

University Differences in the Graduation of Minorities in STEM Fields: Evidence from California*

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Abstract

The low number of college graduates with science degrees – particularly among under-represented minorities – is of growing concern. We examine differences across universities in graduating students in different fields. Using student-level data on the University of California system during a period in which racial preferences were in place, we show significant sorting into majors based on academic preparation, with science majors at each campus having on average stronger credentials than their non-science counterparts. Students with relatively weaker academic preparation are significantly more likely to leave the sciences and take longer to graduate at each campus. We show the vast majority of minority students would be more likely to graduate with a science degree and graduate in less time had they attended a lower ranked university. Similar results do not apply for non-minority students.

Keywords: STEM majors, Minorities, College Graduation.

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1 Introduction

Increasing the number of Science, Technology, Engineering, and Math (STEM) majors is seen as one of the key components to keeping the U.S. competitive in a global economy (Carnevale, Smith, and Melton 2011).¹ In a 2012 report, the President’s Council of Advisors on Science and Technology suggested that the number of STEM majors needed to increase by 34% over current rates to meet the demand for STEM professionals. The lack of STEM majors occurs despite STEM majors earning substantially more than other college degrees with the exception of perhaps business (Arcidiacono 2004, Kinsler and Pavan 2012, Melguizo and Wolniak 2012) and that the STEM premium has increased over time (Gemici and Wiswall 2011).²

Of particular concern is the lack of representation of minority students (Council of Graduate Schools 2007). Seymour and Hewitt (2000) point out that the National Science Foundation alone has spent more than \$1.5 billion to increase participation of minorities in the sciences, and two programs at the National Institute of Health have invested \$675 million in the same endeavor. At college entry, black and Hispanic students exhibit preferences for STEM fields that are similar to white preferences, yet their probabilities of persisting in these fields are much lower (Anderson and Kim 2006). The data for the University of California system between 1995 and 1997 used in this study show similar patterns. Namely, the percentage of college enrollees expressing an interest in science majors is 35% for both minorities and whites.³ Yet, 19% of white enrollees complete a degree in the sciences with the corresponding number for minorities at less than 11%. In a similar vein, among those who complete a degree in five years, 31% of whites and 17% of minorities graduate with a STEM major.

While different programs have been implemented with the aim to reduce the current racial disparities in shares of the U.S. workforce with STEM degrees, little is known about the role that colleges play in “producing” STEM degrees, especially for underrepresented minority groups.

¹The importance of STEM majors has recently been highlighted in a Florida proposal to freeze tuition for majors that are in high demand (Alvarez 2012) as a way of facilitating recovery from the recession. At the same time, some schools charge high tuition for more lucrative majors, citing fairness issues and differences in educational costs of different majors (Stange 2012).

²Data on subjective expectations from a variety of schools indicates students are aware of the general differences in earnings across fields. See Arcidiacono, Kang, and Hotz (2012), Stinebrickner and Stinebrickner (2011), Wiswall and Zafar (2012), and Zafar (forthcoming).

³Asian students have a higher initial interest in the sciences at 51%.

An important exception is the study by Griffith (2010), who finds that characteristics of colleges play a key role in the decision of students to remain in a STEM major and obtain a degree in any of these fields. For example, she finds that students at selective colleges with large research expenditures relative to total educational expenditures have lower persistence rates of students in the sciences, especially minority students. In this regard, understanding campus disparities in terms of the benefits and costs of producing STEM majors among minorities (and non-minorities) may have important implications for the way agencies, such as the National Science Foundation (NSF) and National Institutes of Health (NIH), allocate resources across colleges in the U.S. to increase the representation of minorities in such majors. Moreover, studying these differences by types of colleges (e.g., more selective vs. less selective) among minorities can be relevant to assess whether programs, such as affirmative action, improve minority representation among STEM degree holders or hinder it by encouraging minority students to attend colleges where success in STEM fields is unlikely.

In this paper, we make use of a rich database that contains information on applicants, enrollees and graduates of baccalaureate programs at the various campuses within the University of California (UC) system. These data include measures of students' academic preparation, intended major, and, conditional on graduating, their final major. The data reveal substantial sorting across majors between freshmen and senior year. Those with SAT scores that are high relative to the campus average are more likely to persist in a science major and graduate with a science degree.⁴ This is especially true for minority students. For example, at UC Berkeley minorities who persisted in the sciences had SAT scores over 100 points higher than those who switched to a major outside of the sciences. For non-minority students the gap was only 30 points. These differences also are reflected in the likelihood of graduating. At UC Berkeley, minority students who began in the sciences had less than a 31% chance of graduating with a science degree within five years, with the corresponding four-year graduation rate of 11%.

The differences across campuses in the rates of persistence in STEM majors and graduation

⁴Arcidiacono, Aucejo, and Spenner (2012) find that science, engineering, and economics classes give lower grades and require more study time than courses in the humanities and social sciences at the university they study. Further, those who switch majors were more likely to report it was due to academic issues if the initial major was in the sciences, engineering, or economics. Differences in grading standards may be part of the reason Sjoquist and Winters (2013) find negative effects of state merit-aid programs on STEM graduation as these programs often have GPA requirements.

rates reflect, in part, differences across campuses in the academic preparation of their students. But, they may also reflect campus differences in how academic preparation, especially in STEM majors, translates into graduation. As we discuss below – and document in our empirical analysis – while the more selective UC campuses (e.g., UC Berkeley and UCLA) have greater success in graduating better prepared students in STEM fields, they are not as successful as less-selective campuses (e.g., UC Riverside) in graduating less-prepared students in such majors.

We use data on minority and non-minority students⁵ who enrolled at one of the UC campuses between 1995 through 1997 to estimate a model of students’ decision to graduate from college with a particular major. We account for the initial selection into colleges via a Dale and Krueger (2002) approach, taking advantage of the rich data on where students submitted applications and where they were accepted. In addition, we allow campuses to differ in the attractiveness of particular majors. We do so by allowing the returns to academic preparation to be specific to the school and major combination. These returns are the combination of the reward in the labor market net of the difficulty of the course work. Schools and majors that reward academic preparation more than others will have relatively high persistence rates for those with high levels of academic preparation but relatively low persistence rates for those with lower levels of academic preparation.⁶

Estimates of the choice model reveal that the match between the student and the university is an important component for persistence in STEM majors. Students with relatively low levels of academic preparation will find majoring in a STEM field relatively less attractive at the most selective schools.⁷ Our estimates suggest that the vast majority of minority students who begin in the sciences at UC Berkeley would be more likely to graduate with a science degree had they enrolled in a less-selective campus, such as UC Santa Cruz or UC Riverside.⁸ The potential

⁵Throughout this paper, minority students consist of African Americans, Hispanics, and Native Americans, i.e., “under-represented minority groups” and non-minority students consist of whites and Asian Americans.

⁶Clearly those with higher levels of academic preparation will be more likely to persist at all schools. However, the school which makes it most likely that a particular student will graduate in a particular major may depend on the academic preparation of the student.

⁷Smyth and McArdle (2004) and Luppino and Sander (2012) also illustrate the importance of relative preparation in the choice of college major, finding that those who are significantly under-prepared are less likely to persist in the sciences. What distinguishes our work is the importance of the matching of student preparation with campus selectivity: students with strong (weak) academic characteristics are more likely to graduate in the sciences at the more (less) selective campuses.

⁸This finding is related to those in Arcidiacono (2005), who examines how the returns to college quality in

gains in minority graduation rates in the sciences from reallocating minority students are quite large. For example, minorities from UC Berkeley that are in the bottom quartile of the SAT score distribution would be twice as likely to graduate in the sciences at UC Santa Cruz or UC Riverside as they are observed to do so at UC Berkeley.⁹ In contrast, non-minority students that were enrolled at UC Berkeley would have had lower rates of persistence in the sciences if they had attended the two lowest-ranked UC campuses (UC Santa Cruz and UC Riverside). That is, for the purposes of science graduation rates, non-minority students are well-matched.

The rest of the paper is organized as follows. In Section 2 we describe the data we use on students who entered a UC campus in the falls of 1995, 1996 or 1997 and provide summary statistics. We also document the across-campus differences in the rates at which minority students persisted in and graduated with STEM and non-STEM majors. In Section 3 we develop an econometric model of the decision of students to graduate in alternative majors or not graduate when colleges differ in the net returns to students' academic preparation. Section 4 shows model estimation results and presents counterfactual simulations. Section 5 concludes.

2 The Data and Descriptive Findings by Race across UC Campuses

2.1 Majors and Graduation Rates

The data we use were obtained from the University of California Office of the President (UCOP) under a California Public Records Act request. These data contain information on applicants, enrollees and graduates of the UC system. The data are organized by years in which these students would enter as freshmen. Due to confidentiality concerns, some individual-level information was suppressed. In particular, the UCOP data have the following limitations:¹⁰

terms of subsequent earnings vary by a student's choice of major. His estimates suggest that, while the returns to college quality are slightly higher in the social sciences/humanities (but not education) than in the natural sciences, the differences in the return to college quality are small relative to the differences in earnings across majors.

⁹The fraction of minority students at Berkeley in the bottom quartile of the applicant distribution was 34% for the years 1995-1997, the period of our study.

¹⁰See Antonovics and Sander (2012) for a more detailed discussion of this data set.

1. The data does not provide the exact year in which a student entered as a freshman, but rather a three year interval.
2. The data provide no information on gender, and race is aggregated into four categories: white, Asian, under-represented minority, and other.¹¹
3. Academic data, such as SAT scores and high school grade point average (GPA), were only provided as categorical variables, rather than the actual scores and GPAs.
4. Detailed information on the specific majors that students stated on their college application or graduated in was not provided. Rather, we were provided information on groups of majors: *Science* (i.e., STEM), Humanities and Social Science majors.¹² In the following analyses, we aggregated the Humanities and Social Science categories into one, the *Non-Science* category.

Weighed against these limitations is having access to the universe of students who applied to at least one campus in the UC system and also whether they were accepted or rejected at every UC campus where they submitted an application.

Our analysis focuses on the choices and outcomes of minority and non-minority students who enrolled at a UC campus during the interval 1995-1997. During this period, race-conscious admissions were legal at all of California’s public universities. Starting with the entering class of 1998, the UC campuses were subject to a ban on the use affirmative action in admissions enacted under Proposition 209.¹³ While available, we do not use data on the cohorts of students for this later period (i.e. 1998-2005) as there is evidence that the campuses changed their admissions selection criteria in order to conform with Prop 209.¹⁴

We begin by examining the differences across campuses in enrollments, graduation rates and SAT scores by UC campus for both non-minority and minority students. Tabulations are presented in Table 1, with the UC campuses listed according to the *U.S. News & World Report* rankings as of the fall of 1997.¹⁵ Minorities made up 18.5% of the entering classes at UC campuses during this period. The three campuses with the highest highest minority shares are

¹¹The other category includes those who did not report their race.

¹²A list of what majors were included in each of these categories is found in Table 12 in the Appendix.

¹³See Arcidiacono, Aucejo, Coate and Hotz (2012) for analyses of the effects of this affirmative action ban on graduation rates in the UC system.

¹⁴See Arcidiacono, Aucejo, Coate and Hotz (2012).

¹⁵The 1997 *U.S. News & World Report* rankings of National Universities included 6 of the 8 UC campuses in their Top 50: UC Berkeley (27); UCLA (31); UC San Diego (34); UC Irvine (37); UC Davis (40); and UC Santa Barbara (47). Neither UC Santa Cruz or UC Riverside ranked in the Top 50 National Universities.

at the two most-selective universities (UCLA and UC Berkeley) and the least-selective university (UC Riverside). A similar U-shaped pattern was found in national data in Arcidiacono, Khan, and Vigdor (2011), suggesting diversity at the top campuses comes at the expense of diversity of middle tier institutions.

We next examine the distribution of SAT scores across the campuses for minorities and non-minorities.¹⁶ For both non-minority and minority students, the average test scores generally follow the rankings of the UC campuses. However, SAT scores for minority students are substantially lower than their white counterparts at each campus, with the largest racial gaps occurring at UC Berkeley (193) and UCLA (161). Moreover, the spread of scores across campuses is greater for non-minorities (235 points) than it is for minority students (177 points).

Differences in the academic preparation of students across campuses appear to track differences in graduation rates, regardless of whether one looks at on-time graduation (in 4 years) or 5 year graduation rates. Non-minority students at UC Berkeley have 5-year graduation rates that are almost 18 percentage points higher than minority students at UC Berkeley, while the gap at UC Riverside is less than 3 percentage points. Differences in four-year graduation rates are even starker, with 56.1% of non-minority students at UC Berkeley graduating in four years compared to only 32.5% for minorities. Notwithstanding the racial differences, the tabulations in Table 1 indicate that, within each racial group, the top-ranked UC campuses tend to attract students with better academic preparation and achieve higher graduation rates.

Table 1 also indicates that a substantial fraction of students intended to major in the sciences when they entered college – 42.7% for non-minorities and 35.4% for minorities.¹⁷ However, sizeable fractions of initial STEM majors end up switching to a different majors; 42.9% and 57.3% of non-minority and minority students who initially declared a STEM major ended up in

¹⁶As noted above, the UCOP data does not include the exact scores students received on the verbal and math sections of the SAT test. Rather, it provides only whether a student’s score on each section fell into one of the following one of the following seven ranges: 200-449; 450-499; 500-549; 550-599; 600-649; 650-699; 700 or above. We assigned students the midpoint of the range their score was in for the verbal and math tests, respectively, and summed these values to get a student’s SAT score.

¹⁷The initial major is taken from the application of the school they attended. The difference in initial interests between minority and non-minority students is driven by Asians. White students have the same initial interest in the sciences as minority students. Of those who applied to two or more UC schools, less than 19% listed a science major on one application and a non-science major on another application, with the fraction similar across races. We explore gaming of the initial major in the next section.

Table 1: Average SAT Scores and Graduation Rates by UC Campus & Minority Status, 1995-97

| | San | | | | | Santa | | | All |
|--|----------|--------|--------|-------|--------|---------|-------|-----------|--------|
| | Berkeley | UCLA | Diego | Davis | Irvine | Barbara | Cruz | Riverside | |
| <i>No. of Freshmen Enrollees:</i> | | | | | | | | | |
| Non-Minority | 8,073 | 8,256 | 7,525 | 8,638 | 7,445 | 8,277 | 4,511 | 3,415 | 56,140 |
| Minority | 2,287 | 2,803 | 1,081 | 1,497 | 1,129 | 1,845 | 970 | 1,156 | 12,768 |
| % of Enrollment Minority | 22.1% | 25.4% | 12.6% | 14.8% | 13.2% | 18.2% | 17.7% | 25.3% | 18.5% |
| <i>Ave. SAT Scores:</i> | | | | | | | | | |
| Non-Minority | 1,335 | 1,279 | 1,245 | 1,182 | 1,136 | 1,156 | 1,164 | 1,100 | 1,211 |
| Minority | 1,142 | 1,119 | 1,121 | 1,071 | 1,025 | 1,023 | 1,019 | 965 | 1,074 |
| Difference | 193 | 161 | 124 | 111 | 111 | 133 | 145 | 135 | 136 |
| <i>5-Year Graduation Rates:</i> | | | | | | | | | |
| Non-Minority | 85.9% | 83.3% | 80.4% | 76.1% | 68.3% | 72.5% | 67.7% | 63.0% | 76.1% |
| Minority | 68.4% | 66.0% | 66.4% | 54.8% | 63.2% | 60.0% | 60.9% | 59.2% | 63.0% |
| Difference | 17.6% | 17.2% | 14.0% | 21.3% | 5.1% | 12.5% | 6.7% | 3.8% | 13.1% |
| <i>4-Year Graduation Rates:</i> | | | | | | | | | |
| Non-Minority | 56.1% | 48.2% | 49.5% | 37.2% | 32.7% | 44.5% | 45.9% | 38.9% | 44.5% |
| Minority | 32.5% | 26.1% | 32.2% | 20.1% | 24.9% | 27.8% | 38.4% | 29.3% | 28.4% |
| Difference | 23.5% | 22.1% | 17.3% | 17.1% | 7.9% | 16.8% | 7.5% | 9.5% | 16.0% |
| <i>% of Race/Ethnic Group Enrollees whose Initial Major = Science:</i> | | | | | | | | | |
| Non-Minority | 48.9% | 43.9% | 52.2% | 45.4% | 48.0% | 29.0% | 26.0% | 40.1% | 42.7% |
| Minority | 29.9% | 34.7% | 50.1% | 44.4% | 46.9% | 28.2% | 26.9% | 30.5% | 35.4% |
| Difference | 19.0% | 9.2% | 2.1% | 1.0% | 1.2% | 0.8% | -0.9% | 9.6% | 7.2% |
| <i>% of Initial Science Majors that Switch Out of Science:</i> | | | | | | | | | |
| Non-Minority | 38.5% | 41.2% | 36.4% | 41.5% | 46.4% | 48.2% | 65.4% | 44.7% | 42.9% |
| Minority | 65.1% | 58.1% | 52.9% | 50.0% | 55.2% | 52.9% | 70.9% | 60.1% | 57.3% |
| Difference | -26.6% | -16.9% | -16.5% | -8.5% | -8.8% | -4.7% | -5.5% | -15.4% | -14.4% |
| <i>% of Graduates whose Major = Science:</i> | | | | | | | | | |
| Non-Minorities | 38.4% | 31.7% | 41.3% | 34.3% | 29.2% | 16.9% | 17.6% | 31.7% | 31.2% |
| Minorities | 14.1% | 16.9% | 27.2% | 24.0% | 19.8% | 12.8% | 12.9% | 14.8% | 17.2% |
| Difference | 24.3% | 14.8% | 14.1% | 10.3% | 9.4% | 4.1% | 4.8% | 17.0% | 13.9% |

Data Source: UCOP.

All figures are on an annual basis.

a non-science major by the time they graduated or dropped out of school. The racial difference in switching is greatest at UC Berkeley and UCLA, the two most-selective campuses. For example, almost two-thirds (65.1%) of minorities at UC Berkeley who initially declared themselves to be science majors had switched out of science by the time they graduated or dropped out. As a result of this lack of persistence in the sciences, only 17.2% of minorities that graduate from a UC campus do so in the sciences, which is around 14 percentage points lower than the corresponding share of non-minorities (31.2%).

2.2 Persistence in the Sciences

Given these sizeable rates of switching out of science majors and the low graduation rates in the sciences shown in Table 1, especially for minorities, we take a closer look at the across-campus and across-race differences in the characteristics of students that persist in and graduate with STEM majors. Table 2 displays both average SAT scores (top row) and the share of students (second row) for the three completion categories (graduate in the sciences, graduate but not in the sciences, do not graduate) by initial major and race for each campus, using completion status 5 years after enrollment.

Table 2 shows significant sorting on academic preparation at UC campuses, with students that graduate in the sciences having higher average SAT scores than those who do not, regardless of initial major. SAT scores for non-minority students who persist in the sciences – i.e., start in and graduate with a science major – are between 8 to 43 points higher than those who switch to a non-science major. The differences are much larger for minority students. At each campus, minority students who persist and graduate in the sciences have SAT scores that are between 27 and 115 points higher than those students who switch out of the sciences and graduate with a non-science major. Moreover, as reflected in the rates of switching from the sciences in Table 1, non-minorities are much more likely to persist in and graduate with a degree in the sciences than are minorities. For example, while 55% non-minorities who start in start in the sciences at UC Berkeley graduate in that major, only 24.9% of minorities who start in the sciences do so. This racial gap in persistence rates in the sciences, i.e., the share of students who remain in a science major and graduate, shrinks with the selectivity of the UC campus. We also note

that switching into the sciences and graduating with a science degree is low for both racial groups but is much lower for minority students, with gaps again largest at the top campuses. While 9.2% of non-minority students in the non-sciences switch into the sciences, only 3.5% of minority students do so.

It is also the case that students who start in science majors are less likely graduate from their initial UC campus compared to those who start out in majors outside of the sciences. With the exception of UC Berkeley, non-minority students whose initial major is in the sciences are less likely to graduate than those whose majors are not in the sciences, despite those who start out in the sciences having higher SAT scores. This shows the importance of the initial major, both in its effect on the student's final major and on whether the student graduates at all. Differences in graduation rates between initial science and non-science majors are much starker for minorities. Among non-minorities who start out in the sciences, 25.2% do not graduate; in contrast, 40.7% of minorities who start out in the sciences do not graduate. For minorities, those who begin in a non-science major are between 2.7 (for UC San Diego) and 10.5 (for UC Santa Cruz) percentage points more likely to graduate in 5 years than those who start in a non-science major, again despite the fact that those with initial science majors had higher SAT scores.

Table 2 showed that persistence rates in the sciences were higher at the top campuses but that these campuses also had higher average SAT scores. Similarly, persistence rates were higher for non-minority students than minority ones, but this, too, may be the result of differences in average SAT scores by race. We now take a first step towards separating out whether higher persistence rates at top campuses are due to better students or due to something top campuses are doing differently than the the less-selective campuses by breaking out persistence rates by quartiles of the SAT score distribution.

We define the quartiles of the SAT score distribution based on all applicants to the UC system between 1995 and 1997 regardless of whether the applicant attended or even was admitted to a UC campus. Table 3 shows the share of minority and non-minority students in each quartile at each institution. At each of the campuses, minority students are disproportionately represented in the bottom quartile. Even at UC Berkeley, over 34% of minorities are in the bottom quartile

Table 2: Average SAT Scores and Shares for Major/Graduation Completion Outcomes for Freshman entering a UC Campus in 1995-1997, by Initial Major, Campus, and Minority Status[†]

| Initial Major | Graduation Status | San | | | | | Santa | | | All Campuses |
|----------------------|----------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| | | Berkeley | UCLA | Diego | Davis | Irvine | Barbara | Cruz | Riverside | |
| <i>Non-Minority:</i> | | | | | | | | | | |
| Science | Grad. in Science | 1,359 55.3% | 1,299 48.1% | 1,266 50.1% | 1,220 42.2% | 1,171 34.1% | 1,193 32.2% | 1,172 27.8% | 1,177 35.1% | 1,260 43.2% |
| | Grad. in Non-Science | 1,331 30.7% | 1,285 33.1% | 1,241 27.8% | 1,184 32.2% | 1,136 32.1% | 1,163 35.5% | 1,164 36.4% | 1,134 27.5% | 1,218 31.6% |
| | Did Not Graduate | 1,334 14.0% | 1,275 18.8% | 1,224 22.1% | 1,183 25.7% | 1,125 33.9% | 1,158 32.4% | 1,138 35.8% | 1,098 37.4% | 1,188 25.2% |
| Non-Science | Grad. in Science | 1,352 11.6% | 1,295 9.4% | 1,253 14.7% | 1,193 12.8% | 1,141 6.8% | 1,163 4.2% | 1,189 6.3% | 1,125 9.8% | 1,232 9.2% |
| | Grad. in Non-Science | 1,324 74.3% | 1,274 75.5% | 1,239 68.4% | 1,170 64.8% | 1,129 63.5% | 1,153 70.4% | 1,165 62.5% | 1,072 53.4% | 1,203 67.9% |
| | Did Not Graduate | 1,300 14.1% | 1,240 15.1% | 1,236 16.9% | 1,150 22.4% | 1,122 29.7% | 1,141 25.5% | 1,166 31.1% | 1,069 36.8% | 1,165 22.9% |
| <i>Minority:</i> | | | | | | | | | | |
| Science | Grad. in Science | 1,266 24.9% | 1,179 25.8% | 1,177 30.7% | 1,175 22.3% | 1,109 22.7% | 1,089 23.8% | 1,064 18.8% | 1,062 20.1% | 1,161 24.3% |
| | Grad. in Non-Science | 1,151 39.8% | 1,133 35.1% | 1,108 34.4% | 1,087 29.4% | 1,036 38.0% | 1,029 33.7% | 1,037 34.5% | 991 34.6% | 1,087 35.0% |
| | Did Not Graduate | 1,155 35.4% | 1,108 39.1% | 1,095 34.9% | 1,077 48.3% | 1,038 39.3% | 1,022 42.5% | 1,012 46.7% | 982 45.3% | 1,072 40.7% |
| Non-Science | Grad. in Science | 1,185 3.2% | 1,179 3.4% | 1,169 5.4% | 1,122 5.9% | 1,060 3.5% | 1,137 1.4% | 1,037 3.8% | 989 3.7% | 1,125 3.5% |
| | Grad. in Non-Science | 1,129 66.8% | 1,118 65.4% | 1,127 62.4% | 1,059 51.5% | 998 61.8% | 1,025 59.6% | 1,024 59.9% | 949 57.4% | 1,070 61.6% |
| | Did Not Graduate | 1,112 30.0% | 1,085 31.2% | 1,090 32.2% | 1,021 42.6% | 998 34.7% | 1,001 39.0% | 998 36.2% | 945 38.9% | 1,037 34.9% |

[†] For each Initial Major & Graduation Status cluster, the top row is average SAT Score and second row is percentage of enrollees who started in a particular Initial Major.

Table 3: Share of Non-Minority and Minority Students in each Quartile of the 1995-1997 Applicant SAT Score Distribution by Institution

| SAT Score Quartile | Berkeley | UCLA | San Diego | San Davis | Irvine | Santa Barbara | Santa Cruz | Riverside |
|-----------------------|----------|-------|--------------|--------------|--------|------------------|---------------|-----------|
| <i>Non-Minority:</i> | | | | | | | | |
| Q1 | 2.8% | 5.0% | 7.5% | 19.1% | 30.5% | 24.4% | 25.1% | 44.1% |
| Q2 | 11.4% | 20.6% | 32.0% | 40.2% | 43.9% | 45.2% | 39.5% | 34.1% |
| Q3 | 21.4% | 35.7% | 33.8% | 26.4% | 17.3% | 20.6% | 22.3% | 11.9% |
| Q4 | 64.3% | 38.7% | 26.8% | 14.2% | 8.4% | 9.8% | 13.2% | 9.9% |
| <i>Minority:</i> | | | | | | | | |
| Q1 | 34.5% | 37.1% | 35.7% | 51.5% | 65.2% | 62.4% | 62.5% | 77.8% |
| Q2 | 32.3% | 40.4% | 41.7% | 31.1% | 23.6% | 28.2% | 22.9% | 18.3% |
| Q3 | 20.6% | 16.3% | 15.0% | 10.8% | 7.9% | 6.6% | 9.8% | 2.9% |
| Q4 | 12.7% | 6.2% | 7.6% | 6.6% | 3.4% | 2.8% | 4.9% | 1.0% |

of the applicant SAT score distribution. The share of minority students in the bottom quartile at UC Berkeley (34.5%) is actually higher than the share of non-minority students in the bottom quartile at all institutions except for UC Riverside (44.1%). In contrast, less than 3% of non-minority students at UC Berkeley were in the bottom quartile with over 64% in the top quartile. As we move down the selectivity/rankings of campuses, the share of both minority and non-minority students in the bottom quartile rises, topping out at 78% for minority students and 44% for non-minority students at UC Riverside.

Given the shares of non-minority and minority students in each SAT quartile, we now turn to persistence rates conditional on institution and SAT quartile. Table 4 gives the results for minority students. (The corresponding tabulations for non-minority students are found in Table 13 in the Appendix.) The evidence indicates that minority students with low SAT scores would be more likely to persist in the sciences if they attended a less-selective institution. For example, minority students in the bottom quartile of the SAT score distribution who attended UC Berkeley graduated in the sciences at a lower rate than similar students at UC Riverside, despite those in the bottom quartile at UC Berkeley presumably being stronger in other dimensions, e.g., high school GPA, parental education, etc., than those in the bottom quartile at UC Riverside. Note that the total graduation rate for initial science majors in the bottom quartile is actually higher at UC Berkeley and UC Riverside. The primary difference is that at UC Berkeley many of the students switch to non-science majors. Indeed, initial science majors in the bottom quartile at

UC Berkeley are close to five times as likely to graduate in the non-sciences than in the sciences (47.1% vs. 10.3%).

The results are different for minorities in the top quartiles, with those attending UC Berkeley graduating at a higher rate in the sciences than those at UC Riverside. This suggests that matching may be important – at least in the sciences – with top campuses being particularly advantageous for those in the top part of the academic preparation distribution and less selective campuses being more advantageous for those lower down in that distribution. But beyond differences across campuses, the reality is that those in the bottom quartiles of the SAT score distribution have very low persistence rates in the sciences.

Table 4 also reinforces the point that an initial major in the sciences makes graduation in any field in five years less likely, particularly for minorities in the bottom quartile of the SAT score distribution. Overall, minorities in the bottom quartile with an initial major in the sciences have graduation probabilities that are over eight percentage points lower than their non-science counterparts. The corresponding gap for those in the top quartile is around four percentage points.

The corresponding results for non-minority students, displayed in Table 13 in the Appendix, are very different. In particular, at all quartiles of the SAT score distribution non-minority students are, on average, more likely to graduate in the sciences at UC Berkeley than at UC Riverside, and are significantly more likely to graduate, regardless of major, at UC Berkeley than at UC Riverside.

The patterns of persistence in science majors and probabilities of graduating in any field are even more striking if we instead examine 4-year graduation rates. Table 5 repeats the analysis of Table 4, but this time examines 4-year graduation rates. (The corresponding results for non-minorities are recorded in Table 14 in the Appendix.) The probability that a minority in the bottom quartile of the SAT score distribution who initially was interested in a science major actually graduates in the sciences in four years at UC Berkeley is astonishingly low at 0.6% and is substantially lower than the corresponding probability at UC Riverside. This again occurs despite students at UC Berkeley presumably having stronger academic preparation on other

Table 4: Unadjusted Shares of Minority Students Graduating in 5 Years with Science or Non-Science Majors, by Campus, SAT Quartile, and Initial Major

| Initial Major | SAT Quartile | San | | | | | | | All Campuses | |
|---|--------------|----------|-------|-------|-------|--------|---------|------------|--------------|----------|
| | | Berkeley | UCLA | Diego | Davis | Irvine | Barbara | Santa Cruz | Riverside | Campuses |
| <i>Share Graduating with Science Major:</i> | | | | | | | | | | |
| Science | Q1 | 10.3% | 15.5% | 19.7% | 13.1% | 17.3% | 18.3% | 16.7% | 15.6% | 15.9% |
| | Q2 | 14.6% | 27.4% | 32.1% | 21.9% | 26.6% | 27.4% | 21.7% | 28.9% | 25.2% |
| | Q3 | 37.6% | 34.8% | 36.6% | 39.8% | 28.8% | 41.3% | 17.9% | 27.8% | 35.4% |
| | Q4 | 45.5% | 40.0% | 57.4% | 42.4% | 50.0% | 40.0% | 29.4% | 50.0% | 49.0% |
| Non-Science | Q1 | 2.6% | 2.0% | 3.0% | 3.9% | 3.3% | 0.6% | 4.0% | 3.5% | 2.6% |
| | Q2 | 2.3% | 3.5% | 6.6% | 5.9% | 2.4% | 2.0% | 1.9% | 4.7% | 3.4% |
| | Q3 | 3.5% | 4.8% | 5.0% | 13.7% | 8.1% | 5.3% | 6.0% | 6.3% | 5.4% |
| | Q4 | 7.6% | 9.0% | 11.4% | 15.0% | 10.0% | 5.4% | 6.7% | 0.0% | 8.7% |
| <i>Share Graduating with Non-Science Major:</i> | | | | | | | | | | |
| Science | Q1 | 47.1% | 35.3% | 37.2% | 30.8% | 42.8% | 35.3% | 32.7% | 35.7% | 36.9% |
| | Q2 | 49.8% | 35.4% | 34.4% | 32.9% | 33.6% | 34.1% | 40.0% | 32.5% | 36.7% |
| | Q3 | 31.8% | 34.8% | 34.1% | 21.6% | 28.8% | 21.7% | 32.1% | 33.3% | 30.7% |
| | Q4 | 23.1% | 33.3% | 23.4% | 20.3% | 25.0% | 33.3% | 35.3% | 25.0% | 25.8% |
| Non-Science | Q1 | 65.5% | 60.5% | 55.1% | 47.9% | 62.1% | 58.0% | 58.2% | 58.0% | 58.6% |
| | Q2 | 66.3% | 68.3% | 65.2% | 57.6% | 58.5% | 62.4% | 63.0% | 53.9% | 64.2% |
| | Q3 | 70.0% | 69.6% | 73.8% | 56.2% | 67.6% | 60.0% | 58.2% | 56.3% | 67.1% |
| | Q4 | 67.5% | 67.0% | 60.0% | 50.0% | 70.0% | 70.3% | 73.3% | 75.0% | 65.9% |
| <i>Share Graduating, Any Major:</i> | | | | | | | | | | |
| Science | Q1 | 57.5% | 50.8% | 56.9% | 43.9% | 60.1% | 53.6% | 49.4% | 51.2% | 52.8% |
| | Q2 | 64.4% | 62.8% | 66.5% | 54.8% | 60.1% | 61.6% | 61.7% | 61.4% | 61.9% |
| | Q3 | 69.4% | 69.5% | 70.7% | 61.4% | 57.7% | 63.0% | 50.0% | 61.1% | 66.1% |
| | Q4 | 68.7% | 73.3% | 80.9% | 62.7% | 75.0% | 73.3% | 64.7% | 75.0% | 70.8% |
| Non-Science | Q1 | 68.1% | 62.5% | 58.1% | 51.9% | 65.3% | 58.6% | 62.2% | 61.5% | 61.3% |
| | Q2 | 68.6% | 71.8% | 71.8% | 63.4% | 61.0% | 64.3% | 64.8% | 58.6% | 67.6% |
| | Q3 | 73.5% | 74.4% | 78.8% | 69.9% | 75.7% | 65.3% | 64.2% | 62.5% | 72.5% |
| | Q4 | 75.2% | 76.0% | 71.4% | 65.0% | 80.0% | 75.7% | 80.0% | 75.0% | 74.6% |

dimensions.¹⁸

The above results suggest that mismatch of students with STEM majors intentions to the various UC campuses may be sizeable for minorities. This mismatch may be a consequence of the affirmative action policies that prevailed at the UC campuses during the period we examine. During this period, race as well as academic preparation affect which campus students attend. Moreover, as argued above, it would appear that the above tabulations, if anything, understates the extent of mismatch, since students with lower SAT scores at top schools like UC Berkeley who intended to major in the sciences were likely to be stronger on other dimensions (e.g., high school gpa, etc.) than their counterparts at less-ranked campuses.

However, drawing strong conclusions about mismatch for minorities in STEM majors from the above tabulations is premature, since they do not adjust for differences in the other dimensions of the student academic preparation. In the next section we describe a model of student choice concerning majors and graduation and how we use additional measures of preparation to deal with such selection. Before doing so, we consider the potential for students engaging in strategic reporting of their intended major.

Given the striking results for minorities, one may be concerned that they are driven by the gaming of which major to put on the application to which school. As discussed in the previous section, a small fraction of students report different initial majors for different schools. If, for example, it was easier for minority students to get into top schools by putting down science as their initial major, while intending to switch to non-science, then this could explain the low persistence rates. However, there is no evidence that this is the case: if anything, students are more likely to apply to the top schools in the non-sciences. Indeed, it appears that it was easier for minority students to get into both UC Berkeley and UCLA by listing a non-science rather than a science major.¹⁹ Further, given that so few minority students switch from non-science to science majors and that those who list science as their initial major are more likely to dropout, it is clear that the initial major is an important determinant of future academic outcomes.

¹⁸Switching majors on average delays graduation. While 24% of those who graduated in five years had switched majors, the corresponding share of those who graduated in four years was 20%.

¹⁹We estimated separate logits on the probability of being admitted conditional on applying. At UC Berkeley and UCLA, the minority in advantage in admissions was cut almost in half if science was listed as the initial major. Similar penalties were not seen at the other schools.

Table 5: Unadjusted Shares of Minority Students Graduating in 4 Years with Science or Non-Science Majors, by Campus, SAT Quartile, and Initial Major

| Initial Major | SAT | | San | | | | Santa | | | All | |
|---|----------|----------|-------|-------|-------|--------|---------|-------|-----------|----------|--|
| | Quartile | Berkeley | UCLA | Diego | Davis | Irvine | Barbara | Cruz | Riverside | Campuses | |
| <i>Share Graduating with Science Major:</i> | | | | | | | | | | | |
| Science | Q1 | 0.6% | 2.2% | 5.9% | 1.4% | 4.9% | 6.1% | 7.7% | 8.2% | 4.5% | |
| | Q2 | 5.5% | 6.5% | 14.7% | 5.3% | 8.4% | 12.8% | 11.7% | 16.9% | 9.0% | |
| | Q3 | 19.7% | 12.3% | 18.3% | 19.3% | 15.4% | 21.7% | 14.3% | 22.2% | 17.0% | |
| | Q4 | 23.1% | 20.0% | 23.4% | 25.4% | 28.6% | 26.7% | 29.4% | 50.0% | 24.3% | |
| Non-Science | Q1 | 0.2% | 0.3% | 1.5% | 0.6% | 0.0% | 0.0% | 2.2% | 1.7% | 0.7% | |
| | Q2 | 0.8% | 0.5% | 2.2% | 1.7% | 0.8% | 0.6% | 0.6% | 1.6% | 0.9% | |
| | Q3 | 1.6% | 1.5% | 2.5% | 2.7% | 5.4% | 1.3% | 1.5% | 0.0% | 1.8% | |
| | Q4 | 4.5% | 4.0% | 11.4% | 12.5% | 10.0% | 5.4% | 6.7% | 0.0% | 6.1% | |
| <i>Share Graduating with Non-Science Major:</i> | | | | | | | | | | | |
| Science | Q1 | 14.4% | 6.5% | 13.8% | 7.6% | 11.8% | 12.2% | 16.7% | 12.7% | 11.3% | |
| | Q2 | 22.4% | 11.6% | 16.1% | 13.2% | 9.1% | 14.0% | 16.7% | 16.9% | 14.6% | |
| | Q3 | 12.7% | 13.4% | 17.1% | 10.2% | 9.6% | 13.0% | 10.7% | 22.2% | 13.1% | |
| | Q4 | 9.7% | 17.3% | 12.8% | 6.8% | 7.1% | 26.7% | 23.5% | 25.0% | 12.5% | |
| Non-Science | Q1 | 27.2% | 22.6% | 21.7% | 16.6% | 28.1% | 27.2% | 36.9% | 28.5% | 26.3% | |
| | Q2 | 34.1% | 33.2% | 38.8% | 25.6% | 30.9% | 32.3% | 46.3% | 30.5% | 33.6% | |
| | Q3 | 43.5% | 35.9% | 46.3% | 28.8% | 37.8% | 34.7% | 43.3% | 37.5% | 39.3% | |
| | Q4 | 41.4% | 38.0% | 40.0% | 30.0% | 50.0% | 29.7% | 56.7% | 25.0% | 39.5% | |
| <i>Share Graduating, Any Major:</i> | | | | | | | | | | | |
| Science | Q1 | 14.9% | 8.7% | 19.7% | 9.0% | 16.7% | 18.3% | 24.4% | 20.9% | 15.7% | |
| | Q2 | 27.9% | 18.1% | 30.8% | 18.4% | 17.5% | 26.8% | 28.3% | 33.7% | 23.6% | |
| | Q3 | 32.5% | 25.7% | 35.4% | 29.5% | 25.0% | 34.8% | 25.0% | 44.4% | 30.1% | |
| | Q4 | 32.8% | 37.3% | 36.2% | 32.2% | 35.7% | 53.3% | 52.9% | 75.0% | 36.8% | |
| Non-Science | Q1 | 27.4% | 22.9% | 23.2% | 17.2% | 28.1% | 27.2% | 39.1% | 30.2% | 27.0% | |
| | Q2 | 34.9% | 33.7% | 41.0% | 27.3% | 31.7% | 32.9% | 46.9% | 32.0% | 34.6% | |
| | Q3 | 45.0% | 37.4% | 48.8% | 31.5% | 43.2% | 36.0% | 44.8% | 37.5% | 41.1% | |
| | Q4 | 45.9% | 42.0% | 51.4% | 42.5% | 60.0% | 35.1% | 63.3% | 25.0% | 45.5% | |

3 Modeling Student Persistence in College Majors and Graduation

The descriptive statistics in Section 2 suggest that the match between the academic preparation and the selectivity of the college may be important, particularly in the sciences and for minorities. We now propose a model that is flexible enough to capture these matching effects. We model a student's decision regarding whether to graduate from college and, if they do, their final choice of major. In particular, student i attending college k can choose to major and graduate in a science field, m , or in a non-science field, h , or choose to not graduate, n . Denote the student's decision by d_{ik} , $d_{ik} \in \{m, h, n\}$. In what follows, the student's college, k , is taken as given. But, as noted above, ignoring choice process governing which campus a student selected may give rise to selection bias in estimating the determinants of their choice of a major to the extent that admission decisions are based on observed and unobserved student characteristics that may also influence their choice of majors and likelihood of graduating from college. We discuss the selection problem in more detail in section 3.2.

We assume that the utility student i derives from graduating with a major in j from college k depends on three components: (i) the *net returns* she expects to receive from graduating with this major from this college; (ii) the *costs of switching* one's major, if the student decides to change from the one with which she started college; and (iii) other factors which we treat as idiosyncratic and stochastic. The net returns from majoring in field j at college k , R_{ijk} , is just the difference between the expected present value of future benefits, b_{ijk} , of having this major/college combination, less the costs associated with completing it, c_{ijk} , i.e., $R_{ijk} = b_{ijk} - c_{ijk}$.²⁰ In particular, the benefits would include the expected stream of labor market earnings that would accrue to someone with this major-college combination (e.g., an engineering degree from UC Berkeley), where these earnings would be expected to vary with a student's ability and the quality of training provided by the college.

The costs of completing a degree in field j at k depend on the effort a student would need to exert to complete the curriculum in this major at this college, where this effort is likely to

²⁰For a similar approach to modeling the interaction between colleges and majors in determining college graduations in particular majors, see Arcidiacono (2004).

vary with i 's academic preparation, the quality of the college and its students. With respect to switching costs, each student arrives on campus with an initial major, j^{int} (as with the college she attends, her initial, or intended, major, j^{int} , is taken as given). The student may remain in and graduate with her initial major or may decide to switch to and graduate with a different major in which case the switching cost, C_{ijk} , is paid. Finally, we allow for an idiosyncratic taste factor, ϵ_{ijk} . It follows that the payoff function for graduating with major j at school k is given by:

$$U_{ijk} = R_{ijk} - C_{ijk} + \epsilon_{ijk} \quad (1)$$

for $j \in \{m, h\}$. Below, we characterize the specific functional forms for R_{ijk} and C_{ijk} that we use in estimation.

Since discrete choice models depend on differences in payoffs, without loss of generality we normalize the student's utility of not graduating from college k , denoted as U_{ink} , to zero. It follows that the major/graduation choice of student i attending college k is made according to:

$$d_{ik} = \arg \max_{m,h,n} \{U_{imk}, U_{ihk}, 0\} \quad (2)$$

3.1 Net Returns

We assume that the net returns of a particular major/college combination, R_{ijk} , varies with an index of a student's academic preparation for major j , denoted by AI_{ij} , and that these net returns to AI_{ij} may differ across campuses. In particular, we assume that R_{ijk} is characterized by the linear function:

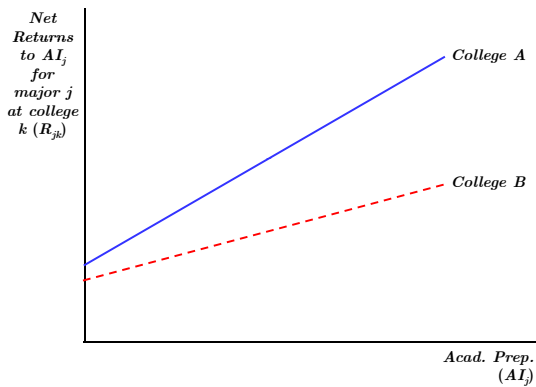
$$R_{ijk} = \phi_{1jk} + \phi_{2jk}AI_{ij} \quad (3)$$

The specification in (3) allows college-major combinations to differ in their net returns to the academic index with higher net returns associated with higher values of ϕ_j . As noted above, such differences in ϕ_{2jk} may result from colleges gearing their curriculum in a particular major to students from a particular academic background which, in turn, produce differences in subsequent labor market earnings. Degrees in various majors from different colleges also may

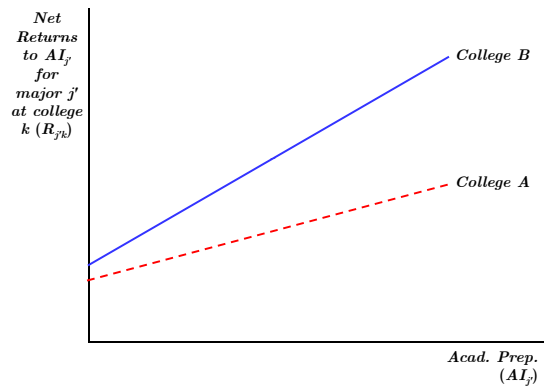
produce differing net returns that do not depend on a student's academic preparation which is reflected in differing values of ϕ_{1jk} . For example, the curriculum in majors at some colleges (e.g., engineering at MIT) may have different course requirements that all students have to meet, regardless of their academic preparation, that impose differing effort and time costs to completing the major.

We are interested in how differences across colleges of differing quality, or selectivity, differ in their ability to educate and graduate students of differing academic preparation in various majors. To see how the specification of the net returns functions in (3) capture such differences, suppose that College A is an elite, selective college (e.g., UC Berkeley, UCLA or UC San Diego), while College B is a less selective one (e.g., UC Santa Cruz or UC Riverside). One possibility is that highly selective colleges (A) have an *absolute advantage* relative to less selective ones (B) in the net returns students from any level of academic preparation would receive and that such advantage is true for all majors. This case is illustrated in Panel (a) of Figure 1, where the absolute advantage holds for *all* majors. Alternatively, selective colleges may not generate higher net returns for students with all levels of academic preparation in all fields. For example, selective colleges may have an absolute advantage in moving all types of students through its science curriculum, whereas less selective colleges (B) may have an absolute advantage in training students in the humanities. This case is characterized by Panels (a) and (b) in which elite colleges (A) have absolute advantage in getting students through major j , while less selective colleges (B) have an absolute advantage in graduating all students from major (j'). This second case might arise if colleges develop faculties and facilities to educate students in some majors, but not others, such as “technology institutes” (e.g., Caltech, Georgia Tech) which focus on their curriculum and research in science and technology.

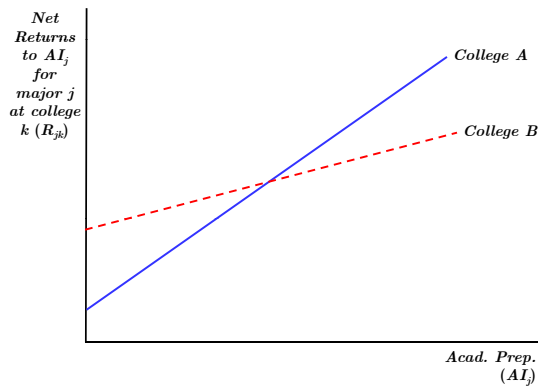
But some colleges may produce higher net returns in some major j for less-prepared students, while others are geared to better-prepared students and produce higher net returns for the latter type of student. This case is illustrated in Panel (c) for major j . At first glance, this differences-in-relative-advantage between highly selective and less selective colleges may account for the differential success UC Berkeley and UCLA had in graduating minorities versus non-minorities with STEM majors compared to lesser-ranked UC campuses, like UC Santa Barbara and UC



(a) Net Returns to AI of graduating in major j from College A is *greater* than from B for *all* AI_j .



(b) Net Returns to AI of graduating in major j' from College B is *greater* than from A for *all* $AI_{j'}$.



(c) Net Returns to AI of graduating in major j from College A is *greater* than B for *better prepared* students, but *greater* from B than A for *less prepared* ones.

Figure 1: Differences in Net Returns to Student Academic Preparation (AI) by Major at Selective (A) and Non-Selective (B) Colleges

Riverside. Below, we examine the empirical validity of this latter explanation, after explicitly accounting for differences in student preparation and student persistence in majors across the UC campuses.

3.2 Academic Preparation for Majors

We now specify how the student's academic index is constructed. We assume that the various

abilities of the student can be characterized by a set of characteristics X_i . These characteristics are then rewarded in majors differently. For example, math skills may be rewarded more in the sciences while verbal scores may be more rewarded outside of the sciences. The academic index for major $j \in \{m, h\}$, AI_{ij} , is then given by:

$$AI_{ij} = X_i \beta_j \tag{4}$$

where β_j allows for the weights on the various measures of preparation to vary by major.

Our estimation problem is analogous to that in the literature concerning the effects of college quality on graduation and later-life outcomes. In particular, whether a student remains in a major and graduates from a particular college is the result of student decisions that are influenced by the quality of the campus – in our case the campus-specific net returns to graduating with a major and the costs of switching a major – and by observed and unobserved dimensions of her academic preparation. To account for the selection effects in our context, we employ the approach used by Dale and Krueger (2002) by constructing a set of academic indices for each student that depend not only on observables, such as SAT math and verbal scores, but also on dimensions not fully captured by such measures but that are reflected in where a student applied and the rankings/quality of UC campuses to which she was admitted. The full set of characteristics, X_i , is given by: observed measures of academic preparation (H_i), which includes high school GPA, and SAT math and verbal scores; parental background (B_i), which includes dummy variables for each family income category and each parental education category; dummy variables for each of the schools in the UC system where the individual submitted an application, where $s_{ik} = 1$ if the individual submitted an application to school k and zero otherwise; and an indicator variable of whether the individual was admitted to school k , a_{ik} . That is:

$$X_i = \left[H_i \quad B_i \quad S_i \quad A_i \right]$$

where:

$$S_i = \left[s_{i1} \quad \cdots \quad s_{iK} \right]$$

$$A_i = \left[a_{i1} \quad \cdots \quad a_{iK} \right]$$

The academic index for individual i in major j , AI_{ij} , is then given by a major-specific weighted average of the characteristics in X_i as in (4). In this way, we allow the possibility that characteristics such as SAT math may be more important for science majors than non-science majors.

3.3 Costs of Switching Majors

Finally, we specify the cost of switching majors, C_{ijk} . We allow these costs to depend on the individual's academic index (AI_{ij}), B_i , which contains measures of parental support such as parental income and education, and a college specific component, α_{3k} .

$$C_{ijk} = \begin{cases} AI_{ij}\alpha_{1j} + B_i\alpha_2 + \alpha_{3k} & \text{if } j^{int} \neq j \\ 0 & \text{if } j^{int} = j \end{cases} \quad (5)$$

3.4 Estimation

We specify the error structure for the choice-specific utilities to have a nested logit form, allowing the errors to be correlated among the two graduation options, i.e., graduating with a science major (m) and graduating with a non-science degree (h). In this way we account for shocks after the initial choice of school and major that may influence the value of a student continuing their education. For example, a shock to one's finances or personal issues may reduce the utility of staying in college. Given our assumption regarding the error distribution, the probability of choosing to graduate from k with major j , conditional on X and B (but not ϵ), is given by:

$$p_{ijk} = \frac{\left(\sum_{j'} \exp\left(\frac{u_{ij'k}}{\rho}\right)\right)^{\rho-1} \exp\left(\frac{u_{ijk}}{\rho}\right)}{\left(\sum_{j'} \exp\left(\frac{u_{ij'k}}{\rho}\right)\right)^{\rho} + 1} \quad (6)$$

for $j = m, h$ and where the probability of choosing not to graduate from k is given by:

$$p_{i0k} = \frac{1}{\left(\sum_{j'} \exp\left(\frac{u_{ij'k}}{\rho}\right)\right)^{\rho} + 1} \quad (7)$$

We estimate separate nested logit models for minority and non-minority students, as well as separate models for 4- and 5-year graduation outcomes.

4 Results

We begin with the estimation results for our model of student graduation/major choices. Estimates of the key parameters for the four-year graduation outcome are given in Table 6.²¹ We present estimates for the net return functions in (3), the switching majors cost function in (5) and some of the indices of students' academic preparation from (4) for minorities and non-minorities and, for each group, for majoring in science and the non-sciences.²²

Consider first the estimates for the indices of academic preparation found at the bottom of Table 6. For both minorities and non-minorities, SAT Math scores have a strong, positive effect for majoring in science, but either a negative or insignificant effect for majoring in the non-sciences. In contrast, SAT Verbal scores are relatively more important for majoring in non-sciences compared to the sciences for both groups, although the estimates are not precisely estimated for minorities.²³ Finally, while a student's high school GPA is important for both majors, it is relatively more important for Science than non-science, although again the effects for minorities are insignificant.

Estimates for the net returns functions are displayed at the top of Table 6. The estimated campus intercepts and slope coefficients for the specification in (3) are measured relative to those for UC Berkeley (the slope for UC Berkeley is normed to one). We make three points about these campus-specific functions. First, the net returns to academic preparation (the ϕ_{2jk} s) are larger for higher-ranked campuses, consistent with the previous evidence on the "returns to quality" literature. Moreover, these returns to quality hold for both majors and both demographic groups.²⁴ Second, while there is a return to quality, the campus-specific intercept (ϕ_{1jk})

²¹The corresponding parameter estimates for data on four-year graduation rates are found in Table 15 in the Appendix and show similar patterns.

²²The full model includes has 144 parameters. For ease of exposition, we do not report the coefficients in the academic index or the switching costs for each family income and parental education category. Nor do we report the estimates for the Dale and Krueger controls. The full set of estimates are available upon request from the authors.

²³The lack of precision for the estimates based on the (smaller) sample of minorities is exacerbated by the flexibility of our specification. For example, using a less flexible function for the returns to parental income education, as opposed to dummifying out each category, results in statistically significant effects for the main academic measures.

²⁴The average of the campus-specific slopes of the net returns functions are remarkably similar, with 0.87 being the average for minorities of graduating with a science major and 0.77 for non-minorities and 0.89 being the average for minorities of graduating with a non-science major and 0.86 for non-minorities.

Table 6: Nested Logit Coefficients for Choice of Final Major based on 5-year Graduation Criteria[†]

| | Non-Minority | | Minority | |
|---|----------------------|----------------------|---------------------|---------------------|
| | Science | Non-Science | Science | Non-Science |
| <i>Net Returns Function:</i> | | | | |
| UCLA | -0.061 (0.482) | -0.671** (0.305) | -0.059 (0.605) | -0.405 (0.554) |
| San Diego | 1.310*** (0.441) | 0.043 (0.290) | 1.029 (0.879) | 0.562 (0.856) |
| Davis | 1.299*** (0.418) | 0.178 (0.271) | -0.003 (0.609) | -0.321 (0.555) |
| Irvine | 1.555*** (0.433) | 0.304 (0.282) | 0.718 (0.728) | 0.385 (0.682) |
| Santa Barbara | 2.249*** (0.460) | 0.644** (0.323) | 0.802 (0.767) | 0.568 (0.737) |
| Santa Cruz | 3.214*** (0.513) | 0.711* (0.375) | 1.656 (1.180) | 0.912 (1.174) |
| Riverside | 2.651*** (0.475) | 0.585* (0.336) | 1.273 (1.121) | 0.995 (1.078) |
| UCLA $\times AI_j$ | 0.996*** (0.063) | 1.136*** (0.076) | 1.002*** (0.104) | 1.076*** (0.116) |
| San Diego $\times AI_j$ | 0.823*** (0.054) | 0.913*** (0.067) | 0.792*** (0.117) | 0.817*** (0.139) |
| Davis $\times AI_j$ | 0.821*** (0.051) | 0.879*** (0.061) | 0.972*** (0.109) | 1.012*** (0.125) |
| Irvine $\times AI_j$ | 0.756*** (0.050) | 0.835*** (0.064) | 0.880*** (0.115) | 0.905*** (0.135) |
| Santa Barbara $\times AI_j$ | 0.663*** (0.050) | 0.766*** (0.062) | 0.845*** (0.101) | 0.838*** (0.118) |
| Santa Cruz $\times AI_j$ | 0.484*** (0.055) | 0.678*** (0.073) | 0.695*** (0.125) | 0.763*** (0.146) |
| Riverside $\times AI_j$ | 0.583*** (0.052) | 0.683*** (0.070) | 0.761*** (0.111) | 0.723*** (0.129) |
| <i>Switching Majors Cost Function:</i> | | | | |
| UCLA | -0.003 (0.021) | | 0.019 (0.018) | |
| San Diego | -0.087*** (0.021) | | -0.001 (0.021) | |
| Davis | -0.152*** (0.021) | | -0.035* (0.020) | |
| Irvine | -0.066** (0.026) | | -0.007 (0.023) | |
| Santa Barbara | 0.026 (0.027) | | 0.082*** (0.025) | |
| Santa Cruz | -0.136*** (0.032) | | -0.005 (0.025) | |
| Riverside | -0.159*** (0.033) | | -0.017 (0.023) | |
| <i>Academic Preparation Index Function:</i> | | | | |
| HS GPA | 1.128*** (0.151) | 0.767*** (0.147) | 0.975 (0.846) | 0.826 (0.789) |
| SAT Math | 3.567*** (0.279) | -0.684*** (0.206) | 1.433*** (0.455) | 0.073 (0.425) |
| SAT Verbal | -0.849*** (0.194) | 0.565*** (0.177) | 0.343 (0.679) | 0.627 (0.626) |
| <i>Nesting parameter</i> | | | | |
| ρ | 0.453*** (0.072) | | 0.143 (0.134) | |

[†] All campus dummies are measured relative to UC Berkeley (the omitted category). The coefficient on AI for Berkeley is normalized to one.

and slope (ϕ_{2jk}) estimates imply that campuses differ in the net returns they produce for students from different parts of the AI_j distribution. For better-prepared students, higher-ranked campuses, such as UC Berkeley and UCLA, produce higher net returns than do lower-ranked campuses, such as UC Santa Cruz and UC Riverside. But, for lesser-prepared students, lower-ranked campuses produce higher returns than do their higher-ranked counterparts. This pattern corresponds to that in Panel (c) of Figure 1 and it holds for both racial groups and both majors. Third, although not immediately obvious from the coefficients themselves, the range of AI_j scores for which lower-ranked campuses have this comparative advantage with less-prepared students is greater in the sciences than in the non-sciences. Taken together, the second and third points imply that re-allocating the latter type of student from higher- to lower-ranked campuses would improve the chances of graduating with a science degree among both groups but especially for minorities. We explore the potential magnitude of such effects in Section 4.2.

Lastly, consider the estimates of the campus-specific major-switching cost function found in the middle of Table 6. (The campus components are measured relative to those for UC Berkeley, which is normalized to zero.) In contrast to the net returns, the costs of switching majors are not ordered according to campus rankings and differ by minority status. Among non-minorities, the costs of switching majors is highest at UC Berkeley but there is no pattern to the remaining coefficients. In contrast, minorities at Berkeley have similar switching costs to those at other campuses. The only exception is UC Santa Barbara, which has slightly higher switching costs.

4.1 Adjusting for Across-Campus Student Differences

As noted in Section 2.2, the across-campus differences in persistence and graduation rates in the sciences by quartiles in Tables 4 and 5 for minorities (and in Tables 13 and 14 for non-minorities) do not adjust for differences in other characteristics of students across campuses. We now use the estimates from our model to adjust for these differences across across students in order to better isolate the role that campus differences play in STEM persistence and graduation for minorities (and non-minorities). More precisely, we use the estimates in Tables 6 and 15 to predict the shares of students who would graduate, in 5 and 4 years or less respectively, with

a science major ($d_i = m$), a non-science major, ($d_i = h$), and any major ($d_i = m$ or $d_i = h$) at each UC campus for each initial-major (j^{int}) and SAT score quartile (Q) “cell.” We predict these outcomes for *all* students who enrolled at one of the UC campuses, regardless of where they actually attended, in order to net out the influence of these other characteristics. The selection-adjusted predicted shares based on a 5-year graduation criteria are found in Table 7 and in Table 8 for the 4-year graduation criteria. To facilitate their comparison with the observed (unadjusted) shares, the results in these tables are displayed in much the same format as used in Tables 4 and 5.

Consider the selection-adjusted shares for minorities for the 5-year graduation criteria in Table 7. In this and subsequent tables, we tabulate the average difference between the selection-adjusted and actual shares for each UC campus (“Ave. Diff.”) and include a measure of the differences in the across-campus heterogeneity of the shares (“Diff. in Across-Campus Hetero.”) for each quartile of the distribution of SAT scores.²⁵ For almost every initial-major–SAT–quartile cell, adjusting for selection results in less across-campus heterogeneity in minority persistence rates in the sciences and non-sciences and overall graduation rates than is the case for the unobserved shares in the earlier tables. That is, equalizing the within-cell differences in student academic preparation and family background tends to *reduce* the persistence rates at the higher ranked campuses and to *increase* them at the lower-ranked campuses. There are two notable exceptions to this pattern. Equalizing student preparation and family background of minorities would actually *increase* the across-campus heterogeneity in science persistence rates and the share of students switching into the sciences for those students in the bottom SAT quartile. This is due to the strong comparative advantage that less-selective campuses (i.e., UC Santa Barbara, UC Santa Cruz and UC Riverside) have over higher ranked ones (i.e., UC Berkeley and UC San Diego) in producing higher net returns to graduating less-prepared minority students in the sciences.

The selection-adjusted shares based on a 4-year graduation criteria are displayed in Table 8. There are several points to make about these estimates. First, predicted science persistence and overall graduation rates for minorities are much lower based on a 4-year graduation criteria than

²⁵We use the coefficient of variation of shares for each SAT quartile to measure across-campus heterogeneity. Note that this does not take into account differences in the size of the quartiles in the actual data.

Table 7: Selection-Adjusted Shares of Minority Students Graduating in 5 Years with Science or Non-Science Majors, by Campus, SAT Quartile, and Initial Major

| Initial Major (j^{int}) | SAT Quartile | Berkeley | UCLA | San Diego | Davis | Irvine | Santa Barbara | Santa Cruz | Riverside | Diff. in Across-Campus Hetero. [†] |
|--|--------------|----------|-------|-----------|-------|--------|---------------|------------|-----------|---|
| <i>Share Graduating with Science Major</i> | | | | | | | | | | |
| Science | Q1 | 9.3% | 13.5% | 17.6% | 13.8% | 15.3% | 19.8% | 19.0% | 18.4% | 3.5% |
| | Q2 | 19.6% | 24.6% | 28.5% | 25.3% | 26.8% | 32.9% | 27.5% | 30.7% | -6.8% |
| | Q3 | 28.9% | 33.6% | 36.5% | 34.6% | 35.7% | 42.2% | 33.6% | 39.6% | -12.2% |
| | Q4 | 40.3% | 43.9% | 45.5% | 45.2% | 45.8% | 52.2% | 40.4% | 49.3% | -10.1% |
| Ave. Diff. [‡] | | -2.5% | -0.5% | -4.4% | 0.4% | 0.2% | 5.0% | 8.7% | 3.9% | |
| Non-Science | Q1 | 1.1% | 1.6% | 3.0% | 3.3% | 2.5% | 1.2% | 3.7% | 3.7% | 3.7% |
| | Q2 | 2.7% | 3.2% | 5.4% | 6.7% | 4.9% | 2.4% | 5.4% | 7.2% | -12.5% |
| | Q3 | 4.6% | 4.9% | 7.7% | 10.4% | 7.4% | 3.9% | 6.9% | 11.0% | -11.2% |
| | Q4 | 7.2% | 7.1% | 10.5% | 15.0% | 10.5% | 5.7% | 8.5% | 15.4% | -18.3% |
| Ave. Diff. [‡] | | -0.1% | -0.6% | 0.2% | -0.8% | 0.4% | 0.0% | 1.5% | 5.7% | |
| <i>Share Graduating with Non-Science Major</i> | | | | | | | | | | |
| Science | Q1 | 45.0% | 38.0% | 35.0% | 35.4% | 40.6% | 33.0% | 37.4% | 36.8% | -4.5% |
| | Q2 | 43.0% | 35.8% | 31.4% | 32.6% | 36.8% | 27.6% | 35.4% | 31.1% | -2.3% |
| | Q3 | 38.9% | 32.5% | 28.0% | 28.9% | 32.7% | 23.2% | 33.4% | 26.5% | -1.9% |
| | Q4 | 32.4% | 27.5% | 23.5% | 23.7% | 27.1% | 18.0% | 30.4% | 20.9% | -1.9% |
| Ave. Diff. [‡] | | 1.9% | -1.3% | -2.8% | 3.8% | 1.8% | -5.7% | -0.9% | -2.8% | |
| Non-Science | Q1 | 60.0% | 56.4% | 56.6% | 51.6% | 60.0% | 60.2% | 59.7% | 58.5% | -3.8% |
| | Q2 | 66.8% | 63.9% | 61.4% | 57.2% | 65.2% | 66.0% | 64.4% | 61.3% | -2.9% |
| | Q3 | 69.9% | 67.8% | 63.6% | 59.2% | 67.3% | 69.0% | 67.0% | 61.5% | -5.2% |
| | Q4 | 70.4% | 69.1% | 63.6% | 58.2% | 67.0% | 69.9% | 67.8% | 59.7% | -5.0% |
| Ave. Diff. [‡] | | -0.6% | -2.1% | -2.2% | 3.6% | 0.3% | 3.6% | 1.6% | -0.6% | |
| <i>Share Graduating with Any Major</i> | | | | | | | | | | |
| Science | Q1 | 54.4% | 51.4% | 52.6% | 49.2% | 55.9% | 52.8% | 56.4% | 55.1% | -5.3% |
| | Q2 | 62.6% | 60.4% | 59.9% | 57.9% | 63.6% | 60.5% | 62.9% | 61.8% | -2.5% |
| | Q3 | 67.8% | 66.0% | 64.5% | 63.5% | 68.4% | 65.4% | 67.0% | 66.1% | -8.7% |
| | Q4 | 72.7% | 71.4% | 69.0% | 68.9% | 72.9% | 70.1% | 70.8% | 70.2% | -6.2% |
| Ave. Diff. [‡] | | -0.6% | -1.8% | -7.3% | 4.2% | 2.0% | -0.7% | 7.8% | 1.1% | |
| Non-Science | Q1 | 61.2% | 58.0% | 59.7% | 54.8% | 62.6% | 61.4% | 63.5% | 62.2% | -3.4% |
| | Q2 | 69.4% | 67.1% | 66.8% | 63.9% | 70.1% | 68.5% | 69.8% | 68.5% | -4.4% |
| | Q3 | 74.5% | 72.7% | 71.3% | 69.6% | 74.7% | 72.9% | 73.8% | 72.4% | -6.2% |
| | Q4 | 77.6% | 76.2% | 74.2% | 73.2% | 77.6% | 75.7% | 76.3% | 75.0% | -4.4% |
| Ave. Diff. [‡] | | -0.7% | -2.7% | -2.0% | 2.8% | 0.7% | 3.7% | 3.1% | 5.1% | |

[†] The “difference in across-campus heterogeneity” is the difference, for each SAT quartile, in the coefficients of variation for the selection-adjusted *row* entries and the corresponding unadjusted entries in Table 4.

[‡] The “average difference” the average difference between the selection-adjusted *column* entries in this table and the corresponding unadjusted entries from Table 4.

for the 5-year one. Furthermore, adjusting for student differences magnifies the comparative advantage that lesser-ranked campuses have over higher ones in graduating minorities based on the 4-year graduation criteria. As seen in Table 8, our measure of across-campus heterogeneity increases for students who initially select a STEM major for all but those in the top SAT quartile. While somewhat weaker, the same increase in across-campus differentiation would occur in the non-STEM fields. In short, the comparative advantage of lower-tiered campuses over higher-ranked ones in the net returns to minorities of persisting in the sciences is much stronger for “on-time” graduations.

Finally, the consequences of equalizing across-campus differences in student preparation and family background within the initial-major–SAT–quartile cells for non-minorities are displayed in Tables 16 and 17 for 5- and 4-year graduation outcomes, respectively. While the differences between the selected adjusted and unadjusted shares are qualitatively similar to those for minorities, the increase in heterogeneity is only found in the bottom quartile. The cross-race differences reflect, in part, the large differences between minorities and non-minorities in dimensions other than SAT scores, such as parental income and education, and differences in unobserved preparation captured by the Dale-Krueger measures.

4.2 Gains from Re-Allocating Students to Counterfactual Campuses

The across-campus differences in persistence and graduation rates in the sciences for minorities and non-minorities when academic preparation and family backgrounds are equalized suggest that there may be gains from re-allocating students across campuses, especially less-prepared ones and ones from less-advantaged backgrounds. In this section we use the estimates from our model to assess these potential gains. In particular, we estimate the proportion of students enrolled at a particular campus who would have a higher probability of (i) persisting and graduating in the sciences, (ii) persisting and graduating in the non-sciences, and (iii) graduating with any major at each of the other UC campuses. Unlike in the previous section, in this exercise the characteristics of students are not equalized at all campuses but are fixed according to the campus the students actually attended.²⁶

²⁶We note that this case is almost equivalent to graduating in the non-sciences conditional on not beginning in the sciences as we have seen that switch rates from non-science majors to science majors are rare.

Table 8: Selection-Adjusted Shares of Minority Students Graduating in 4 Years with Science or Non-Science Majors, by Campus, SAT Quartile, and Initial Major

| Initial Major (j^{int}) | SAT Quartile | Berkeley | UCLA | San Diego | Davis | Irvine | Santa Barbara | Santa Cruz | Riverside | Diff. in Across-Campus Hetero. \dagger |
|--|--------------|----------|-------|-----------|-------|--------|---------------|------------|-----------|--|
| <i>Share Graduating with Science Major</i> | | | | | | | | | | |
| Science | Q1 | 1.3% | 1.6% | 4.9% | 2.8% | 3.9% | 6.5% | 11.2% | 8.9% | 6.1% |
| | Q2 | 5.5% | 5.6% | 11.9% | 8.4% | 9.5% | 14.8% | 19.2% | 19.2% | 3.7% |
| | Q3 | 12.3% | 11.4% | 19.5% | 15.7% | 15.8% | 23.2% | 25.9% | 29.1% | 13.8% |
| | Q4 | 24.6% | 21.4% | 29.9% | 27.0% | 24.9% | 34.2% | 33.9% | 41.2% | -10.9% |
| Ave. Diff. \ddagger | | -1.3% | -0.3% | 1.0% | 0.6% | -0.8% | 2.9% | 6.8% | 0.3% | |
| Non-Science | Q1 | 0.1% | 0.1% | 0.7% | 0.4% | 0.3% | 0.6% | 1.5% | 1.4% | -14.2% |
| | Q2 | 0.6% | 0.5% | 2.2% | 1.7% | 0.8% | 1.7% | 3.1% | 4.0% | 10.1% |
| | Q3 | 1.6% | 1.2% | 4.2% | 3.9% | 1.6% | 3.3% | 4.7% | 7.4% | -15.9% |
| | Q4 | 4.2% | 2.6% | 7.5% | 8.1% | 2.9% | 5.9% | 6.9% | 12.6% | -10.1% |
| Ave. Diff. \ddagger | | -0.2% | -0.5% | -0.8% | -0.9% | -2.7% | 1.0% | 1.3% | 5.5% | |
| <i>Share Graduating with Non-Science Major</i> | | | | | | | | | | |
| Science | Q1 | 12.6% | 8.0% | 11.6% | 9.5% | 10.9% | 10.7% | 18.9% | 15.7% | 0.2% |
| | Q2 | 15.7% | 11.1% | 14.3% | 11.3% | 12.9% | 11.7% | 20.5% | 16.5% | -4.1% |
| | Q3 | 16.2% | 12.4% | 15.0% | 11.5% | 13.3% | 11.3% | 20.6% | 15.5% | -9.6% |
| | Q4 | 14.7% | 12.6% | 14.6% | 10.5% | 12.9% | 10.2% | 19.9% | 13.5% | -28.4% |
| Ave. Diff. \ddagger | | 0.0% | -1.2% | -1.1% | 1.3% | 3.1% | -5.5% | 3.1% | -3.9% | |
| Non-Science | Q1 | 24.9% | 18.4% | 22.9% | 17.8% | 27.5% | 27.6% | 39.8% | 31.5% | 4.4% |
| | Q2 | 34.1% | 28.6% | 32.2% | 24.9% | 36.3% | 35.7% | 47.6% | 39.0% | 1.4% |
| | Q3 | 40.0% | 36.1% | 38.2% | 29.3% | 42.1% | 40.6% | 51.9% | 42.6% | 1.2% |
| | Q4 | 43.2% | 41.3% | 41.3% | 31.1% | 45.7% | 43.1% | 54.1% | 43.1% | -12.9% |
| Ave. Diff. \ddagger | | -1.0% | -1.3% | -3.1% | 0.5% | 1.2% | 5.8% | 2.6% | 8.7% | |
| <i>Share Graduating with Any Major</i> | | | | | | | | | | |
| Science | Q1 | 14.0% | 9.6% | 16.6% | 12.2% | 14.8% | 17.2% | 30.1% | 24.6% | 5.5% |
| | Q2 | 21.2% | 16.7% | 26.2% | 19.7% | 22.4% | 26.4% | 39.7% | 35.7% | 5.6% |
| | Q3 | 28.5% | 23.8% | 34.5% | 27.2% | 29.1% | 34.5% | 46.5% | 44.6% | 3.2% |
| | Q4 | 39.2% | 34.0% | 44.6% | 37.5% | 37.7% | 44.4% | 53.7% | 54.6% | -16.0% |
| Ave. Diff. \ddagger | | -1.3% | -1.4% | 0.0% | 1.9% | 2.3% | -2.7% | 9.9% | -3.6% | |
| Non-Science | Q1 | 25.0% | 18.5% | 23.6% | 18.3% | 27.8% | 28.2% | 41.3% | 33.0% | 4.5% |
| | Q2 | 34.7% | 29.1% | 34.4% | 26.6% | 37.1% | 37.4% | 50.7% | 43.0% | 3.3% |
| | Q3 | 41.7% | 37.3% | 42.4% | 33.3% | 43.6% | 43.9% | 56.6% | 50.0% | 2.2% |
| | Q4 | 47.4% | 43.9% | 48.8% | 39.3% | 48.6% | 49.0% | 61.0% | 55.8% | -14.0% |
| Ave. Diff. \ddagger | | -1.1% | -1.8% | -3.8% | -0.2% | -1.5% | 6.8% | 3.9% | 14.3% | |

\dagger The “difference in across-campus heterogeneity” is the difference, for each SAT quartile, in the coefficients of variation for the selection-adjusted *row* entries and the corresponding unadjusted entries in Table 5.

\ddagger The “average difference” the average difference between the selection-adjusted *column* entries in this table and the corresponding unadjusted entries from Table 5.

Table 9 displays the proportion of non-minority students that are enrolled at campus *A* (“Actual Campus”) who would be predicted to have higher persistence rates if they had enrolled at each of the other UC campus (“Counterfactual Campus”) for each of the graduation outcomes noted above. A number of patterns stand out in the predicted gains from these counterfactual reallocations of students for graduating with a science degree, conditional on science as the initial major, for this group of students. First, with respect to persisting in the sciences, UC San Diego is very strong. Among initial science majors who attended one of the top five UC campuses, virtually all of them would have higher net returns to graduating in the sciences if they were enrolled at UC San Diego, and a majority of students enrolled at the bottom three UC campuses would have higher net returns in the sciences at UC San Diego. Second, UC Davis and UC Riverside appear to have strong relative advantages for graduating students from top-five and bottom-three UC campuses, respectively, in the sciences. For example, science students at UC Berkeley or UCLA would have higher persistence rates in the sciences at UC Davis, less than a third of the science students at UC Santa Barbara, or UC Riverside would be better off at Davis. Third, aside from these three “science” schools, re-allocating science students from the campus they enrolled at to the other campuses tends to produce improvements persistence rates in the sciences for less than half of the non-minority students. In short, among non-minorities, students in the sciences appear to be relatively well-matched to campuses, although there would be gains if more of them had gone, or could have gone, gone to UC San Diego.

The pattern for the gains from these hypothetical re-allocations of non-minority students across the UC campuses with respect to graduation outside of the sciences are quite different from the persistence-in-the-sciences outcome. Our estimates imply that most non-minority students at a particular UC campus (e.g., UC Berkeley) would not gain from moving to lesser-ranked one. (Note the greater proportions of gainers above the diagonal in the bottom two panels of Table 9 compared to those below the diagonal.) This pattern is especially true for students who start out in the non-sciences, where almost every non-minority student enrolled at a campus other than UC Berkeley would gain in terms of graduation if they were allowed to go to UC Berkeley. Thus, while which campus one is matched to appears to be particularly important for the persistence in the sciences, being allocated to a more-selective campus improves overall graduation rates, especially for non-minority students who start out in a non-science major.

Table 9: Estimated Proportions of Non-Minority Students who would Increase their Payoffs to Graduating if they had been at a Different (Counterfactual) UC Campus

| Campus Enrolled at: | Counterfactual Campus: | | | | | | | |
|---|------------------------|------|--------------|--------------|--------|------------------|---------------|-----------|
| | UC Berkeley | UCLA | San Diego | San Davis | Irvine | Santa Barbara | Santa Cruz | Riverside |
| <i>Graduating with Science Major, Conditional on Initial Major = Science:</i> | | | | | | | | |
| Berkeley | — | 45% | 100% | 98% | 32% | 42% | 9% | 34% |
| UCLA | 46% | — | 100% | 99% | 52% | 66% | 14% | 56% |
| San Diego | 0% | 0% | — | 0% | 0% | 4% | 2% | 9% |
| Davis | 0% | 0% | 100% | — | 1% | 45% | 17% | 46% |
| Irvine | 10% | 18% | 100% | 99% | — | 99% | 48% | 91% |
| Santa Barbara | 3% | 2% | 63% | 22% | 0% | — | 27% | 83% |
| Santa Cruz | 11% | 14% | 55% | 36% | 26% | 59% | — | 84% |
| Riverside | 12% | 14% | 55% | 33% | 11% | 35% | 18% | — |
| <i>Graduating with Any Major, Conditional on Initial Major = Science:</i> | | | | | | | | |
| Berkeley | — | 0% | 9% | 11% | 1% | 3% | 1% | 1% |
| UCLA | 100% | — | 61% | 59% | 11% | 15% | 5% | 5% |
| San Diego | 84% | 27% | — | 66% | 0% | 5% | 3% | 1% |
| Davis | 59% | 13% | 24% | — | 0% | 7% | 4% | 2% |
| Irvine | 83% | 31% | 98% | 100% | — | 93% | 35% | 27% |
| Santa Barbara | 60% | 29% | 56% | 76% | 11% | — | 12% | 0% |
| Santa Cruz | 57% | 32% | 56% | 72% | 42% | 80% | — | 20% |
| Riverside | 65% | 41% | 70% | 83% | 60% | 99% | 62% | — |
| <i>Graduating with Any Major, Conditional on Initial Major = Non-Science:</i> | | | | | | | | |
| Berkeley | — | 0% | 0% | 0% | 0% | 2% | 0% | 0% |
| UCLA | 100% | — | 15% | 19% | 11% | 19% | 6% | 3% |
| San Diego | 100% | 84% | — | 82% | 5% | 44% | 3% | 1% |
| Davis | 99% | 53% | 6% | — | 2% | 67% | 5% | 1% |
| Irvine | 100% | 38% | 54% | 92% | — | 100% | 20% | 2% |
| Santa Barbara | 84% | 35% | 13% | 16% | 0% | — | 0% | 0% |
| Santa Cruz | 97% | 57% | 75% | 87% | 86% | 100% | — | 0% |
| Riverside | 95% | 48% | 78% | 91% | 93% | 100% | 100% | — |

Results based on criteria of graduating in 5 years or less.

The corresponding results for minority students are presented in Table 10. They are very different from those for non-minorities. First, almost all minorities that were enrolled at a UC campus would have higher persistence rates in the sciences if they were reallocated to a lesser-ranked campus. (The percentages above the diagonal in the first panel of Table 10 are generally close to 100% and are much larger than those below the diagonal.) The one exception is again UC San Diego where relatively strong minority students would have higher persistence rates in the sciences. This stronger pattern of the relative advantage in persistence in the sciences for minorities at lower-ranked campuses results in large part from the large differences in academic preparation between the minorities and non-minorities.

Re-allocating minority students to a lesser-ranked campus also would improve overall graduation rates in either the sciences or non-sciences (see the bottom two panels of Table 10), although there are some exceptions. In particular, over half of minority students at UC Berkeley would see decreases in their overall graduation rates if they moved to any of the lower-ranked campuses with the exception of UC Irvine. Further, while UC San Diego and UC Davis do well in the sciences, their overall graduation rates tend to be lower. Nonetheless, the general pattern is that moving minorities to less-selective campuses results in increases in overall graduation rates.

To get a better sense of how the graduation rates of students with differing academic backgrounds would fare by moving to different campuses, Table 11 displays, for the 5-year graduation criteria, the gains (losses) of moving minority and non-minority students enrolled at the three highest ranked campuses (UC Berkeley, UCLA, and UC San Diego) to the two lowest-ranked ones (UC Santa Cruz and UC Riverside). Here, we report results by SAT quartiles in order to capture, in part, the differences in the academic preparation of (minority and non-minority) students across the various campuses. We continue to focus on the same graduation outcomes as we considered in Tables 9 and 10.

The first three panels of Table 11 give the results for non-minority students enrolled at UC Berkeley, UCLA and UC San Diego. Non-minority students in the bottom quartile of the SAT distribution at UC Berkeley or UCLA would see a higher probability of graduating the sciences had they instead attended UC Santa Cruz or UC Riverside. Recall that not many non-minority

Table 10: Estimated Percentages of Minority Students who would Increase their Payoffs to Graduating if they had been at a Different (Counterfactual) UC Campus

| Campus Enrolled at: | Counterfactual Campus: | | | | | | | |
|---|------------------------|------|--------------|--------------|--------|------------------|---------------|-----------|
| | UC Berkeley | UCLA | San Diego | San Davis | Irvine | Santa Barbara | Santa Cruz | Riverside |
| <i>Graduating with Science Major, Conditional on Initial Major = Science:</i> | | | | | | | | |
| UC Berkeley | — | 94% | 97% | 100% | 100% | 100% | 77% | 100% |
| UCLA | 3% | — | 95% | 70% | 100% | 100% | 73% | 100% |
| San Diego | 1% | 3% | — | 10% | 13% | 98% | 34% | 86% |
| Davis | 0% | 52% | 92% | — | 96% | 100% | 78% | 100% |
| Irvine | 0% | 0% | 92% | 2% | — | 100% | 71% | 97% |
| Santa Barbara | 0% | 0% | 20% | 0% | 0% | — | 51% | 1% |
| Santa Cruz | 3% | 7% | 20% | 9% | 12% | 36% | — | 28% |
| Riverside | 0% | 1% | 44% | 0% | 2% | 98% | 63% | — |
| <i>Graduating with Any Major, Conditional on Initial Major = Science:</i> | | | | | | | | |
| UC Berkeley | — | 0% | 8% | 0% | 68% | 8% | 39% | 28% |
| UCLA | 100% | — | 32% | 0% | 95% | 40% | 65% | 53% |
| San Diego | 96% | 73% | — | 33% | 100% | 93% | 100% | 100% |
| Davis | 100% | 100% | 86% | — | 100% | 96% | 95% | 94% |
| Irvine | 14% | 3% | 0% | 0% | — | 0% | 43% | 22% |
| Santa Barbara | 80% | 32% | 36% | 4% | 100% | — | 97% | 93% |
| Santa Cruz | 19% | 9% | 0% | 2% | 31% | 3% | — | 0% |
| Riverside | 44% | 21% | 0% | 3% | 65% | 6% | 100% | — |
| <i>Graduating with Any Major, Conditional on Initial Major = Non-Science:</i> | | | | | | | | |
| UC Berkeley | — | 0% | 9% | 0% | 65% | 26% | 50% | 32% |
| UCLA | 100% | — | 36% | 0% | 90% | 60% | 68% | 54% |
| San Diego | 98% | 75% | — | 19% | 100% | 100% | 100% | 91% |
| Davis | 100% | 100% | 93% | — | 100% | 99% | 99% | 94% |
| Irvine | 18% | 2% | 0% | 0% | — | 0% | 58% | 33% |
| Santa Barbara | 48% | 18% | 0% | 0% | 98% | — | 97% | 68% |
| Santa Cruz | 23% | 11% | 0% | 0% | 32% | 3% | — | 0% |
| Riverside | 36% | 14% | 0% | 1% | 48% | 24% | 100% | — |

Results based on criteria of graduating in 5 years or less.

students are in the bottom quartile of the total SAT score distribution at these campuses (see Table 3). As we move to higher SAT quartiles, the comparative advantage of lower-ranked campuses in graduating non-minority students in the sciences diminishes and then flips, i.e., moving non-minority students in higher SAT quartiles to the lower-ranked campuses would result in losses, not gains, in persistence rates in the sciences. As noted above, non-minority students at UC San Diego were more likely to persist and graduate in the sciences, on average, than if they moved to any other UC campus. We see from Table 11 this holds within each SAT quartile, at least when UC Santa Cruz and UC Riverside are the counterfactual campuses. And, consistent with our more aggregated results in Table 17, non-minority students enrolled at UC Berkeley, UCLA or UC San Diego for each SAT quartile would be *less* likely to graduate overall if they were switched to either of the lower-ranked campuses, regardless of their initial major.

The net gains of moving minority students from top- to lower-ranked campuses by quartile of the SAT distribution are found in the bottom three panels of Table 11. As before, the patterns for the net gains among minority students differ from those for non-minorities. With the exception of switching students from UC San Diego to UC Santa Cruz, minority students in the bottom two SAT quartiles who attended one of the top three campuses would persist in the sciences at higher if they had attended either of the lower-ranked campuses. Recall from Table 3 that the share of minority students in these bottom two quartiles range from a low of 66.8% ($= 34.5\% + 32.3\%$) at UC Berkeley to a high of 77.5% ($= 37.1\% + 40.4\%$) UCLA for the top three campuses. UC Riverside seems especially good at graduating minority students in the sciences as minority students from each quartile that were enrolled at any of the top three campuses would have higher net returns to graduating in the sciences if they had enrolled at UC Riverside. In contrast, UC Santa Cruz tends to be better at graduating students overall. Finally, we note that the apparent gains of re-allocating minority students are lower in terms of graduating with any major than they are for graduating in the sciences, again stressing that the match between the school and the student is especially important in the sciences.

This potential for sizeable gains in graduating with science degrees among minorities by re-allocating less-prepared students from higher- to lower-ranked campuses raises an obvious question: Why were minority students wanting to major in the sciences attending more selective

Table 11: Estimated Gains (Losses) in 5-Year Graduations Moving from More Selective to Less Selective UC Campuses

| SAT Quartile | Berkeley | | Gain (Loss) from switch to: | | UCLA | | Gain (Loss) from switch to: | | UCSD | | Gain (Loss) from switch to: | |
|---|-------------------|-------------------------|--------------------------------|-------------------------|-------------------|-------------------------|--------------------------------|-------------------------|-------------------|-------------------------|--------------------------------|-------------------------|
| | Base Grad Rate | Santa Cruz Grad Rate | Riverside Grad Rate | Santa Cruz Grad Rate | Base Grad Rate | Santa Cruz Grad Rate | Riverside Grad Rate | Santa Cruz Grad Rate | Base Grad Rate | Santa Cruz Grad Rate | Riverside Grad Rate | Santa Cruz Grad Rate |
| Non-Minority: | | | | | | | | | | | | |
| <i>Share Graduating in Sciences, Conditional on Initial Major = Science:</i> | | | | | | | | | | | | |
| Q1 | 28.2% | 3.2% | 9.3% | 27.7% | 2.0% | 7.8% | 36.1% | -6.9% | -1.6% | | | |
| Q2 | 47.0% | -7.1% | 1.9% | 42.2% | -5.4% | 3.4% | 46.7% | -12.3% | -4.4% | | | |
| Q3 | 53.9% | -11.9% | -1.0% | 48.7% | -9.2% | 1.3% | 52.0% | -15.1% | -5.9% | | | |
| Q4 | 56.5% | -14.0% | -2.0% | 52.2% | -11.3% | 0.1% | 57.3% | -18.0% | -7.4% | | | |
| <i>Share Graduating with Any Major, Conditional on Initial Major = Science:</i> | | | | | | | | | | | | |
| Q1 | 72.6% | -4.2% | -4.3% | 69.4% | -1.0% | -1.2% | 70.5% | -3.2% | -3.5% | | | |
| Q2 | 79.9% | -6.8% | -5.9% | 77.7% | -4.7% | -3.9% | 77.0% | -5.4% | -5.0% | | | |
| Q3 | 84.4% | -8.1% | -6.8% | 81.8% | -6.3% | -5.2% | 79.8% | -6.2% | -5.5% | | | |
| Q4 | 86.1% | -8.5% | -7.1% | 83.9% | -7.0% | -5.7% | 82.4% | -6.8% | -5.7% | | | |
| <i>Share Graduating with Any Major, Conditional on Initial Major = Non-Science:</i> | | | | | | | | | | | | |
| Q1 | 75.4% | -5.1% | -6.8% | 71.9% | -1.1% | -2.9% | 76.8% | -2.6% | -4.1% | | | |
| Q2 | 82.1% | -6.3% | -7.4% | 81.3% | -4.1% | -5.3% | 81.6% | -3.6% | -4.8% | | | |
| Q3 | 86.6% | -6.8% | -7.5% | 86.0% | -5.4% | -6.2% | 82.5% | -3.8% | -4.9% | | | |
| Q4 | 88.8% | -7.0% | -7.5% | 87.6% | -5.8% | -6.4% | 83.1% | -3.9% | -4.8% | | | |
| Minority: | | | | | | | | | | | | |
| <i>Share Graduating in Sciences, Conditional on Initial Major = Science:</i> | | | | | | | | | | | | |
| Q1 | 11.0% | 9.3% | 10.1% | 16.1% | 4.9% | 5.6% | 22.2% | -0.2% | 2.0% | | | |
| Q2 | 20.8% | 7.5% | 11.2% | 26.8% | 2.2% | 6.7% | 29.6% | -2.2% | 3.2% | | | |
| Q3 | 33.6% | 2.4% | 10.6% | 35.2% | -0.6% | 6.6% | 37.3% | -3.3% | 3.3% | | | |
| Q4 | 42.9% | -0.8% | 8.3% | 44.5% | -3.9% | 5.8% | 45.5% | -5.7% | 4.4% | | | |
| <i>Share Graduating with Any Major, Conditional on Initial Major = Science:</i> | | | | | | | | | | | | |
| Q1 | 58.1% | 1.2% | -0.1% | 55.3% | 3.9% | 2.6% | 59.4% | 3.2% | 1.9% | | | |
| Q2 | 63.6% | 0.1% | -1.0% | 63.3% | 1.7% | 0.6% | 63.6% | 2.6% | 1.6% | | | |
| Q3 | 71.1% | -1.6% | -2.3% | 68.7% | 0.1% | -0.7% | 65.4% | 2.3% | 1.5% | | | |
| Q4 | 73.2% | -2.0% | -2.5% | 72.7% | -0.9% | -1.5% | 70.5% | 1.6% | 1.1% | | | |
| <i>Share Graduating with Any Major, Conditional on Initial Major = Non-Science:</i> | | | | | | | | | | | | |
| Q1 | 63.8% | 1.7% | 0.3% | 62.5% | 4.1% | 2.7% | 66.1% | 3.1% | 1.7% | | | |
| Q2 | 70.5% | 0.1% | -1.2% | 69.4% | 2.0% | 0.6% | 71.2% | 2.5% | 1.1% | | | |
| Q3 | 74.9% | -0.8% | -2.2% | 74.9% | 0.4% | -1.0% | 73.5% | 2.2% | 0.9% | | | |
| Q4 | 77.6% | -1.3% | -2.6% | 77.4% | -0.2% | -1.5% | 74.1% | 2.1% | 0.8% | | | |

colleges when our evidence indicates that their chances of graduating would have been higher elsewhere? There are at least two potential answers to this question. First, students may not be choosing to maximize their probabilities of graduating in the sciences when deciding where to enroll. While our results show that their graduation rates in the sciences rise significantly if more minorities attended less-selective schools, we also find that such re-allocations would have much smaller impacts on their overall graduation rates.²⁷ Second, students may be ill-informed about their success probabilities in various fields. Arcidiacono, Aucejo, Fang, and Spenner (2012) show that affirmative action can result in welfare losses for minority students if universities have private information about how well the student will perform at their school. Both Bettinger et al. (2009) and Hoxby and Avery (2012) show that lack of information may be a serious concern among low income students.

5 Conclusion

Our evidence suggests significant heterogeneity in how campuses produce college graduates in science and non-science fields. The most-selective UC campuses have a comparative advantage in graduating academically better-prepared students while less selective campuses have a comparative advantage in graduating less-prepared ones. Further, some campuses, such as UC San Diego and UC Davis, are particularly good at graduating students in sciences but perform poorly when looking at overall graduation rates.

We find evidence that the match between the college and the student is particularly important in the sciences. Our evidence suggests that, in a period when racial preferences in admissions were strong, minority students were in general over-matched, resulting in low graduation rates in the sciences and a decreased probability of graduating in four years. In contrast, non-minority students were better-placed for graduating in the sciences. Policies that improve the matching of students to colleges – at least when the student is interested in the sciences – have the potential to mitigate some of the under-representation of minorities in the sciences.

²⁷Arcidiacono, Aucejo, Coate and Hotz (2012) examine UC graduation rates before and after Proposition 209, which banned the use of racial preferences in admission. They find that better matching of minority students to schools as a result of Proposition 209 and that it had a positive effect on minority graduation rates, regardless of major, although the effect was small.

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A Appendix

Table 12: Classification of Majors at UC Campuses

| Science (STEM) | Humanities | Social Science |
|--|--------------------------------------|-------------------------|
| Aerospace Engineering | American Culture | Anthropology |
| Biochemistry | Architecture | Anthropology-Zoology |
| Biology | Asian Studies | Business Administration |
| Bio-psychology & Cognitive Science | Creative Writing | Economics |
| Cellular & Molecular Biology | Literature | Environmental Policy |
| Chemical Engineering | Dance | & Behavior |
| Chemistry | Education - Elementary | History |
| Civil Engineering | Education - Secondary | Organizational Studies |
| Computer Science | English | Political Science |
| Electrical Engineering | Film & Video Studies | Psychology |
| Engineering - First Year | French | Resource Ecology |
| General Biology | General Studies | & Management |
| Industrial & Operations Engineering | German | Sociology |
| Materials Science | Graphic Design | Women's Studies |
| & Engineering | History of Art | |
| Mathematics | Individualized | |
| Mechanical Engineering | Concentration | |
| Microbiology | Industrial Design | |
| Movement Science | Japanese | |
| Nuclear Engineering & Radiological Science | L S & A Undeclared | |
| Pharmacy | Linguistics | |
| Statistics | Music Education | |
| | Music Theatre | |
| | Naval Architect & Marine Engineering | |

Table 13: Unadjusted Shares of Non-Minority Students Graduating in 5 Years with Science or Non-Science Majors, by Campus, SAT Quartile, and Initial Major

| Initial Major | SAT Quartile | San | | | | | | | | All Campuses |
|---|--------------|----------|-------|-------|-------|--------|---------|------------|-----------|--------------|
| | | Berkeley | UCLA | Diego | Davis | Irvine | Barbara | Santa Cruz | Riverside | |
| <i>Share Graduating with Science Major:</i> | | | | | | | | | | |
| Science | Q1 | 25.0% | 28.0% | 33.7% | 31.2% | 25.1% | 23.8% | 22.3% | 23.8% | 26.4% |
| | Q2 | 42.4% | 44.2% | 45.9% | 40.2% | 35.5% | 32.2% | 28.7% | 38.8% | 38.7% |
| | Q3 | 51.0% | 49.4% | 51.0% | 45.0% | 39.6% | 36.8% | 30.0% | 44.8% | 46.2% |
| | Q4 | 59.1% | 50.3% | 57.7% | 51.8% | 43.8% | 38.0% | 33.3% | 44.0% | 53.5% |
| Non-Science | Q1 | 5.1% | 5.3% | 13.2% | 10.8% | 5.5% | 3.5% | 5.2% | 7.7% | 6.5% |
| | Q2 | 5.0% | 6.5% | 12.1% | 11.2% | 7.6% | 3.8% | 6.4% | 10.0% | 7.6% |
| | Q3 | 12.2% | 9.9% | 15.2% | 14.8% | 6.8% | 5.0% | 5.7% | 17.3% | 10.5% |
| | Q4 | 13.2% | 11.3% | 18.2% | 17.7% | 8.2% | 5.9% | 9.3% | 14.2% | 12.8% |
| <i>Share Graduating with Non-Science Major:</i> | | | | | | | | | | |
| Science | Q1 | 34.6% | 36.4% | 31.4% | 36.2% | 34.3% | 37.9% | 35.5% | 30.3% | 34.5% |
| | Q2 | 41.6% | 33.6% | 30.3% | 34.5% | 32.7% | 37.2% | 34.4% | 23.0% | 33.4% |
| | Q3 | 36.3% | 33.6% | 27.4% | 32.9% | 28.2% | 33.3% | 39.5% | 23.6% | 31.9% |
| | Q4 | 27.3% | 32.2% | 24.7% | 22.4% | 29.7% | 29.5% | 39.2% | 33.9% | 28.1% |
| Non-Science | Q1 | 63.4% | 63.9% | 63.2% | 59.1% | 62.7% | 68.2% | 60.6% | 53.6% | 61.8% |
| | Q2 | 79.0% | 75.9% | 72.0% | 69.5% | 63.8% | 71.3% | 65.5% | 54.6% | 69.0% |
| | Q3 | 74.6% | 77.4% | 69.3% | 64.3% | 62.4% | 71.1% | 62.5% | 49.0% | 69.4% |
| | Q4 | 73.9% | 75.4% | 63.5% | 59.9% | 67.6% | 69.9% | 56.9% | 51.7% | 69.9% |
| <i>Share Graduating, Any Major:</i> | | | | | | | | | | |
| Science | Q1 | 59.6% | 64.5% | 65.0% | 67.4% | 59.4% | 61.7% | 57.8% | 54.1% | 60.9% |
| | Q2 | 83.9% | 77.8% | 76.2% | 74.8% | 68.2% | 69.4% | 63.1% | 61.8% | 72.1% |
| | Q3 | 87.3% | 83.0% | 78.4% | 77.9% | 67.8% | 70.1% | 69.6% | 68.5% | 78.0% |
| | Q4 | 86.4% | 82.5% | 82.4% | 74.2% | 73.4% | 67.5% | 72.5% | 78.0% | 81.6% |
| Non-Science | Q1 | 68.6% | 69.2% | 76.4% | 69.9% | 68.2% | 71.7% | 65.9% | 61.3% | 68.3% |
| | Q2 | 83.9% | 82.4% | 84.1% | 80.7% | 71.5% | 75.2% | 71.9% | 64.6% | 76.6% |
| | Q3 | 86.9% | 87.3% | 84.5% | 79.2% | 69.2% | 76.1% | 68.2% | 66.3% | 79.9% |
| | Q4 | 87.2% | 86.7% | 81.7% | 77.6% | 75.8% | 75.7% | 66.1% | 65.8% | 82.7% |

Table 14: Unadjusted Shares of Non-Minority Students Graduating in 4 Years with Science or Non-Science Majors, by Campus, SAT Quartile, and Initial Major

| Initial Major | SAT | | | | | | | | | | Overall |
|---|----------|----------|-------|-----------|-------|--------|---------|------------|-----------|---------|---------|
| | Quartile | Berkeley | UCLA | San Diego | Davis | Irvine | Barbara | Santa Cruz | Riverside | Overall | |
| <i>Share Graduating with Science Major:</i> | | | | | | | | | | | |
| Science | Q1 | 9.6% | 14.0% | 14.5% | 9.2% | 10.2% | 10.3% | 10.7% | 11.6% | 10.8% | |
| | Q2 | 26.3% | 17.9% | 26.1% | 16.6% | 16.2% | 16.9% | 17.3% | 24.6% | 19.3% | |
| | Q3 | 34.4% | 24.4% | 29.9% | 20.5% | 21.0% | 21.5% | 18.6% | 30.0% | 25.6% | |
| | Q4 | 42.4% | 28.2% | 38.9% | 27.6% | 31.3% | 23.7% | 22.9% | 35.8% | 35.3% | |
| Non-Science | Q1 | 0.6% | 0.0% | 4.3% | 3.6% | 2.3% | 1.1% | 2.6% | 2.6% | 2.2% | |
| | Q2 | 2.2% | 2.5% | 5.7% | 4.4% | 2.2% | 1.5% | 3.1% | 5.6% | 3.1% | |
| | Q3 | 7.0% | 4.9% | 8.6% | 6.1% | 2.7% | 2.0% | 2.9% | 12.4% | 5.3% | |
| | Q4 | 8.2% | 6.4% | 10.5% | 7.8% | 4.1% | 2.9% | 5.2% | 12.5% | 7.4% | |
| <i>Share Graduating with Non-Science Major:</i> | | | | | | | | | | | |
| Science | Q1 | 9.6% | 11.2% | 12.9% | 11.6% | 14.0% | 15.8% | 22.0% | 16.3% | 14.7% | |
| | Q2 | 21.8% | 13.9% | 16.9% | 15.8% | 11.7% | 19.5% | 19.4% | 11.6% | 15.7% | |
| | Q3 | 19.6% | 17.2% | 15.1% | 14.9% | 10.2% | 18.8% | 27.7% | 14.3% | 16.5% | |
| | Q4 | 15.0% | 16.5% | 14.0% | 11.5% | 16.1% | 17.9% | 25.5% | 28.9% | 15.7% | |
| Non-Science | Q1 | 34.3% | 30.1% | 38.0% | 25.9% | 30.8% | 44.7% | 41.7% | 32.2% | 35.3% | |
| | Q2 | 44.1% | 44.0% | 48.7% | 39.3% | 34.6% | 46.7% | 47.8% | 36.5% | 42.9% | |
| | Q3 | 49.7% | 52.4% | 48.5% | 38.2% | 33.8% | 48.0% | 45.5% | 29.2% | 45.8% | |
| | Q4 | 52.5% | 53.6% | 41.7% | 38.6% | 36.1% | 47.5% | 41.3% | 35.8% | 48.4% | |
| <i>Share Graduating, Any Major:</i> | | | | | | | | | | | |
| Science | Q1 | 19.2% | 25.2% | 27.4% | 20.7% | 24.2% | 26.1% | 32.7% | 27.8% | 25.4% | |
| | Q2 | 48.2% | 31.8% | 43.0% | 32.4% | 27.9% | 36.4% | 36.7% | 36.2% | 35.0% | |
| | Q3 | 54.0% | 41.6% | 45.0% | 35.4% | 31.2% | 40.2% | 46.2% | 44.3% | 42.1% | |
| | Q4 | 57.4% | 44.7% | 52.9% | 39.1% | 47.4% | 41.6% | 48.4% | 64.7% | 50.9% | |
| Non-Science | Q1 | 34.9% | 30.1% | 42.2% | 29.4% | 33.1% | 45.7% | 44.3% | 34.8% | 37.5% | |
| | Q2 | 46.3% | 46.5% | 54.4% | 43.7% | 36.7% | 48.2% | 51.0% | 42.2% | 46.0% | |
| | Q3 | 56.7% | 57.3% | 57.2% | 44.3% | 36.4% | 50.0% | 48.5% | 41.6% | 51.0% | |
| | Q4 | 60.7% | 60.0% | 52.1% | 46.5% | 40.2% | 50.4% | 46.5% | 48.3% | 55.8% | |

Table 15: Nested Logit Coefficients for Choice of Final Major based on 4-year Graduation Criteria

| | Non-Minority | | Minority | |
|---|----------------------|----------------------|---------------------|---------------------|
| | Science | Non-Science | Science | Non-Science |
| <i>Net Returns Function:</i> | | | | |
| UCLA | -0.174 (0.728) | -1.657*** (0.361) | 0.818 (1.672) | -1.440** (0.685) |
| San Diego | 2.368*** (0.595) | -0.299 (0.327) | 3.958 (1.641) | -0.492 (0.742) |
| Davis | 2.006*** (0.587) | -0.506* (0.305) | 2.193 (1.615) | -0.422 (0.630) |
| Irvine | 1.902*** (0.607) | -0.313 (0.311) | 4.129** (1.870) | 0.412 (0.669) |
| Santa Barbara | 3.517*** (0.609) | 0.188 (0.317) | 4.632*** (1.603) | 0.557 (0.559) |
| Santa Cruz | 5.079*** (0.671) | 1.046*** (0.340) | 7.256*** (1.772) | 1.453* (0.626) |
| Riverside | 3.584*** (0.627) | 0.139 (0.340) | 5.143*** (1.772) | 0.830 (0.626) |
| UCLA $\times AI_j$ | 0.997*** (0.074) | 1.404*** (0.113) | 0.917*** (0.133) | 1.319*** (0.171) |
| San Diego $\times AI_j$ | 0.786*** (0.055) | 1.055*** (0.093) | 0.709*** (0.121) | 1.124*** (0.202) |
| Davis $\times AI_j$ | 0.778*** (0.054) | 1.029*** (0.088) | 0.828*** (0.123) | 0.998*** (0.168) |
| Irvine $\times AI_j$ | 0.803*** (0.058) | 1.036*** (0.095) | 0.670*** (0.130) | 0.916*** (0.182) |
| Santa Barbara $\times AI_j$ | 0.647*** (0.054) | 0.970*** (0.088) | 0.661*** (0.112) | 0.875*** (0.141) |
| Santa Cruz $\times AI_j$ | 0.473*** (0.057) | 0.706*** (0.090) | 0.472*** (0.101) | 0.779*** (0.119) |
| Riverside $\times AI_j$ | 0.670*** (0.057) | 0.972*** (0.102) | 0.654*** (0.119) | 0.858*** (0.167) |
| <i>Switching Majors Cost Function:</i> | | | | |
| UCLA | -0.009 (0.036) | | 0.133 (0.116) | |
| San Diego | -0.120*** (0.036) | | -0.127 (0.124) | |
| Davis | -0.191*** (0.038) | | -0.176 (0.135) | |
| Irvine | -0.020 (0.047) | | 0.186 (0.157) | |
| Santa Barbara | 0.086* (0.047) | | 0.122 (0.136) | |
| Santa Cruz | -0.184*** (0.052) | | -0.056 (0.148) | |
| Riverside | -0.254*** (0.054) | | -0.146 (0.143) | |
| <i>Academic Preparation Index Function:</i> | | | | |
| HS GPA | 1.317*** (0.104) | 0.618*** (0.082) | 1.405*** (0.305) | 0.647*** (0.193) |
| SAT Math | 5.475*** (0.371) | -0.765*** (0.158) | 7.404*** (1.040) | -0.466 (0.329) |
| SAT Verbal | -0.151 (0.224) | 1.405*** (0.186) | 1.663* (0.973) | 1.895*** (0.598) |
| <i>Nesting parameter</i> | | | | |
| ρ | 0.593*** (0.052) | | 0.611*** (0.160) | |

[†] All campus dummies are measured relative to UC Berkeley (the omitted category). The coefficient on AI for Berkeley is normalized to one.

Table 16: Selection-Adjusted Shares of Non-Minority Students Graduating in 5 Years with Science or Non-Science Majors, by Campus, SAT Quartile, and Initial Major

| Initial Major (j^{int}) | SAT Quartile | San Diego | | | | | | | | | | Diff. in | |
|--|--------------|-----------|-------|-----------|-------|--------|---------|------------|-----------|----------------|---|----------|--|
| | | Berkeley | UCLA | San Diego | Davis | Irvine | Barbara | Santa Cruz | Riverside | Campus Hetero. | † | | |
| <i>Share Graduating with Science Major</i> | | | | | | | | | | | | | |
| Science | Q1 | 18.0% | 20.3% | 29.7% | 26.3% | 24.4% | 28.8% | 26.7% | 30.0% | | | 2.2% | |
| | Q2 | 30.6% | 32.5% | 42.1% | 38.5% | 35.3% | 38.9% | 33.0% | 39.1% | | | -4.5% | |
| | Q3 | 41.1% | 42.0% | 51.3% | 47.6% | 43.5% | 46.1% | 37.1% | 45.6% | | | -7.4% | |
| | Q4 | 50.9% | 50.8% | 59.3% | 55.8% | 50.8% | 52.4% | 40.5% | 51.3% | | | -8.9% | |
| Ave. Diff.† | | -9.2% | -6.6% | -1.5% | 0.0% | 2.5% | 8.9% | 5.8% | 3.7% | | | | |
| <i>Non-Science</i> | | | | | | | | | | | | | |
| | Q1 | 2.2% | 2.8% | 6.5% | 6.7% | 4.5% | 4.1% | 7.0% | 8.9% | | | -4.1% | |
| | Q2 | 3.8% | 4.5% | 9.7% | 10.1% | 6.7% | 5.7% | 8.4% | 11.8% | | | -0.4% | |
| | Q3 | 6.3% | 6.9% | 14.1% | 14.8% | 9.6% | 7.8% | 10.3% | 15.5% | | | -8.9% | |
| | Q4 | 10.5% | 10.8% | 20.6% | 21.8% | 14.1% | 11.0% | 12.8% | 20.8% | | | -3.8% | |
| Ave. Diff.† | | -0.7% | 1.0% | 4.4% | 5.2% | 5.0% | 4.4% | 5.9% | 6.4% | | | | |
| <i>Share Graduating with Non-Science Major</i> | | | | | | | | | | | | | |
| Science | Q1 | 45.5% | 38.8% | 33.8% | 38.2% | 37.6% | 35.1% | 35.7% | 31.6% | | | 3.8% | |
| | Q2 | 41.1% | 36.1% | 29.4% | 33.6% | 34.0% | 31.6% | 34.7% | 28.6% | | | -4.3% | |
| | Q3 | 37.2% | 34.0% | 26.4% | 30.3% | 31.7% | 29.6% | 35.1% | 27.1% | | | -4.0% | |
| | Q4 | 32.5% | 31.0% | 23.3% | 26.8% | 29.1% | 27.5% | 35.2% | 25.5% | | | -4.3% | |
| Ave. Diff.† | | 4.1% | 1.0% | -0.2% | 0.7% | 1.9% | -3.5% | -2.0% | 0.5% | | | | |
| <i>Non-Science</i> | | | | | | | | | | | | | |
| | Q1 | 70.3% | 64.6% | 62.3% | 62.8% | 64.5% | 67.5% | 61.0% | 57.1% | | | -0.6% | |
| | Q2 | 74.1% | 69.6% | 64.8% | 64.9% | 67.5% | 70.4% | 63.9% | 58.9% | | | -4.1% | |
| | Q3 | 76.0% | 72.6% | 65.1% | 64.7% | 68.8% | 72.0% | 65.8% | 59.3% | | | -5.6% | |
| | Q4 | 75.6% | 73.5% | 62.9% | 61.9% | 68.3% | 72.2% | 66.7% | 58.0% | | | -3.7% | |
| Ave. Diff.† | | 1.3% | -3.1% | -3.2% | 0.4% | 3.2% | 0.4% | 3.0% | 6.1% | | | | |
| <i>Share Graduating with Any Major</i> | | | | | | | | | | | | | |
| Science | Q1 | 63.5% | 59.1% | 63.5% | 64.5% | 62.1% | 63.9% | 62.4% | 61.5% | | | -4.3% | |
| | Q2 | 71.7% | 68.6% | 71.6% | 72.0% | 69.4% | 70.5% | 67.7% | 67.8% | | | -8.0% | |
| | Q3 | 78.2% | 76.0% | 77.7% | 77.9% | 75.2% | 75.7% | 72.1% | 72.8% | | | -6.8% | |
| | Q4 | 83.4% | 81.8% | 82.6% | 82.6% | 79.9% | 79.9% | 75.7% | 76.9% | | | -4.7% | |
| Ave. Diff.† | | -5.1% | -5.6% | -1.7% | 0.7% | 4.5% | 5.3% | 3.7% | 4.2% | | | | |
| <i>Non-Science</i> | | | | | | | | | | | | | |
| | Q1 | 72.5% | 67.4% | 68.8% | 69.5% | 69.0% | 71.6% | 68.0% | 66.0% | | | -3.2% | |
| | Q2 | 77.9% | 74.1% | 74.4% | 74.9% | 74.1% | 76.1% | 72.3% | 70.7% | | | -6.3% | |
| | Q3 | 82.3% | 79.5% | 79.2% | 79.5% | 78.5% | 79.8% | 76.0% | 74.8% | | | -8.2% | |
| | Q4 | 86.2% | 84.3% | 83.5% | 83.7% | 82.4% | 83.2% | 79.5% | 78.7% | | | -7.6% | |
| Ave. Diff.† | | -1.9% | -5.1% | -5.2% | 0.0% | 4.8% | 3.0% | 5.9% | 8.1% | | | | |

† The “difference in across-campus heterogeneity” is the difference, for each SAT quartile, in the coefficients of variation for the selection-adjusted *row* entries and the corresponding unadjusted entries in Table 13.

‡ The “average difference” the average difference between the selection-adjusted *column* entries in this table and the corresponding unadjusted entries from Table 13.

Table 17: Selection-Adjusted Shares of Non-Minority Students Graduating in 4 Years with Science or Non-Science Majors, by Campus, SAT Quartile, and Initial Major

| Initial Major (j^{int}) | SAT Quartile | San Diego | | | | | | | | Santa Barbara | | Santa Cruz | | Riverside | | Diff. in Across-Campus Hetero. \dagger | |
|--|--------------|-----------|----------|-------|--------|-------|--------|---------|--------|---------------|-------------------|------------|--|-----------|--|--|--|
| | | UCLA | Berkeley | Davis | Irvine | Davis | Irvine | Barbara | Cruz | Riverside | Hetero. \dagger | | | | | | |
| <i>Share Graduating with Science Major</i> | | | | | | | | | | | | | | | | | |
| Science | Q1 | 5.8% | 5.7% | 13.2% | 8.8% | 9.7% | 13.8% | 14.4% | 15.8% | 18.6% | | | | | | | |
| | Q2 | 13.3% | 12.3% | 22.7% | 15.9% | 17.6% | 21.6% | 20.4% | 24.7% | 1.8% | | | | | | | |
| | Q3 | 22.3% | 20.1% | 31.8% | 23.3% | 25.8% | 28.7% | 25.4% | 32.7% | -5.6% | | | | | | | |
| | Q4 | 34.1% | 30.2% | 42.2% | 32.2% | 35.6% | 36.8% | 30.9% | 41.4% | -9.9% | | | | | | | |
| Ave. Diff. \ddagger | -9.3% | -4.1% | 0.1% | 1.6% | 2.5% | 7.1% | 5.4% | 3.2% | | | | | | | | | |
| Non-Science | Q1 | 0.6% | 0.7% | 2.6% | 1.9% | 1.4% | 1.6% | 3.3% | 4.3% | -6.6% | | | | | | | |
| | Q2 | 1.4% | 1.5% | 4.5% | 3.4% | 2.5% | 2.5% | 4.4% | 6.6% | 4.7% | | | | | | | |
| | Q3 | 3.0% | 2.9% | 7.5% | 5.8% | 4.4% | 3.8% | 6.0% | 9.9% | -15.7% | | | | | | | |
| | Q4 | 6.6% | 5.7% | 12.9% | 10.3% | 8.0% | 6.0% | 8.6% | 15.5% | -6.9% | | | | | | | |
| Ave. Diff. \ddagger | -0.9% | -0.1% | 2.1% | 1.9% | 2.4% | 2.3% | 3.6% | 2.9% | | | | | | | | | |
| <i>Share Graduating with Non-Science Major</i> | | | | | | | | | | | | | | | | | |
| Science | Q1 | 18.2% | 12.1% | 14.7% | 13.6% | 13.8% | 14.9% | 20.4% | 18.5% | | | | | | | | |
| | Q2 | 18.9% | 14.2% | 14.9% | 14.4% | 14.4% | 15.4% | 20.6% | 18.7% | -9.1% | | | | | | | |
| | Q3 | 18.8% | 15.8% | 14.8% | 15.0% | 14.6% | 15.9% | 21.1% | 18.7% | -7.7% | | | | | | | |
| | Q4 | 17.1% | 16.3% | 13.9% | 14.8% | 14.1% | 15.8% | 21.3% | 18.1% | -15.7% | | | | | | | |
| Ave. Diff. \ddagger | 1.8% | -0.1% | -0.2% | 1.0% | 1.2% | -2.5% | -2.8% | 0.7% | -17.9% | | | | | | | | |
| Non-Science | Q1 | 38.7% | 28.5% | 34.4% | 28.9% | 33.7% | 40.5% | 41.9% | 37.7% | | | | | | | | |
| | Q2 | 44.9% | 36.3% | 40.0% | 34.2% | 39.6% | 46.4% | 45.9% | 42.6% | -4.0% | | | | | | | |
| | Q3 | 49.4% | 42.7% | 43.7% | 38.1% | 44.0% | 51.0% | 48.7% | 45.5% | -1.5% | | | | | | | |
| | Q4 | 52.6% | 48.7% | 45.7% | 40.9% | 47.4% | 54.9% | 51.0% | 46.8% | -10.2% | | | | | | | |
| Ave. Diff. \ddagger | 1.3% | -6.0% | -3.3% | 0.0% | 7.4% | 1.5% | 2.8% | 9.7% | -7.2% | | | | | | | | |
| <i>Share Graduating with Any Major</i> | | | | | | | | | | | | | | | | | |
| Science | Q1 | 24.0% | 17.9% | 27.9% | 22.4% | 23.5% | 28.7% | 34.8% | 34.4% | 5.4% | | | | | | | |
| | Q2 | 32.3% | 26.6% | 37.5% | 30.3% | 32.0% | 37.0% | 41.0% | 43.4% | -1.4% | | | | | | | |
| | Q3 | 41.1% | 35.8% | 46.6% | 38.2% | 40.4% | 44.6% | 46.5% | 51.4% | -4.6% | | | | | | | |
| | Q4 | 51.2% | 46.5% | 56.1% | 47.0% | 49.7% | 52.6% | 52.1% | 59.5% | -8.7% | | | | | | | |
| Ave. Diff. \ddagger | -7.6% | -4.1% | 0.0% | 2.6% | 3.7% | 4.7% | 2.6% | 3.9% | | | | | | | | | |
| Non-Science | Q1 | 39.4% | 29.3% | 37.0% | 30.9% | 35.1% | 42.1% | 45.1% | 42.0% | -2.5% | | | | | | | |
| | Q2 | 46.3% | 37.8% | 44.5% | 37.6% | 42.1% | 48.9% | 50.3% | 49.2% | -0.5% | | | | | | | |
| | Q3 | 52.4% | 45.6% | 51.1% | 43.9% | 48.4% | 54.7% | 54.8% | 55.5% | -7.3% | | | | | | | |
| | Q4 | 59.2% | 54.4% | 58.7% | 51.2% | 55.4% | 60.9% | 59.6% | 62.3% | -7.3% | | | | | | | |
| Ave. Diff. \ddagger | -0.3% | -6.7% | -3.7% | -0.1% | 8.7% | 3.1% | 4.9% | 10.5% | | | | | | | | | |

\dagger The “difference in across-campus heterogeneity” is the difference, for each SAT quartile, in the coefficients of variation for the selection-adjusted *row* entries and the corresponding unadjusted entries in Table 14.

\ddagger The “average difference” the average difference between the selection-adjusted *column* entries in this table and the corresponding unadjusted entries from Table 14.