Race and College Success: Evidence from Missouri[1]

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Conditional on enrollment, African American entrants at 4-year public universities are much less likely to graduate, and graduate in STEM fields, than white entrants. Using administrative micro data from Missouri, we show that the success gaps between African-American and white students in college can be explained by three factors: (1) racial differences in how students sort to universities and majors, (2) racial differences in high-school quality prior to entry, and (3) racial differences in other observed pre-entry skills. We decompose the success gaps between African Americans and whites to identify the relative importance of these three factors. Even holding racial differences in high-school quality and pre-entry skills fixed, we find that a non-negligible fraction of the racial gap in graduation rates can be explained by differences in student sorting across universities and majors (10 to 20 percent). Differences in observed measures of pre-entry skills – primarily students' high-school class rankings conditional on high school of attendance – are consistently the most important determinants of the success gaps by race. Differences in pre-entry skills explain a larger share of the graduation gap for men than for women, and most of the racial gaps in STEM attainment (conditional on STEM entry) for both genders.

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I. Introduction

It has been well-documented that there are large returns to receiving a 4-year college degree (Heckman, Lochner, and Todd 2006; Bound and Turner 2011). Despite these large sheepskin effects, the college dropout rate in the United States is substantial. Indeed, conditional on starting college, the United States ranks near the bottom of developed countries in degree attainment (Bound and Turner, 2011).

Racial disparities in college completion rates are also large. At just over 40%, six-year graduation rates for African Americans are over twenty percentage points lower than for whites (DeAngelo et al., 2011). African American men in particular have high dropout rates coupled with low enrollment rates. Using data from the 1997 National Longitudinal Survey of Youth, Aucejo (2012) finds an over 25 percentage point difference between the fraction of African American men who enroll in college compared to African American women. The gap between African American men and women increases to 33 percentage points when looking at the fraction who complete a four-year college degree, resulting in African American women outnumbering African American men by two to one among college graduates.

While persistence-to-degree rates are low, they are lower still in STEM fields, making the racial disparity even more pronounced. For example, using data on students at Duke University and conditioning on graduation, Arcidiacono, Aucejo, and Spenner (2012) show that African American males are 20 percentage points less likely to complete a degree in STEM fields than their white-male counterparts, despite African American males expressing more initial interest in STEM fields than whites.

In this paper we decompose racial differences in 4-year college completion rates, both overall and in STEM fields. We seek to understand how much of the racial disparities are due to each of three factors. First is where students enroll in college. Whites and African Americans attend colleges of different qualities—due to some combination of preferences and pre-entry skills—and this may in turn affect persistence. Higher quality colleges may produce higher persistence rates for all students, or certain schools may be a better match for students of certain abilities.[2] Second, whites and African Americans attend very different high schools and this can lead to differences in academic preparation through access to, for example, more advanced courses. Finally, we examine differences in observed preparation as measured by test scores and pre-entry academic achievement.

We take advantage of administrative data from the system of four-year public universities in Missouri in order to understand these educational disparities. The advantages to these data are three-fold. First, we have panel data on the entire system allowing us to examine a wide range of college qualities – the graduation rates across the universities in the system range from 30% to 80%. Second, we know the high schools from which students graduated and have large numbers of students from each high school, in addition to pre-entry variables such as high school class rank and ACT scores. The high-school-attendance information is independently important, and additionally improves the predictive power of information about students' class rankings (also see Fletcher and Tienda, 2010). Finally, the data allow us to track students throughout the entire system over time, and provide information on initial and final major.

Our approach to examining college sorting is to estimate flexible logit models of the probability of graduating conditional on attending particular institutions and entering with particular majors, paying specific attention to allowing for match effects between the student and the school-major combination (Arcidiacono, Aucejo, and Hotz 2012; Light and Strayer 2000). We then estimate multinomial logits to predict the probabilities of whites attending each of the colleges in the system

[2] Dillon and Smith (2010) discuss the determinants and consequences of being under and overmatched with one's university. The match between the student and the school has received attention in the literature on mismatch and how it relates to affirmative action. See, for example, Arcidiacono, Aucejo, Coate, and Hotz (2012) and Arcidiacono, Aucejo, and Hotz (2012). See Arcidiacono, Aucejo, Fang, and Spenner (2011) for a discussion of how mismatch can arise with students making rational enrollment decisions.

(as STEM or non-STEM majors). These probabilities are used to assign African Americans to counterfactual university-major cells. Given the counterfactual assignment scenario and the estimated graduation probabilities, we can assess how African American graduation rates would change under the alternative assignment rules.

We use empirical estimates of high-school quality, estimated from the graduation model, to quantify the importance of differences in high-school quality between African Americans and whites as a determinant of success. We predict the gains in African American success rates that would accompany an improvement in high-school quality so that African Americans and whites, on average, attend high schools of equal quality. Finally, we similarly predict the effect of raising African Americans' class rankings and entrance exam scores to align them with whites.

We find that African American graduation rates, in total, would increase by 2.5 percentage points (from approximately 48.0 to 50.5 percent) under the counterfactual sorting scenario where African Americans are sorted to universities and majors like observationally similar whites. This improvement comes with no change in African Americans' observed pre-entry skills or high school quality. The gains from counterfactual sorting are larger for African American women than for men, explaining 20 and 10 percent of the racial graduation gaps by gender, respectively. The remaining graduation gaps are explained by racial differences in high school quality and other observed pre-entry skills. For women and men respectively, differences in high school quality explain 28.5 and 18.9 percent of the gap. The disparity is owing to the fact that minority women in college, on average, are more likely to come from lower-quality schools than their male counterparts.[3]

The remaining racial differences in graduation rates can be explained almost entirely by differences in pre-entry observed skills, which are particularly important for explaining the graduation gap for men (67.5 percent). For women, pre-entry differences in observed skills explain a

[3] Put differently, minority women are particularly overrepresented relative to men as attendees from the lowest-quality high schools.

smaller but still substantial share of the racial disparity in graduation rates (47.9 percent). These results highlight the importance of skill differences in persistence to degree, complementing Cameron and Heckman (2001) who find that skill differences and other differences in family background are the primary drivers behind differences in college enrollment rates between African Americans and whites.

Conditional on entering the four-year university system in pursuit of a STEM degree, an analogous decomposition suggests that pre-entry skill differences explain a much larger share of the racial gap in STEM attainment. For both genders, differences in pre-entry skills explain over 80 percent of the gap in STEM attainment between African American and white students. This result is driven in part because pre-entry skills are more important predictors of success as measured by STEM attainment, and in part because conditional on observed measures of pre-entry skills and high-school quality, African Americans are more likely to pursue a STEM degree upon entry.

II. Background and Data

The four-year public university system in Missouri consists of 13 campuses; Figure 1 shows their geographic locations. The major population centers in Missouri are in Kansas City and St. Louis and their surrounding areas. The metro areas are both located in the middle of the state vertically, and at the western and eastern borders respectively. We divide the 13 universities in the public system into four broad groupings for expositional purposes:

> Group 1: The three most selective universities: Truman State University, the University of Missouri at Rolla and the University of Missouri at Columbia (the latter being the state flagship)
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> Group 2: The two urban universities: the University of Missouri at Kansas City and the University of Missouri at St. Louis.
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> Group 3: The four moderately-selective, non-urban universities: Missouri State University, Northwest Missouri State University, Southeast Missouri State University and the University of Central Missouri

Group 4: The four least-selective universities: Missouri Southern State University, Western Missouri State University, Lincoln University and Harris Stowe State University (the latter two universities are HBU's).

We use administrative data files from the Missouri Department of Higher Education for our analysis. The data track students beginning with entry into the system, and subsequently on a semester-by-semester basis through potential graduation. Because we are primarily interested in student-sorting patterns for disadvantaged minorities, and the Hispanic population in Missouri is small, we compare African American and white students.[4] We restrict our analytic sample to include full-time, state-resident, non-transfer students who entered the public university system between 1996 and 2001 as college freshman.[5] We track students for up to eight years after initial entry into the system to determine whether they graduated and, if so, the field of their degree. Details about the construction of the analytic sample are provided in Appendix Table A.1.

The administrative data track students during college and also include detailed information about pre-entry qualifications.[6] In addition to the standard entrance exam scores (from the ACT), two notable data elements are students' high schools of attendance and class rankings. Most records for state residents contain this information, including students from private schools.[7] An advantage of working with a large student sample from within a single state, rather than a nationally-representative but thinly-spread dataset (e.g., the NELS or NLSY), is that we can condition directly on students' high schools of attendance in our econometric models. We need not rely on proxies for high school quality, which prior research suggests may be insufficient (Roderick et al., 2008). Empirically, students' high schools of attendance and class rankings are strong predictors of success

[4] The 2000 Missouri census reports that Missouri's Hispanic population share was 2.1 percent. The African American share was 11.7 percent, just below the national average of 12.9 percent. Asians are also considerably underrepresented in Missouri, making up just 1.4 percent of the population.
[5] A small number of students who enter a university with sophomore status but no prior university experience are also included. These are students who have collected a full year's worth of college credits while in high school.
[6] We have access to data on student transfer behaviors and grades in college, but we do not use these data for the present study.
[7] Approximately 6 percent of in-state students do not have either an assigned high school or class ranking.

in college. A simple linear model that predicts students' college-graduation outcomes as a function of high-school indicator variables and a continuous class ranking variable, for example, explains 16.5 percent of the total variance in outcomes. Alternatively, a model that uses ACT math and reading scores instead explains less than a third as much; just 5.4 percent.

Table 1 provides basic descriptive statistics for each university in the state system relative to the system as a whole, and internally. The universities are ordered by the average value of a pre-entry preparation index for incoming students, which we use as a measure of selectivity.[8] Several features of the Missouri system are notable. Beginning with how enrollment is distributed across the system, forty percent of the students in the analytic sample enter into just two universities: the University of Missouri at Columbia and Missouri State University. Several universities have enrollment shares at or near 10 percent, and 5 of the 13 universities enroll fewer than five percent of the students in our data. The enrollment shares presented in Table 1 are not entirely representative of total enrollment shares because we exclude transfer students and part-time students and these students are not evenly distributed across the system. Still, the enrollment shares in Table 1 are broadly reflective of relative size of the public universities in Missouri.

The third column of Table 1 shows the distribution across universities for students who enter with intended majors in a science- or mathematics-related field (STEM). STEM majors include students who initially enter college with a major in the natural or physical sciences, engineering, computer science, mathematics, or economics. All other students in the data are assigned as humanities and social-science majors (HSS).[9] STEM majors are heavily concentrated at the three

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[8] The preparation index is a weighted average of the student's ACT score, high school class rank, and high school quality where the weights come from their importance in determining college graduation. See section III for details. Further information about selectivity and student sorting across universities is provided in Appendix B.

[9] Appendix Table A.2 provides information about the most common major codes among STEM and HSS majors. Note that HSS includes a large number of majors outside of humanities and social science. Economics is included with the STEM group for two reasons (1) there is a mathematical bent in the economics discipline, and (2) the grade distributions in economics courses look more similar to the grade distributions in STEM fields than in HSS fields (Koedel, 2011).

most-selective institutions, which account for 58 percent of incoming STEM majors despite accounting for just 35 percent of total enrollment. No university outside of the most-selective group has a sizeable STEM-major share.

The fourth column shows the distribution of minority students across institutions. Comparing the minority shares to the total enrollment shares reveals minorities' unconditional representation across the system. Minorities are substantially overrepresented at the least selective institutions in the state and at the urban campuses. They are also mildly underrepresented at the two most-selective schools, essentially proportionally represented at the University of Missouri at Columbia (again, the state flagship), and underrepresented at the four moderately-selective non-urban schools (Missouri State, Northwest, Southeast and Central Missouri).

The second vertical panel of the table provides internal descriptive statistics for each university to complete the system overview. Among the statistics provided is the 8-year graduation rate (degree independent), which maps fairly closely to the pre-entry preparation index. The most notable differences between the entering index values and graduation rates occur at the urban campuses, which have much lower graduation rates than would be predicted by students' index values alone. This finding is similar to what is reported by Bowen et al. (2009), and we return to this point later on.[10] Also note the sharp drop in graduation rates at the four least-selective schools. Minority students are substantially overrepresented at three of these four campuses.

III. Empirical Approach

We seek to decompose differences in graduation rates between African Americans and whites into three factors: 1) initial college and major assignment, 2) the quality of high schools attended, and 3) pre-entry observed skills (ACT scores and high-school class rankings). To the

However, note that economics majors make up such a small share of the STEM-major group that excluding them from our analysis, or shifting them to the HSS group, does not substantively affect our findings.

[10] Bowen et al. (2009) find that graduation success is negatively related to the commuter share. A distinguishing feature of the urban campuses is that they have larger commuter populations relative to the other universities in the system.

extent that discrimination or differences in family income may be important, they may manifest themselves indirectly through our skills measure. In order to perform the decomposition, we need to know students' probabilities of enrolling in particular schools with particular majors, as well as their probabilities of graduating conditional on enrollment. We first describe how we estimate the graduation probabilities and then describe our model of initial college and major enrollment.

Modeling Graduation Outcomes

Denote the academic index of student *i* at time *t* as AI_{it}. Time *t* refers to the student's year cohort; *t* = 1996, 1997,…, 2001. The academic index in part determines graduation probabilities at each of the institutions. It is a linear function of X_{it} which includes race-gender indicators, test scores, high school class rank, and indicators for high-school attended:[11]

$$AI_{it} = X_{it}\alpha \tag{1}$$

Conditional on attending university *j* with initial major *k*, we specify the latent utility of graduating (within 8 years) as:

$$Y^*_{ijkt} = \delta_{0jkt} + AI_{it}\delta_{1jk} + \varepsilon_{ijkt} \tag{2}$$

Individuals who graduate, $Y_{ijkt} = 1$, have latent indexes greater than zero, with $Y_{ijkt} = 0$ otherwise.

This specification allows for school-major combinations to differ along two dimensions. First is the intercept term δ_{0jkt}. If a school-major combination has a high intercept term relative to other school-major combinations, then, all else equal, students who enroll in that school and major will have higher probabilities of graduating. Second is the return to the academic index. A school-major combination with a high δ_{1jk} disproportionately rewards students who have higher academic indexes. If university fit is important, then we would expect school-major combinations that enroll

[11] We omit students from high schools from which fewer than five students are observed over the course of the data panel as full-time, non-transfer college entrants. Only a small number of observations are dropped from the analytic sample for this reason. See Appendix Table A.1 for more information.

students with high academic index values to have high slopes but low intercepts, while school-major combinations that enroll low academic index students having high intercepts but low slopes.

The model in (1) identifies the index parameters using variation within university-major-year cells. Table 2 shows the raw logit coefficients for the index variables from our preferred specification, per equation (1), as well as from several sparser variants that include subsets of the information in the full index (where the omitted index information is entirely excluded from the model). As indicated above, the two most important student-level predictors of graduation success are high school of attendance and class ranking.

The table reports the effect of a one-standard-deviation move in the distribution of high-school quality, where high school quality is defined empirically and the variance of the distribution is adjusted for estimation error in the fixed-effect estimates, following Koedel (2009). Noting that a one-standard deviation move in the class-ranking variable is approximately 22.0, moving a standard deviation in the distribution of high-school quality is equivalent to moving 0.80 standard deviations in the distribution of high-school class ranking. It is also important to note that attending a better high school will likely result in a lower class ranking. This can be seen in alternative specification 4, which shows that the effect of class rank is diminished when we do not condition on high school fixed effects. None of the other variables in the index are nearly as important as high school attended or class ranking.

The coefficients on the race-gender indicators from the index are also of interest and show that our measures of academic preparation are quite good. Conditional on the other measures of pre-entry preparation, African American men are no less likely than white men to obtain a degree. African American women are conditionally more likely to graduate than their white counterparts.[12]

[12] Our finding that African American men and women are more likely to graduate than whites (or, in the case of men, no less likely to graduate) conditional on pre-entry skills is consistent with previous studies that examine racial differences in college matriculation (Cameron and Heckman, 2001; Rivkin, 1995).

The fact that we can fully explain racial differences in gradation probabilities conditional on our covariates is a reflection of the power of our controls. For example, the alternative index formulations show that African American men are less likely to obtain a degree unconditionally (alternative 1) and conditional on entrance exam scores alone (alternative 3). Unconditionally, African American women perform worse than white men and white women by a wide margin, but outperform white men and perform comparably to white women conditional on ACT scores alone.

White women outperform all other race-gender groups unconditionally. As shown in Table 3, their class rankings are substantially higher than the other race-gender pairings. Conditional on their superior preparation, however, white women are actually less likely to graduate than their male counterparts (Table 2). Table 3 also shows large differences across races. African Americans attend significantly worse high schools than whites and this is especially apparent for African American women. That the high school effects are different for African American women and men may have to do with the large gender disparity in college enrollment rates for African Americans (Aucejo 2011); African American men are substantially less at risk of going to college.

Table 4 describes the distribution of index values, based on the raw logit coefficients, for the different race-gender combinations. Consistent with the descriptive statistics in Table 3 and coefficients from Table 2, the index distributions show that white women have considerably higher index values than their male counterparts throughout. African American men and women have lower index values than whites. As with whites, women score higher on the index than men among African American students, but the gender gap is even more pronounced for African Americans.

University and Major Sorting

We now turn to the issue of student sorting across majors and universities within the Missouri system. A key aspect of our analysis is to compare observed African-American student sorting across universities and majors to counterfactual sorting that we predict if African Americans sorted in the same ways as observationally comparable whites.

To construct the counterfactual sorting scenario for minority students, we begin by estimating a multinomial logit model for white students that predicts placement into each of the 24 unique university-by-major cells in the Missouri system.[13] The latent utility of initially enrolling in school *j* in initial major *k* is given by:

$$U_{ijkt} = \phi_{0jkt} + AI_{it}\phi_{1jkt} + \eta_{ijkt} \tag{3}$$

Individuals then choose the school/major combination that yields the highest utility. Since white women sort differently than white men—both with regard to schools and majors (see Appendix C; also, Turner and Bowen, 1999)—we estimate separate multinomial logit models for each gender. Further, note that the coefficients in equation (3) have *t* subscripts which allow for differential sorting over time as some schools become more or less attractive to particular types of students.

Estimation of (3) yields the white-sorting parameter vectors which we then apply to minority students to predict counterfactual sorting. An implicit assumption in applying these parameters to minority students is that sorting differences by gender are similar within races. Broadly speaking this appears to be the case, and we provide evidence to support this simplifying assumption in Appendix C.

The counterfactual sorting outcomes for minorities predicted by the parameters from equation (3) reflect two changes to minority sorting. First, the distribution of minority students across the system shifts to align more-closely with the distribution of white students. That is, minority students are re-allocated to universities and majors from their actual placements. Second,

[13] There are 24 university-by-major cells in the system. Eleven universities have STEM and HSS programs; UM-Rolla enrolls only STEM majors and Harris Stowe State enrolls only HSS majors.

holding constant the minority shares in each university-by-major cell, the re-sorting procedure alters the composition of which minority students enter into which cells. Below we dissect the differences between minority and white sorting and assess the implications for minority graduation outcomes.

IV. Student Sorting Across Universities and Majors

Before we compare sorting differences across races, it is useful to provide some perspective regarding the potential to affect outcomes from changing how students are sorted to universities and majors. In Table 5 we use the parameter estimates from the model in (2) to show predicted graduation rates for entering students in each university-by-major cell, holding students' index values fixed at different points in the distribution. The table is divided by entering major-type; the first panel of the table is for STEM entrants and the second panel is for HSS entrants. Graduation probabilities are reported at the 5th percentile and by decile from the 10th to 90th percentiles of the full index distribution from Table 4 (for all students). Reading down the rows in any given column compares observationally equivalent students in different university-by-major cells.[14] The estimates in Table 5 can be mapped to the race-gender-specific index distributions in Table 4.

We predict the graduation rates in each cell in Table 5 holding non-index values fixed at their sample averages (e.g., year cohorts). Note that although the graduation model allows for differential graduation rates by entering major, the outcome is not degree-specific. So, for example, the completion of a HSS degree for an entering STEM student is treated as a positive graduation outcome in Table 5. Later we examine STEM degree completion as a unique outcome.

The table reveals interesting patterns in predicted graduation outcomes across universities and majors, and also provides useful information about sorting. With regard to sorting, note that although the average index values at the least-selective universities are clearly lower than those at the moderately selective institutions (by definition), there is considerable overlap. The third column in

[14] The parameters that underlie the predictions in Table 5 are provided in Appendix D.

either panel of the table shows that the 90th percentile of the index distribution at each of the least-selective schools is well above the median index value for the moderately selective schools. This overlap is consistent with previous studies by Bowen et al. (2009) and the Roderick et al. (2008), who show that students from disadvantaged backgrounds who are well-qualified for college have the tendency to "under match."

Continuing to focus on the comparison between the least-selective and moderately-selective schools in Table 5, predicted graduation rates are much higher at the moderately selective schools over the range of index values. For example, take the median African American male student in Missouri, whose index value from Table 4 is 1.51. This roughly corresponds to the 20th percentile in the overall distribution of the index. His predicted graduation probability as an HSS major if he moves from Lincoln University to Central Missouri University goes from 40 to 50 percent.[15] In fact, moving from any of the least-selective to any of the moderately-selective schools corresponds to a large increase in his likelihood of degree attainment. More generally, a takeaway from Table 5 is that the universities in which minority students are most overrepresented in the system – the least-selective and urban campuses – are also the ones with the lowest graduation rates conditional on students' pre-entry preparation. Overall, Table 5 is consistent with the possibility that improved minority sorting across universities and majors can lead to higher success rates as measured by graduation.

Next we turn to the direct comparison between actual and counterfactual minority sorting. Table 6 applies the sorting parameters obtained from equation (3), using data from white students only, to minority students. The table is constructed as follows. First, within each panel, we calculate the average index value and enrollment share at each university based on where students actually

[15] An issue that may be of interest to some readers is whether African American enrollment shares across universities are associated with differential African American success rates. We examine this issue in Appendix E and find no evidence of an association.

entered the system. Then we replicate these same calculations, but replace each student's actual placement with the vector of predicted placements from the multinomial logistic regression. The predicted student shares for each university are the summations of the predicted probabilities across all students, and the average index values are weighted averages where the predicted probabilities serve as the weights.

Table 6 shows how the index values and sorting patterns change with the change in assignments. There is movement of minority students across most schools in the system, reflecting a combination of the intercept and slope parameters from the sorting model. For example, consistent with the descriptive statistics provided thus far, the counterfactual sorting scenario shifts a large fraction of minority students out of the urban and least-selective schools and into the moderately-selective schools. Unsurprisingly, the differences between actual and counterfactual sorting are particularly stark at the two historically African American universities in the system (Lincoln University and Harris Stowe State University). Also note that while minorities are roughly evenly represented at the University of Missouri at Columbia unconditionally, the counterfactual-sorting scenario reveals that fewer minorities would attend UM-Columbia if they sorted like observationally similar whites.

Table 7 expands on the sorting differences for minorities by showing differences at the university-by-major level. Column 3 shows the net re-sorting effects for each university-by-major cell in the system. Negative entries indicate that minorities are being added to the given cell under the counterfactual; positive entries indicate that minorities are being exited. An insight from Table 7 is that minority students are shifted out of STEM majors and into HSS majors under the counterfactual scenario, and substantially so. Conditional on their pre-entry preparation index, African American women appear to be particularly overrepresented as science majors throughout the system.

V. Minority Re-Sorting and Predicted Graduation Outcomes

Using minorities' actual university-by-major placements, the graduation model in equation (2) predicts a graduation rate of 48.05 percent (the actual graduation rate for minorities is 48.25 percent). Table 8 gives predicted African American graduation rates across a variety of different sorting scenarios. The full counterfactual sorting scenario is shown in the third row. It allows minorities to move between majors in addition to between universities. Table 5 shows that degree attainment conditional on pre-entry preparation is more likely in HSS majors – that is, STEM entrants are observationally more prepared than HSS majors within universities, but do not graduate at a higher rate (also see Appendix D where we provide the parameter estimates for the full graduation model – entering as a STEM major is associated with lower graduation rates conditional on the other controls in the model).

We begin by comparing minority outcomes under actual and full-counterfactual sorting. From the model's baseline predicted graduation rate of 48.05 percent, Table 8 shows that the full counterfactual sorting scenario produces a roughly 2.5 percentage-point increase (to 50.53 percent). Recall that counterfactual sorting embodies two changes to minority sorting: (1) holding the minority shares within university-by-major cell fixed, it changes *which* minorities sort into which cells, and (2) it shifts minorities across university-by-major cells to more-closely reflect the sorting patterns of white students. We isolate the influence of the former, holding minority shares across university-by-major cells fixed, by reweighting the predicted probabilities from equation (2) *ex post*.

Denote $\hat{P}_{ijkt}$ as the predicted probability that African American i in cohort t would be assigned to school j and major k under the white sorting rules. The predicted share of African Americans in school j and major k in year t, denoted as $\hat{M}^{p}_{jkt}$, is then given by:

$$\hat{M}_{jkt}^{p} = \frac{\sum_{i=1}^{M} \hat{P}_{ijkt}}{M}$$

where M is the number of African American students in the entire system. Denoting M_{jkt}^{a} as the actual share of minorities at school *j* in major *k* in year-cohort *t*, we can isolate the effects of resorting minorities while holding the share of minorities in each cell constant by calculating $\hat{P}_{ijkt}{}'$:

$$\hat{P}_{ijkt}{}' = \frac{\hat{P}_{ijkt} M_{jkt}^{a}}{\hat{M}_{jkt}^{p}}$$

The second row of Table 8 shows the predicted change in minority graduation by shuffling which minorities attend which schools, holding schools' minority shares fixed. This effect is small and negative, suggesting that conditional on school shares, minorities sort better than whites. However, as the third row indicates, allowing the shares across cells to change results in notable improvements in African American graduation rates, with stronger effects for African American women.

As described above, the graduation-rate gains from full counterfactual sorting include gains from shifting African American enrollment from STEM to HSS cells – this type of re-sorting is wrapped up in the estimates. In a separate analysis not shown in Table 8, we use an analogous sorting procedure to re-allocate African American students across majors within universities like observationally similar whites. The STEM/HSS re-allocation within universities increases predicted graduation rates by approximately 0.30 percentage points, or just over 10 percent of the total counterfactual sorting gain.

The partial-sorting scenarios in the remaining rows of Table 8 use the same probability-reweighting approach as described above to dissect the full counterfactual sorting scenario. That is, we take the baseline predicted probabilities for all minority students based on the parameters from equation (3), then adjust the weights *ex post* as needed to re-allocate minority students throughout the system. The partial sorting scenarios show that the counterfactual gains from redistributing African American students has two main sources. First is getting students out of urban campuses. Despite having an academically strong student body, urban campuses have low graduation rates. The second source, which is particularly strong for African American women, is getting students out of the least-selective schools. In summary, African American students benefit from attending moderately-selective universities relative to the alternative of urban or less-selective schools. Like in other states, minorities in Missouri are vastly underrepresented at moderately-selective universities and overrepresented at the least-selective and urban campuses.[16]

VI. STEM Attainment

Thus far we have modeled minority "success" in terms of general graduation outcomes. However, there may be value in increasing minority representation in STEM fields in the workforce, in which case degree attainment in a STEM field is of independent interest. Enrolling in college as a STEM major and completing a degree in a STEM field are two very different things. This point is illustrated in Table 9, which shows the fraction of STEM and HSS enrollees who graduate with STEM and HSS degrees. The graduation rate for STEM majors, overall, is 65.9 percent. But conditional on graduation, only 59.2 percent of initial STEM entrants complete their degree in a STEM field. Table 9 also shows that HSS entrants rarely switch over and complete a degree in a STEM field (less than 3 percent).

We evaluate the implications of minority sorting for STEM degree completion using an analysis parallel to above, except that the analytic dataset is restricted to include initial STEM entrants only. We begin with a model that predicts STEM degree attainment, again specifying an

[16] Arcidiacono et al. (2011) document a U-shaped relationship between average college SAT scores and percent African American.

academic index analogous to equation (1) and a latent index for graduation analogous to equation (2):

$$AI_{it}^{SM} = X_{it}\beta \tag{4}$$

$$Y_{ijt}^{*SM} = \lambda_{0jt} + AI_{it}^{SM}\lambda_j + \varepsilon_{ijt}^{SM} \tag{5}$$

Table 10 describes the index parameters from Equation (4), and again reports estimates from several sparsely constructed indexes. High school of attendance and class ranking are still powerful predictors of success, but unlike in the general model, so are ACT math scores.[17] Also note that conditional on observed measures of pre-entry preparation, women who initially enter as STEM majors are much less likely than their male counterparts to complete a STEM degree (this is true for both racial groups).

Similarly to the general graduation analysis, we use the index values obtained from equation (4) to model white sorting to universities for STEM majors. Then we estimate a STEM-specific sorting model analogous to equation (3), and apply the sorting parameters to minority STEM entrants.

Table 11 reports the distribution of index values and corresponding graduation probabilities for each school in the system. Institutional fit seems to be more important for STEM attainment than graduation in general. Namely, top schools are particularly good at graduating high index-value students. However, moderately selective schools often dominate the flagship school, UM-Columbia, for lower index values. Table 12 shows actual and counterfactual minority sorting; the familiar pattern from above is maintained in terms of minority over and underrepresentation at universities.

[17] Even though the coefficient on ACT math scores in the first column of Table 10 is large, variation in ACT math scores is still less important for predicting STEM success than high school of attendance or class ranking. The reason is that there is much less variation in ACT math scores relative to the other measures (e.g., the standard deviation of high-school class rankings in the STEM subsample is 19.2; for ACT math scores it is 4.7).

Table 13 considers the implications of re-sorting minority STEM students across universities in terms of producing STEM degrees. Like above, predicted minority success rates rise under the full counterfactual sorting scenario, although the increase is smaller than in our analysis of general graduation outcomes. In addition to the net gains from re-sorting being smaller in the STEM models, our findings differ when we examine the specifics of the sorting process. While moving students out of urban campuses again improves attainment rates, the effects from moving students out of the least selective schools are small. This is because there are relatively few minority STEM entrants at these universities to begin with, and the STEM entrants at these schools are highly unlikely to complete a STEM degree at any school.

VII. Decomposing graduation rate gaps

While reallocating African American students using the white assignment rules would increase graduation rates, large racial gaps would remain. In this section we seek to decompose the total difference in graduation rates—both in general and in STEM fields—by additionally incorporating racial differences in (1) high school attended, (2) academic preparation, and (3) college matching as a result of attending better higher schools and being more academically prepared.

We begin by considering the scenario where African Americans attend high schools of equal quality to whites (in terms of empirically predicting success), holding the pool of minority entrants fixed.[18] To bring high-school quality for minorities in line with high-school quality for whites we adjust minorities' high school fixed effects, and correspondingly, their class rankings. The class-ranking adjustment is important because holding other things constant, attending better schools should lead to lower minority class rankings. The adjustment to the high-school fixed effects is a straightforward shift of the distribution of estimates from the initial model for minority students:

[18] In practice, improving high-school quality for minorities would likely increase college attendance. Our data are insufficient to examine the likely implications along this dimension.

$$\hat{\theta}_i^{adj} = \hat{\theta}_i + C \tag{6}$$

Equation (6) adds a constant, C, to each fixed effect, where $C = \bar{\hat{\theta}}^{W} - \bar{\hat{\theta}}^{AA}$ (the average high school fixed effect for whites minus the average fixed effect for African Americans). The adjustment is performed separately by gender.

We then adjust African Americans' class rankings based on output from the following regression, estimated for the entire analytic sample:

$$R_i = Z_i\beta_1 + \hat{\theta}_i\beta_2 + e_i \tag{7}$$

Equation (7) regresses students' class rankings on a vector of characteristics that includes race and gender, math and reading ACT scores, as well as the fixed-effect coefficient corresponding to the high school of attendance from the main model ($\hat{\theta}_i$). We use $\hat{\beta}_2$ from equation (7) to predict the average decline in class rankings for minority students associated with the improvement in high school quality, which is 9.7 percentage points.

To see how graduation gaps additionally close when the academic preparation gap closes, we shift the index values for all African American students by a constant such that the mean academic index is the same for both whites and African Americans. Finally, given that we have now increased African Americans' preparation and high school quality, we reassign them throughout the system, again according to the white sorting rules.

The proportion of the racial graduation gap explained by the various factors is given in Table 14. Consistent with the results in the two previous sections, resorting according to the white assignment rules has a larger effect on overall graduation rates than it does for STEM graduation rates. However, the differences in our findings between overall and STEM graduation rates are being driven by women; the closing of the gaps from using the white assignment rules is the same (in percentage terms) for African American men.

Differences in high school quality can explain a significant proportion of the general graduation gap, particularly for women. Recall that college-going African American women attend worse high schools than their male counterparts. Differences in high school quality explain 28.5 and 18.9 percent of the general graduation gap for women and men, respectively. Results are significantly smaller for science attainment.

By far the biggest component of differences in graduation rates is the pre-entry skills gap. For general graduation, it explains 47.9 and 67.5 percent of the gap for women and men, respectively. For science attainment, the numbers are much higher at 85 and 83 percent. Until significant changes occur in the pre-entry skills gap, large differences in college graduation rates, and STEM attainment rates, will remain.

Finally, the additional gains to resorting African American students after improving their high school quality and pre-entry skills are small, at 3.5 percent for women and 2.6 percent for men for general graduation rates. The contributions are slightly higher for science attainment. Recall that institutional fit seemed more important in the sciences where the best schools were particularly good at graduating students with high index values.

VIII. Conclusion

Differences in college graduation rates between African Americans and whites are stark. In the Missouri system, the gap for women is over 14 percentage points, while for men it is over 18 percentage points. Similar gaps are seen in STEM attainment.

These gaps can be partially diminished by re-sorting African American students across schools so that their enrollment decisions are similar to comparable white students. Although we find evidence that matching effects—where some schools are better at graduating less prepared students and other schools are better at graduating more prepared students—are present (particularly in the sciences), changes in matching effects are not the primary drivers behind the gains from resorting. Rather, the gains result from shifting African American students away from urban campuses and from the very bottom schools to moderately selective schools, both of which have relatively low graduation rates at all skill levels.

Pre-entry skills, however, are the primary driver for differences in graduation rates. This holds particularly for attaining degrees in the sciences, with 83-85 percent of the differences in STEM attainment being driven by pre-entry skills. Differences in high school quality (which may also reflect differences in pre-entry skills) can explain a significant portion of the overall graduation gap as well—almost 29 and 19 percent for women and men respectively—but have much smaller effects on graduation rates in STEM fields.

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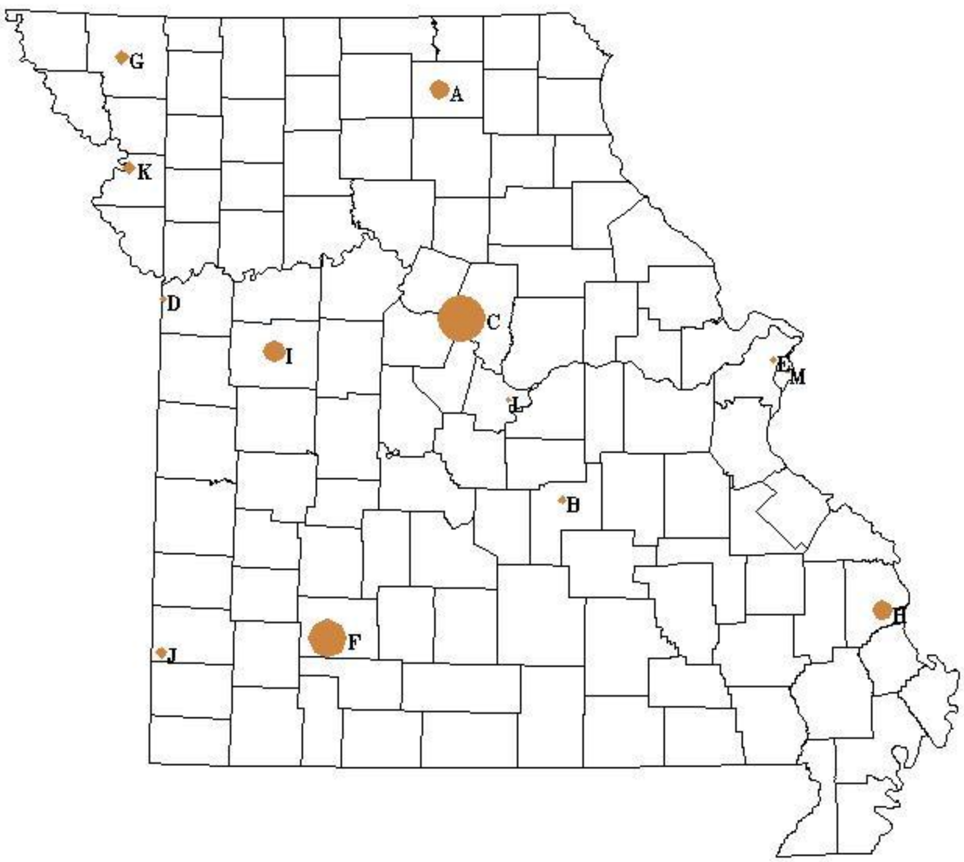
Figure 1. Geographic Locations of Missouri Public Universities.



<u>Legend</u>

A: Truman State University
B: UM-Rolla
C: UM-Columbia
D: UM-Kansas City
E: UM-St. Louis
F: Missouri State University
G: Northwest Missouri State University
H: Southeast Missouri State University
I: University of Central Missouri
J: Missouri Southern State University
K: Western Missouri State University
L: Lincoln University
M: Harris Stowe State University

Note: Circle sizes correspond to enrollment shares from the analytic sample.

Table 1. University Descriptive Statistics for Analytic Sample.

	Avg. Preparation Index	Descriptive Statistics Relative to Full System: Enrollment Share	Initial STEM Share	Minority Share	Internal Descriptive Statistics: Initial STEM Share	Minority Share	Total Grad Rate
All	2.38	1.000	0.218	0.063			
Truman State Univ	3.00	0.09	0.10	0.04	0.23	0.03	0.80
Univ of Missouri -Rolla	2.92	0.04	0.17	0.02	1.00	0.03	0.74
Univ of Missouri-Columbia	2.85	0.22	0.31	0.23	0.30	0.06	0.76
Univ of Missouri -Kansas City	2.60	0.03	0.07	0.07	0.44	0.12	0.54
Univ of Missouri -St. Louis	2.50	0.03	0.02	0.06	0.17	0.12	0.52
Missouri State Univ	2.22	0.18	0.08	0.06	0.09	0.02	0.59
Northwest Missouri State Univ	2.19	0.07	0.05	0.03	0.15	0.03	0.64
Southeast Missouri State Univ	2.14	0.09	0.05	0.08	0.11	0.05	0.59
University of Central Missouri	2.10	0.10	0.08	0.07	0.17	0.04	0.60
Missouri Southern State Univ	1.81	0.05	0.03	0.01	0.13	0.02	0.44
Western Missouri State Univ	1.56	0.06	0.04	0.11	0.14	0.11	0.42
Lincoln Univ	1.54	0.02	0.01	0.16	0.08	0.40	0.40
Harris Stowe State Univ	1.13	0.01	0.00	0.05	0.00	0.63	0.30
N		63,135	13,740	3,952			

Notes: The analytic sample includes full-time, resident, non-transfer students who entered the system between 1996 and 2001 as college freshman (African American and white only). It omits students whose high school of attendance, class rank, and/or ACT scores are unavailable (combined data loss ≈ 6 percent). See Appendix A for more details about the construction of the analytic sample.

Table 2. Index Parameters from Primary and Alternative Specifications for the Index.

	Primary Specification	Alternative Specifications (1)	(2)	(3)	(4)	(5)
High-School Class Rank	0.045				0.025	0.044
	(0.001)**				(0.001)**	(0.001)**
ACT Math Score	0.000		0.064	0.076	0.032	0.003
	(0.003)		(0.005)**	(0.005)**	(0.003)**	(0.003)
ACT Reading Score	-0.014		0.006	0.003	-0.010	-0.015
	(0.002)**		(0.002)**	(0.002)	(0.002)**	(0.002)**
White Female	-0.086	0.256		0.305	0.060	
	(0.022)**	(0.036)**		(0.024)**	(0.018)**	
African American Male	0.047	-0.461		-0.144	-0.197	
	(0.070)	(0.084)**		(0.050)**	(0.054)**	
African American Female	0.104	-0.089		0.257	-0.083	
	(0.060)	(0.039)*		(0.040)**	(0.044)	
HS Fixed Effects* (Standard Deviation)	0.78					0.77

* The reported standard deviation for the high-school fixed effects is unweighted and adjusted for estimation error in the fixed-effects estimates following Koedel (2009).

Table 3. Race-Gender Sample Averages for Index Components.

	White Women	White Men	African American Women	African American Men
Class Ranking	74.59	67.55	64.00	53.15
HS Fixed Effect	0.031	0.028	-0.479	-0.393
ACT Math	22.14	23.83	18.34	19.13
ACT Reading	24.71	24.70	20.35	19.86
N	32,680	26,503	2,486	1,466

Note: HS fixed effects are reported in standard deviation units and centered around sample average (weighted).

Table 4. Distribution of Index Values Overall and by Race-Gender Group.

	Percentile of Index Distribution								
	10	20	30	40	50	60	70	80	90
All	1.02	1.56	1.93	2.23	2.48	2.72	2.95	3.21	3.55
White Women	1.29	1.79	2.13	2.39	2.61	2.82	3.03	3.27	3.59
White Men	0.89	1.42	1.79	2.11	2.38	2.64	2.90	3.17	3.54
African American Women	0.42	1.03	1.42	1.72	2.05	2.29	2.56	2.81	3.17
African American Men	-0.15	0.44	0.81	1.18	1.51	1.77	2.12	2.45	2.89

Table 5. Predicted Graduation Probabilities at Index Intervals Across Universities and Majors

Panel A. STEM Entrants.

	N (All)	10/50/90 Index (Minorities)	10/50/90 Index (Whites)	Predicted Graduation Rates by Unconditional Percentiles of the Index Distribution 5 (0.57)	10 (1.02)	20 (1.56)	30 (1.93)	40 (2.23)	50 (2.48)	60 (2.72)	70 (2.95)	80 (3.21)	90 (3.55)
Truman State	1329	1.68/2.82/3.82	2.22/3.04/4.07	0.49	0.56	0.63	0.68	0.72	0.75	0.77	0.80	0.82	0.85
UM-Rolla	2397	1.22/2.56/3.48	1.88/3.02/3.85	0.22	0.31	0.44	0.53	0.61	0.67	0.72	0.77	0.81	0.86
UM-Columbia	4253	1.43/2.55/3.54	1.99/3.08/3.91	0.18	0.27	0.40	0.51	0.59	0.66	0.71	0.76	0.81	0.86
UM-Kansas City	956	1.14/2.47/3.63	1.92/3.01/3.75	0.18	0.24	0.32	0.39	0.45	0.50	0.55	0.60	0.65	0.71
UM-St. Louis	312	0.70/1.88/2.64	1.46/2.79/3.69	0.23	0.28	0.35	0.40	0.44	0.48	0.52	0.55	0.59	0.64
Missouri State	1045	0.27/1.67/3.07	1.12/2.45/3.40	0.15	0.22	0.35	0.44	0.53	0.60	0.66	0.71	0.77	0.83
Northwest Missouri State	636	0.66/1.90/2.77	1.15/2.41/3.42	0.25	0.33	0.45	0.53	0.60	0.65	0.70	0.74	0.78	0.83
Southeast Missouri State	676	0.39/2.04/3.13	1.04/2.38/3.46	0.21	0.29	0.40	0.48	0.55	0.61	0.66	0.71	0.76	0.81
Central Missouri	1098	0.36/1.53/2.62	0.89/2.25/3.34	0.28	0.36	0.47	0.55	0.61	0.66	0.71	0.75	0.79	0.83
Missouri Southern State	359	1.63/2.51/2.99	0.83/2.35/3.18	0.11	0.16	0.26	0.35	0.42	0.49	0.56	0.62	0.68	0.76
Western Missouri State	561	-0.58/0.92/2.20	0.40/1.86/3.01	0.15	0.22	0.34	0.43	0.51	0.57	0.63	0.69	0.74	0.81
Lincoln	118	-0.37/1.13/2.58	0.46/2.06/3.30	0.18	0.25	0.35	0.44	0.50	0.56	0.61	0.66	0.71	0.77
Harris Stowe State	0												
Panel B. HSS Entrants.													
Truman State	4507	1.66/2.55/3.29	2.05/2.96/4.00	0.28	0.38	0.52	0.62	0.69	0.74	0.78	0.82	0.86	0.90
UM-Rolla	0												
UM-Columbia	9881	1.34/2.45/3.44	1.77/2.87/3.77	0.29	0.39	0.52	0.61	0.68	0.73	0.78	0.82	0.85	0.89
UM-Kansas City	1236	0.79/2.13/2.92	1.39/2.52/3.42	0.21	0.27	0.36	0.43	0.48	0.53	0.57	0.61	0.66	0.71
UM-St. Louis	1576	0.99/2.15/3.06	1.44/2.62/3.55	0.15	0.21	0.31	0.39	0.46	0.52	0.57	0.62	0.68	0.74
Missouri State	10310	1.09/2.04/2.98	1.04/2.29/3.27	0.24	0.33	0.45	0.55	0.62	0.68	0.73	0.77	0.81	0.86
Northwest Missouri State	3592	0.74/1.58/2.83	0.97/2.24/3.28	0.31	0.41	0.53	0.61	0.68	0.72	0.77	0.80	0.84	0.87
Southeast Missouri State	5269	0.38/1.58/2.80	0.89/2.20/3.32	0.27	0.36	0.48	0.57	0.63	0.69	0.73	0.77	0.81	0.85
Central Missouri	5317	0.61/1.53/2.84	0.89/2.19/3.24	0.29	0.38	0.50	0.58	0.65	0.70	0.74	0.78	0.81	0.86
Missouri Southern State	2494	-0.11/1.19/2.24	0.36/1.90/2.95	0.20	0.27	0.38	0.46	0.53	0.59	0.64	0.69	0.74	0.79
Western Missouri State	3457	-0.31/0.90/2.23	0.26/1.66/2.89	0.19	0.28	0.40	0.49	0.57	0.63	0.69	0.74	0.78	0.84
Lincoln	1435	-0.45/0.86/2.49	0.40/1.91/3.41	0.23	0.29	0.38	0.45	0.51	0.56	0.60	0.64	0.69	0.74
Harris Stowe State	321	-1.37/1.21/2.78	-0.53/1.49/2.99	0.20	0.26	0.33	0.39	0.44	0.48	0.52	0.56	0.60	0.65

Note: Predictions are made by using sample average values for year cohorts. Index values at different points in the unconditional distribution are reported in parenthesis at the top of the columns that show the predictions. The 10/50/90 index values are from the race-specific distributions in each university-by-major cell.

Table 6. University-Average Index Values and Enrollment Shares by Race and Overall, for Actual and White-Predicted Sorting.

	African American Women				African American Men				Whites (Actual=Predicted)			
	Actual		Predicted		Actual		Predicted		Women		Men	
	Avg Index	Share	Avg Index	Share	Avg Index	Share	Avg Index	Share	Avg Index	Share	Avg Index	Share
Truman State	2.55	0.037	2.71	0.072	2.75	0.036	2.44	0.047	3.06	0.106	2.94	0.084
UM-Rolla	2.87	0.007	2.78	0.009	2.40	0.042	2.39	0.041	3.11	0.014	2.89	0.070
UM-Columbia	2.59	0.243	2.61	0.153	2.15	0.207	2.22	0.152	2.97	0.214	2.77	0.235
UM-Kansas City	2.30	0.073	2.30	0.028	1.94	0.061	1.87	0.024	2.76	0.034	2.51	0.031
UM-St. Louis	2.14	0.064	2.23	0.023	1.79	0.046	1.82	0.024	2.67	0.027	2.45	0.030
Missouri State	2.15	0.063	1.85	0.209	1.70	0.064	1.39	0.195	2.35	0.196	2.06	0.177
Northwest Missouri State	1.92	0.027	1.86	0.077	1.49	0.044	1.34	0.074	2.35	0.073	2.01	0.065
Southeast Missouri State	1.81	0.084	1.76	0.115	1.30	0.081	1.30	0.101	2.29	0.103	1.99	0.085
Central Missouri	1.76	0.071	1.77	0.115	1.29	0.075	1.23	0.129	2.30	0.103	1.92	0.104
Missouri Southern State	1.45	0.010	1.41	0.063	0.87	0.015	0.82	0.077	2.02	0.047	1.58	0.048
Western Missouri State	1.14	0.112	1.11	0.104	0.56	0.119	0.63	0.099	1.80	0.066	1.41	0.053
Lincoln	1.23	0.146	1.58	0.020	0.62	0.179	0.88	0.023	2.14	0.016	1.64	0.015
Harris Stowe State	1.07	0.063	-0.99	0.010	0.64	0.030	-1.03	0.013	1.55	0.002	1.16	0.002
N		2486				1466				32680		26503

Table 7. Minority Placements by University-Major Cell under Real and Counterfactual Sorting Scenarios.

	Actual Sorting	Counterfactual Sorting	Difference	Difference (Women)	Difference (Men)
Truman State STEM	0.009	0.013	-0.004	-0.005	-0.003
Truman State HSS	0.028	0.050	-0.022	-0.029	-0.008
UM-Rolla STEM	0.020	0.021	-0.001	-0.002	0.001
UM-Columbia STEM	0.078	0.037	0.041	0.042	0.039
UM-Columbia HSS	0.151	0.115	0.036	0.048	0.017
UM-Kansas City STEM	0.028	0.010	0.018	0.017	0.020
UM-Kansas City HSS	0.041	0.017	0.024	0.028	0.017
UM-St. Louis STEM	0.008	0.003	0.005	0.006	0.003
UM-St. Louis HSS	0.049	0.020	0.029	0.035	0.019
Missouri State STEM	0.006	0.016	-0.010	-0.007	-0.015
Missouri State HSS	0.057	0.188	-0.131	-0.139	-0.116
Northwest STEM	0.006	0.010	-0.004	-0.005	-0.001
Northwest HSS	0.027	0.066	-0.039	-0.044	-0.029
Southeast STEM	0.012	0.010	0.002	0.005	-0.001
Southeast HSS	0.070	0.100	-0.030	-0.036	-0.019
Central STEM	0.015	0.018	-0.003	0.003	-0.013
Central HSS	0.058	0.103	-0.045	-0.047	-0.041
Southern STEM	0.001	0.006	-0.005	-0.003	-0.009
Southern HSS	0.011	0.062	-0.051	-0.051	-0.053
Western STEM	0.015	0.011	0.004	0.005	0.001
Western HSS	0.099	0.091	0.008	0.003	0.019
Lincoln STEM	0.014	0.001	0.013	0.010	0.016
Lincoln HSS	0.144	0.020	0.124	0.116	0.140
Harris Stowe HSS	0.051	0.011	0.040	0.053	0.017
STEM/HSS Majors	0.213 / 0.787	0.156 / 0.844	+0.057 / -0.057	+0.065 / -0.065	+0.039 / -0.039

Table 8. Predicted Minority Graduation Rates Under Various Sorting Scenarios. Sorting Occurs Across Universities and Majors.

	Predicted Minority Graduation Rate		
	All	Women	Men
Actual Sorting	48.05%	51.30%	42.54%
Change which minorities attend which universities holding minority shares in university-by-major cells fixed (Baseline)	47.72	50.94	42.26
Percentage-Point Gain:	*(-0.33)*	*(-0.36)*	*(-0.28)*
<u>Adjustments to minority shares by university-by-major cell</u>			
Full minority redistribution across university-by-major cells (i.e., full counterfactual sorting)	**50.53**	**54.16**	**44.39**
Percentage-Point Gain:	***(+2.81)***	***(+3.22)***	***(+2.13)***
Set minority enrollment at Truman State, UM-Rolla and UM-Columbia to predicted levels, distribute all excess to four moderately-selective universities; hold enrollment at urban and least-selective campuses fixed based on actual minority enrollment	47.78	50.99	42.34
Percentage-Point Gain:	*+0.06**	*+0.05**	*+0.08**
Set minority enrollment at UM-Kansas City and UM-St. Louis at predicted levels, distribute all excess to four moderately-selective universities; hold enrollment at most- and least-selective campuses fixed based on actual minority enrollment	48.81	52.19	43.09
Percentage-Point Gain:	*+1.09*	*+1.18*	*+0.83*
Set minority enrollment at four least-selective universities at predicted levels, distribute all excess to four moderately-selective universities; hold enrollment at urban and most-selective campuses fixed based on actual minority enrollment	49.40	52.90	43.47
Percentage-Point Gain:	*+1.68*	*+1.96*	*+1.19*

Note: The graduation rates for minorities in the analytic sample are 48.25, 51.69 and 42.43 percent for all students, women and men, respectively. The comparable numbers for whites are 63.90, 66.21 and 61.05.
* The graduation rate changes in this scenario are the net result of two effects: (1) a small increase in graduation rates owing to higher enrollment shares at Truman State and UM-Rolla and (2) a small decrease in graduation rates owing to the net student excess from top-3 campuses moving to the moderately selective schools. See Table 6 for details.

Table 9. Degree Attainment for STEM and HSS Entrants.

	STEM Attainment	HSS Attainment	No Degree	N
Initial STEM	0.390	0.269	0.341	13740
Initial HSS	0.029	0.591	0.380	49395
N	6803	32922	23410	

Table 10. Index Parameters from Primary and Alternative Specifications for the Index, STEM Attainment Model.

		Alternative Specifications				
	Primary Specification	(1)	(2)	(3)	(4)	(5)
High-School Class Rank	0.046				0.032	0.041
	(0.005)**				(0.004)**	(0.005)**
ACT Math Score	0.090		0.151	0.143	0.108	0.109
	(0.012)**		(0.022)**	(0.021)**	(0.001)**	(0.014)**
ACT Reading Score	-0.012		0.004	0.006	-0.008	-0.017
	(0.005)*		(0.004)	(0.004)	(0.005)†	(0.005)**
White Female	-0.479	-0.183		-0.139	-0.384	
	(0.071)**	(0.153)		(0.046)**	(0.064)**	
African American Male	0.271	-0.256		0.118	0.232	
	(0.152)†	(0.221)		(0.128)	(0.135)†	
African American Female	-0.541	-0.444		-0.142	-0.510	
	(0.188)**	(0.376)		(0.149)	(0.169)**	
HS Fixed Effects* (Standard Deviation)	0.58					0.57

Table 11. Predicted STEM-Degree-Attainment Probabilities at Index Intervals Across Universities, STEM Entrants Only.

	N (All)	10/50/90 Index (Minorities)	10/50/90 Index (Whites)	Predicted Graduation Rates by Unconditional Percentiles of the Index Distribution 5 (2.83)	10 (3.41)	20 (4.11)	30 (4.60)	40 (4.97)	50 (5.30)	60 (5.60)	70 (5.89)	80 (6.19)	90 (6.59)
Truman State	1306	3.98/5.30/6.66	4.53/5.64/6.53	0.05	0.09	0.16	0.24	0.31	0.38	0.44	0.52	0.59	0.68
UM-Rolla	2345	3.76/5.31/6.30	4.34/5.78/6.85	0.10	0.17	0.30	0.42	0.51	0.59	0.66	0.73	0.78	0.85
UM-Columbia	4141	3.48/4.73/5.99	4.21/5.67/6.77	0.03	0.06	0.12	0.20	0.27	0.35	0.43	0.52	0.60	0.70
UM-Kansas City	927	2.80/4.63/6.18	3.85/5.42/6.54	0.07	0.08	0.11	0.13	0.15	0.17	0.19	0.21	0.23	0.26
UM-St. Louis	305	2.90/3.87/5.23	3.49/5.14/6.37	0.05	0.07	0.11	0.15	0.19	0.23	0.27	0.32	0.37	0.44
Missouri State	999	1.91/3.46/5.52	3.19/4.83/6.17	0.03	0.06	0.11	0.17	0.23	0.29	0.36	0.43	0.50	0.60
Northwest Missouri State	603	2.91/3.66/5.81	2.63/4.36/5.89	0.01	0.03	0.07	0.13	0.21	0.29	0.39	0.50	0.60	0.73
Southeast Missouri State	649	2.53/3.87/5.25	2.97/4.58/6.24	0.08	0.13	0.20	0.28	0.34	0.40	0.46	0.52	0.59	0.66
Central Missouri	1058	2.27/3.54/4.83	2.66/4.34/5.83	0.14	0.18	0.24	0.29	0.33	0.37	0.41	0.45	0.49	0.54
Missouri Southern State	336	2.63/4.00/5.42	2.68/4.54/5.87	0.03	0.07	0.14	0.22	0.30	0.38	0.46	0.55	0.63	0.73
Western Missouri State	522	1.15/2.68/4.75	1.93/3.84/5.64	0.05	0.08	0.16	0.24	0.31	0.39	0.47	0.54	0.62	0.71
Lincoln	109	1.84/2.99/4.71	2.03/3.64/5.41	0.05	0.07	0.10	0.14	0.17	0.20	0.24	0.22	0.25	0.31
Harris Stowe State	0												

Note: Predictions are made by using sample average values for year cohorts. Index values at different points in the unconditional distribution are reported in parenthesis at the top of the columns that show the predictions. The 10/50/90 index values are from the race-specific distributions in each university-by-major cell.

Table 12. University-Average Index Values and Enrollment Shares by Race and Overall, for Actual and White-Predicted Sorting. STEM Entrants; Model is for STEM Degree Attainment

	African American Women				African American Men				Whites (Actual=Predicted)			
	Actual		Predicted		Actual		Predicted		Women		Men	
	Avg Index*	Share	Avg Index*	Share	Avg Index*	Share	Avg Index*	Share	Avg Index*	Share	Avg Index*	Share
Truman State	4.81	0.038	4.72	0.096	5.20	0.040	5.20	0.065	5.43	0.141	5.73	0.079
UM-Rolla	4.81	0.043	4.67	0.063	5.60	0.164	5.19	0.188	5.48	0.096	5.73	0.230
UM-Columbia	4.44	0.405	4.60	0.213	5.11	0.345	5.13	0.261	5.36	0.298	5.69	0.313
UM-Kansas City	4.23	0.160	4.38	0.092	5.20	0.101	4.93	0.039	5.16	0.106	5.48	0.042
UM-St. Louis	3.56	0.036	3.87	0.027	4.53	0.029	4.67	0.024	4.77	0.022	5.17	0.022
Missouri State	3.38	0.029	3.90	0.104	3.81	0.032	4.32	0.089	4.69	0.085	4.80	0.074
Northwest Missouri State	3.95	0.024	3.48	0.105	4.04	0.040	4.01	0.046	4.20	0.067	4.51	0.035
Southeast Missouri State	3.71	0.062	3.63	0.072	3.80	0.050	4.19	0.061	4.44	0.048	4.69	0.048
Central Missouri	3.25	0.064	3.53	0.101	3.82	0.072	3.80	0.128	4.27	0.065	4.29	0.089
Missouri Southern State	--	0.010	3.43	0.047	--	0	4.04	0.032	4.18	0.029	4.51	0.025
Western Missouri State	2.64	0.069	3.14	0.069	2.88	0.072	3.41	0.060	3.83	0.037	3.81	0.037
Lincoln	3.16	0.062	2.96	0.012	3.14	0.056	3.18	0.007	3.82	0.006	3.52	0.004
N		420				377				4581		7922

Notes: There are less than 5 minority STEM entrants at Missouri Southern State University (four women). The analytic sample for the STEM-degree-attainment model is slightly smaller than the full STEM-entrant sample because some high school fixed effects are no longer identified for the STEM sample.
* The index values presented in this table are from a model that predicts graduating with a STEM degree conditional on entering with a STEM degree. They are not comparable to the index values reported in earlier tables, which are obtained using a general graduation model. The standard deviation of the STEM-model index is approximately 1.25.

Table 13. Predicted STEM Degrees Awarded to Minority Students Under Various Sorting Scenarios. Analysis Based on Initial STEM Entrants Only.

	Predicted Minority STEM Attainment		
	All	Women	Men
Actual Sorting	23.46%	18.07%	29.48%
Change which minorities attend which universities holding minority shares in university cells fixed (Baseline)	23.03	17.50	29.19
Percentage-Point Gain:	*(-0.43)*	*(-0.57)*	*(-0.29)*
<u>Adjustments to minority shares by university cells</u>			
Full minority redistribution across university cells (i.e., full counterfactual sorting)	**24.19**	**18.18**	**30.89**
Percentage-Point Gain:	***(+1.16)***	***(+0.68)***	***(+1.70)***
Set minority enrollment at UM-Columbia to predicted levels, distribute all excess to four moderately-selective universities, Truman State, and UM-Rolla; hold enrollment at urban and least-selective campuses fixed based on actual minority enrollment	23.17	17.50	29.49
Percentage-Point Gain:	*+0.14**	*+0.00**	*+0.30**
Set minority enrollment at UM-Kansas City and UM-St. Louis at predicted levels, distribute all excess to four moderately-selective universities; hold enrollment at most- and least-selective campuses fixed based on actual minority enrollment	23.85	18.01	30.36
Percentage-Point Gain:	*+0.82*	*+0.51*	*+1.17*
Set minority enrollment at three least-selective universities at predicted levels, distribute all excess to four moderately-selective universities; hold enrollment at urban and most-selective campuses fixed based on actual minority enrollment	23.22	17.65	29.42
Percentage-Point Gain:	*+0.19*	*+0.15*	*+0.23*

Note: The STEM degree attainment rates for minorities in the analytic sample are 24.59, 18.57 and 31.30 percent for all students, women and men, respectively. The comparable numbers for whites are 40.31, 32.85 and 44.62.
* The graduation rate changes in this scenario are the net result of two effects: (1) an increase in the degree-attainment rate owing to higher enrollment shares at Truman State and UM-Rolla and (2) a decrease in the degree-attainment rate owing to the net student excess from top-3 campuses moving to the moderately selective schools. See Table 12 for details.

Table 14. Decompositions of the Black-White Graduation and STEM-Degree-Attainment Gaps.

	General Graduation		STEM Degree Attainment	
	Women	Men	Women	Men
White predicted success rate	66.22	61.16	33.56	43.68
Black predicted success rate	51.30	42.54	18.07	29.48
Total gap (percentage points)	14.92	18.62	15.49	14.2
Share of gap explained by:				
Initial university-major resorting	+19.2%	+9.9%	+0.7%	+9.9%
High school quality adjustment	+28.5	+18.9	+7.7	+0.1
Pre-entry skills gap	+47.9	+67.5	+85.0	+83.3
College resorting post *AI*-adjustment	+3.5	+2.6	+4.9	+5.7

Appendix A
Data Details

Appendix Table A.1. Construction of the Analytic Sample.

	Records Lost	Remaining Sample
First-time entering freshman at one of the 13 public, four-year campuses in Missouri between 1996 and 2001[a]		106,747
Assigned to a non-Missouri county of residence, or a foreign country, or county of residence unknown	-17,249	89,498
Not full time upon entry (less than 12 credit hours attempted in first semester)	-10,113	79,385
Older than 20 at the beginning of the fall semester	-3,515	75,870
Unknown high school[b]	-1,886	73,984
Missing high school percentile rank[b]	-2,601	71,383
Missing ACT scores (math or reading)	-566	70,817
Race other than white or African American (including unknown)	-4,008	66,809
Unspecified combination major[c]	-3,418	63,391
Other data restrictions[d]	-256	63,135

[a] Students who enter with sophomore status are included as long as they did not transfer from a previous university (in Missouri or elsewhere). This is to facilitate high school students who take college credits prior to entry.
[b] High school codes are available for most public and private high schools in the state. Not all high schools report class rankings, but most do.
[c] The pre-entry characteristics of unspecified dual majors suggest that this group includes both STEM and HSS students. We were unable to convincingly divide this group into major types.
[d] Students from high schools that sent fewer than five students to college over the course of the data panel were dropped, as well as a small number of individuals who were coded as entering HSS majors at UM-Rolla (less than 50).

Appendix Table A.2. Top Five Majors in STEM and HSS Categories.

	Major Share of Category (STEM or HSS)
Top STEM Majors	
General Biology	0.248
General Engineering	0.203
Computer and Information Sciences	0.154
Chemistry	0.040
Pre-Medicine	0.030
Top HSS Majors	
Undeclared	0.285
General Business	0.098
Teacher Education	0.054
General Psychology	0.045
Business Administration and Management	0.034

Appendix Table A.3. Comparison of students entering as undeclared majors to those entering with STEM and other HSS majors.

	Undeclared	Other HSS	STEM
HS Percentile Rank	64.44	70.34	78.12
ACT Math	21.27	22.01	25.58
ACT Reading	23.26	24.23	26.12
Graduation Rate	56.92	64.13	65.95
Science Degree Completion Rate	5.48	1.91	39.00
N	14079	35316	13740

Description of Appendix Tables A.2 and A.3

Appendix Table A.2 shows the top five major assignments for STEM and HSS majors in the data. Just over 6 out of every 10 STEM majors come from general biology, general engineering and computer/information sciences. The remaining STEM entrants are spread out across a large number of smaller fields.

The most common HSS major category includes undeclared entrants. *Ex ante*, it was not clear that these individuals should be categorized as HSS entrants. But after examining their pre-entry characteristics we concluded that they were a much better fit as HSS than STEM majors, despite being somewhat negatively selected even among HSS majors. A notable characteristic of undeclared majors is that they rarely complete a STEM degree (5.48 percent). Although their STEM degree completion rate is higher than declared HSS majors, which is perhaps not surprising given that some undeclared majors may have a preference for STEM fields, it is still very far below the STEM degree completion rate for STEM entrants (this is true conditional on general graduation, or unconditionally).

Appendix B
University Sorting Details by Race

Table B.1. Average ACT Scores, High School Class Rank, and High School Fixed Effects (from General Graduation Model) for African Americans and Whites, by University.

	Minorities						Whites					
	ACT Composite	ACT Math	ACT Reading	Class Rank	HS Fixed Effect	N	ACT Composite	ACT Math	ACT Reading	Class Rank	HS Fixed Effect	N
Truman State	23.44	22.40	24.55	72.33	0.069	146	27.01	25.84	28.24	79.93	0.365	5690
UM-Rolla	23.06	24.05	22.38	73.83	-0.184	80	27.70	28.38	27.75	83.97	-0.019	2317
UM-Columbia	22.25	21.15	23.09	73.34	-0.252	908	25.88	25.05	26.74	78.94	0.216	13226
UM-KC	20.30	19.11	20.71	72.89	-0.604	271	25.02	23.81	25.73	78.46	-0.052	1921
UM-STL	20.31	19.24	21.13	70.19	-0.627	226	24.14	23.29	24.97	71.32	0.223	1662
MO State	19.91	18.60	21.02	62.94	-0.276	251	23.15	21.92	24.04	69.62	-0.124	11104
Northwest	18.82	17.65	19.16	59.95	-0.475	133	22.11	20.99	22.86	67.78	-0.061	4095
Southeast	19.78	18.76	20.31	52.28	-0.135	327	22.66	21.51	23.44	64.96	0.066	5618
Central	19.01	17.90	19.77	60.44	-0.672	286	22.08	21.00	22.84	66.46	-0.093	6129
Southern	18.54	17.11	19.67	48.06	-0.473	46	21.84	20.64	22.74	65.70	-0.45	2807
Western	16.48	15.91	16.68	45.10	-0.695	453	20.35	19.32	21.04	56.75	-0.182	3565
Lincoln	16.41	15.87	16.92	44.96	-0.608	625	20.07	19.46	20.34	53.39	0.355	928
Harris	18.65	17.67	19.13	47.30	-0.709	200	21.12	19.79	22.17	48.54	-0.076	121

Appendix C
Gender Sorting, by Race

Appendix Table C.1 Gender Differences in Enrollment Shares, by Race.

	White Men	White Women	Difference	African American Men	African American Women	Difference
Truman State STEM	0.024	0.020	0.004	0.026	0.008	0.018
Truman State HSS	0.060	0.086	-0.026	0.042	0.030	0.012
UM-Rolla STEM	0.070	0.014	0.056	0.010	0.007	0.003
UM-Columbia STEM	0.095	0.043	0.052	0.092	0.070	0.022
UM-Columbia HSS	0.139	0.171	-0.032	0.115	0.173	-0.058
UM-Kansas City STEM	0.013	0.015	-0.002	0.028	0.028	0
UM-Kansas City HSS	0.018	0.019	-0.001	0.033	0.045	-0.012
UM-St. Louis STEM	0.007	0.003	0.004	0.008	0.008	0
UM-St. Louis HSS	0.023	0.024	-0.001	0.038	0.056	-0.018
Missouri State STEM	0.023	0.013	0.01	0.008	0.005	0.003
Missouri State HSS	0.154	0.184	-0.03	0.056	0.058	-0.002
Northwest STEM	0.011	0.010	0.001	0.010	0.004	0.006
Northwest HSS	0.054	0.063	-0.009	0.034	0.023	0.011
Southeast STEM	0.015	0.007	0.008	0.014	0.012	0.002
Southeast HSS	0.070	0.096	-0.026	0.068	0.072	-0.004
Central STEM	0.028	0.009	0.019	0.018	0.012	0.006
Central HSS	0.077	0.094	-0.017	0.057	0.058	-0.001
Southern STEM	0.008	0.004	0.004			
Southern HSS	0.040	0.043	-0.003	0.015	0.008	0.007
Western STEM	0.012	0.006	0.006	0.020	0.012	0.008
Western HSS	0.041	0.060	-0.019	0.099	0.100	-0.001
Lincoln STEM	0.001	0.001	0	0.018	0.011	0.007
Lincoln HSS	0.014	0.015	-0.001	0.161	0.138	0.023
Harris Stowe HSS	0.002	0.002	0	0.030	0.063	-0.033
N	26503	32680		1466	2486	

Notes: Only four African American women, and zero African American men, enter Missouri Southern State University as STEM majors.

Appendix Table C.2 Gender Differences in Index-Based Sorting, by Race.

	White Men	White Women	Difference	African American Men	African American Women	Difference
Truman State STEM	2.99	3.17	-0.18	2.97	2.88	0.09
Truman State HSS	2.92	3.03	-0.11	2.66	2.47	0.19
UM-Rolla STEM	2.89	3.11	-0.22	2.40	2.87	-0.47
UM-Columbia STEM	2.95	3.13	-0.18	2.33	2.65	-0.32
UM-Columbia HSS	2.65	2.93	-0.28	2.01	2.56	-0.55
UM-Kansas City STEM	2.77	3.01	-0.24	2.26	2.53	-0.27
UM-Kansas City HSS	2.32	2.56	-0.24	1.67	2.15	-0.48
UM-St. Louis STEM	2.62	2.82	-0.2	1.93	1.84	0.09
UM-St. Louis HSS	2.40	2.65	-0.25	1.76	2.19	-0.43
Missouri State STEM	2.18	2.58	-0.4	1.24	1.87	-0.63
Missouri State HSS	2.04	2.34	-0.3	1.77	2.17	-0.40
Northwest STEM	2.21	2.45	-0.24	1.48	2.02	-0.54
Northwest HSS	1.97	2.34	-0.37	1.50	1.90	-0.40
Southeast STEM	2.13	2.49	-0.36	1.34	2.20	-0.86
Southeast HSS	1.95	2.28	-0.33	1.29	1.75	-0.46
Central STEM	2.06	2.42	-0.36	1.34	1.61	-0.27
Central HSS	1.87	2.29	-0.42	1.27	1.79	-0.52
Southern STEM	2.05	2.34	-0.29			
Southern HSS	1.48	1.98	-0.50	0.87	1.26	-0.39
Western STEM	1.64	2.03	-0.39	0.33	1.29	-0.96
Western HSS	1.34	1.78	-0.44	0.60	1.12	-0.52
Lincoln STEM	1.73	2.34	-0.61	0.80	1.51	-0.71
Lincoln HSS	1.63	2.13	-0.50	0.60	1.20	-0.60
Harris Stowe HSS	1.16	1.55	-0.39	0.64	1.07	-0.43
Across-Cell Variance	0.28	0.19		0.50	0.31	
N	26,503	32,680		1,466	2,486	

Notes: Only four African American women, and zero African American men, entered Missouri Southern State University as STEM majors.

Description of Appendix Tables C.1 and C.2

Appendix Tables C.1 and C.2 compare gender differences in sorting between white and minority college entrants. Differential sorting by gender is similar across races, although there are differences in some instances. Also note that some of the university-by-major cells are very small for minorities, particularly for STEM entrants outside of UM-Columbia.

Table C.1 reveals that women are less likely to enter in STEM fields, which is consistent with previous research (Turner and Bowen, 1999). This descriptive pattern in the data is supported by linear regression analysis. Conditional on high school of attendance, class ranking, and ACT math and reading scores, white men are 12.8 percentage points more likely to enter with a STEM degree relative to white women; for African Americans, the analogous number is 9.2 percentage points. Both differences are highly significant.

Table C.1 also highlights gender similarities in enrollment behavior within races. For example, at universities where minorities are underrepresented, African American men and women are typically both underrepresented, and similarly for universities where minorities are overrepresented.

Appendix Table C.2 documents the extent to which sorting is hierarchical by race-gender status. Within both racial groups, men sort more-hierarchically across university-by-major cells than women. One implication is that women college-goers are more likely to attend universities where their pre-entry preparation indexes suggest that they are overqualified, at least relative to men. The data for minorities is somewhat noisier due to the small samples in some cells, but the pattern is clear nonetheless. Consistent with Table 4 in the main text, index values for women in both racial groups are considerably higher than for men.

Appendix D
Parameter Estimates for General Graduation and STEM-Degree-Attainment Models

Appendix Table D.1. Raw Logit Parameter Estimates for General Graduation Model and STEM-Degree Attainment Model

	General Graduation Model	STEM-Degree Attainment Model
Index Parameters		
High-School Class Rank	0.045	0.046
	(0.001)**	(0.005)**
ACT Math Score	0.000	0.090
	(0.003)	(0.012)**
ACT Reading Score	-0.014	-0.012
	(0.002)**	(0.005)*
White Female	-0.086	-0.479
	(0.022)**	(0.071)**
African American Male	0.047	0.271
	(0.070)	(0.152)
African American Female	0.104	-0.541
	(0.060)	(0.188)**
Other Parameters		
STEM Entrant	-0.662	
	(0.291)*	
Truman State Entrant	0.440	0.517
	(0.220)*	(0.833)
Truman State STEM Entrant	1.318	
	(0.502)*	
UM-Rolla Entrant (STEM Only)	0.747	1.181
	(0.359)*	(0.741)
UM-Columbia Entrant	0.412	-0.419
	(0.135)**	(0.710)
UM-Columbia STEM Entrant	-0.041	
	(0.356)	
UM-Kansas City Entrant	0.240	2.596
	(0.256)	(0.920)**
UM-Kanas City STEM Entrant	0.408	
	(0.490)	
UM-St. Louis Entrant	-0.445	0.259
	(0.230)	(1.359)
UM-St. Louis STEM Entrant	1.036	
	(0.582)	
Northwest Entrant	0.509	-2.846
	(0.150)**	(1.422)*
Northwest STEM Entrant	0.197	
	(0.447)	
Southeast Entrant	0.403	1.451
	(0.0136)**	(0.887)
Southeast STEM Entrant	-0.242	
	(0.493)	
Central Entrant	0.254	2.846
	(0.133)	(0.753)**
Central STEM Entrant	0.594	
	(0.388)	
Southern Entrant	0.249	-0.744
	(0.170)	(0.137)
Southern STEM Entrant	-0.373	
	(0.593)	
Western Entrant	-0.256	-0.131
	(0.160)	(1.134)
Western STEM Entrant	0.296	
	(0.471)	
Lincoln Entrant	0.512	1.991
	(0.194)*	(2.291)
Lincoln STEM Entrant	0.169	
	(0.836)	
Harris Stowe State Entrant (HSS Only)	-0.319	
	(0.520)	

Index Interaction Parameters		
STEM Entrant	0.112	
	(0.105)	
Truman State Entrant	0.036	-0.034
	(0.076)	(0.140)
Truman State STEM Entrant	-0.560	
	(0.171)**	
UM-Rolla Entrant (STEM Only)	-0.085	0.025
	(0.124)	(0.131)
UM-Columbia Entrant	-0.001	0.132
	(0.048)	(0.136)
UM-Columbia STEM Entrant	0.020	
	(0.125)	
UM-Kansas City Entrant	-0.254	-0.573
	(0.080)**	(0.117)**
UM-Kanas City STEM Entrant	-0.047	
	(0.163)	
UM-St. Louis Entrant	-0.064	-0.260
	(0.081)	(0.199)
UM-St. Louis STEM Entrant	-0.445	
	(0.188)**	
Northwest Entrant	-0.084	0.454
	(0.056)	(0.272)
Northwest STEM Entrant	-0.124	
	(0.162)	
Southeast Entrant	-0.079	-0.177
	(0.048)	(0.138)
Southeast STEM Entrant	-0.098	
	(0.156)	
Central Entrant	-0.111	-0.473
	(0.047)*	(0.091)**
Central STEM Entrant	-0.148	
	(0.137)	
Southern Entrant	-0.080	0.146
	(0.062)	(0.252)
Southern STEM Entrant	0.057	
	(0.212)	
Western Entrant	0.029	0.036
	(0.059)	(0.208)
Western STEM Entrant	-0.080	
	(0.174)	
Lincoln Entrant	-0.240	-0.324
	(0.065)**	(0.432)
Lincoln STEM Entrant	0.049	
	(0.279)	
Harris Stowe State Entrant (HSS Only)	-0.332	
	(0.163)*	
Constant	-1.892	-6.146
	(0.125)**	(0.666)**
N	63,135	13,300

Notes: Parameters that allow for differential outcomes across university-by-major cells in different years, and high school fixed effects, are suppressed for brevity. Recall that some entering STEM entrants were dropped from the STEM-only models, primarily STEM entrants from high schools with fewer than five STEM-entrant observations. The omitted university in all instances is Missouri State University. The baseline parameters for STEM-entrant and the STEM-entrant interaction with the index apply to Missouri State. Parameters for the other university-by-major cells are relative to the Missouri State baseline. The net effects for STEM entrants at any university can be obtained by summing the general-entrant effect and the STEM-entrant effect for that university. Note that some differences between the university-specific parameters for STEM entrants across models can be attributed to STEM entrants who graduate but switch to an HSS degree.

Appendix E
African American Predicted and Actual Success Rates and African American Representation, by University

Appendix Table E.1. Differences between Actual and Predicted Success Rates for African Americans by University. Full Graduation and STEM-Degree Completion Models.

	All Minorities, General Graduation Model				Entering STEM Majors, STEM Model			
	Grad Rate	Predicted Grad Rate	Gap	N	STEM Grad Rate	Predicted STEM Grad Rate	Gap	N
Truman State	0.658	0.742	-0.085*	146	0.121	0.381	-0.259*	33
UM-Rolla	0.713	0.654	0.058	80	0.680	0.548	0.131*	78
UM-Columbia	0.659	0.677	-0.018	908	0.287	0.265	0.022	300
UM-Kansas City	0.461	0.468	-0.007	271	0.191	0.142	0.049	105
UM-St. Louis	0.367	0.422	-0.055	226	0.039	0.118	-0.079	26
Missouri State	0.562	0.545	0.017	251	0.167	0.108	0.059	24
Northwest Missouri State	0.534	0.545	-0.011	133	0.080	0.129	-0.049	25
Southeast Missouri State	0.480	0.489	-0.009	327	0.311	0.189	0.122*	45
Central Missouri	0.535	0.500	0.035	286	0.093	0.202	-0.109*	54
Missouri Southern State	0.435	0.315	0.120	46	N/A	N/A	N/A	4
Western Missouri State	0.320	0.291	0.030	453	0.071	0.087	-0.016	56
Lincoln	0.318	0.303	0.015	625	0.064	0.075	-0.011	47
Harris Stowe State	0.310	0.270	0.040	200	N/A	N/A	N/A	N/A
Totals	0.4825	0.4805	0.002	3952	0.2459	0.2346	0.0113	797

* Indicates statistically significant gap at 5 percent level or better.

Description of Appendix Table E.1

In Table E.1 we compare actual and predicted minority success rates across the 13 universities in the system. Note that our graduation model does not explicitly allow for racial differences in the intercepts, or for the returns to the academic index, by university. There is little evidence in our data to suggest that universities with higher African-American representation produce better outcomes for African Americans. For example, Western Missouri State and Lincoln University look similar observationally in many ways, except that Lincoln University has a much higher proportion of African American students, but the differences between actual and predicted graduation rates for African Americans at these schools are very similar. Missouri State University is another interesting example. Although the STEM-entrant sample is too small to be informative, African Americans who enter Missouri State as HSS majors do better than the model predicts despite the particularly sparse representation of minorities at that school.