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Examining the Impact of State-Level Affirmative Action Bans on the Enrollment of Historically Excluded Students in Engineering Schools

Dr. Alison Leigh Banka, University of Georgia

Dr. Alison Banka is a Lecturer in the School of Chemical, Materials, and Biomedical Engineering at the University of Georgia. Her current educational and research interests include the incorporation of professional skills (such as teamwork and industry-relevant types of technical communication) and active learning into core engineering courses.

Dr. Agnes Germaine d'Entremont, P.E., University of British Columbia, Vancouver

Dr. Agnes d'Entremont, P.Eng., is an Associate Professor of Teaching in the Department of Mechanical Engineering at UBC. Her work focuses on student learning and curriculum development in mechanical engineering. She teaches courses in mechanics, including orthopaedic biomechanics and injury biomechanics, and mechanical design, and teaches Arts and Commerce students about engineering. Her teaching-related interests include active learning, open educational resources (OER), and open pedagogy. She also focuses on student mental wellbeing and equity, diversity and inclusion (EDI) issues in engineering education and the broader engineering profession.

Dr. Katherine A. Lyon

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Introduction

Affirmative action policies were originally implemented in the United States to correct disadvantages felt by historically excluded groups [1]. Nine individual U.S. states have since banned affirmative action practices. These bans extend to college admissions, where applicant characteristics such as race and gender can no longer be taken into consideration. Past research on university enrollment in all degree programs has shown a decrease in enrollment of Black students, both overall and at public institutions specifically, associated with state-level affirmative action bans [2]. Because affirmative action policies traditionally have benefitted both white women students [3] and racialized students of all genders, there may be a downstream effect of affirmative action bans on the undergraduate enrollment of these students in engineering schools. However, a comprehensive study of the enrollment of historically excluded students by gender and race specifically in engineering schools both before and after state-level affirmative action bans have taken place has yet to be undertaken. This study aims to address the following questions: 1. Do affirmative action bans impact the enrollment of historically excluded groups, by race and gender, in engineering schools in the US? 2. Is there a difference in how affirmative action bans impact the enrollment of historically excluded students in engineering schools between private (not-for-profit) and public institutions? 3. How does the proportion of historically excluded engineering students change over time in states that enacted bans? 4. Do affirmative action bans impact the enrollment of underrepresented women of color in engineering in unique ways in states with bans?

Our study utilized annual survey data on enrollment (by gender and racial categories) from the American Society for Engineering Education (ASEE) and information about public/private status from the National Center for Education Statistics. We examined six states with current affirmative action bans for which there was sufficient enrollment data both before and after the ban (2005-2021): Michigan, Nebraska, Arizona, New Hampshire, Oklahoma, and Idaho. We used multi-level models to examine percentage enrollment before and after the ban, public/private institutional control, the interaction of the ban and institutional control, and changes over time, in multiple student groups by gender and race.

Background

Affirmative action (AA) in the United States (US) grew out of the civil rights movement and was first implemented in the labor market through executive orders in the 1960s [1]. Though legislation for AA in higher education does not exist at the federal level, many US colleges and universities individually implemented AA programs targeting African American students, and later incorporated other historically excluded groups. Nine states have outlawed race-based AA since the mid-1990s: California, Arizona, Florida, Idaho, Michigan, Nebraska, New Hampshire, Oklahoma, and Washington. At the time of writing, the US Supreme Court had heard oral arguments in two separate court cases brought against Harvard University and the University of North Carolina; the court's decision will likely be decided in June 2023 and will have far-reaching consequences on the state of AA within the US [4].

The nine state-level affirmative action bans occurred through a variety of methods in two branches of the government: executive and legislative. The AA ban in the state of Florida is the only ban to be enacted via the executive branch; this ban was implemented via an executive order by the governor in 1999 [5]. The bans in New Hampshire and Idaho were passed by the state legislature [6], [7], while the remaining bans were approved via voter referenda. AA bans are often influenced by the judiciary; the appearance of AA bans as voter initiatives often occurred after high-profile court cases brought by students that were denied admission to a university or professional school. For instance, in 2003, the University of Michigan president served as the defendant in two cases, *Grutter v. Bollinger* and *Gratz v. Bollinger*, in which a white student or students were denied application to either the University of Michigan Law School or for undergraduate admission [8], [9]. Three years later, a ballot initiative to ban AA practices in Michigan was passed. Conversely, the state of Texas had an AA ban in place beginning in 1996 following a court case brought against the University of Texas Law School [10]. This ban, originally due to the court case against a Texas law school, was later overturned in 2003 by the U.S. Supreme Court in a separate case brought against the University of Michigan's Law School. The Supreme Court ruled in 2003 that the University of Michigan Law School's holistic "race-conscious admissions program does not unduly harm nonminority applicants" [8]; this ruling re-established that affirmative action policies could be used in admissions, provided that explicit quotas are not used.

AA bans, and the racial rhetoric that accompanies them [11], can have widespread effects in anti-affirmative action states both within and beyond educational institutions. AA bans have been shown to increase the health risk behaviors of underrepresented (UR) minority youth, and UR minority adults who were exposed to bans while in high school are more likely to smoke years later [12]. In the workforce, bans reportedly impact the demographic makeup of employees in private sector firms housed in ban states [13]. Rates of interracial marriage also decrease in states with bans in place [14].

Within education, scholars have considered the impact of AA bans on UR student applications, admissions, yield rates [15], enrollment [16], [17], attendance [2], persistence, and degree attainment across post-secondary fields of study, with some attention to STEM in particular [18],

[19]. Findings show a decrease in UR student STEM undergraduate degree attainment in states with AA bans [14], [20], with UR student degree completions at highly selective colleges the most impacted [21]. Yet few scholars have considered the impact of bans in engineering specifically. It is of particular importance to consider the impacts within engineering undergraduate education because this field has historically had low rates of UR student enrollment, particularly for Black, Native American, and Hispanic groups [22], [23]. More specifically, the percentage of engineering bachelor's degrees awarded to Black, Native American, and Hispanic students has stagnated over the last ~20 years. These groups remain underrepresented in comparison to their proportion of the population as a whole in the US.

The percentage of engineering bachelor's degrees awarded to women overall has similarly stalled [22]. White women students, and UR men and women students are more likely to switch out of a STEM major or leave college without a degree or certificate in comparison to white men [19]. These findings can be explained in part by a 'chilly' environment for UR men and women, and white women engineering students, that may be marked by the social pain of isolation, invisibility, stereotype threat, harassment (including sexual harassment), and discrimination [24], [25].

Engineering education has also been associated with less inviting institutional structures and cultural climates specifically for underrepresented women of color in engineering (UWOCE) [24], [25]. Scholarship utilizing an intersectional lens [26]–[28] shows that racialized women in STEM education encounter systemic barriers, tied to interlocking systems of racism and sexism [24], [25], [29]. Ong, Jaumot-Pascual and Lily [25] find that when racialized women persist in pursuing engineering education trajectories they do so "in spite of strong, pervasive cultural messages that WOC do not belong in the field due to both their race/ethnicity and gender." The rejection and lack of belonging experienced by WOCE cannot be reduced to race or gender, but an interaction between these social locations, within "predominantly White and male" engineering environments [25].

While much STEM scholarship examining AA bans focuses on UR students with little attention to student gender, we build on a growing body of intersectional work acknowledging the unique positioning of underrepresented women of color in engineering (UWOCE). We contribute to the research on UWOCE by focusing on the role of state-level legislation in shaping racialized women's access to engineering education, thus expanding the lens beyond the established focus on factors within educational institutions (such as programs, faculty and peer interactions, and extracurricular opportunities) [25].

The impact of AA programs (and the banning of these programs) upon white women also tends to be overlooked in US literature, though gender is given more attention in research from other nations [30]. Gender becomes more or less relevant to AA depending on how this legislation is interpreted and applied [30]. The US Supreme Court mandates a holistic AA approach in comparison to mechanistic programs in countries such as India where UR student quotas must be met per the Indian Constitution [1]. AA programs that consider race as only one of many factors are likely to benefit white women (particularly those from lower-income families). For example, the University of Michigan has previously utilized AA programs targeting students from rural areas, including northern Michigan, which has a large white population [31]. There may be some irony here, since white women are often the ones to bring anti-AA lawsuits despite potentially indirectly benefiting from them [32].

Our research aims to address several gaps within the current literature. First, much of the existing literature focuses on one specific state pre- and post-ban. We aim to look at all states with AA bans instead as a whole to determine the impact of bans throughout the US in disparate states. Second, much of the existing research focuses on UR students regardless of gender; we aim to examine the impact of AA bans on white and racialized women by incorporating an intersectional approach. Third, much of the existing research has examined the impact of bans on UR student enrollment overall; fewer studies explored the impact of bans on engineering specifically. Instead, previous studies typically grouped engineering together to examine STEM enrollment overall.

In sum, this study aims to address the following questions: Do affirmative action bans impact the enrollment of historically excluded groups, by race and gender, in engineering schools in the US? Is there a difference in how affirmative action bans impact the enrollment of historically excluded students in engineering schools between private (not-for-profit) and public institutions? How does the proportion of historically excluded engineering students change over time in states that enacted bans? Do affirmative action bans impact the enrollment of underrepresented women of color in engineering in unique ways in states with bans?

Methods

We obtained ASEE College Profiles data for 2005-2021 - these are the years for which undergraduate enrollment data by gender and race were available. Since this data is publicly available, our research ethics board does not require research study review.

Gender data was limited to the categories “male” and “female”. We will use these terms when examining the data, but will use the terms “men” and “women” in discussing the results in line with our constructionist approach to gender [33]. We acknowledge that there is a difference in meaning between these terms (e.g., male versus man), and that the dataset does not represent all genders (i.e., non-binary).

Racial data was distributed among the following categories:

- American Indian/Alaska Native

- Asian
- Black
- Foreign
- Hispanic
- Multiracial (added in 2010)
- Native Hawaiian/Pacific Islander
- White
- Other/Unknown (changed name of category in 2010)

We acknowledge that these categories do not all represent racialized status (e.g. Foreign). Further, we acknowledge that individuals may prefer to self-identify as Latino/a/x/e rather than, or in addition to, Hispanic or another racial category from this data set [34], [35]. However, for consistency, we decided to utilize the terms reported in the ASEE College Profiles data rather than attempt to recategorize or redistribute student data.

Because the numbers of students who identified as American Indian/Alaska Native or Native Hawaiian/Pacific Islander were very small, these categories were combined into one Indigenous category.

Information about a school's state and "control-of-institution" (public, private non-profit, or private for-profit) was attached to this data using information from the Integrated Postsecondary Education Data System (https://nces.ed.gov/ipeds/).

Data cleaning was performed by examining the data for unexpected values (such as zeroing out a large gender-racial group in only one year) and duplication of multiple categories of data across years. We removed 885 suspect school-year rows, which resulted in removing 7 schools entirely. The final national data set included 4,667 school-year rows, with 364 schools in 52 states/territories.

The overall national trends in each gender-racialized group were determined in order to remove larger demographic shifts, such as the consistent increase in the fraction of women in engineering nationally over this timeframe (Fig. 1). We also focused on fractional changes (change in student body make-up), to remove the effect of changes in total enrollment at some schools over time. Because some of the racial categories were not fully available (Multiracial) or sometimes seemed to change with a shift into or out of other categories in some years (e.g., one year had a large bump in "unknown" and a drop in a mix of other categories), we chose our denominator to be the sum of "known" racial categories (i.e., Indigenous, Asian, Black, Hispanic, and White). We also expected that an affirmative action ban may lead to more impact on incoming students than students who are already enrolled. As such, we also examined the fractions (relative to the overall US fractions) of gender-racial groups among first-year students only. The US national trends in first-year student enrollment gender-racial categories (Fig. 2) are similar to the US national trends in total enrollment.

Multi-level models (MLMs) were used to determine the change after a ban in states that banned affirmative action within the period of data we have available (6 states). Multi-level models are statistical models that allow a nested comparison, where the schools within a state are not expected to be independent because they are all influenced by some of the same factors (e.g., state-level policy, state racial population distribution, etc.). As a result, the data for each school is fit prior to the ban and again after the ban, and considers that schools within a state are likely to be related (e.g., drawing from a similar population). These models include fixed effects (such as the presence or absence of a ban - that is, a variable that can only attain certain values) and random effects (such as the cumulative qualities of different states that impact the outcomes in that state differently from other states).

For each gender-racialized category (2 genders x 5 racial categories = 10 fits), several MLMs were fit to the data for all 6 states, and the best model was determined by the lowest Bayesian Information Criterion (BIC). The BIC approach considers how well the model fits the data, but penalizes for each additional factor added to the model. This provides an optimal model for that group. In addition to the gender-racial categories above, we also looked at female students overall (all racial categories, 1 model) and underrepresented (UR) female and male students (together and separately, 3 models total), again finding the best model for each of these three fits as the one with the lowest BIC. UR was defined as Black, Hispanic, and Indigenous students.

To account for multiple comparisons in non-independent data, we used the Bonferroni correction for 14 models and an original α of 0.05, leading to an α of 0.0036 for statistical significance.

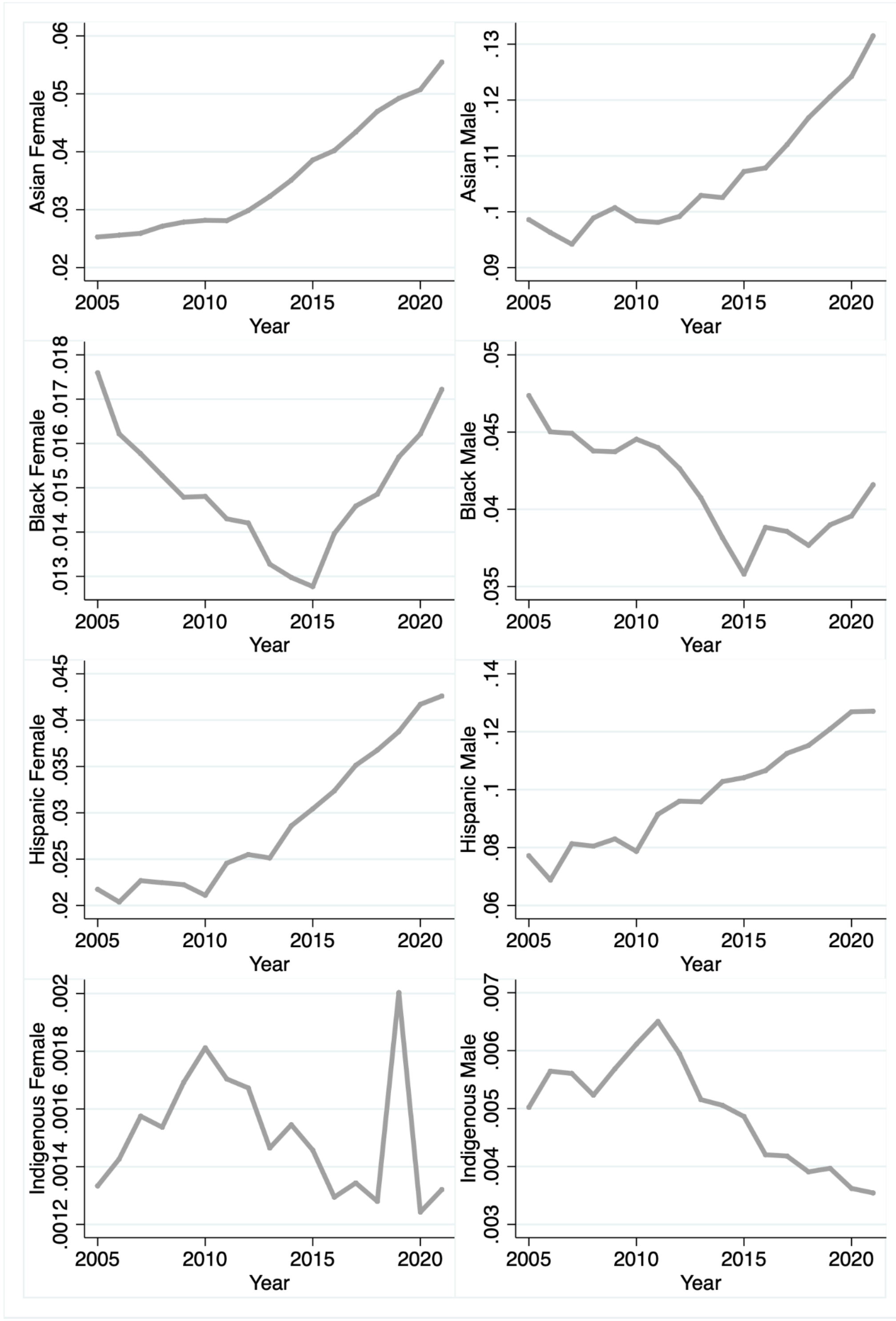

Figure 1. US changes in gender-racial groups as fractions of total engineering undergraduate enrolment 2005-2021. Note that graphs are not to the same scale in order to view changes of groups with smaller fractions of the total US engineering undergraduate population.

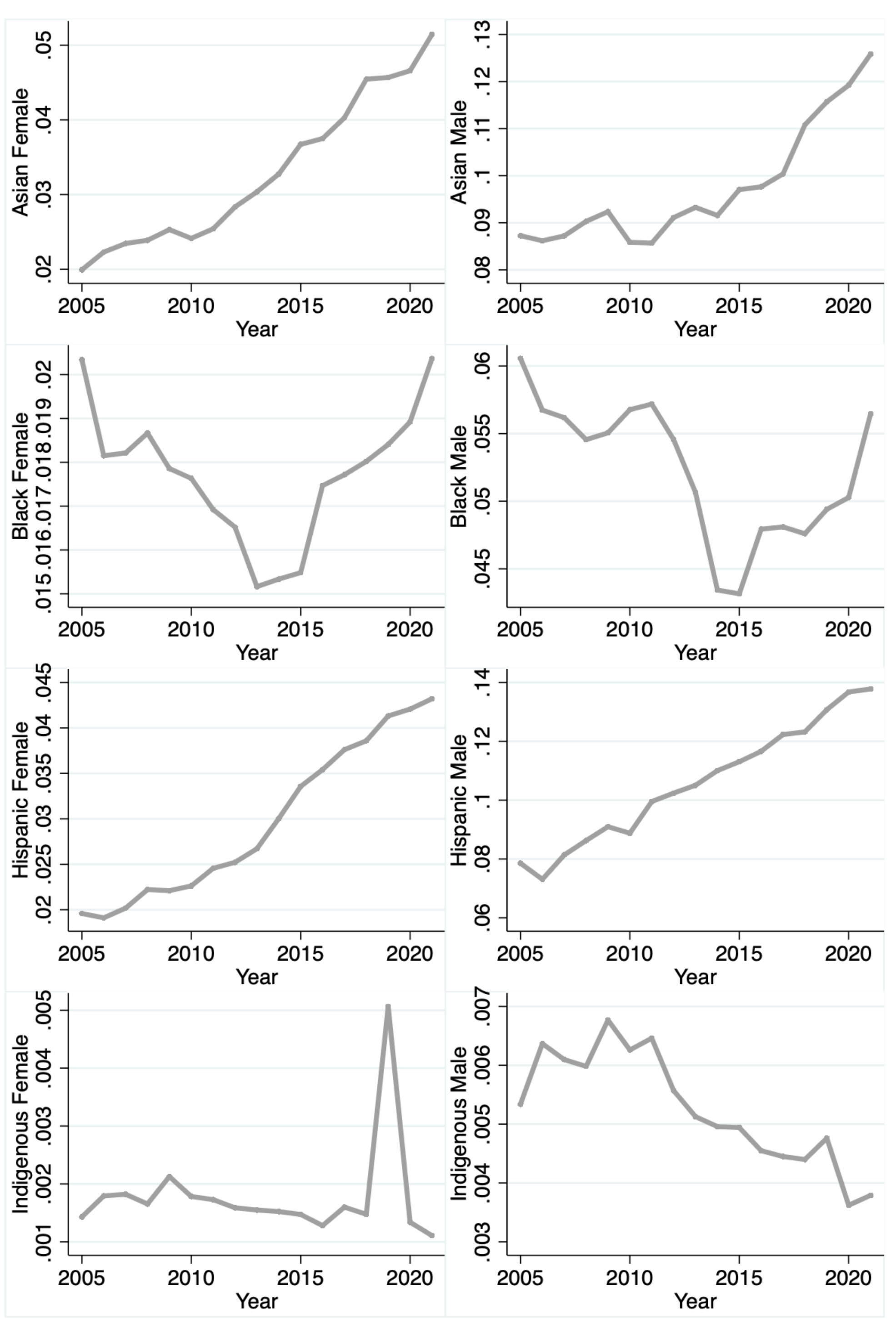

Figure 2. US changes in gender-racial groups as fractions of total first-year engineering undergraduate enrolment 2005-2021. Note that graphs are not to the same scale in order to view changes of groups with smaller fractions of the total US first-year engineering undergraduate population.

Results

We had data for 35 schools within the six states that enacted affirmative action bans between 2005 and 2021 (that is, Arizona, Michigan, Nebraska, New Hampshire, Oklahoma, and Idaho), with 460 school-year observations total. There were only public and private not-for-profit institutions in this sample (i.e., no private for-profit institutions). We took the calendar year of the ban as the academic year (starting September) of data that would have been impacted by the ban.

In each group, the model had fixed effects of year, control-of-institution, and ban status. In some models (specific models are listed in detail below), an interaction between ban status and control-of-institution was included as a fixed effect (that is, asking if the ban impacted private institutions differently from public ones).

For overall enrollment (Table 1), the best models for Asian Female, Asian Male, Black Female, Hispanic Male, and White Male included the interaction term between ban and control-of-institution. For Black Male only, the best model allowed each state to have its own slope (change over time) as well as intercept.

For larger groups in overall enrollment (Table 2), all best models include the interaction term between ban and control-of-institution, and the best UR Male + Female model allowed each state to have its own slope as well as intercept.

For first-year enrollment (Table 3), the best model for every group except Hispanic Female and Indigenous Female included the interaction term between ban status and control-of-institution. The best models for Asian Male and White Female also allowed each state to have its own slope as well as intercept.

For larger groups in first-year enrollment (Table 4), all best models include the interaction term between ban and control-of-institution, and both overall Female and UR Male groups had best models where each state allowed its own slope as well as intercept.

The results of the models by gender-racial groups showed that the fraction of Hispanic female students increased (+0.63%) when a ban was in place (Table 1). There were several significant results related to control-of-institution - for example, Indigenous Male students are -0.65% lower at private not-for-profit institutions than at public institutions (regardless of the ban status) in these states. There were no statistically significant interaction effects of an affirmative action ban and control-of-institution - that is, we don’t expect that the bans impacted public institutions and private not-for-profit institutions differently.

When considering the effect of time, we saw statistically-significant decreases in Asian and Hispanic Females, and Hispanic Males year-over-year in these states that implemented affirmative action bans (e.g. -0.12% per year for Asian Females, Table 1). Note that this change over time is independent of the impact of a ban within the model - a ban is modeled as a change in intercept, while the year-over-year change is modeled as the slope, and the models assume the same slope before and after the ban. A direct effect of the implementation of an affirmative action ban would be shown as a significant result in the "effect of ban" factor instead.

Other observations related to change over time include non-significant (but $p < 0.08$) decreases in Black and Indigenous Females and Asian and Indigenous Males year-over-year in these states (Table 1). White Female students had a statistically-significant increase over time in these states, and White Males had a non-significant (but $p < 0.05$) increase over time. These numbers represent the change in fraction of each group as part of the student population. Therefore, when one group sees a year-on-year increase, at least one other group must see a year-on-year decrease.

Since we are considering fractions of each known gender-racial group, the sum of all of the changes to all groups together over time should equal zero. However, we fit each group with separate models, so we wouldn't expect the sum of the changes per year in all the known gender-racial groups to equal zero exactly. The sum comes to -0.02% per year, giving us some confidence that the changes being modeled are internally consistent.

We also considered larger overall groups of Females, UR Females and Males, UR Females, and UR Males (Table 2). While there was no statistically significant effect of a ban, control-of-institution or the interaction between these terms for any group, we see a statistically significant decrease in UR Female students over time (-0.10% per year) in these states as compared to the national fraction of those students in the same years.

Table 1: MLM results for effects of time, affirmative action bans and control-of-institution on fraction of engineering undergraduate students in states that implemented bans. Each row represents the results from the best model for that group. All values are relative to the model of the original value (not shown), which was the fraction of that group at each school minus the fraction of that group at US schools overall in the same year. For example, the effect of the ban on Hispanic females was a 0.63% increase in their population at schools in these six states after the ban compared to before the ban, accounting for year-on-year changes in national trends. Another example, Indigenous Male students had a population that was 0.65% lower at private not-for-profit institutions in these six states compared to public institutions in these six states. (Note: "--" indicates that the term was not included in the best model for that group). $p < 0.0036$ is statistically significant.

Gender-Racial Group (All years)	**Effect of time (slope, change per year)**		**Effect of ban (change with enacting ban)**		**Effect of control- of-institution (diff. at private institutions (vs public institutions))**		**Effect of interaction between ban and control-of- institution (diff. at private instit. after the ban)**	
	Diff. in fraction of group	**p-value**	**Diff. in fraction of group**	**p-value**	**Diff. in fraction of group**	**p-value**	**Diff. in fraction of group**	**p-value**
Asian Female	**-0.0012**	**<0.001**	0.0044	0.138	-0.0001	0.981	0.0018	0.635
Asian Male	-0.0009	0.027	0.0056	0.359	-0.0026	0.702	-0.0044	0.585
Black Female	-0.0004	0.018	0.0012	0.636	0.0056	0.045	-0.0019	0.568
Black Male	0.0001	0.921	0.0062	0.388	0.0047	0.353	–	–
Hispanic Female	**-0.0006**	**<0.001**	**0.0063**	**<0.001**	**0.0036**	**0.001**	–	–
Hispanic Male	**-0.0010**	**0.001**	0.0103	0.028	-0.0117	0.023	0.0129	0.033
Indige-nous Female	-0.0001	0.055	-0.0009	0.199	-0.0007	0.104	–	–
Indige-nous Male	-0.0003	0.077	-0.0044	0.026	**-0.0065**	**<0.001**	–	–
White Female	**0.0016**	**<0.001**	-0.0095	0.088	**0.0144**	**<0.001**	–	–
White Male	0.0026	0.041	-0.0024	0.896	0.0102	0.375	-0.0419	0.083

Table 2: MLM results for effects of time, affirmative action bans and control-of-institution on fraction of engineering undergraduate students in states that implemented bans. All values are relative to the original value (not shown), which was the fraction of that group at each school minus the fraction of that group at US schools overall in the same year. $p < 0.0036$ is statistically significant.

Gender and/or Racial Group (All years)	**Effect of time (slope, change per year)**		**Effect of ban (change with enacting ban)**		**Effect of control- of- institution (diff. at private institutions (vs public institutions))**		**Effect of interaction between ban and control-of- institution (diff. at private instit. after the ban)**	
	Diff. in fraction of group	**p-value**	**Diff. in fraction of group**	**p-value**	**Diff. in fraction of group**	**p-value**	**Diff. in fraction of group**	**p-value**
Female	-0.0006	0.375	-0.0112	0.225	-0.0026	0.800	0.0294	0.014
UR Female and Male	-0.0019	0.038	0.0075	0.554	-0.0125	0.374	0.0215	0.196
UR Female	**-0.0010**	**<0.001**	0.0012	0.751	-0.0011	0.784	0.0115	0.016
UR Male	-0.0011	0.100	0.0095	0.347	-0.0127	0.256	0.0114	0.386

We also considered first-year enrollment separately, as the impact of affirmative action bans may affect initial enrollment more than persistence. Indigenous Male First-years were the only group to demonstrate a direct impact of affirmative action bans, with a change of -0.94% with a ban (Table 3). Otherwise, results were similar to the overall enrollment results, with statistically-significant decreases in Asian Females and Hispanic Females over time and non-significant trends showing decreases in many racialized/UR groups and increases in white students in these states that implemented affirmative action bans. There were no differences based on control-of-institution - that is, student populations were not different at public and private not-for-profit institutions in general - and, as before, there were no statistically significant interaction effects of an affirmative action ban and control-of-institution - that is, we don’t expect that the bans impacted public institutions and private not-for-profit institutions differently.

When considering the same larger groups as we did with overall enrollment, we similarly found that UR Female First-years showed a statistically significant year-over-year change (-0.13% per year) in these states that implemented affirmative action bans (Table 4).

Table 3: MLM results for effects of time, affirmative action bans and control-of-institution on fraction of first-year engineering undergraduate students in states that implemented bans. Each row represents the results from the best model for that group. All values are relative to the model of the original value (not shown), which was the fraction of that group at each school minus the fraction of that group among first-years at US schools overall in the same year. For example, the effect of the ban on Indigenous male first-years was a 0.94% decrease in their population at schools in these six states after the ban compared to before the ban, accounting for year-on-year changes in national trends. (Note: "--" indicates that the term was not included in the best model for that group). $p < 0.0036$ is statistically significant.

Gender-Racial Group (First-years)	**Effect of time (slope, change per year)**		**Effect of ban (change with enacting ban)**		**Effect of control- of-institution (diff. at private institutions (vs public institutions))**		**Effect of interaction between ban and control-of- institution (diff. at private instit. after the ban)**	
	Diff. in fraction of group	**p-value**	**Diff. in fraction of group**	**p-value**	**Diff. in fraction of group**	**p-value**	**Diff. in fraction of group**	**p-value**
Asian Female	**-0.0012**	**<0.001**	0.0040	0.355	0.0014	0.778	0.0016	0.787
Asian Male	-0.0011	0.122	0.036	0.601	0.0030	0.689	-0.0072	0.414
Black Female	-0.0006	0.022	0.0017	0.640	0.0075	0.072	-0.0028	0.563
Black Male	-0.0001	0.936	0.0145	0.158	0.0189	0.107	-0.0222	0.109
Hispanic Female	**-0.0006**	**<0.001**	0.0038	0.076	0.0029	0.042	–	–
Hispanic Male	-0.0011	0.009	0.0080	0.199	-0.0117	0.088	0.0108	0.182
Indige-nous Female	-0.0002	0.044	-0.0006	0.565	-0.0001	0.924	–	–
Indige-nous Male	-0.0002	0.278	**-0.0094**	**0.002**	-0.0072	0.029	0.0043	0.268
White Female	0.0011	0.069	-0.0120	0.179	-0.0066	0.515	0.0144	0.227
White Male	0.0030	0.033	0.0012	0.956	0.0077	0.744	-0.0177	0.523

Table 4: MLM results for effects of time, affirmative action bans and control-of-institution on fraction of first-year engineering undergraduate students in states that implemented bans. All values are relative to the original value (not shown), which was the fraction of that group at each school minus the fraction of that group at US schools overall in the same year. $p < 0.0036$ is statistically significant.

Gender and/or Racial Group (First-years)	**Effect of time (slope, change per year)**		**Effect of ban (change with enacting ban)**		**Effect of control- of-institution (diff. at private institutions (vs public institutions))**		**Effect of interaction between ban and control-of- institution (diff. at private instit. after the ban)**	
	Diff. in fraction of group	**p-value**	**Diff. in fraction of group**	**p-value**	**Diff. in fraction of group**	**p-value**	**Diff. in fraction of group**	**p-value**
Female	-0.0010	0.204	-0.0102	0.378	-0.0039	0.763	0.0205	0.206
UR Female and Male	-0.0025	0.024	0.0087	0.594	-0.0010	0.954	0.0054	0.799
UR Female	**-0.0013**	**<0.001**	-0.0007	0.896	0.0005	0.934	0.0109	0.101
UR Male	-0.0012	0.167	0.0082	0.522	-0.0005	0.971	-0.0065	0.705

Discussion

Our approach allows us to comment on both the direct effect of the bans on the fraction of UR students in undergraduate engineering programs in six states with bans, as well as changes in UR student enrollment in undergraduate engineering over time in these states. In addressing these questions, we highlight the unique outcomes for underrepresented women of color in engineering (UWOCE) and white women in engineering.

(Lack of) Impacts of Affirmative Action Bans (Addresses Research Questions 1 and 2)

Our data indicate that the bans did not have a direct, statistically-significant impact on UR student populations at engineering schools in ban states – even when these groups were broken down by gender – with the exception of a decrease in Indigenous male first-years and an increase in Hispanic females. Though previous literature indicates that white women are indirect beneficiaries of affirmative action [32], [36], we did not see a decrease in their numbers after the ban, suggesting white women in engineering school do not benefit more than any other group from affirmative action in these particular states, though this requires further study. Further, our data do not indicate that there is a difference between the impact of bans on enrollment in engineering at private schools in comparison to public schools. In sum, the AA bans don't seem to be as impactful as we might have expected in shaping the number of UR students in undergraduate engineering education in states with bans. However, there may be at least three processes at work that we did not capture: 1) changes in the qualifications of UR students enrolled, 2) the decline-rebound process, and 3) indirect policies with equity impacts.

First, although the overall numbers of UR students are not significantly impacted by the AA bans, it may be higher-achieving UR students increased in enrollment post-ban than otherwise would have, with lower achieving UR students pushed to less selective public institutions [37] and for-profit private institutions [14] (not captured by our data).

Second, existing research suggests that AA bans initially decrease numbers of UR students across undergraduate fields of study, but that the population of these student groups recovers within a few years. For example, when affirmative action was banned by ballot in Washington State, the proportion of minority high school seniors who went to college in Washington State decreased temporarily, due to declines in minority application rates, though this decrease did not last [38]. Given that our model considers all of the years after the ban, the lack of statistically significant results may be because the initial impact of the bans is averaged out over time. More research is needed to determine whether UR student enrollment in engineering programs follows the decline-rebound process found in other fields of study.

Third, the lack of impact of the AA bans on UR student population is likely tied to schools and individual states taking other steps to get around bans, or so called 'indirect' affirmative action [39]. For example, California's affirmative action ban first effectively impacted the incoming class of 1998. There is evidence that University of California schools responded by redistributing the weight of aspects of undergraduate applications, specifically by lowering the weight given to SAT scores and increasing the weight to high school GPA and family background, including familial income and parental college attendance [37]. Similarly, following its (temporary) affirmative action ban in 1997, the state of Texas proposed several strategies to reduce the impact on UR student enrollment at its universities, including admitting the top 10% of each high school's graduates to any public university in the state, changing scholarship criteria, and revamping the application process such that students were evaluated 'holistically' [39], [40]. On a single university basis, the University of Michigan complied with the state's affirmative action ban while also giving additional weight to college applications from underrepresented 'clusters' (influenced by neighborhood and family affluence), changing scholarships, and heavily recruiting [41]. These 'indirect' policies may help blunt a decline in UR student enrollment in engineering and additionally contribute to the 'rebound' of UR enrollment several years post-ban.

‘Chilly’ States and Underrepresented Women of Color in Engineering (UWOCE) (Addresses Research Questions 3 and 4)

In addition to commenting on the direct effect of the bans, we can comment on changes in UR student enrollment in undergraduate engineering over time in the six states which enacted bans within the timeframe of our dataset. UWOCE – specifically Black, Indigenous, and Hispanic women students – saw reductions in their numbers over time in states with a ban (as compared to their numbers at the national level in the same years). In other words, our findings show that UWOCE students were less likely to be enrolled in undergraduate engineering education programs in ban states over time. Though we cannot identify whether this is due to lower UWOCE student applicants, admissions, or persistence, our finding suggests that there are social factors beyond the bans themselves at play.

The social and political context in which bans emerge and persist has been associated with socio-psychological effects for UR students. Bowen [42] argues that at a state level, the rhetoric legitimizing bans reifies racialized status hierarchies and increases racialized stigma under the guise of misapplied colorblindness. For example, UR biomedical students in states with a ban were more likely to report experiencing internal and external race-based stigma than their UR peers in states with affirmative action, suggesting that “higher rates of hostility and stigma persist in schools located in anti-affirmative action states” [42]. In comparison to UR students in states that permit race-based admissions, UR students in states with bans were more likely to report encountering overt acts of racism from other students, to report feeling pressure to prove themselves “because of their racial group membership,” to have questioned their qualifications to be at the school, and to believe that their faculty and/or advisors have lower expectations of them in comparison to their white peers [42]. Presumably, racialized hierarchies and stigma were not entirely created by the bans, but also preexisted (and may have normalized) the bans. In other words, affirmative action bans are a symptom of preexisting “chilly” conditions within a state. These conditions include but are not limited to public narratives communicated through political discourse and public policy debates many years before a ban is put into place [11].

Yet it is racialized women–not racialized men or White women–who are less likely to be enrolled in undergraduate engineering education over time in anti-affirmative action states (independent of the specific ban timing). One interpretation of this finding, which requires further study, is that UWOCE are more likely than other student groups to be concerned with or impacted by the perceived social and political climate of the states in which they study. Across studies, WOCE report valuing faculty, staff, programs and resources that they perceive as “safe spaces” and that affirm their “belonging in engineering” to help them navigate barriers shaped by both racism and sexism [25]. It may be that state social and political climates perceived to be unwelcoming run counter to the heightened and persistent need for safety and belonging felt by WOCE students and/or prospective students.

Methodologically, it is worth noting that when we ran the data and grouped all women together (across racial categories) the results were not statistically significant. Similarly, when we ran the data and grouped all underrepresented racial groups together (across all genders), the results were not statistically significant. It was only when we ran the data based on gender-racial groups (e.g., Hispanic women, UWOCE, etc.) that we saw statistically significant results, thus reaffirming the importance of an intersectional approach to the study of AA bans for engineering education. We would have missed this significant outcome had we not considered the interaction of gender and race.

Future Directions, Strengths, and Limitations

Future research must consider not only the impact of the bans themselves, but the impact of the social context in which they arise. This broader context could be captured through more precise data teasing out distinctions between rates of UWOCE student applications, admissions, enrollment, persistence, and degree attainment in ban states over time. More qualitative research utilizing interviews, focus groups, and participant observation would also capture classroom climate dynamics and the perceptions and experiences of students from dominant and historically excluded groups. Further, future work can explore if school size and 'eliteness' of schools changes the impact of bans in this broader social context. A common theme with UR groups in engineering is the feeling of isolation, or 'being the only one' [25]; affirmative action bans may then impact enrollment and persistence of UR students in smaller schools, where UR students are more likely to be the 'only one', more than larger schools. Previous research determined that affirmative action bans had the largest negative impact on the enrollment of UR students at highly selective schools [21], [37], [43], [44], so further exploration to determine if this trend holds for engineering enrollment specifically is needed. In particular, given recent court proceedings filed against elite private institutions (*Students for Fair Admissions, Inc. v. President & Fellows of Harvard College*; [4]), subdividing schools into private, public, elite, and non-elite may elucidate interactions between these two school characteristics and impact of bans.

Strengths of this approach using MLMs include being able to consider non-independent data (e.g. we expect changes within a state to be related), being able to manage missing data (not all schools report every year), and allowing each state to have its own intercept (and slope for state in some models) for linear fitting; this separation of states is key as we expect states like Michigan and Arizona, for instance, to differ from each other significantly in terms of demographics and college enrollment trends. This type of model also allows us to include states where bans took place at different times. We were able to remove underlying national demographic changes, which allows us to separate changes due to bans in different years from larger shifts nationally. Note that the national data will include both these six states, as well as other states that have bans in place but did not enact the bans during the period for which we have data, namely California, Washington, and Florida. The inclusion of these states with bans likely makes this national demographic correction conservative to the impact of a ban as the non-ban states' use of affirmative action is 'diluted' by states with bans. This inclusion gives us confidence that changes we are seeing are real changes.

Limitations in this study include limitations in the underlying ASEE data about: other genders; Latinx versus Hispanic students; differences between sub-groups of Asian students; lack of intersectionality reported for international ("Foreign") students (i.e., international students were not classified by racialized status, therefore we could not include this population in UR groups); missing data for specific schools and years; and more. Further, there were some variables we were not able to explore in the current study. For instance, we did not explore the impact of school size or 'eliteness' on enrollment post-ban. It's also not clear how long after a ban the effects would show up in the student population - because the "after ban" period was fit to the same slope but with a different intercept, all the calendar years after the ban would have equal impact on the result, but some may be more impacted by the policy than others (e.g. students already enrolled at the time of the ban may not have been affected to the same extent as students applying to universities), and some states had more time post-ban in our data set. However, we were able to explore the idea that the enrolled upper year students might be less affected by examining first-year enrollment only, and found similar results. Finally, the current model assumed that the year of the ban would be the first year that academic enrollment data could be affected; future work can more finely explore the enrollment data *after* the ban was practically implemented in each state, rather than when it was decided on.

Conclusion

Our research demonstrates that AA bans do not appear to significantly impact the enrollment of historically excluded students in undergraduate engineering programs within anti-affirmative action states. However, there are at least three processes at work that we did not capture: 1) changes in the qualifications of UR students enrolled, 2) the decline-rebound process, and 3) indirect policies with equity impacts. Our data does suggest that underrepresented women of color are less likely to be enrolled in undergraduate engineering education over time in anti-affirmative action states (independent of the specific ban timing). A key take-away from this finding is that affirmative action bans may be a symptom of preexisting "chilly" conditions within a state. In comparison to other historically excluded groups, UWOCE students may therefore be more concerned with or impacted by the perceived social and political climate of the states in which they seek to study. We conclude by echoing Ong *et al*.'s argument [25] that the changes necessary to foster belonging for *all* students in engineering education "require engaging in the hard work of recognizing that … institutional cultures and expectations stem from a history of gender and racial/ethnic discrimination in which White men have been held up as the standard and embodiment of success."

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