	299,295	299,295	299,295	299,295	299,295	299,295	
Panel B: Admission conditional on application (%)									
URM	39.1	30.4	21.6	14.2	13.3	29.0	9.9	7.2	10.3
	(0.5)	(0.4)	(0.4)	(0.4)	(0.5)	(0.4)	(0.5)	(0.5)	(0.2)
URM × Prop. 209	−24.5	−19.2	−15.8	−3.9	−7.6	−20.7	−9.0	−6.5	−9.0
	(0.6)	(0.5)	(0.5)	(0.5)	(0.6)	(0.6)	(0.6)	(0.6)	(0.3)
$\overline{Y}$	32.8	35.4	50.4	63.6	65.3	69.6	83.1	85.5	82.6
Number of Obs.	134,808	164,054	150,098	127,053	108,300	115,198	72,464	73,605	299,295
Panel C: Enrollment conditional on application (%)									
URM	14.1	9.8	0.8	−0.1	−4.1	1.4	−3.5	−2.3	4.8
	(0.4)	(0.4)	(0.4)	(0.5)	(0.5)	(0.5)	(0.6)	(0.6)	(0.3)
URM × Prop. 209	−9.7	−7.4	−1.8	1.7	1.1	−1.5	0.9	0.5	−7.0
	(0.5)	(0.4)	(0.4)	(0.5)	(0.6)	(0.6)	(0.7)	(0.7)	(0.4)
$\overline{Y}$	16.5	13.9	12.0	15.9	17.5	18.7	17.0	17.7	49.9
Number of Obs.	134,808	164,054	150,098	127,053	108,300	115,198	72,464	73,605	299,295
Panel D: Estimated annual effect of Prop 209 on URM UC enrollment									
Change in URM Enr.[a]	−398	−381	−58	3	20	−65	−36	51	−865
Implied URM Enr. Effect of Aff. Action	+ 75.2%	+ 59.0%	+ 17.2%	-0.5%	-4.2%	+ 12.6%	+ 9.2%	-7.1%	+ 20.3%
Panel E: Change in URM enrollment explained by Panel C estimates (conditional on applications)									
Estimated Change in URM Enrollment[b]	-297	-301	-59	54	28	-34	17	12	-581
Residual[b]	−101	−80	1	−51	−8	−31	−53	40	−284

Note: OLS coefficient estimates from independent campus-specific difference-in-difference regressions of likelihood of application, admission, or enrollment on URM status interacted with a post-1998 indicator (after Prop 209 was implemented), across 1995–2000 California-resident freshman UC applicants and including high school fixed effects and academic covariates (SAT I and II scores and high school GPA). Robust standard errors in parentheses. The 'Total' column indicates admission or enrollment to at least one UC campus (A–C) or sums across campuses (D–E). [a]The difference between the average proportion of URM students at each campus in 1998–2000 and in 1995–1997, multiplied by the school's average incoming class size in 1998–2000 (Eq. (3)). [b]The predicted change in URM enrollment among applicants to that campus from β_{3c} in Panel C, and the residual enrollment change unexplained by the change in URM enrollment likelihood conditional on application.
Source: UC Corporate Student System.

Table 1 presents estimates of β_2 and β_3 for each model. UC's affirmative action policy slightly shifted URM applicants toward sending applications to the more-selective Berkeley and UCLA campuses, where they enjoyed 30–40 percentage point admission advantages relative to academically-comparable non-URM applicants. Those admission advantages fell by two-thirds when affirmative action ended, with proportional declines at UC's other campuses.[20] Overall, affirmative action increased URM applicants' likelihood of admission to at least one UC campus by 9 percentage points.

Panel C of Table 1 shows that URM applicants' greater relative enrollment likelihood at UC's more-selective campuses also fell by about two-thirds after affirmative action was terminated. However, net URM enrollment was much less affected at the other UC campuses as a result of a cascade effect, with URM applicants who would previously have attended the more-selective campuses now more likely to attend other campuses because of their changed likelihood of admission (Conrad and Sharpe, 1996). Nevertheless, affirmative action increased URM UC applicants' overall likelihood of UC enrollment by 7 percentage points relative to UC's post-1998 race-neutral admission regime.

Affirmative action thus may have increased aggregate URM UC enrollment in two ways: by shifting URM students' UC application decisions – potentially at the extensive margin (Antonovics and Backes, 2013) – and by shifting URM UC applicants' conditional admission outcomes. I estimate the net effect of affirmative action on URM UC enrollment using a scaled single-difference estimator:

$$(\%URM_{c,95-97} - \%URM_{c,98-00}) * \frac{ENR_{c,98-00}}{3} \quad (3)$$

the difference in the URM share of 1995–1997 students and 1998–2000 students at c, scaled by the average number of students at c in 1998–2000. Notice that these statistics capture *net* changes in URM enrollment caused by Prop 209, allowing for 'crowding-in' students to replace those who lose access because of the policy change.

The first row of Panel D in Table 1 shows that Berkeley and UCLA's annual URM enrollments fell by 398 and 381 students – suggesting that affirmative action had increased URM enrollment at those campuses by over 60 percent – while the other campuses experienced smaller enrollment changes. Affirmative action increased overall URM enrollment by about 850 freshmen students per year, or 20 percent.

Fig. A-3 shows that some UC campuses may have begun phasing out their affirmative action policies in 1996, two years prior to Prop 209's implementation. Table A-1 shows that attributing the decline in URM enrollment between 94–95 and 98–00 to Prop 209 implies that affirmative action had been increasing URM enrollment by as much as 34 percent, and over 80 percent at Berkeley and UCLA. However, this long difference confounds UC's upward trend in

[20] Fig. A-3 interacts the β coefficients in Eq. (2) with year fixed effects to visualize the year-over-year patterns in admission and enrollment likelihoods following Prop 209, showing that URM admission likelihoods sharply declined at most UC campuses in 1998. The observed URM enrollment declines at Berkeley and UCLA are also sharply concentrated in 1998, though UCLA had exhibited a downward trend in relative URM enrollment likelihoods.

selectivity – which disadvantaged URM applicants due to their poorer average academic preparation – with the effects of ending affirmative action. Nevertheless, these evidence highlight that 20 percent (from Table 1) is a lower bound on the URM enrollment effects of affirmative action.

Affirmative action may have increased URM UC enrollment both by changing URM students' admission outcomes and as a result of behavioral application responses to the policy. I decompose the aggregate URM enrollment effect into application and admission channels by using the coefficients in Panel C of Table 1 to estimate the enrollment change that can be explained by admission policies and yield rates as opposed to changes in application behavior. Using these difference-in-difference estimates to measure aggregate net effects of affirmative action requires adjusting the coefficients for the policy's direct crowd-out effect on non-URM enrollment, since Prop 209 did not alter universities' capacity constraints: an x percentage point *relative* increase in URM applicants' enrollment likelihood corresponds mechanically to a $(x \times NU_{cy})$ percent absolute increase in URM applicants' enrollment likelihood, where NU_{cy} is the non-URM applicant share.[21]

As a result, Panel E of Table 1 presents the product between the estimated change in URM applicants' enrollment likelihood at each campus (β_{3c} from Panel C), NU_{c98-00} (which averaged 0.84 across the UC system), and that campus's average number of 1998–2000 URM applicants. The conditional expected enrollment declines suggest that admission and yield rates explain two-thirds of affirmative action's aggregate effect on URM UC enrollment, while students' application responses to affirmative action explain almost one-third of the URM enrollment effect.[22]

5. Top percent policies

The University of California has implemented two top percent policies, both called Eligibility in the Local Context (ELC): the 2001–2011 4% policy and the 2012-present 9% policy. Both policies guaranteed that the top x% of students from each California high school – ranked by a specially-calculated ELC GPA – would be admitted to at least one UC campus. As a result, both policies affected UC's enrollment composition by shifting applicants' admission likelihood at certain campuses. Under the 4% ELC policy, students were informed of their ELC eligibility prior to the fall application deadline, potentially also affecting the composition of UC enrollment by encouraging some high school students to send an application to the university system.

Under both ELC policies, each UC campus generally maintained independence in choosing whether to provide an admission advantage or guarantee to eligible students. Because campuses changed the admission advantage provided to targeted applicants following the 2012 reform, the two ELC policies had very different effects on UC admission and enrollment. I discuss the two policies in turn.

5.1. 2001–2011: The 4% ELC policy

5.1.1. Admission channel

Between 2001 and 2011, the top four percent of applicants from each California high school were deemed 'ELC-eligible'. I measure the admission advantage provided by each campus to ELC-eligible applicants by plotting binned scatterplots of admission likelihood at each campus by students' GPA distance from their high schools' estimated ELC GPA eligibility threshold, among all applicants and among URM applicants. Fig. 3 shows that each of the four selective UC campuses provided large admission advantages to ELC-eligible students, with near-threshold URM applicants becoming 20–50 percentage points more likely to be admitted to each campus because of their ELC eligibility. Appendix Figs. A-4 and A-5 show very different patterns at the more- and less-selective UC campuses: Berkeley and UCLA provided very small (if any) admission advantage to ELC-eligible students, while the less-selective campuses had such high admission rates for high-GPA students that they had no scope to provide further advantages to ELC-eligible students.[23]

Fig. 3 also visualizes extrapolations from quadratic fit lines on either side of the eligibility threshold – which appear to closely fit the observed admission rates – suggesting that ELC's admission advantages fade out at each selective UC campus around 0.3 GPA points above the eligibility threshold. Applicants with even higher GPAs are unlikely to receive meaningful admission advantages as a result of their ELC eligibility, in part because nearly all such students would be admitted regardless of the ELC policy. As a result, I focus on UC applicants between 0 and 0.3 GPA points above their high schools' ELC eligibility thresholds in order to measure the gross enrollment effects of the 4% ELC policy.

The ELC policy's admission effects grew between 2001 and 2011 as the selective UC campuses' admission rate declined, pushing ELC-ineligible students' counterfactual admission likelihood downward.[24] As a result, difference-in-difference estimates at the policy's 2001 implementation would underestimate the policy's enrollment effects.

Instead, I estimate the annual number of URM students who enroll at UC in 2010–2011 because of the 4% ELC policy – an upper bound on ELC's net enrollment effects, both because these new enrollees likely crowded out some other URM students and because the ELC policy is at its most impactful in those later years – by estimating an empirical integral (over the distribution of ELC-eligible UC applicants) between two curves: the proportion of ELC-eligible URM students who enroll at UC and the estimated proportion of those students who would have enrolled absent the ELC policy. I estimate the latter curve in two ways. First, I estimate local linear best-fit lines for URM UC enrollment above and below the ELC GPA threshold (following Calonico et al., 2014) and extrapolate the below-threshold curve as an estimate of URM UC enrollment absent the ELC policy. Second, I estimate counterfactual URM enrollment by a line segment that connects the below-threshold curve's intersection with the ELC threshold to the above-threshold curve 0.3 GPA points above the threshold.

Both curves are shown in Panel (a) of Fig. 4, and they closely mirror each other. The empirical integral between actual and counterfactual UC enrollment suggests that about 150 additional URM students enrolled at UC campuses as a result of the 4% ELC policy, with block-bootstrapped 95 percent confidence intervals rejecting URM enrollment increases above 225 students.[25] Implementing the

[21] Consider two corner cases. When there are the same number of URM and non-URM applicants, a 1% relative increase in URM likelihood of enrollment (relative to non-URM applicants) corresponds to a $1 \times 0.5 = 0.5\%$ absolute increase in URM likelihood of enrollment, which would in turn lead to a one-for-one 0.5% decrease in non-URM likelihood of enrollment (generating an overall gap of 1%). When the number of URM applicants is marginal (and nearly 100 percent of applicants are non-URM), on the other hand, the 1% increase in each applicant's relative enrollment likelihood would correspond to a $1 \times (1 - \epsilon) \approx 1\%$ overall increase for URM applicants, since each non-URM applicant would only need to become ϵ less likely to be admitted to equalize aggregate enrollment.

[22] This residual may also capture the effects of UC's increasing selectivity in the mid-1990s.

[23] Niu and Tienda (2010) use a similar strategy to measure the admission advantage provided by a Texas top percent policy.

[24] The near-threshold admission advantage at UC Davis (Santa Barbara), for example, grew from 12 (0) to 31 (12) percentage points between 2003 and 2011.

[25] Confidence intervals were derived from standard errors estimated by 500 block-bootstraps over the estimation sample, defining blocks by school-year.

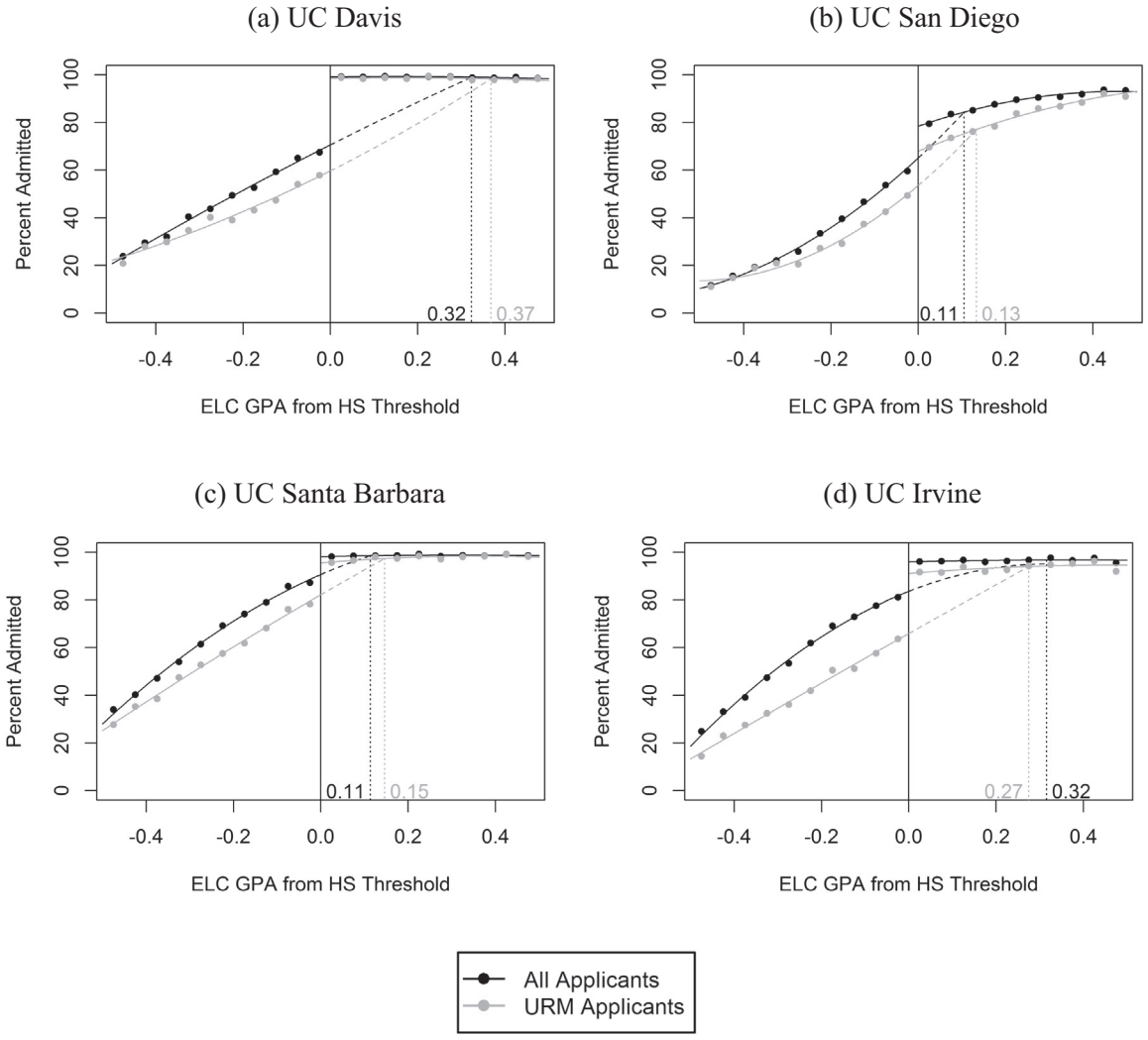

Fig. 3. Extent of 4% ELC admission advantages at the selective UC campuses. *Note:* Extrapolated quadratic best fit lines for the proportion of 2010–2011 UC applicants who are admitted the each selective UC campus by the distance between students' ELC GPA and their high school's ELC threshold, with best fit lines estimated separately on each side of the threshold. The below-threshold fit line is extrapolated to meet the above-threshold fit line (or, at UC Irvine, to its vertex); the location of that intercept is indicated on the x-axis. Data and best fit lines are presented overall (black) and among URM applicants (gray), which includes Black, Hispanic, and Native American applicants. Source: UC Corporate Student System.

same estimation strategy for enrollment at the six more-selective and selective UC campuses (where ELC may have increased enrollment) and for UC's three less-selective campuses (where ELC could have no impact on admission), I find that the selective campuses likely gained closer to 200 additional URM students through the ELC policy (largely driven by the four selective campuses), with as many as 60 of them pulled from the less-selective campuses. Fig. A-6 shows that URM students make up about half of the total UC enrollment effect of the 4% ELC policy through the admission channel.

5.1.2. Application channel

The 4% ELC policy could have also increased URM enrollment at UC by encouraging enrollment among URM high school graduates who would not have applied to UC if they had not been informed of their guaranteed UC admission prior to UC's application deadline. Fig. 5 visualizes the effect of informing students of their ELC eligibility by plotting the share of high school graduates who applied to UC by their GPA-rank distance to their high school's ELC eligibility threshold. Using a regression discontinuity design (Hahn et al., 2001), it shows that higher-GPA students are more likely to send an application to at least one UC campus, but that students became 6 percentage points more likely to apply if they were ELC-eligible.[26] URM students were even more affected by ELC eligibility, becoming 9 percentage points more likely to apply to UC.

Estimating the effect of this increased likelihood of UC application on gross UC enrollment requires assumptions over the increased application likelihood across the GPA distribution of ELC-eligible applicants (not just at the eligibility threshold) and over the new URM applicants' likelihood of UC enrollment. I make liberal assumptions in order to place an upper bound on the effect of the ELC application channel. While the below-threshold slope is somewhat steeper than the above-threshold slope in Fig. 5, I assume that 10.2 percent of above-threshold applicants at every ELC GPA only applied because of their knowledge of their ELC eligibility.[27] I also assume that new UC applicants are similarly likely to

[26] Estimates are from local linear regression (Calonico et al., 2015) with conventional standard errors. The relationship between ELC GPA rank and UC application had no trend between 2002 and 2011.

[27] This reflects the quotient between 9.0 and the 87.8 percent of ELC-eligible URM students who applied to UC in those years.

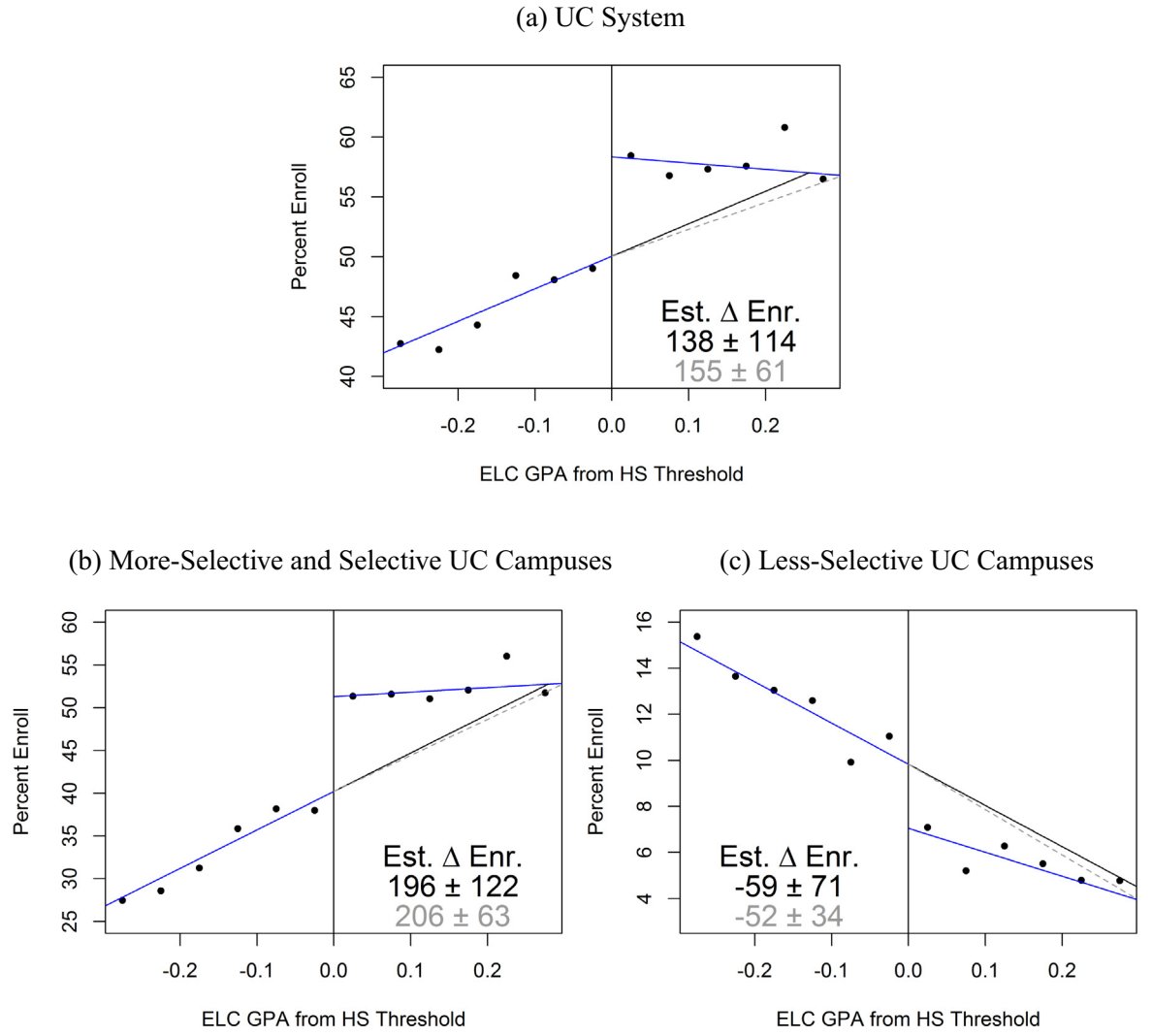

Fig. 4. Estimated effect of the 4% ELC policy on URM enrollment via admission channel. *Note:* Extrapolated triangular-kernel local linear best fit lines (black) and end-to-end linear splines (gray) for the proportion of 2010–2011 URM UC applicants who enroll at any UC campus, a more-selective (Berkeley or UCLA) or selective (Davis, Irvine, Santa Barbara, or San Diego) UC campus, or a less-selective UC campus (Merced, Riverside, or Santa Cruz) by the distance between students' ELC GPA and their high school's ELC threshold, with best fit lines estimated separately on each side of the threshold. The linear extrapolations extend to 0.3 GPA points above the threshold, and the positive gaps between the lines are integrated across the true distribution of applicants to estimate the change in the number of enrolled UC students as a result of the ELC program, conditional on application. Ninety-five percent confidence intervals for each procedure estimated from block-bootstraps by high-school-year and color-coded by estimation strategy: black for local linear, gray for end-to-end linear spline. URM is defined to include Black, Hispanic, and Native American applicants. Source: UC Corporate Student System.

enroll at UC as other UC applicants with the same relative ELC GPA (visualized in Fig. 4(a)).

Under these assumptions, in 2010–2011 the ELC application channel may have increased gross URM UC enrollment by as much as 171 students per year, suggesting that ELC's application channel may have been about as large as the admission channel in increasing URM UC enrollment.[28] Overall gross UC enrollment from the ELC application channel is similarly estimated to increase by 468 ± 23 students (where $\pm$ indicates a 95 percent confidence interval), suggesting that URM students make up about a third of the application-channel enrollment effect of the 4% ELC policy.[29]

5.1.3. Net effect of the 4% ELC policy

The University of California annually enrolled about 9,100 new URM freshman students in 2010 and 2011, with 4,000 of those students at the selective UC campuses. Assuming that the new UC applicants primarily enrolled at the UC campuses – where their admission was guaranteed – this implies that the URM students who enrolled at UC (at the selective UC campuses) because of the 4% ELC policy increased total URM enrollment by as much as 4 (9) percent. However, ELC did not expand total enrollment at the selective UC campuses, so other ELC-ineligible applicants were

[28] This estimates results from taking 10.2 percent of the empirical integral under the local linear best-fit line between ELC GPAs 0 and 0.3 in Fig. 4(a), using the best-fit line to avoid double-counting new URM enrollees through the application and admission channels. The block-bootstrapped 95-percent confidence interval is 171 ± 16. Assuming that the 10.2 percent of applicants who only applied because of their ELC eligibility linearly declines to 0 at 0.3 GPA points above the eligibility threshold results in a conservative estimate of 100 ± 8 students who enroll through the application channel.

[29] These estimates result from the assumption that 7.7 percent of ELC-eligible UC applicants applied because of their eligibility. The more conservative estimation strategy from the previous footnote implies 276 ± 13 additional UC enrollees resulting from the application channel.

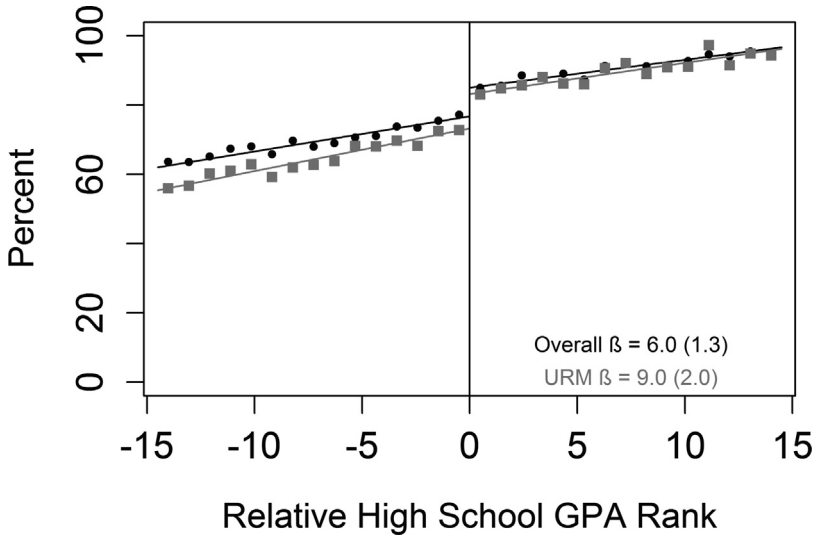

Fig. 5. Estimated effect of the 4% ELC policy on URM UC application. *Note:* Local linear regression discontinuity estimates of the share of all and URM 2010–2011 California high school seniors who applied to at least one UC campus by their ELC GPA rank above or below their school's ELC eligibility threshold in that year, and estimates of the change in application likelihood at the threshold with conventional standard errors. Data are restricted to the 77 percent of students matched to College Board SAT records; see Appendix A. School-years with fewer than ten GPA ranks are omitted. URM is defined to include Black, Hispanic, and Native American applicants. Source: UC Office of the President and College Board.

crowded out by the policy. As a result, the *net* effect of the 4% ELC policy on URM UC enrollment was likely positive but smaller than 4 percent. Appendix B presents suggestive difference-in-difference evidence from the end of the 4% ELC policy indicating that the net effect of the 4% ELC policy on URM enrollment was about one-third less than its gross effect.[30]

5.2. Since 2012: The 9% ELC policy

In 2012, the University of California extended ELC eligibility to the top nine percent of students from each California high school but stopped informing ELC-eligible students of their ELC eligibility prior to UC application. The university system also began informing each campus of their applicants' ELC percentile rank, between one and nine, in addition to their eligibility status, permitting campuses (e.g.) to maintain their 4% admission guarantee instead of extending that guarantee to nine percent of high school graduates. As under the 4% policy, no campus was coerced into admitting ELC-eligible applicants unless she was rejected from every campus to which she applied, though the results below show that this became much more common under the 9% policy.

I estimate the admission and enrollment effect of ELC eligibility (or achieving a given ELC percentile) using a regression discontinuity design. Let $Y_i(1)$ and $Y_i(0)$ denote applicant i's potential outcomes if they are ELC-eligible or ineligible, respectively. The effect of ELC eligibility on near-threshold applicants is:

$$LATE_{RD}(Y) = \lim_{GPA \downarrow 0} E[Y_i(1)|GPA] - \lim_{GPA \uparrow 0} E[Y_i(0)|GPA] \quad (4)$$

where GPA is the difference between an applicant's ELC GPA and their school's ELC eligibility threshold. This particular LATE is likely the maximum local effect of ELC eligibility (across the distribution of GPA), since higher-GPA students would have higher counterfactual admission likelihoods. I estimate $LATE_{RD}(Y)$ by $\hat{\beta}$ from a linear regression model over 2012–2017 UC applicants:

$$Y_{it} = \beta ELC_i + f(GPA_i) + \delta X_i + \alpha_{h_i} + \gamma_t + \epsilon_{it} \quad (5)$$

where ELC_i indicates being above the eligibility or percentile threshold, X_i includes gender-race indicators and a quadratic in SAT scores to absorb spurious variation in Y_{it}, and α_{h_i} and γ_t are high school (for i's school h_i) and application year (t) fixed effects. I estimate Eq. (5) stacked across all participating high schools with the error terms ϵ_{it} clustered by $h_i \times t$, the level of treatment assignment.[31]

I restrict the sample to freshman fall California-resident UC applicants within 0.3 GPA points of each respective threshold and estimate Eq. (5) by local linear regression with bias-corrected clustered standard errors following Calonico et al. (2014).[32]

While the four selective UC campuses had provided large admission advantages to marginally ELC-eligible URM applicants under the 4% ELC policy, those admission advantages disappeared with the 9% policy. Fig. 6 shows that only UC Merced provided a substantial admission advantage to on-the-margin ELC-eligible students after 2012. Table 2 summarizes the estimated effect of ELC eligibility on marginally-eligible applicants' likelihood of admission and enrollment to each UC campus between 2012 and 2017, overall ($N = 250,770$) and among URM applicants ($N = 73,959$). The evidence reject any admission advantage above 5 percentage points at all four selective UC campuses. Only UC Merced maintained a measurable admission advantage for ELC-eligible students with a continuing near-guarantee; eligible students' admission likelihood increased from 80 to 96 percent at the threshold, though there was no measurable shift in Merced enrollment. Plugging overall UC enrollment into the regression discontinuity model shows that ELC-eligible URM students' overall UC

[30] Bleemer (2021) estimates a similar gross enrollment effect of the 4% ELC policy in this period using a structural model of UC admission, though the model only accounts for changed application behavior between UC campuses, not overall UC application growth.

[31] Because the eligibility and percentile thresholds are slightly fuzzy, the baseline estimates treat an indicator for having an above-threshold ELC GPA ($\mathbb{1}_{GPA_i \geq 0}$) as an instrumental variable for ELC_i, though this has no substantive impact on the presented results. I cluster by treatment level instead of running variable bin because the number of running variable values on each side of the threshold is relatively large (Kolesar and Rothe, 2018).

[32] Estimates are similar if the model is estimated by OLS parameterizing f by third-order polynomials on either side of each threshold; see Tables A-3 and A-4. Local linear regressions were estimated using the *rdrobust* package in R (Calonico et al., 2015). The package does not permit fixed effects; instead, I include indicator variables for all high schools with more than 50 applicants in the sample as controls.

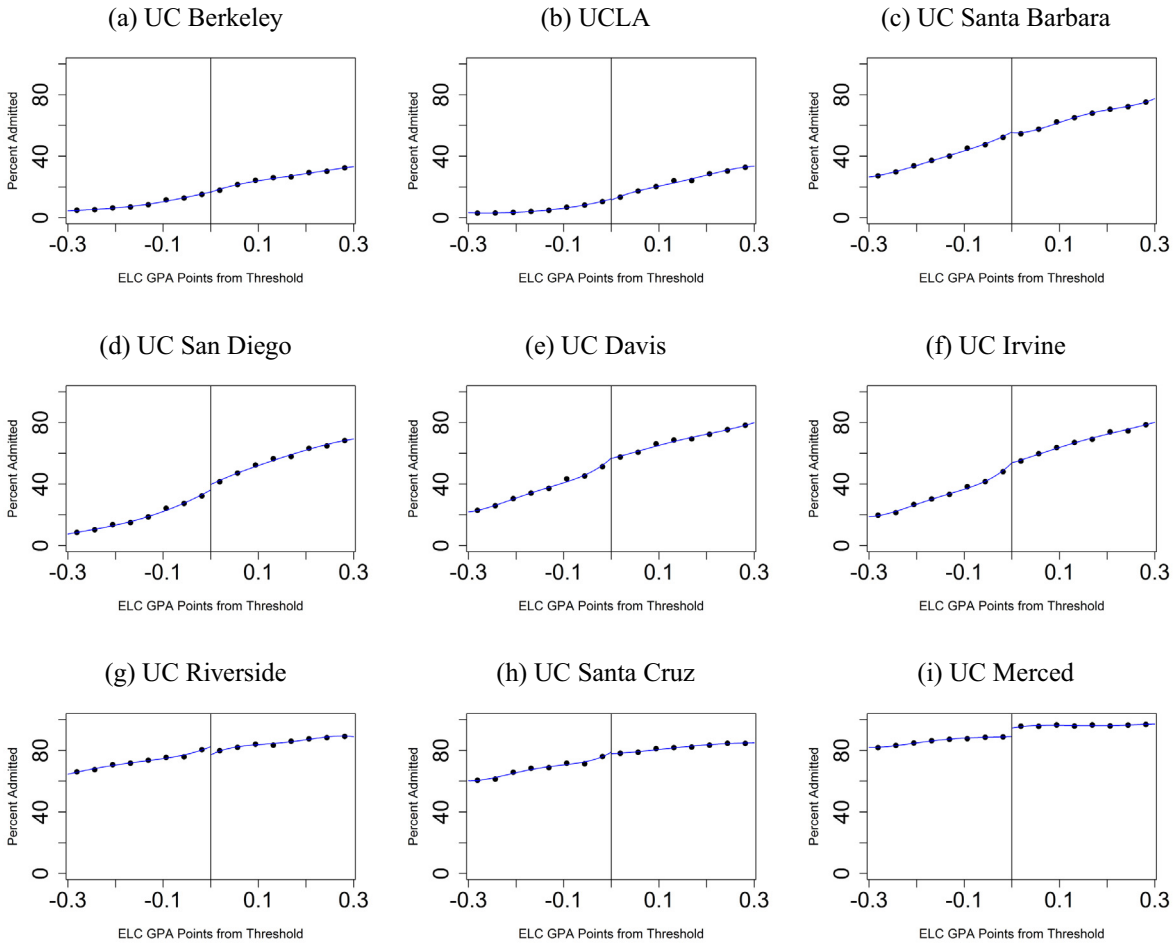

Fig. 6. Likelihood of UC admission near the 9% ELC threshold by campus. *Note:* Binned averages of 2012–2017 applicants' likelihood of admission to each undergraduate UC campus by ELC GPA distance to their high school's ELC eligibility threshold. Thresholds are at the ninth percentile of ELC GPAs by high school and are approximated by a support vector machine algorithm described in the text. Each chart includes 20 evenly-spaced bins on either side of the ELC threshold; the fit lines are fifth-order polynomials. Source: UC Corporate Student System.

enrollment likelihood increased by 1.4 ± 4.8 percentage points at the ELC eligibility threshold, far smaller than the 9.1 ± 4.0 increase similarly estimated from the 4% ELC policy.

Recalling that the 9% ELC policy *at minimum* guarantees admission to at least one UC campus, these results imply that since 2012, UC Merced has been required to admit every ELC-eligible student who is not admitted to any other UC campus, but that eligibility has no further effects on admission or enrollment across the UC system. However, campuses may have instead leveraged the 9% ELC policy by providing admission advantages to applicants at other percentiles: for example, campuses could have continued guaranteeing admission to the top 4% of applicants. Table 3 shows that only UC Davis provided a notable admission advantage to URM applicants at any percentile other than Merced's 9% admission guarantee, and the admission advantage is both relatively small – bounded above at 15 percentage points – and did not generate a measurable increase in enrollment (Table A-2).[33] Overall URM UC enrollment increased by 2.7 ± 4.3 percentage points at the 4% threshold, again providing minimal evidence of any enrollment effect of the 9% ELC policy.

The 4% ELC policy increased on-the-margin URM UC applicants' likelihood of UC enrollment by 9 percentage points among URM applicants and annually generated about 150 new URM UC gross enrollments. The 9% ELC policy, on the other hand, increased on-the-margin URM UC applicants' likelihood of UC enrollment by perhaps 1 percentage point, with no magnified increase among URM applicants and presumably no effect on applying to UC (since students were not informed of their ELC eligibility prior to applying). These estimates justify a back-of-the-envelope estimate that the 9% ELC policy increased UC's URM enrollment by (far) fewer than 30 URM students per year, a precise null result relative to UC's 11,300 URM freshman enrollment in 2015.

6. Holistic review

Six UC campuses have implemented holistic review: Berkeley in 2002, UCLA in 2007, San Diego and Irvine in 2011, and Davis and Santa Cruz in 2012. Because those policy changes were not widely publicized, there is little reason to expect application responses to these policy changes. I focus on the admissions margin, estimating the effect of holistic review on URM applicants' admission and enrollment using a stacked triple-difference design that compares outcomes for URM applicants relative to non-URM applicants before and after each policy's implementation:

$$Y_{ic} = \alpha_{hc} + \sum_{k\in[-5,4]} \beta_k \mathbb{1}_{u,\mathbb{HR}_c=y+k} + \gamma_c \mathbb{X}_i + \delta_{ycge} + \zeta_{cuge} + \eta_{yuge} + \theta_{\mathbb{Sel}_c \mathbb{E}_y uge} + \epsilon_{ic} \quad (6)$$

[33] Estimates across all UC applicants yield similar results; see Tables A-5 and A-6.

Table 2
Impact of 9% ELC policy on admission and enrollment for 9th percentile students by UC campus.

	Admission (%)				Enrollment (%)			
	Overall		URM		Overall		URM	
	Baseline	β	Baseline	β	Baseline	β	Baseline	β
More-Selective Campuses								
Berkeley	16.3	0.4	10.2	−1.2	6.0	−0.1	2.2	0.0
		(1.2)		(1.9)		(0.6)		(0.7)
UCLA	13.2	0.1	8.8	0.7	3.7	0.4	2.8	0.6
		(1.2)		(1.4)		(0.6)		(0.8)
Selective Campuses								
Davis	60.0	−0.8	39.4	−5.6	7.6	0.3	4.4	0.5
		(1.8)		(2.6)		(0.8)		(1.2)
San Diego	36.4	3.8	17.8	1.0	5.4	0.8	2.6	−0.2
		(1.4)		(1.9)		(0.6)		(0.7)
Santa Barbara	59.1	−0.7	40.2	−2.9	6.8	−0.5	6.4	−0.7
		(1.4)		(2.2)		(0.5)		(1.1)
Irvine	55.8	1.4	38.2	−2.1	7.0	0.4	6.0	−0.3
		(1.6)		(2.7)		(0.6)		(1.1)
Less-Selective Campuses								
Riverside	83.0	−3.0	71.1	−2.7	3.6	−0.2	6.1	0.4
		(1.8)		(2.4)		(0.7)		(1.2)
Santa Cruz	82.1	1.4	61.2	4.0	3.4	0.2	3.6	0.7
		(1.7)		(3.9)		(0.5)		(1.0)
Merced	85.9	10.8	80.2	15.7	1.2	0.3	2.4	0.6
		(1.7)		(3.4)		(0.4)		(0.9)

Note: The estimated baseline (ELC-ineligible) proportion of marginal students at their high school's ninth percentile ELC threshold admitted or enrolled at each UC campus 2003–2011 ($\hat{\alpha}$), and the estimated change in admission or enrollment for marginally ELC-eligible applicants (β), overall and for students from the bottom SAT quartile of high schools. Values in percentages. Enrollment is not conditional on admission to that campus. Estimates from local linear regression discontinuity models controlling for year, gender-race, and high school fixed effects (for high schools with more than 50 students in the sample) and a quadratic in SAT score; bias-corrected cluster-robust (by school-year) standard errors in parentheses (Calonico et al., 2014).
Source: UC Corporate Student System and National Student Clearinghouse.

Table 3
Estimated impact of ELC percentile on URM admission by UC campus.

	UCB	UCLA	UCSB	UCD	UCSD	UCI	UCR	UCSC	UCM
First Centile	−2.78	2.75	−2.98	−2.34	4.08	1.00	−3.87	4.72	−1.79
	(3.07)	(3.35)	(2.49)	(2.13)	(2.59)	(1.63)	(2.16)	(3.01)	(4.69)
Second Centile	−5.13	−2.04	−4.19	−2.67	1.59	0.73	−3.22	3.63	−1.38
	(3.95)	(4.11)	(3.44)	(3.10)	(3.47)	(2.05)	(2.51)	(2.53)	(3.07)
Third Centile	4.85	3.27	1.72	**− 5.26**	2.05	−2.22	−1.14	4.62	1.35
	(4.09)	(3.15)	(3.30)	(2.52)	(2.55)	(2.00)	(2.98)	(2.66)	(2.59)
Fourth Centile	−2.78	−2.05	−3.87	**7.56**	−5.34	0.23	−0.51	3.06	−1.27
	(3.08)	(2.48)	(3.24)	(3.51)	(3.62)	(2.51)	(2.09)	(2.98)	(3.55)
Fifth Centile	−1.77	0.08	−0.35	−4.74	−1.11	−1.09	−1.21	−0.83	1.99
	(2.78)	(1.73)	(2.64)	(3.17)	(3.51)	(2.75)	(2.31)	(2.73)	(1.87)
Sixth Centile	−1.34	−2.78	−4.13	−1.74	4.51	−3.61	0.07	−0.03	−2.00
	(2.69)	(2.35)	(2.98)	(3.58)	(2.99)	(2.17)	(2.72)	(3.80)	(2.65)
Seventh Centile	1.56	0.61	−2.55	−0.86	0.90	0.30	0.60	−0.55	4.03
	(1.98)	(1.51)	(2.18)	(2.52)	(2.53)	(2.32)	(2.83)	(2.44)	(2.41)
Eighth Centile	0.47	0.10	0.39	1.91	0.82	−0.78	−3.81	1.96	1.06
	(1.64)	(1.51)	(2.79)	(2.64)	(2.40)	(2.71)	(2.88)	(2.90)	(1.97)
Ninth Centile	−1.18	0.68	−2.95	**− 5.64**	0.96	−2.14	−2.72	3.96	**15.65**
	(1.91)	(1.37)	(2.18)	(2.60)	(1.86)	(2.74)	(2.41)	(3.85)	(3.43)

Note: Beta (treatment) coefficients on URM applicants' likelihood of admission to each UC campus and at each 2012–2017 ELC GPA centile threshold from local linear regression discontinuity estimation, with bias-corrected cluster-robust (by school-year) standard errors in parentheses (Calonico et al., 2014). Estimates control for year, gender-race, and high school fixed effects (for high schools with more than 50 students in the sample) and a quadratic in SAT score. Estimates with $\hat{\beta}/\hat{\sigma} > 2$ **in bold**.
Source: UC Corporate Student System.

with coefficient of interest β_k measuring URM applicants' differential outcome k years after c implemented holistic review in HR_c.[34] I suppress the i subscripts on i's cohort year y, gender g, race u, high school h, and 4% ELC eligibility e, and include each of the two-way fixed effects δ, ζ, and η by gender and 4% ELC eligibility. I also absorb race-related effects of the 4% ELC policy with fixed effects ($\theta_{Sel_c E_y uge}$) for the selective UC campuses (indicated by Sel_c) in the 2001–2011 period (indicated by E_y).[35] The sample is restricted to 1998–2017 California-resident freshman fall applicants and stacked across each UC campus. The $\beta_{\{-4,-3\}}$ terms are set to 0 for identification, allowing β_{-2} and β_{-1} to be estimated as placebos testing for parallel trends, and β_{-5} and β_4 are estimated over all years at least 5 years before or 4 years after HR_c. Standard errors are clustered by applicant.[36] Campuses did not make any further public changes to their admission policies in the years that they implemented holistic review, but β_k could partially capture the URM-specific effects of other contemporaneous internal policy changes at implementing campuses.

Fig. 7 presents estimates of $\beta_{[-3,3]}$ for UC application and enrollment, showing that holistic review substantially increases URM applicants' likelihood of admission and enrollment relative to non-URM applicants, with no evidence of differential pre-trends in the years prior to the policy's implementation. The effect is largest in the first year following implementation, when URM applicants are 3.0 percentage points more likely to be admitted and 1.2 percentage points more likely to enroll, but appears to have stabilized by a few years after implementation with admission and enrollment increases around 1.5 and 0.7 percentage points, respectively.[37]

As in the case of affirmative action above, using these estimates to measure the aggregate net effect of holistic review on URM enrollment requires adjusting the coefficients for the policy's direct crowd-out effect on non-URM enrollment: an x percentage point *relative* increase in URM applicants' enrollment likelihood corresponds mechanically to a $(x \times NU_{cy})$ percent absolute increase in URM applicants' enrollment likelihood, where NU_{cy} is the non-URM applicant share. The percent of non-URM applicants to campuses implementing holistic review in the sample period was 67.4. I assume that the enrollment effect of holistic review had stabilized by four years after implementation at $\bar{\beta}_{[0,3]} = 0.71$.[38]

An important limitation of the presented estimates is that Eq. (6) measures campus-specific changes in URM enrollment following holistic review's implementation, but some of those students would have otherwise enrolled at other UC campuses. As a result, summing across campuses' enrollment effects produces an overestimate of the number of URM students brought into the UC system by holistic review. The exercise nevertheless remains useful as an upper bound on the UC-wide enrollment effect of holistic review and as an estimate of how a single school's policy affects its URM enrollment.[39]

Fig. A-9 visualizes the estimated aggregate effect of holistic review on URM enrollment at UC campuses. The total number of URM students who enrolled at UC as a result of holistic review was only about 45 in 2002, when only Berkeley had implemented the policy, but grew to about 600 in 2017, with most of the growth occurring in 2011 and 2012. Holistic review led implementing campuses' to enroll about 7 percent more URM students on average, varying by year depending on URM applicant shares. By 2017, then, holistic review increased URM enrollment at each implementing campus by about 7.6 ± 5.1 percent, corresponding to a UC system-wide URM enrollment increase of up to (but less than) 4.7 ± 3.0 percent.[40]

7. Effects on lower-income enrollment

The previous sections have developed a series of feasible research designs that estimate the URM enrollment effects of affirmative action, top percent policies, and holistic review. As highlighted in this study's epigraph, however, UC's access-oriented admissions policies were also intended to increase students' socioeconomic diversity by broadening access for lower-income students (Douglass, 2007). This section turns to estimating each policy's effects on the enrollment of students with parental incomes below either the California household median ("lower-income") or half the household median ("very low-income").

Each of the previously-discussed designs can be extended to instead estimate each policy's effect on the enrollment of lower-income students. For example, Table 4 presents estimates of Eqs. (2) and (3) where URM_i is redefined as an indicator for i being a below-median student, which can be interpreted as the effect of affirmative action on lower-income UC applicants' UC application, admission, and enrollment. Affirmative action caused a small shift of below-median applicants toward applying to more-selective universities, as in the case of URM applicants, but had sharply differing effects on lower-income students' admission likelihoods: lower-income students' admission advantage at the more-selective Berkeley, UCLA, San Diego, and Santa Barbara campuses *grew* by one to four percentage points when race-based affirmative action was terminated, though their advantages at several less-selective campuses declined by similar amounts. Lower-income UC applicants' relative likelihood of being admitted to at least one UC campus remained precisely unchanged. As a result, UC's affirmative action policy appears to have slightly depressed lower-income students' enrollment at UC's more-selective campuses, though this is more than offset by its increasing lower-income enrollment at UC Irvine; overall, affirmative action had a precise null effect on lower-income students' relative likelihood of enrolling at a UC campus (conditional on application).

A comparison of lower- and higher-income enrollment across the UC campuses in the years before and after Prop 209 following Eq. (3) suggests that affirmative action slightly increased below-median UC enrollment, primarily at the Irvine and Santa Cruz cam-

[34] Because UC stopped collecting SAT II Mathematics and Writing scores in the 2000s, I reparameterize X_i from above by the interaction between SAT score and high school GPA.

[35] The average effect of the UC campuses' simultaneous switch to a "Comprehensive Review" policy in 2002 is absorbed by η_{yuge}.

[36] Because I use these models to estimate the effect of holistic review on applicants' outcomes, treating holistic review as a uniform policy implemented at various UC campuses that learned how to implement the policy from each other, I do not cluster standard errors at the campus-year level. Since only six campuses have implemented holistic review, such standard errors are considerably larger than those reported, though the policy's effect on URM enrollment remains statistically greater than 0 at the 10% level.

[37] Following the 'new difference-in-difference' literature summarized by Roth et al. (2022), Fig. A-7 presents event study estimates averaged from separate regressions of each campus's policy implementation compared to control campuses, where any campus that implemented the campus before or during that campus's event window was omitted from the control campuses, thus purging bias or spurious variation that could arise from heterogeneous treatment effects in two-way fixed effect models. The figure shows slightly larger effects of holistic review on URM admission and enrollment – with enrollment increasing by as much as one percentage point – but otherwise provides similar qualitative and quantitative estimation patterns.

[38] Estimates are similar if the annual relative URM enrollment advantage to holistic review implementation is estimated by $\beta_4 = 0.91$, but that coefficient could be biased by other admission policy changes implemented years after holistic review at those campuses.

[39] Fig. A-8 presents estimates from Eq. (6) with enrollment at any UC campus as the outcome variable. The estimates suggest that at least half of the estimated $\bar{\beta}_{[0,3]}$ enrollment effect comes from students switching from other UC campuses, but the observed pre-trends in the estimates belie omitted variable bias that isn't easily remedied given the available research design.

[40] 95% confidence intervals constructed from 1,000 block-bootstraps, with each applicant constituting a 'block'.

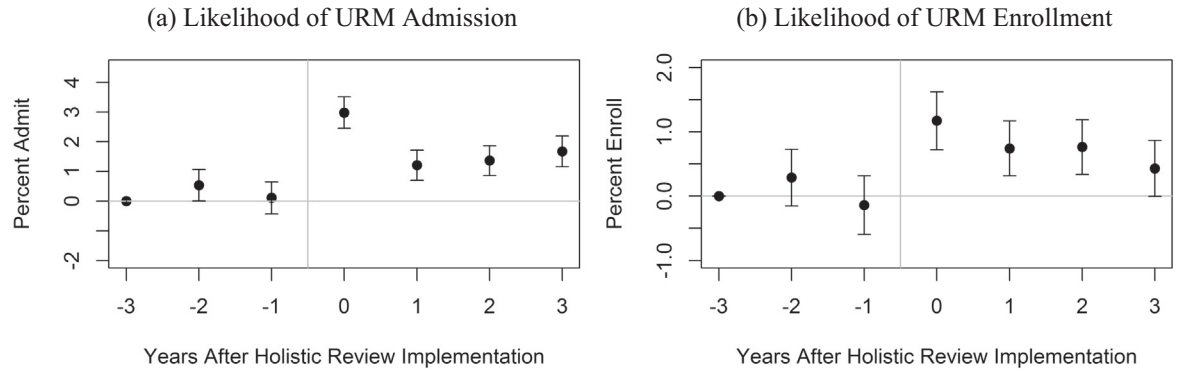

Fig. 7. Estimated impact of holistic review on URM UC admission and enrollment. *Note:* Difference-in-difference estimates of the impact of holistic review on URM admission and enrollment at implementing UC campuses, differenced across time, campus, and URM status. Sample restricted to 1997–2017 freshman California residents and stacked across UC campuses; admission is conditional on application to that campus. OLS regressions control for campus-by-high-school fixed effects as well as campus-race, year-race, and campus-year fixed effects all interacted with gender and whether the student is in the top four percent of their class (post-2000), as well as an additional race-specific ELC indicator at the selective UC campuses and SAT-score-by-GPA interactions by campus. Standard errors are clustered by applicant. The beta coefficient three years prior to HR implementation is set to 0. The campuses that implemented holistic review are Berkeley (starting 2002), UCLA (2007), San Diego (2011), Irvine (2011), Davis (2012), and Santa Cruz (2012); other campuses are included and combined with indicator for more than four years prior to implementation. Source: UC Corporate Student System.

Table 4
The impact of Proposition 209 on lower-income UC admission and enrollment.

Campus:	UCB	UCLA	UCSD	UCSB	UCI	UCD	UCSC	UCR	Total
Panel A: Application conditional on any UC application (%)									
Low Inc.	5.6	5.1	−2.5	−6.7	2.0	−1.8	−1.4	0.4	
	(0.3)	(0.3)	(0.3)	(0.3)	(0.3)	(0.3)	(0.2)	(0.2)	
Low Inc. × Prop. 209	-0.2	−2.4	0.2	−1.9	0.9	0.6	−0.3	1.5	
	(0.3)	(0.4)	(0.4)	(0.4)	(0.3)	(0.3)	(0.3)	(0.3)	
$\overline{Y}$	45.0	54.8	50.2	42.5	36.2	38.5	24.2	24.6	
Number of Obs.	299,230	299,230	299,230	299,230	299,230	299,230	299,230	299,230	
Panel B: Admission conditional on application (%)									
Low Inc.	5.6	4.4	5.5	5.5	1.5	4.0	1.4	2.2	1.9
	(0.4)	(0.3)	(0.3)	(0.3)	(0.4)	(0.4)	(0.4)	(0.4)	(0.2)
Low Inc. × Prop. 209	1.2	2.5	3.5	3.2	−3.0	3.6	−1.5	−3.2	−0.3
	(0.5)	(0.4)	(0.4)	(0.5)	(0.4)	(0.5)	(0.5)	(0.5)	(0.3)
$\overline{Y}$	32.8	35.4	50.4	63.6	65.3	69.6	83.1	85.5	82.6
Number of Obs.	134,786	164,024	150,068	127,037	108,274	115,180	72,449	73,583	299,230
Panel C: Enrollment conditional on application (%)									
Low Inc.	4.0	1.2	1.2	0.5	0.7	1.1	−0.4	0.7	3.8
	(0.3)	(0.3)	(0.3)	(0.4)	(0.4)	(0.4)	(0.5)	(0.5)	(0.3)
Low Inc. × Prop. 209	0.2	0.9	0.8	0.2	−3.7	0.3	−1.4	0.3	0.1
	(0.4)	(0.4)	(0.4)	(0.5)	(0.5)	(0.5)	(0.6)	(0.6)	(0.4)
$\overline{Y}$	16.5	13.9	12.0	15.9	17.5	18.7	17.0	17.7	49.9
Number of Obs.	134,786	164,024	150,068	127,037	108,274	115,180	72,449	73,583	299,230
Panel D: Estimated annual effect of Prop 209 on below-median UC enrollment									
Change in URM Enr.[a]	−18	−6	54	−34	−164	23	−68	13	−199
Implied URM Enr. Effect of Aff. Action	+ 1.4%	+ 0.5%	-5.8%	+ 3.9%	+ 13.3%	-2.0%	+ 10.9%	-1.0%	+ 2.3%
Panel E: Change in below-median enrollment explained by Panel C estimates (conditional on applications)									
Estimated Change in URM Enrollment[b]	10	56	43	9	-166	12	-37	10	-65
Residual[b]	-28	−62	11	−42	2	12	−31	3	−135

Note: OLS coefficient estimates from independent campus-specific difference-in-difference regressions of likelihood of application, admission, or enrollment on whether the student comes from a family with below-median income interacted with a post-1998 indicator (after Prop 209 was implemented), across 1995–2000 California-resident freshman UC applicants and including high school fixed effects and academic covariates (SAT I and II scores and high school GPA). 'Below-median' is defined as having family income below the California household median in the application year; see Appendix A for details. Robust standard errors in parentheses. The 'Total' column indicates admission or enrollment to at least one UC campus (A–C) or sums across campuses (D–E). [a]The difference between the average proportion of URM students at each campus in 1998–2000 and in 1995–1997, multiplied by the school's average incoming class size in 1998–2000 (Eq. (3)). [b]The predicted change in URM enrollment among applicants to that campus from β_{3c} in Panel C, and the residual enrollment change unexplained by the change in URM enrollment likelihood conditional on application.
Source: UC Corporate Student System.

puses, but only by about 2 percent. Only a quarter of this effect is driven by changes in enrollment conditional on application, suggesting that behavioral responses in lower-income students' UC application decisions (especially to the more-selective UCs) also played an important role. These estimates suggest that the proportional net effect of race-based affirmative action with regard to URM enrollment is an order of magnitude larger than its effect on below-median enrollment, suggesting that while URM students

tend to come from lower-income families than their non-URM peers, the family incomes of targeted URM applicants were generally similar to those of the non-URM students who replaced them after Prop 209.[41] Table A-7 shows that affirmative action's effect on UC enrollment among very low-income students (with parental incomes below half the California household median) is larger, with changes in application behavior contributing to a 7 percent net enrollment increase among those students.[42]

Appendix C similarly replicates the previous analyses of top percent policies and holistic review to estimate each policy's effect on lower-income UC enrollment. It shows that the 4% ELC policy increased below-median UC enrollment by no more than 1.4 percent – the 9% policy had no measurable effects on enrollment of any kind – and that if anything, the implementation of holistic review leads to a slight *decline* in below-median or very low-income admission and enrollment, though there is some evidence of non-parallel enrollment pre-trends among very low-income students that challenges clean interpretation. In short, these findings suggest that affirmative action, top percent policies, and holistic review have only modest effects on the economic composition of selective universities, particularly when compared proportionally to the magnitude of affirmative action's effects on URM enrollment.

8. Conclusion

Many universities implement access-oriented admission policies designed to increase underrepresented minority and lower-income enrollment in order to maintain a diverse student population and promote socioeconomic mobility. This study examines the racial and socioeconomic composition effects of three such policies – race-based affirmative action, top percent policies, and holistic review – as implemented at the University of California. It shows that race-based affirmative action had a large positive effect on URM enrollment, particularly at UC's most-selective campuses, but only a small effect – one-fifth the size in terms of student counts and one-tenth in terms of proportions – on the enrollment of students from California families with below-median income. This implies that the family incomes of targeted URM applicants were only slightly lower than those of the non-URM students who replaced them after Prop 209, particularly at the more-selective UC campuses. Top percent policies can have measurable but empirically small effects on universities' racial and socioeconomic composition – though UC's current top percent policy has no measurable effect on UC enrollment – and holistic review appears to have a small positive effect on URM (but not lower-income) enrollment.

These findings suggest that the most common policies adopted to replace affirmative action in states where race-conscious university admission preferences have been prohibited have had non-trivial but comparatively small URM enrollment effects in California, suggesting that preserving racial and socioeconomic diversity using race-neutral admission policies will require policy innovation. Affirmative action and its most common replacements also do not generate the kinds of meaningful shifts in universities' economic composition that Chetty et al. (2020) argue could substantively reduce intergenerational income persistence in the United States. Fortunately, previously implemented access-oriented admission policies have tended to deliver both equity and efficiency gains (Black et al., 2023; Bleemer, 2021; Bleemer, 2022), suggesting the potential promise of further policy innovation.

[41] The median family income of 1997 URM (non-URM) UC applicants was $36,000 ($64,000) and among enrollees was $38,000 ($62,000).

[42] Table A-1 suggests that the estimated family income ramifications of affirmative action would be larger if 94–95 enrollment is used as the affirmative action baseline, before some campuses may have begun phasing out their affirmative action policies. However, these changes are more likely the result of UC's secular rise in selectivity throughout the relevant period – the number of freshman UC applicants rose over 40 percent between 1994 and 2000 – suggesting that the true socioeconomic composition effect of affirmative action is closer to the baseline estimates.

Data availability

The data that has been used is confidential.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.jpubeco.2023.104839.

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