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State affirmative action bans and STEM degree completions

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ABSTRACT

This paper investigates the effect of statewide affirmative action bans on minority STEM degree completions at US public four-year colleges. The number of minority students completing STEM degrees at highly selective colleges falls by 19% five years after affirmative action bans, while there is no change in the total number of students completing STEM degrees. This indicates that a nontrivial number of minority students only admitted to highly selective colleges because of affirmative action graduate in STEM during periods of race preferences in college admissions. There is no convincing evidence of effects at moderately selective colleges. These findings speak to the recent debate about the extent to which minority students admitted to top ranked colleges due to affirmative action may have higher probabilities of graduating in the sciences if they had attended lower ranked colleges. Results are presented with the caveats that changes in race reporting caused by affirmative action bans may upwardly bias estimated effects, and that estimated aggregate effects may not fully capture all student-level responses.

1. Introduction

The low numbers of minorities graduating from programs in science, technology, engineering and mathematics (STEM) is a concern. In 2012, minorities received almost 20% of awarded degrees from public four-year colleges, but only 14% of degrees awarded in STEM. STEM graduates are considered important for the growth of the economy, and it has been argued that the US may lose its competitive edge if the number of students graduating in STEM fields does not increase.[1] The considerable public and private expenditure on programs designed to broaden participation in STEM emphasizes the importance placed on increasing minority STEM graduation levels.[2] Furthermore, increasing minority representation in STEM has the potential to reduce race income gaps given large labor market returns to STEM degrees (Altonji, Blom, & Meghir, 2012; Kinsler & Pavan, 2015). Understanding the factors that affect minority graduation in STEM fields is especially important going forward given the large projected growth in the minority population (Murdock, Cline, Zey, Perez, & Jeanty, 2015).

This paper investigates the effects of statewide affirmative action bans on minority STEM degree completions using difference-in-difference and event study approaches. I find heterogeneity in effects across majors and college selectivity. The share of minorities completing STEM degrees falls by between 10 and 12% at highly selective colleges five years after states ban affirmative action in college admissions (between 1.6 and 2.0 percentage points relative to the mean STEM minority share of 16.1%). This is a large effect, but is smaller than the estimated reduction in the share of minorities completing non-STEM degrees of between 14 and 16%. The reduction in the minority share of STEM degree completions is concentrated in engineering, typically considered the STEM major with the highest labor market returns, while there is no evidence of an effect in the biological sciences and computer science.

The reduction in the minority share of STEM degree completions is broadly consistent with an existing literature investigating the overall effect of affirmative action bans on college graduation rates (Hinrichs, 2012, 2014). However, considering the particular effect of affirmative action bans on STEM degree completions is important given a recent literature arguing that affirmative action in college admissions may promote mismatch in STEM. Arcidiacono, Aucejo, and Hotz (2016) suggest that less prepared minority students at top ranked colleges in California would have higher graduation rates in STEM at lower ranked colleges. Under this hypothesis, it is plausible that affirmative action bans may not reduce the share of minorities completing STEM degrees,

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[1] See Ehrenberg (2010) for an overview.

[2] These include programs such as the NSF's Historically Black Colleges and Universities Undergraduate Program ($32 million), the Louis Stokes Alliance for Minority Participation ($46 million), the Tribal Colleges and Universities Program ($13.5 million) and NASA's Minority University Research and Education Program ($30 million), which are all described in a 2014 White House Progress Report on Coordinating Federal STEM Education. It is available at www.whitehouse.gov/sites/default/files/microsites/ostp/STEM-ED_FY15_Final.pdf (accessed February 3, 2015).

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and may even increase it. In particular, we may expect either no change in the minority share of STEM degrees awarded at highly selective colleges – which would be evidence of marginally admitted minority students being particularly poorly matched to highly selective colleges during periods of affirmative action – or, alternatively, any reduction in STEM minority participation at highly selective colleges being more than offset by an increase at moderately selective colleges.

Race preferences in college admissions remain highly contentious. Several high profile legal battles over affirmative action have been fought through the 2000s, and the extent to which race can be used in college admissions across states remains complex and arguably fragile. In 2014, the Supreme Court upheld a state constitutional amendment that banned affirmative action in college admissions in Michigan, and, also in 2014, a federal appeals court ruled that the University of Texas could justify its limited use of race to achieve diversity. In 2016, the Supreme Court rejected a challenge to the latter ruling.

Affirmative action is likely to affect STEM enrollment and graduation in a variety of ways. First, students who are not enrolled at all cannot be enrolled in STEM. Backes (2012) and Hinrichs (2012) show that affirmative action bans reduce minority enrollment at selective institutions. The extent to which the subset of minorities no longer enrolled at selective institutions after affirmative action bans intersects the subset of minorities who would have been enrolled in STEM is unclear. Second, total enrollment effects may differ from STEM enrollment effects when students are accepted to specific programs. Banning affirmative action may result in minority students not being accepted into capacity-constrained engineering programs, for example, but still enrolling at the college as psychology majors. I cannot investigate individual student pathways in college using the aggregate data considered in this paper, but comparing effects on aggregate STEM and non-STEM degree completions, as well as different fields within STEM, provides an overview of the extent to which this may be occurring. And, third, affirmative action may affect minority persistence in STEM and minority STEM graduation through college match or differences in student preparation. There are race differences in the probability of completing STEM degrees conditional on enrolling in STEM programs.[3] Griffith (2010) argues that differences in preparation and the educational experiences of minorities explain much of this race persistence gap. Affirmative action may increase the number minority students in STEM programs who are underprepared and therefore do not graduate in STEM, but may have been able to graduate in STEM at less selective colleges.[4]

2. Institutional background and relation to previous literature

Several states have banned the use of race in college admissions at public institutions, beginning in the mid-to-late 1990s as a result of a referendum in California (1996) and a court challenge in Texas (1997). In the subsequent decade and a half, citizens or state legislatures of Washington (1998), Michigan (2006), Nebraska (2008), Arizona (2010), New Hampshire (2011) and Oklahoma (2012) have approved banning affirmative action in various spheres of the public sector, while a similar measure was defeated Colorado (2008). In addition, a component of an executive order issued in Florida (1999) banned race as a factor in college admissions in that state. The bans typically went into effect one year after they were passed (two years in the case of California).

This paper compares institutions in the four states in which a policy unambiguously banning affirmative action was introduced during the study period, California, Florida, Texas and Washington, to institutions in states that did not experience changes to college admissions' policies. Following the previous literature, states where the policy implications were more ambiguous are excluded from the treatment group, although their inclusion does not affect the pattern of the findings.[5] In response to affirmative action bans, three of the four states introduced policies designed to compensate for the reductions in minority enrollment anticipated by the bans. In particular, California (2001), Florida (2000) and Texas (1998) enacted what are commonly termed top-x percent plans.

California's Four Percent Plan essentially guarantees that students in the top 4% of their high school class are admitted to at least one college in the University of California (UC) system, the set of more selective state institutions in California (the other being the California State system). The One Florida Plan (the same executive order that banned consideration of race in college admissions) guarantees admission to at least one state university for seniors in the top 20% of their high school class provided they obtain sufficient precollege credits. This could be a nonselective institution. Texas's Ten Percent Plan entitles students from accredited high schools in the top 10% of their high school class admission to any state university (including the flagship schools), although colleges may still require full applications including essays, letters of recommendation, admissions tests and fees.

These policies differ on several dimensions, and some heterogeneity in the effect of top-x percent plans across states is expected. The central intention of all of these policies, though, is to boost minority enrollment in the absence of affirmative action. Given that these policies were introduced directly in response to affirmative action bans (only states that have banned affirmative action in college admissions have ever enacted top-x percent plans), the overall effect of affirmative action bans may be considered the combined effect of the ban and the top-x percent plan.

Arcidiacono and Lovenheim (2016) provide a recent review of the affirmative action in higher education literature. They interpret the current empirical evidence to be consistent with theoretical predictions of declines in underrepresented minority student enrollment at selective colleges when affirmative action is banned, but little effect on overall college enrollment. Several analyses have been state-specific and based on longitudinal student-level data. Evidence from Texas shows that the ban reduced minority enrollment at selective colleges (Kain, O'Brien, & Jargowsky, 2005) and that the Texas Top Ten Percent Plan designed to compensate for the affirmative action ban was insufficient to restore Black and Hispanic applicants' share of admitted students to pre-ban levels (Long & Tienda, 2008). Cortes (2010) shows a reduction in both retention and graduation rates for lower-ranked minorities with the change from affirmative action to the Top Ten Percent Plan in Texas. This is interpreted as evidence against the mismatch hypothesis, which would predict increases in graduation rates if students were better matched after affirmative action is banned. Using student-level data from California, Arcidiacono, Aucejo, Coate, and Hotz (2014) find that minority graduation rates increased after the ban, contrasting the findings of Cortes (2010) for Texas.

Student-level data has also been used to study the effect of affirmative action bans on application behavior and the probability of enrollment conditional on acceptance for minorities.

[3] See Price (2011), Ost (2010), Rask (2010) and Luppino and Sander (2015) for more discussion of factors affecting persistence in STEM.

[4] It is also possible that STEM enrollment may be affected by affirmative action bans through second order effects on students' acceptance of offers and application patterns, although the literature does not find large effects operating through these channels for more general college admissions (Card & Krueger, 2005; Dickson, 2006; Antonovics & Backes, 2013; Antonovics & Sander, 2013).

[5] Specifically, Hinrichs (2012, 2014) drops observations from Alabama, Georgia, Louisiana, Michigan and Mississippi. Affirmative action in these states was not completely banned during the period, although there were policies affecting race considerations in college admissions.

Antonovics and Sander (2013) find no evidence supporting a “chilling effect” in which minorities are dissuaded from accepting college offers after the ban, and Antonovics and Backes (2013) argue that the small effects on SAT score-sending rates are consistent with affirmative action bans not affecting the application behavior of minority students.

My paper follows three papers looking at aggregate effects of affirmative action bans (Backes, 2012; Hinrichs, 2012, 2014). Using difference-in-difference approaches, these papers show that the share of minority enrollment drops at selective institutions after affirmative action is banned, but they find no effect on overall minority enrollment shares. Hinrichs (2014) finds that affirmative action bans lead to fewer underrepresented minorities graduating from selective colleges, indicating that some of the minorities no longer enrolled due to affirmative action bans would have graduated from these highly selective institutions. Heterogeneity by major is not explored in these papers.

Arcidiacono et al. (2016) investigate the role of college match in STEM. Underprepared students could be considered mismatched students if these students would have higher probabilities of graduation in STEM at less selective institutions. Using student-level data from the University of California system before affirmative action bans came into effect, they argue that many minority students would be more likely to graduate in STEM and graduate sooner at less selective institutions.[6] Affirmative action may shift minority students pursuing STEM from less selective colleges to more selective colleges, increasing the probability of mismatch.

My paper complements the Arcidiacono et al. (2016) study by investigating the effect of affirmative action bans on aggregate STEM degree completion across the US. Banning affirmative action may do more than shift minority students pursuing STEM from more selective colleges to less selective colleges. Minority students may also switch majors while enrolling in the same institution, as well as attend community colleges or pursue other career options. The aggregate effects of banning affirmative action investigated in my paper combine all of the possible effects. I do not find increases in minority STEM graduation levels that may have been predicted by Arcidiacono et al. (2016), but with several important caveats. First, the institution-level data used in my paper cannot identify the specific paths taken by minority students who would previously have been enrolled in STEM majors at more selective colleges. It is possible that individual-level data focusing on specific subsets of colleges and students may reveal better college matches for minority students pursuing STEM at these colleges, particularly given their analysis was focused within the relatively selective UC system. And, second, policies introduced in response to and alongside affirmative action bans may work against finding improvements in student-college match in STEM. Specifically, the top-x percent plans introduced in California, Florida and Texas at a similar time to affirmative action bans in these states guarantee some form of college admission to students above a certain rank in their high school, and these policies themselves may lead to mismatch in STEM.[7]

Finally, this paper also contributes to the broader literature investigating the effects of state-specific policies on STEM graduation. Sjoquist and Winters (2015a) find that state merit-aid programs reduce the number of students completing STEM degrees, suggesting this may be driven by students choosing easier courses to maintain eligibility for financial aid, while Sjoquist and Winters (2015b) consider the specific example of the Georgia HOPE Scholarship, showing that it reduces the likelihood of earning a STEM degree.

Table 1
STEM CIP code classification.

STEM CIP Code	Description	Designation in analysis
1	Agricultural sciences	Other STEM
26	Biological sciences	Biological sciences
11	Computer science	Computer science
52	Computer science (Business)	Other STEM
14	Engineering	Engineering
15	Engineering technologies	Other STEM
3	Environmental science	Other STEM
27	Mathematics	Math and physical sciences
52	Mathematics (Business)	Other STEM
40	Physical sciences	Math and physical sciences

3. Data

This paper uses data from the Integrated Postsecondary Education Data System (IPEDS). IPEDS collects information from every college that participates in federal student financial aid programs. I restrict my analysis to public four-year colleges, the set of colleges whose students are likely most directly affected by affirmative action bans. Race groups are broadly categorized in this paper: underrepresented minorities include Black, Hispanic and Native American students, and nonminorities include White and Asian students.

I use data on degree completions by major from 1998 to 2009. These data contain the number of degree awards by type of program and race in a given year. The data is at the award level and not the student level, and later years in the sample include indicators for first or second major. My paper reports results for the first major to avoid the double counting of students.[8] Importantly, the award cannot be matched to the year in which the student enrolled. I investigate effects on degree completions five years after affirmative action is banned in a given state in the difference-in-difference analysis, while the event study approach provides a more flexible investigation of the timing of effects.

Majors are categorized by the Classification of Instructional Programs (CIP), a detailed coding system for postsecondary institutional programs. Using the National Science Foundation's categorization of CIP codes, I categorize STEM majors into the fields of engineering, biological sciences, mathematical and physical sciences, computer science and other STEM majors. Table 1 summarizes the CIP codes and STEM classification used in this paper, and Fig. 1 plots the composition of STEM degrees awarded over time. Engineering and the biological sciences, respectively the STEM majors with the highest and lowest labor market returns, constitute the majority of STEM degrees awarded. A fuller discussion of changes in STEM composition over time is provided in the Appendix.

The data on degree completions is analyzed at the institution level. I consider both the full sample of colleges and subsamples of colleges based on college selectivity. Institutions are divided into selectivity groups based on test scores of incoming students: the decile of most selective colleges, colleges in the second and

[6] It is important to note that they only model the effects of redistributing students among the UC campuses, the majority if which are considered moderately or highly selective in this paper. They do not consider students moving into the less selective California State system, for example.

[7] Dillon and Smith (2017) investigate the determinants of mismatch more generally. They argue that mismatch is driven by student application and enrollment decisions rather than college admissions decisions, which would suggest a mitigated role for affirmative action affecting match quality.

[8] There does not appear to be a disproportionately high or low number of minorities pursuing STEM as a second rather than first major, and results simply adding second majors to the aggregates are very similar to those reported. The share of second majors is also small, indicating that most students have one major in these data.

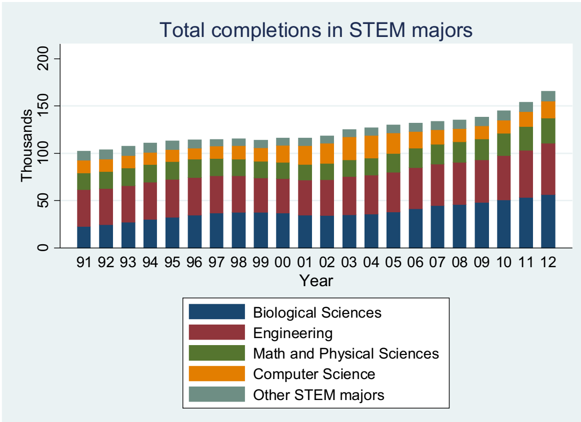

Fig. 1. Major-specific STEM degree completions in US public four-year colleges.

Table 2
Highly and moderately selective colleges in ban states.

College	Selectivity
California	
California Polytechnic State University – San Luis Obispo*	High
University of California – Berkeley	High
University of California – Davis	Moderate
University of California – Irvine	High
University of California – Los Angeles	High
University of California – Riverside	Moderate
University of California – San Diego	High
University of California – Santa Barbara	Moderate
University of California – Santa Cruz	Moderate
Florida	
Florida State University	Moderate
University of Central Florida	Moderate
University of Florida	High
University of North Florida	Moderate
University of South Florida	Moderate
Texas	
Texas A&M University	High
Texas Tech University	Moderate
University of North Texas	Moderate
University of Texas – Austin	High
Washington	
University of Washington	High
Washington State University	Moderate
Western Washington University	Moderate

*This is the only selective college in California not in the UC system. Results are very similar if this institution is excluded from the set of highly selective colleges.

third deciles, and the remainder. My groupings replicate those of Backes (2012), which is useful for comparison purposes. There are nine highly selective and twelve moderately selective institutions in ban states.[9] These are shown in Table 2.

Regression analyses are performed on balanced panels of the overall degree completions data to avoid compositional changes over time distorting results.[10] Descriptive statistics for these samples are reported in Table 3. The balanced degree completions data includes 402 public four-year colleges: 333 in non-ban states and 69 in ban states. The mean share of minorities completing degrees is 12.7% in non-ban states and 24.5% in ban states (upper panel of Table 3), showing that affirmative action bans are more likely to be observed in states with greater shares of minorities. On average, highly selective colleges have lower shares of minority students completing degrees relative to their less selective counterparts in both non-ban and ban states.

The STEM share of students is similar in non-ban (18.5%) and ban (17.8%) states (lower panel of Table 3). The share of minorities completing STEM degrees is consistently lower than the share of minorities completing degrees overall. This difference is particularly large in highly selective colleges in ban states; there is a minority share of 24.5% for all degree completions, but a minority share of 18.6% in STEM. The major-specific distribution of STEM degree completions is reported in the Appendix. Overall, minority shares are lowest in engineering (12.3%) and mathematical and physical sciences (11.9%) in comparison to the biological sciences (14.0%) and computer science (14.1%).

4. Empirical methodology

The effects of affirmative action bans at institution i in state s and year t are estimated using the following difference-in-difference model.

$$y_{ist} = \beta_H(ban_{s,t+5} \times selH_i) + \beta_M(ban_{s,t+5} \times selM_i) + \beta_N(ban_{s,t+5} \times selN_i) + u_i + (year_t \times selH_i) + (year_t \times selM_i) + (year_t \times selN_i) + n_s t + e_{ist}$$

The dependent variable in the primary specification is the natural logarithm of the number of degrees awarded to students in a particular race group. The independent policy variable ban_{st} is a binary variable indicating state-specific year-varying enforcement of affirmative action bans. Given the established literature has emphasized that the effects of affirmative action bans on college composition depend on the selectivity of the institution, the ban indicator is interacted with indicators for highly selective colleges $selH_i$, moderately selective colleges $selM_i$, and nonselective colleges $selN_i$ to separate effects by college selectivity.[11] The model includes institution fixed effects u_i, year by college selectivity fixed effects $year_t \times selX_i$ where $X \in \{H, M, N\}$, and a linear state trend $n_s t$. Some specifications include an additional binary indicator for years in which state-specific top-x percent plans were in place.

As discussed above, the degree completions data does not include the year in which the student receiving the award enrolled. In my primary specification I look at the effects on degree completions five years after affirmative action is banned. This is the median time to graduation in the IPEDS graduation data (which is not major-specific, so otherwise not used in the analysis). I perform a sensitivity analysis in which I consider alternative timings of treatment to ensure that this choice does not affect the pattern of results. Using five years after the ban introduces noise into the estimation as some students graduate in four or six years, although the type of student affected by affirmative action policy is more likely less prepared and takes longer to graduate. Results across races are comparable to the extent that marginally admitted minority and nonminority students affected by affirmative action bans are similar in their times-to-degree.

I also report results from event studies in which the state-specific treatment is normalized to occur in some period T and multiple indicator variables are introduced for years before and after the policy change. These allow us to identify any pre-treatment trends in race-specific completions levels that persist despite the above controls, as well as provide more general information on the robustness and sensitivity of the effect. The event studies reveal

[9] California Polytechnic State University is included in the set of highly selective colleges. It is the only Californian college in the highly selective category not in the UC system. Results are very similar if this institution is not defined as highly selective.

[10] Institutions that do not report degree completions for all the years in the study sample are excluded from the analysis. These are typically small, nonselective colleges. Results are similar when these institutions are included.

[11] Results are similar if models are estimated separately for each subset of colleges rather than using the interaction specification. I report effects for the full sample that does not allow effects to vary by college type in the Appendix.

Table 3
Descriptive statistics - total and STEM degree completions by race.

	All colleges	Colleges in non-ban states				Colleges in ban states			
		All colleges	Highly select	Mod select	Not select	All colleges	Highly select	Mod select	Not select
All									
Number of students	1855	1587	2931	2258	1108	3147	6256	4301	2275
Minority share	16.1	12.7	9.3	9.1	17.1	24.5	14.9	16.9	33.2
Nonminority share	79.7	84.0	87.9	87.3	79.6	69.2	79.5	78.7	59.2
Race unknown share	4.2	3.3	2.8	3.6	3.3	6.3	5.7	4.5	7.6
STEM									
Number of students	290	245	722	369	122	510	1665	658	256
Share of total students	18.3	18.5	24.6	18.5	13.4	17.8	26.6	16.2	12.5
Minority share	13.1	10.7	7.6	8.0	16.9	18.6	11.3	14.4	30.6
Nonminority share	82.4	85.7	89.6	87.9	79.6	74.8	82.4	80.0	61.7
Race unknown share	4.5	3.5	2.9	4.1	3.5	6.6	6.3	5.6	7.8
Number of colleges	402	333	32	88	213	69	9	12	48

Notes. Number of students corresponds to the mean number of degree completions per college in the respective subsample. Minority, nonminority and race unknown shares describe mean race composition weighted by college size.

Table 4
Effect of affirmative action bans on log of degree completions.

	STEM					STEM	non-STEM	
	Underrepresented minority (URM) students					All students	URM	All
	1	2	3	4	5	6	7	8
Ban x highly selective	0.14**	0.09**	−0.11+	−0.23**	−0.19**	−0.03	−0.20**	−0.01
	(0.03)	(0.03)	(0.06)	(0.08)	(0.07)	(0.06)	(0.04)	(0.03)
Ban x moderately selective	0.41**	0.38**	0.13*	−0.01	−0.02	−0.02	0.02	0.03
	(0.05)	(0.05)	(0.05)	(0.05)	(0.08)	(0.05)	(0.03)	(0.02)
Ban x not selective	0.30**	0.28**	0.11	−0.07*	−0.08*	−0.04	−0.01	−0.01
	(0.09)	(0.09)	(0.08)	(0.03)	(0.03)	(0.03)	(0.02)	(0.01)
College fixed effects	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-by-selectivity fixed effects	No	No	Yes	Yes	Yes	Yes	Yes	Yes
State trends	No	No	No	Yes	Yes	Yes	Yes	Yes
Top-x percent plan control	No	No	No	No	Yes	Yes	Yes	Yes
Number of observations				4824				
Number of colleges				402				

Notes. Robust standard errors clustered at the state level. ** Significant at 1% level. * Significant at 5% level. + Significant at 10% level.

that some race-specific trends persist at less selective colleges despite the year by college selectivity fixed effects, indicating that caution should be exercised when interpreting these results.

Two other dependent variables are considered: the minority share of students completing STEM degrees and the share of students completing STEM degrees relative to the total number of students completing degrees. Considering effects of affirmative action bans on the minority share of students completing STEM degrees provides similar information to the model using the log of degree completions with the benefit of mitigating concerns about scale at the cost of masking potential changes in overall STEM degree completions. Modeling the effect on the share of students completing STEM degrees relative to the total number of students completing degrees speaks to whether potential mismatch caused by race preferences in admissions is any more evident in STEM programs (where it is typically argued to occur) in comparison to non-STEM programs. Colleges are weighted by the number of degree completions in 1996 (the last year before bans) when estimating these models.

5. Regression and event study results

Table 4 shows the effect of affirmative action bans on the log of STEM degree completions. Estimated parameters (after scaling by one hundred) are percent changes in minority completions caused by affirmative action bans given the log-linear model. The first five columns report results for minority students adding controls iteratively, the sixth column contrasts the effect on minority students with the effect on all students, while the seventh and eight columns consider effects on non-STEM degree completions for comparison. I report estimates from the model that does not allow heterogeneity by college selectivity in Appendix Table 2.

Without time-varying controls (the first two columns of Table 4), affirmative action bans are associated with increases in minority STEM degree completions. This is because ban states have more minorities than non-ban states and the number of STEM degrees awarded over time is increasing. Year-by-selectivity fixed effects in the third column capture countrywide year-specific shocks and any national trends (allowed to differ by college selectivity) affecting the number of race-specific STEM degree completions, such as trends in the race composition of the college-going population in the US. The coefficient for highly selective colleges is now the expected negative sign. Linear state trends in the fourth column control for state-specific deviations from the national trends affecting STEM degree completions. This is important given that ban states may have higher minority population growth rates than other states. Affirmative action bans are now associated with a twenty-three percent reduction in minority STEM degree completions at highly selective colleges, no effect at moderately selective colleges, and a small reduction in minority STEM degree completions at nonselective colleges. The coefficient for highly selective colleges is of a greater magnitude than the parameter estimated in the third column without state-specific trends, although they are not statistically different.

Table 5
Sensitivity check: Effect of affirmative action bans on STEM degree completions varying ban indicator.

	Log(STEM degree completions)					
	URM students					
Years post ban	1	2	3	4	5	6
Ban x highly selective	−0.05	−0.05	−0.10+	−0.16**	−0.19**	−0.08
	(0.07)	(0.05)	(0.05)	(0.06)	(0.07)	(0.06)
Ban x moderately selective	−0.03	−0.15	−0.13	−0.13	−0.02	0.07
	(0.16)	(0.13)	(0.12)	(0.12)	(0.08)	(0.06)
Ban x not selective	−0.14**	−0.14**	−0.15**	−0.08**	−0.08*	0.00
	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)	(0.04)
Number of observations	4824					
Number of colleges	402					

Notes. Full set of controls included. Robust standard errors clustered at the state level. ** Significant at 1% level. * Significant at 5% level. + Significant at 10% level.

The negative effect at nonselective colleges in the fourth column is sensitive to the specification of the model. The subsequent event study analysis provides no evidence of a reduction in minority degree completions, emphasizing the value of performing both a difference-in-difference and event study analysis.

The fifth column reports estimates from the fullest and preferred specification that includes binary indicators for years with state-specific top-x percent plans. Statewide affirmative action bans in college admissions cause a nineteen percent reduction in STEM degree completions. The magnitude of the effect only falls from 0.23 to 0.19 when controlling for top-x percent plans, indicating that these top-x percent plans only slightly increase the minority share of STEM degree completions at highly selective colleges and do not fully compensate for the affirmative action bans. This is consistent with the finding that the Texas Top Ten Percent Plan only partly offset the effect of affirmative action bans (Long & Tienda, 2008).

Overall, the reduction in the number of minority STEM degree completions at highly selective colleges caused by affirmative action bans indicates that a subset of the marginally admitted minority students enrolled in STEM during periods of affirmative action successfully graduate in STEM. We also do not observe convincing evidence of any increases in minority STEM degree completions at moderately selective colleges that would be consistent with minority students cascading down the college selectivity distribution and finding better matches after affirmative action bans. In addition, results in Appendix Table 2 suggest an overall decline in the number of minorities in STEM both when combining highly and moderately selective colleges and when combining all colleges.

Results reported in the sixth column show that there is no effect on overall STEM degree completions.[12] The seventh and eighth columns report results for non-STEM degree completions. Affirmative action bans reduce the number of minority non-STEM degree completions by 20% at highly selective colleges. This is slightly larger than the effect on STEM degree completions, although the difference is not statistically significant. Subsequent results considering the shares of minorities completing STEM and non-STEM degrees show a larger difference in magnitude.

The sensitivity of results to evaluating effects five years after affirmative action bans is probed in Table 5. This table reports a series of difference-in-difference estimates varying the year in which the ban indicator is activated from one year after the ban in the first column to six years after the ban in the sixth column. Using treatment indicators four or five years after the ban generates statistically negative estimates. This is sensible given degrees take a minimum of four years to complete. The effect estimated using three years after the ban is attenuated given that one year of post-treatment data would not actually be treated in this specification, and the effect in the sixth column (using six years after the ban) is attenuated given some of the effect would have already occurred in two of the pre-treatment years.

[12] Unlike the reduction for minorities, it should be noted that this result was sensitive to the specification of the model. When estimated in levels (not reported), for example, there was an overall increase in STEM degree completions. This provides suggestive evidence that there may have been an increase in STEM degree completions for nonminorities, although estimates were relatively imprecise and did not show clear evidence of this.

Table 6
Robustness check: race reporting.

	Log(STEM degree completions)		
	Nonminorities	Race unknown	URM + race unknown
	1	2	3
Ban x highly selective	−0.02	0.15	−0.07
	(0.06)	(0.23)	(0.10)
Number of observations	4824		
Number of colleges	402		

Notes. Full set of controls included. Robust standard errors clustered at the state level. ** Significant at 1% level. * Significant at 5% level. + Significant at 10% level.

A recent literature has found that race reporting may have changed in response to affirmative action bans (Antman & Duncan, 2015). The extent to which this may impact results is explored in Table 6 by considering the effect on the number of students of unknown race completing STEM degrees. Although not statistically significant, we observe a 15% increase in the number of students with missing race completing STEM degrees after affirmative action is banned. Given that minority students may no longer have an incentive to report their race after affirmative action bans (broadly consistent with Antman & Duncan, 2015), I construct a lower bound of the negative effect on minority STEM degree completions under an assumption that the increase in race unknown STEM degree completions is completely driven by changes in race reporting by minorities. The third column reports the effect on the sum of minority and race unknown students. The magnitude of the effect falls from 19 to 7%, and is now imprecisely estimated; changes in race reporting may explain some of the reduction in minority STEM degree completions. I argue below that the pattern of estimated effects in the event study suggests that this is a conservative lower bound; the true impact is likely larger in magnitude. A limitation of the approach used in this paper is that I cannot assess how individual race reporting changes over time, which would be necessary to provide a more nuanced analysis.

These results are presented with an additional caveat. It is possible that affirmative action bans cause some minority students to attend school out of state, and it is also possible that nonminority students who would previously have attended school out of state attend in state colleges after affirmative action bans. This may be particularly true for students attending highly selective colleges. The aggregate major completions data used in this paper do not allow me to consider this directly, but it is worth noting that Hinrichs (2012) finds no increase in the proportion of students attending college out of state after affirmative bans.

Table 7 reports results from the specification considering the effect of affirmative action bans on the share of minorities completing degrees, which is the primary dependent variable considered in the difference-in-difference analyses employed by Backes (2012) and Hinrichs (2012). I observe a reduction in the minority share in both STEM and non-STEM degree completions at highly selective colleges, and no effect at other colleges. The effect is only partly mitigated when controlling for top-x percent plans in the second and fourth columns, confirming again that

Table 7
Effect of affirmative action bans on URM share of degree completions.

	URM share (URM degree completions/all race degree completions)			
	STEM degrees		Non-STEM degrees	
Mean in treated states	*16.15*		*22.09*	
	1	2	3	4
Ban x highly selective	−2.04**	−1.64**	−3.53**	−3.05**
	(0.57)	(0.46)	(0.26)	(0.29)
Ban x moderately selective	−0.12	−0.17	−0.10	−0.42
	(0.33)	(0.43)	(0.25)	(0.29)
Ban x not selective	0.24	−0.18	0.30	0.20
	(0.36)	(0.36)	(0.20)	(0.21)
College fixed effects	Yes	Yes	Yes	Yes
Year-by-selectivity fixed effects	Yes	Yes	Yes	Yes
State trends	Yes	Yes	Yes	Yes
Top-x percent plan	No	Yes	No	Yes
Number of observations	4824			
Number of colleges	402			

Notes. Regressions include weights for college size. Robust standard errors clustered at the state level. ** Significant at 1% level. * Significant at 5% level. + Significant at 10% level.

Table 8
Effect of affirmative action bans on STEM share of degree completions.

	STEM share (STEM degree completions/total degree completions)			
	All students		URM students	
Mean in treated states	*16.17*		*12.68*	
	1	2	3	4
Ban x highly selective	−0.40	−0.46	0.17	0.03
	(0.36)	(0.32)	(0.81)	(0.76)
Ban x moderately selective	0.26	−0.18	0.92	0.41
	(0.41)	(0.33)	(0.84)	(0.39)
Ban x not selective	−0.45*	−0.27	−0.24	−0.16
	(0.20)	(0.25)	(0.40)	(0.47)
College fixed effects	Yes	Yes	Yes	Yes
Year-by-selectivity fixed effects	Yes	Yes	Yes	Yes
State trends	Yes	Yes	Yes	Yes
Top-x percent plan	No	Yes	No	Yes
Number of observations	4824			
Number of colleges	402			

Notes. Regressions include weights for college size. Robust standard errors clustered at the state level. ** Significant at 1% level. * Significant at 5% level. + Significant at 10% level.

top-x percent plans only partly compensate for the reduction in minority share caused by affirmative action bans.

There is a difference in the magnitude of effects across STEM and non-STEM programs in this specification. The minority share completing STEM degrees falls by between 10 and 12% (between 1.6 and 2.0 percentage points relative to the mean of 16.1%), which is smaller than the 14–16% (3.0 to 3.5 percentage points relative to the mean of 22.0%) reduction in the share of minorities completing non-STEM degrees. The extent to which affirmative action generates mismatch in a given field is arguably inversely related to the reduction in minority degree completions from affirmative action bans in that field; if there is no reduction after a ban in a given field, for example, none of the marginally admitted students enrolled because of affirmative action were matched well enough to complete the degree in that field. The larger effect in non-STEM is therefore broadly consistent with affirmative action-induced mismatch being less evident in less challenging non-STEM programs. Importantly, though, reductions in minority shares are observed in both STEM and non-STEM programs.

Results in Table 8 explore whether affirmative action bans affect the share of students completing STEM degrees relative to non-STEM degrees. If affirmative action bans have sufficiently smaller impacts on minority STEM degree completions than minority non-STEM degree completions, this share should increase for minorities. Estimates in Table 8 indicate that the difference between STEM and non-STEM observed in Table 7 does not translate into convincing evidence of a change in the STEM share; although positive, none of the estimates are statistically significant. In sum, the results in Tables 4, 7 and 8 provide only weak evidence that minority graduation rates in STEM are less affected by affirmative action bans than graduation rates in non-STEM fields, and, if so, the difference does not appear to be large.

The sensitivity and robustness of the difference-in-difference analysis is probed by event studies displayed in Fig. 2. The outcomes are race-specific shares of STEM degree completions and all the controls from the regression analysis other than the linear trends are included. An advantage of the event study approach is that it provides estimated effects for a series of the years after the ban rather than the five years after the ban as in the difference-in-difference analysis. The disadvantage, however, is that year-specific effects are relatively unstable given they are estimated from a small number of observations in treated states. The omitted period is three years after the ban (denoted T + 3), the last period before we could observe an effect given degrees take a minimum of four years to complete, and effects are truncated at periods T and T + 7.

From the top row of Fig. 2, the reduction in the share of minority students completing STEM degrees at highly selective colleges is evident from period T + 5 (five years after the ban), while there is no clear change in minority degree completions at moderately and not selective colleges. The middle row shows that there is no effect of affirmative action on nonminority STEM degree completions. However, in the third row there is a clear increase in the share of students of unknown race completing STEM degrees from period T + 4, which was not as clearly evident in the difference-in-difference analysis. The share of race unknown students completing STEM degrees increases four years after the ban, while the reduction in the share of minority students completing STEM degrees is only evident five years after the ban. This suggests that the set of students changing their race reporting behavior is not exactly the same as the set of minorities no longer graduating. The lower bound of the reduction in minority STEM degree completions reported in Table 6 (7%) in which the change in race reporting is fully attributed to minorities is therefore likely to be conservative.[13]

Table 9 and Fig. 3 report results showing major-specific heterogeneity in the effect of affirmative action bans within STEM. The difference-in-difference estimates in Table 9 indicate that affirmative action bans cause a 30% reduction in minority engineering degree completions, but have no effect in other STEM fields. Given that engineering programs are typically more capacity-constrained than other STEM programs, this is consistent with affirmative action playing a larger role in admissions when capacity constraints are binding. The bottom panel shows that this does not translate into an effect on degree completions in engineering for all students, suggesting some substitution away from minorities to other race groups.

In addition to showing the minority reduction in engineering, the event studies in Fig. 3 show increases in the share of race unknown students across all STEM majors, and not just the STEM majors in which we observed a reduction in the share of minorities. Similar to the argument made above, this indicates that the set of

[13] The event studies plotted in Fig. 2 may be interpreted as providing some evidence of pre-treatment trends at nonselective colleges, indicating that results from the difference-in-difference analysis for nonselective colleges should be interpreted cautiously.

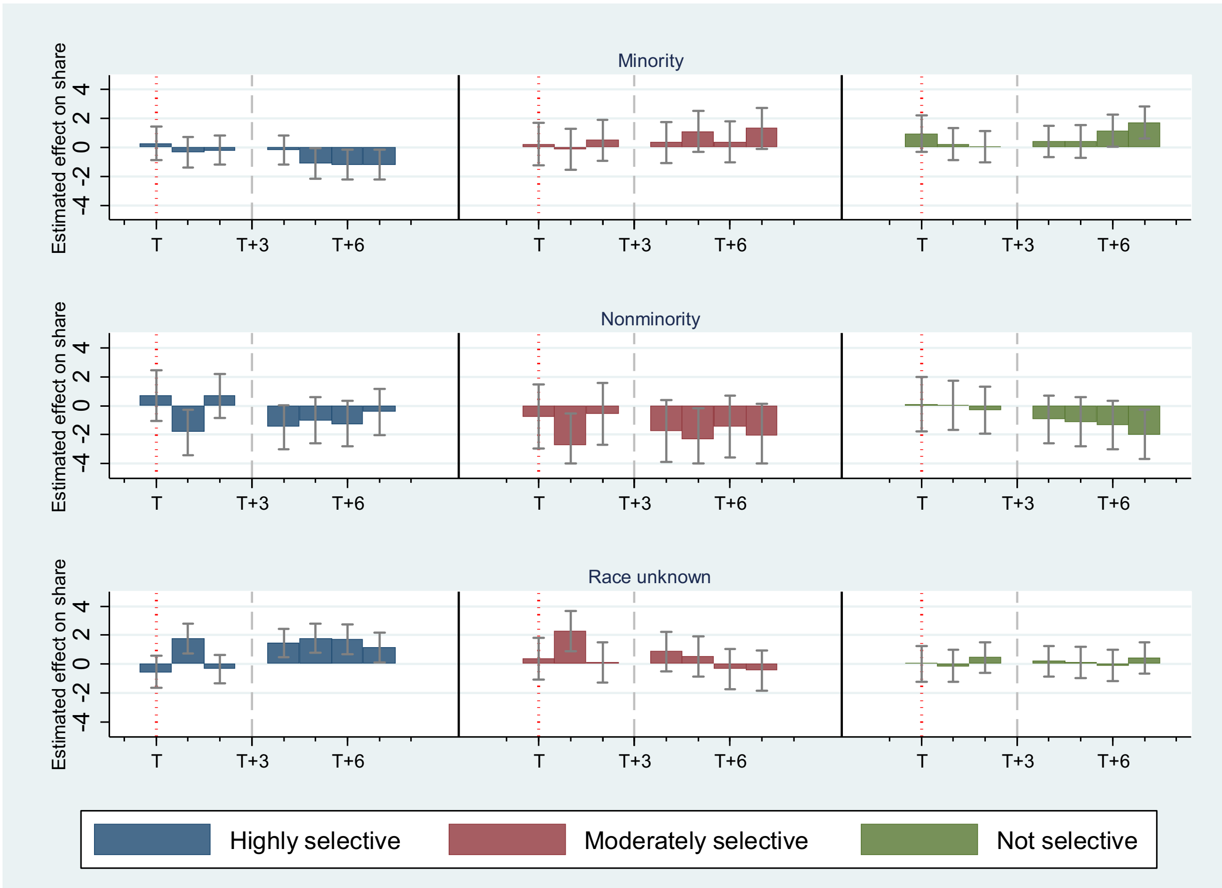

Fig. 2. Effect of affirmative action bans on URM share of STEM degree completions
Notes. Event studies show estimated effects every year from T, the first year of affirmative action bans in college admissions (red dotted line), to T + 7. The omitted year is T + 3 (gray dashed line). Individual graphs are truncated for easier reading in both the horizontal dimension (omitting years before T and years after T + 7) and in the vertical dimension (restricting magnitudes to be between −4 and 4 percentage points). Regressions include weights for college size. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 9
Effect of affirmative action bans on log of major-specific STEM degree completions.

	Biological Sciences	Engineering	Math and Phys Sciences	Computer Science
	URM students			
	1	2	3	4
Ban x highly selective	−0.09	−0.30*	0.00	−0.10
	(0.13)	(0.13)	(0.15)	(0.17)
Ban x moderately selective	0.03	0.08	0.00	−0.06
	(0.11)	(0.12)	(0.13)	(0.16)
Ban x not selective	0.11	−0.10	−0.05	−0.02
	(0.07)	(0.09)	(0.08)	(0.10)
	All students			
	5	6	7	8
Ban x highly selective	−0.06	0.04	0.08	0.02
	(0.08)	(0.10)	(0.09)	(0.12)
Ban x moderately selective	0.02	0.12	0.05	0.18+
	(0.07)	(0.09)	(0.08)	(0.11)
Ban x not selective	0.00	−0.16*	−0.04	−0.01
	(0.04)	(0.07)	(0.05)	(0.07)
Number of observations	4687	2337	4761	4406
Number of colleges	393	225	400	379

Notes. Robust standard errors clustered at the state level. ** Significant at 1% level. * Significant at 5% level. + Significant at 10% level.

students changing their race reporting behavior is not the same as the set of minorities no longer graduating, again suggesting that the lower bound constructed in Table 6 may be conservative.

Finally, I report results from a synthetic control approach (Abadie & Gardeazabal, 2003; Abadie, Diamond, & Hainmueller, 2010) to further probe the robustness and sensitivity of the difference-in-difference estimation. In the context of this study, the synthetic control group is constructed by assigning weights to colleges in non-ban states to form a composite college that best matches the treated college on a vector of pre-treatment characteristics. Following Hinrichs (2012)[14], the weights are assigned based on annual college race composition (1991 until the ban), state race composition (1990 census), and median state household income (1995 census). In addition, the set of potential control colleges is restricted to colleges in the same selectivity tier. Given the method only allows for a single treated unit, treated colleges within each ban state (and selectivity tier) are grouped, which also boosts power, and each treated state is considered separately. Fig. 4 reports results for California, and the weights assigned to control colleges from the synthetic control algorithm are reported in Appendix Table 3.[15]

[14] This paper also provides a more detailed explanation of the method and an application to affirmative action bans.

[15] Synthetic control plots for other ban states are shown in Appendix Fig. 2. The sharp decline in minority STEM degree completions at highly selective colleges is only evident in Texas and to a lesser extent in Washington, while effects in Florida and moderately selective colleges are less clear. As argued by Hinrichs (2012), state-specific synthetic control analyses show that focusing on the mean university may mask heterogeneity in the effect of affirmative action bans across colleges and states.

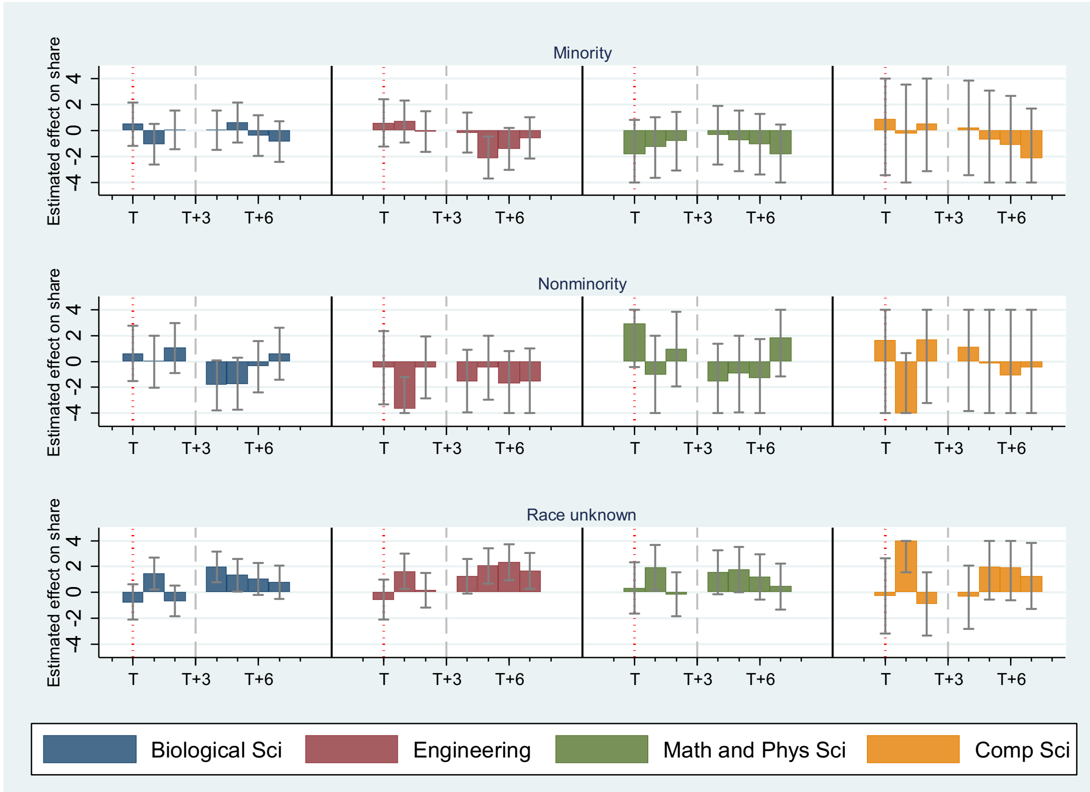

Fig. 3. Major-specific effects of affirmative action bans on URM share of STEM degree completions.
Notes. Event studies show estimated effects every year from T, the first year of affirmative action bans in college admissions (red dotted line), to T + 7. The omitted year is T + 3 (gray dashed line). Individual graphs are truncated for easier reading in both the horizontal dimension (omitting years before T and years after T + 7) and in the vertical dimension (restricting magnitudes to be between −4 and 4 percentage points). Regressions include weights for college size. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

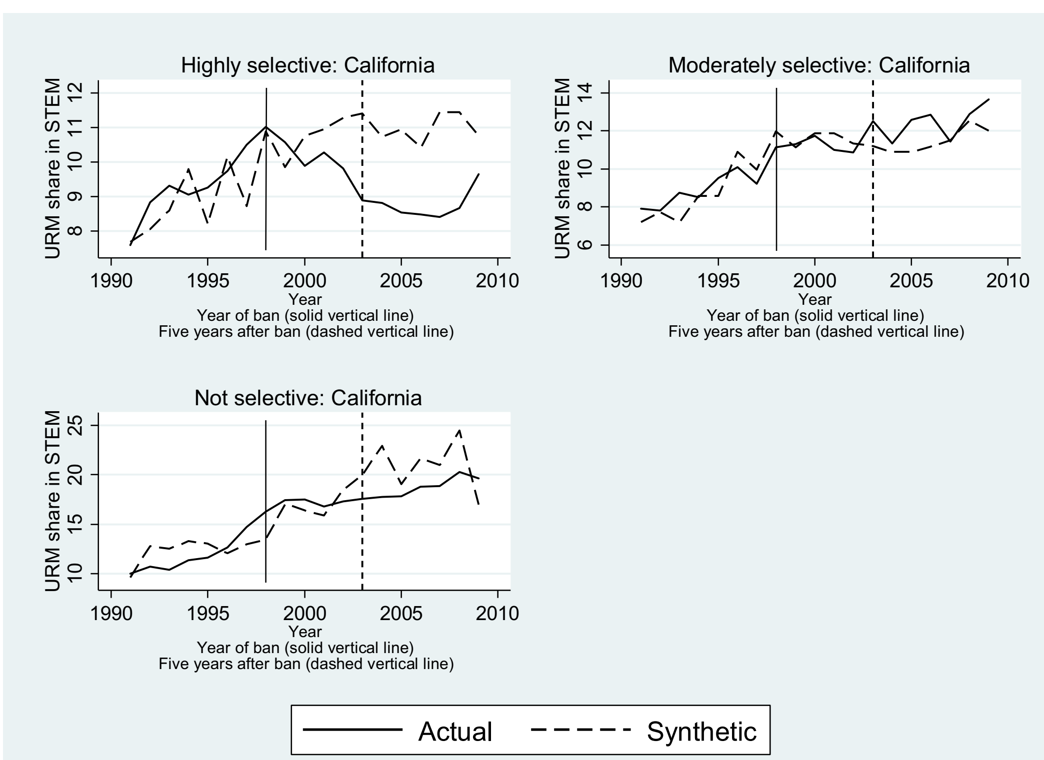

Fig. 4. Synthetic control plots grouping colleges by selectivity: California.

The findings are largely consistent with those from the difference-in-difference analysis. There is a clear reduction in the minority share of STEM degree completions at highly selective colleges four or five years after affirmative action is banned, while there is no effect at moderately selective or nonselective colleges.

6. Conclusion

The importance of increasing the number of minorities completing STEM degrees is underscored by the large projected growth in the minority population and the argument that STEM graduates boost the competitiveness of the US economy. Increasing the number of minorities in STEM also has the potential to reduce race income gaps given the large labor market returns that minorities receive in STEM fields (Melguizo & Wolniak, 2012).

Difference-in-difference, event study and synthetic control analyses reveal that minority STEM degree completions in public four-year colleges decline following statewide affirmative action bans. The effect is found at highly selective colleges and most evident in engineering programs. We cannot find convincing evidence of effects at moderately selective colleges, and, when considering highly and moderately selective colleges combined, minority participation in STEM also appears to decline. Overall, these findings suggest that student-college mismatch in STEM arising from race preferences in college admissions does not appear to be an overarching and pervasive phenomenon in the study sample, and affirmative action may actually be an effective policy for boosting minority representation in STEM in some circumstances.

At the same time, results should be interpreted with caution as the college-level analysis and aggregate effects estimated in the paper cannot fully capture individual student pathways through college. Another notable caveat is that affirmative action bans also increase the number of students of unknown race completing STEM degrees, which is consistent with an emerging literature that argues that minorities may no longer perceive an incentive to report their race after affirmative action is banned (Antman & Duncan, 2015). The effect estimated in this paper may be biased upward if the increase in race unknown degree completions is driven by minorities changing their race reporting behavior, although bounding exercises and the pattern of effects suggests that this is unlikely to explain the full reduction in minority STEM degree completions.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.econedurev.2017.01.003.

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