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The Effects of Merit-based Scholarships on First-year Engineering Student Characteristics and Academic Behaviors

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Abstract

State-sponsored merit-based scholarship programs have proliferated since the 1990s. Using student-level data across institutions, we estimate the effects of merit-based scholarships on first-time students' characteristics and their first-year academic behaviors, with specific focus on engineering students. Difference-in-differences regression models are used in the analysis. We find that merit-based scholarships did not help improve SAT score or first-year GPA of resident students including those majoring in engineering. The average socioeconomic indicator of engineering students increased in the presence of merit-based scholarships, suggesting the socioeconomic diversity of engineering experienced a decline after scholarship adoption. Institutional differences existed in the mean SAT score and socioeconomic status, and this stratification was more prominent in engineering. The presence of merit-based scholarships was associated with an increased likelihood that resident students would withdraw from courses and take summer courses after scholarships were implemented. The effects of merit-based scholarships on first-year course load were disproportionate across states, following credit hour requirements in scholarship retention policies. Compared to total residents, engineering residents were more prone to reduce first-year credit hours with a merit-based scholarship in effect, possibly indicating that coursework for engineering students required more effort so that students chose a lighter load to maintain good grades.

Introduction

The nature of college financial aid programs in the U.S. has changed dramatically over the past two decades[1]. Since the early 1990s, state governments have adopted merit-based scholarships as a tool to attract high school graduates to attend in-state colleges. Scholarship recipients receive tuition subsidies based entirely on their academic performances. While state funding for need-based programs has experienced a downward trend, funding for merit-based programs has increased steadily[2, 3]. By 2011, at least 14 states had introduced merit-based scholarship programs and had distributed billions of dollars for residents who met specified scholarship criteria[3-6]. Despite slight differences across states, typical merit-based scholarships have modest eligibility criteria for initial qualification and annual renewal[3]. In general, to meet initial requirements, a state resident must graduate from an in-state high school with at least a 3.0 grade point average (GPA) and pursue a first-time bachelor's degree at an eligible public or private in-state institution. Initial eligibility may also include specified levels of standardized tests and high school percentile rank. To maintain eligibility for funding, a scholarship recipient usually needs to earn a minimum amount of credit hours and reach a cumulative GPA of at least 3.0 per academic year in college. If a student fails to meet renewal requirements at the checkpoint, that student may restore the scholarship by meeting the standard at the next checkpoint if allowed by the scholarship policy.

To support the creation of state-sponsored merit-based scholarships, policymakers have advanced several rationales. Commonly mentioned rationales include relieving financial stress for residents to attend in-state colleges, increasing student effort and academic achievement, and retaining the most talented students within state[7, 8]. The realization of some rationales has been acknowledged by research studies, such as an increased college enrollment rate and improved academic performances of both high school graduates and college students[9, 10]. However, merit-based scholarships have been criticized for placing students from low-income families at a disadvantage in college enrollment[11]. Also, grade-based criteria have encouraged a number of unintended behavioral responses. To reach the specified academic requirements, students incline to choose less demanding courses, to take fewer credit hours, and to withdraw from courses in which they anticipate a poor grade[12, 13]. While taking a closer look at scholarship impact on engineering students, only little attention has been paid to the issue in the research literature. Compared to the whole population of scholarship recipients, engineering experienced a larger increase in the fraction of students with high socioeconomic status[14]. Disclosed through interview, engineering students were found to adopt similar strategies to retain their scholarships as students in other majors[15].

Given the increasing prominence of merit-based scholarships in the nation, it is critical to understand scholarship influences on engineering cohort characteristics as well as on course choices that directly affect academic achievement. The increasing demand of well-prepared engineering graduates in the workplace further necessitates the study of differences between engineering students and non-engineering students regarding scholarship effects on academic preparedness and performance. Although prior research has provided some hints for possible consequences of merit-based scholarships on college enrollment and academic choices, most studies focused on the whole student body regardless of disciplines that students were in. From the limited literature, it is still inconclusive how merit-based scholarships affect engineering students' academic decisions compared to scholarship effects on students in other disciplines. Using a large student-level database, our study adds to the conversation by comparing engineering students with students in other majors regarding changes in demographics and course selection behaviors. Meanwhile, we use control groups including both non-resident students and states where merit-based scholarships were unavailable. We particularly intend to address the extent to which engineering students react to scholarship rules differently across institutions and states. Therefore, we attempt to answer the following research questions:

1) To what extent do merit-based scholarships affect first-time resident engineering cohort patterns regarding academic preparedness and socioeconomic status?
2) To what extent do merit-based scholarships affect first-time resident engineering students' course enrollment, withdrawal, and course grade in the first academic year?
3) How do these effects vary by state and by institution?

To answer these questions, we utilize two large-scale databases: the Multiple Institution Database for Investigation of Engineering Longitudinal Development (MIDFIELD)[16], and the Common Core of Data (CCD) database[17]. Besides, we gather information of state-wide merit-based scholarships from an earlier research done by Mobley, Brawney, and Ohland[15] and from the websites of state scholarship grant programs. MIDFIELD contains student data of eleven public institutions, five of which are located in three states with state-sponsored merit-based scholarships. The other six institutions are located in four states without a merit-based scholarship. Table 1 summarizes features of merit-based scholarships in the three MIDFIELD states over the period this study focuses.

Table 1. Features of state-sponsored merit-based scholarships for 2008-2009 High School Graduates and earlier in Florida, Georgia, and South Carolina

State	Scholarship	Year	Threshold Criterion	Award Amount	Renewal Requirement	Restoration
Georgia	Helping Outstanding Pupils Educationally (HOPE)	1993	1) First-time bachelor's degree 2) U.S. citizen or eligible non-citizen 3) Georgia residency 4) GPA 3.0 (or an 80 average in college prep courses for students who began college career before 2007)	100% tuition up to 127 credit hours	Collegiate GPA 3.0 * No minimum amount of hours per term required * Grade of summer school may be used to meet renewal requirements	Can be reinstated before 90 hours
Florida	Bright Futures Scholarships	1997	1) First-time bachelor's degree 2) U.S. citizen or eligible non-citizen 3) Florida residency For specific awards: 4) Florida Academic Scholars (FAS): GPA 3.5 & SAT/ACT 1270/28; Community service 75 hours 5) Florida Medallion Scholars (FMS): GPA 3.0 & SAT/ACT 970/20 6) Gold Seal Vocational Scholars (GSV): GPA 3.0 & SAT/ACT 440+440/17+18+19	1) FAS: 110% tuition up to 132 credit hours 2) FMS: 110% tuition up to 132 credit hours 3) GSV: 110% tuition up to 90 credit hours	1) Enroll in at least 12 hours per term for full-time student For specific awards: 2) FAS: Collegiate GPA 3.0 3) FMS: Collegiate GPA 2.75 4) GSV: Collegiate GPA 2.75 * Grade and hour of summer school may be used to meet renewal requirements	For insufficient GPA or insufficient hours, can be reinstated once
South Carolina	Palmetto Fellows	2001	1) First-time full-time bachelor's degree 2) U.S. citizen or eligible non-citizen 3) South Carolina residency 4) GPA 3.5 & SAT/ACT 1200/27 5) high school class rank 5% for 2001-2003 and 6% for 2004-2009	2001: $5,000 up to 8 terms 2002-2009: $6,700 for 1st academic year and $7,500 for 2nd-4th academic year	1) Enroll in at least 30 hours per academic year 2) Collegiate GPA 3.0 * Grade and hour of summer school may be used to meet renewal requirements	Cannot be reinstated
	Legislative Incentive for Future Excellence (LIFE)	1998	1) First-time full-time bachelor's degree 2) U.S. citizen or eligible non-citizen 3) South Carolina residency 1998-1999: 1) GPA 3.0 2) SAT/ACT 1000/21 2000-2001: 1) GPA 3.0 2) SAT/ACT 1050/22 2002-2009 (meet two of the following criteria): 1) GPA 3.0 2) SAT/ACT 1100/24 3) high school class rank 30%	1998-1999: $2,000 up to 8 terms 2000-2001: $3,000 up to 8 terms 2002-2009: The lesser of 100% tuition and $5,000 up to 8 terms	1) Enroll in at least 30 hours per academic year 2) Collegiate GPA 3.0 * Grade and hour of summer school may be used to meet renewal requirements	Can be reinstated
	HOPE	2002	1) First-time full-time bachelor's degree 2) U.S. citizen or eligible non-citizen 3) South Carolina residency 4) GPA 3.0	2002-2006: $2,650 for 1st year only 2007-2009: $2,800 for 1st year only		

Literature Review

Merit-based scholarships have been acknowledged by numerous studies to have substantial influences on resident students with regard to college enrollment, course choices, and academic performance. To understand how engineering students react to scholarship requirements and how their behaviors differ from students in other disciplines, we review studies examining scholarship impacts on academic preparedness, socioeconomic status, course-taking, and course grade.

Academic preparedness and socioeconomic status of first-time students

SAT score is a conventional measure of student academic preparedness. Like other measures of academic qualification, SAT score is positively correlated with student's socioeconomic status (SES)[18]. For example, according to the report of College Board in 2011[19], students from families earning $20,000 to $40,000 per year scored 1398 on average on SAT, while students from families earning $100,000 to $120,000 had a mean score of 1580. Since most merit-based scholarship programs use SAT score as one of the academic qualifications, students from low-income families are less likely to receive those scholarships[1, 3]. Numerous studies have demonstrated that merit-based scholarships are not only positively correlated with an increase of SAT score[9, 20], but also positively related to an increase in the share of students of middle- and high-SES among first-year college students[14, 21, 22]. Cornwell, Mustard, and Sridhar[9] found that average SAT scores of first-year students in public universities rose 40 points after the adoption of Georgia's HOPE program, whereas SAT scores in comparison states increased slightly over the same period. In another study, Cornwell and Mustard[23] noticed that the increase of SAT scores varied by institution type and by states. Georgia's scholarship program significantly increased SAT scores of first-year students in more-selective institutions, whereas changes of SAT scores in less-selective institutions were non-significant. Similarly, Arkansas, Maryland, and South Carolina experienced increases in SAT scores. Louisiana and Florida were two exceptions. The researchers attributed the disproportionate effects of SAT escalation to a relatively lower scholarship threshold criterion in Louisiana and Florida. Dynarski[11] estimated the impact of Georgia's HOPE program on first-time students with different income levels. She found that high-SES students had a greater chance to be awarded and their population as first-time students increased significantly. In contrast, the increase of low-SES students in college enrollment was non-significant. Similarly, Perna and Titus[24] discovered that the fraction of low-SES students decreased in public four-year institutions. They further attributed such decrease to those students' fewer chances to receive a merit-based scholarship. Recently, Chen and Ohland[14] demonstrated that the adoption of merit-based scholarships was positively related to in-state student enrollment and the SES of engineering students.

Academic behaviors—course-taking and course load

Besides the impact of threshold criteria on first-time student characteristics, student academic decisions and behaviors through grade-based renewal requirements are observed to change in the presence of merit-based scholarships. Researchers found that students adopted diverse strategies to remain eligible for the scholarship[10, 12, 15, 25]. Strategies that lead to better academic achievement include improving study habits and paying more attention to coursework. However, the retention rules have increased the cost of failing, and therefore encouraged unintended academic behaviors as well, such as withdrawing from more courses and choosing less demanding courses to maintain the required GPA. For instance, Healy[26] observed that both course drop-out rate and summer course enrollment rate rose at the University of Georgia after HOPE program was implemented. Cornwell et al.[12, 27] used non-residents as well as former students as control groups to study behavioral responses of resident students in Georgia. Their results were similar to the results of Healy. Compared to out-of-state students, in-state students were more inclined to withdraw from courses when performing unsatisfactorily and choose courses with higher expected grades. Also, there was a shifting of course-taking from regular academic year to summer session for resident students. Student credit load strategies were related to the scholarship requirements. When there was no minimum amount of credit hour required for scholarship renewal, students appeared to take fewer courses to help improve their grades. For example, Binder and Ganderton demonstrated that students completed fewer credit hours than students matriculating prior to the inception of New Mexico's merit-based scholarship program[22]. Similarly, Cornwell et al.[12, 27] found that resident students enrolled in fewer courses per term. In another study, they pointed out that Georgia's HOPE program had reduced the number of credit hours completed in math and sciences core courses specifically[13]. When a minimum credit load was required by the scholarship, students adjusted their strategies accordingly. Scott-Clayton[4] examined West Virginia's merit-based scholarship effect on credit hours earned by students. She found that the likelihood of earning at least 30 credits per academic year increased among scholarship recipients. The effect of credit hour increase was concentrated around the annual renewal threshold from first through junior year, but disappeared in the senior year when scholarship recipients were no longer restricted by renewal requirements.

Specifically for engineering students, Mobley et al. adopted a qualitative approach through interview of 16 engineering students at Clemson University[15]. In their study, engineering scholarship recipients responded that they would study hard, become selective about courses and professors, and attend summer school to keep their scholarships. Most strategies they used were similar to those used by students in other majors. However, engineering students expressed their concern that engineering required much harder work than other disciplines in getting similar grades[15]. The belief of difficulty was consistent with the findings of Dee and Jackson[28] that engineering students were 25% more likely than similarly qualified students in non-STEM majors to lose merit-based scholarship eligibility after one academic year. Using *t*-tests to study student-level data at three institutions in Florida, Zhang et al.[10] found that engineering students attempted fewer credit hours than their prior cohort. The effect of scholarship was significant in the first through the seventh semester but disappeared in the eighth semester when students still received funding but did not need to meet any requirement.

College academic performance—collegiate GPA

Since students adopt diverse strategies to remain eligible for merit-based scholarships, it is not surprising that collegiate GPAs are higher when merit-based scholarships are in effect. Henry, Rubenstein, and Bugler compared scholarship recipients who were just above the threshold criterion with similar non-recipients in Georgia public institutions[29]. They discovered that HOPE scholarship positively affected students' four-year GPA. Using non-residents as a control group, Cornwell et al.[13] showed that Georgia residents' first-year GPA had increased by 0.13 after the adoption of HOPE. But the increase effect grew weaker after the first year. Hernández-Julián[25] demonstrated that semester GPA of South Carolina's LIFE scholarship recipients increased by 0.101 compared to the GPA of non-recipients, controlling for student quality and course choice characteristics. The increase effect of GPA was also found among students majoring in engineering. Zhang et al. revealed that recipients of Florida's Bright Futures scholarships had earned higher GPA than students who enrolled prior to the establishment of scholarships[10]. Additionally, the increase effect was more prominent for Academic Scholars recipients than for Medallion Scholars recipients due to higher renewal standards of the former scholarship program.

Although prior studies have examined how merit-based scholarships affect first-time student characteristics and academic behaviors, only a few researchers have investigated the degree to which engineering students differ from other students in enrollment patterns and academic choices. Our study adds to this body of work in that we examine scholarship effects by comparing first-time in-state engineering students with students in other disciplines. Meanwhile, we are able to examine diverse scholarship effects varied by institutions and by states.

Data and Method

In this study, we use two large-scale databases as the main data sources: (1) The Multiple Institution Database for Investigation of Engineering Longitudinal Development (MIDFIELD)[16], which includes student-level data at eleven public institutions and represents approximately 1/9th of all U.S. engineering graduates. The use of student-level data helps us understand how much merit-based scholarships affect engineering student enrollment patterns and academic behaviors from a micro-perspective. Among these institutions, five are located in three states that have introduced state-sponsored merit-based scholarships, and the other six institutions are located in four states without a merit-based scholarship. (2) The Common Core of Data (CCD) database[17]—a database maintained by the National Center for Education Statistics that collects fiscal and non-fiscal data annually from all U.S. public elementary and secondary schools. In this study, student academic variables and demographic information are drawn from MIDFIELD, whereas the information of the National School Lunch Program in each state is drawn from CCD.

To describe a student's socioeconomic status, we use two variables: Peer SES and State SES. Peer SES is defined as the percentage of students not eligible for free meals of the National School Lunch Program at each student's high school[30]. It indicates the poverty status of an academic environment where a student attended high school, and therefore indirectly measures the socioeconomic conditions in which the student was educated. Peer SES has been demonstrated by Orr, Ramirez, and Ohland[31] to be correlated with the enrollment and academic achievement of engineering students. Another variable—State SES is defined as the percentage of students not eligible for free lunch in a state where the high school is located[14]. Using Peer SES and State SES, we compute a Relative Peer SES by subtracting State SES from Peer SES. Relative Peer SES measures the gap between the poverty status of a high school and that of a state where the high school is located. Computing Relative Peer SES in this way measures to what degree each state public institution is serving the state's population. Also, Relative Peer SES controls state influences on Peer SES, because the percentage of students not eligible for free lunch in an individual high school (Peer SES) is related to the percentage of students not eligible for free lunch in a state where the high school is located (State SES). Peer SES is available in MIDFIELD. State SES is calculated from CCD. As we will show, the correlations between Relative Peer SES and SAT score are universally stronger than the correlations between Peer SES and SAT score in our sample institutions, suggesting that Relative Peer SES is a better measure of student's socioeconomic status than Peer SES.

Since we are not able to identify scholarship eligibility directly in MIDFIELD, we restrict attention to Typical First-time Students (TFS) who were non-transfer students matriculating in the fall semester with fewer than 30 credits of advanced placement, dual-enrollment, and/or transfer at matriculation. In the analysis of student academic preparedness and socioeconomic status, engineering students are defined as TFS who enrolled in engineering upon enrollment. In the analysis of first-year academic behaviors and first-year GPA, engineering students are defined as TFS who continuously enrolled in engineering in every semester of the first academic year.

We employ descriptive statistics on the sample of resident TFS to show the correlations between SAT score and SES measures. Meanwhile, we perform straightforward comparisons of SAT score and Relative Peer SES four years before and four years after the inception of merit-based scholarships. Three institutions are excluded from this part of study due to data unavailability of Relative Peer SES in these institutions over the periods this study focuses. Accordingly, the sample of Florida and its comparison states includes 7 institutions from 1993 to 2000, resulting in a total of 107,121 in-state TFS with 18,347 being engineering students. The sample of South Carolina and its comparison states includes 5 institutions from 1994 to 2001, resulting in a total of 74,192 in-state TFS with 16,033 being engineering students.

We use difference-in-differences regression models and logistic regression models to investigate the relationships between merit-based scholarships and changes in student behaviors and academic performance. Both models are used widely to evaluate merit-based scholarship effects[3, 32]. As a common strategy, we compare five years before and five years after scholarship implementation in each institution where a merit-based scholarship was available[9, 33]. Besides the coefficient of scholarship effects that we are interested in, we include control variables to account for factors that might have contributed to changes in the outcome variable. As such, we derive the following difference-in-differences models for total first-time students:

$$Y01HRA = b_0 + b_1 \cdot R_i \cdot M_i + b_2 \cdot SAT + b_3 \cdot G_i + b_4 \cdot E_i + c_k \cdot Y_k \qquad (1)$$
$$Y01GPA = b_0 + b_1 \cdot R_i \cdot M_i + b_2 \cdot SAT + b_3 \cdot G_i + b_4 \cdot E_i + c_k \cdot Y_k \qquad (2)$$

Y01HRA is an outcome variable in (1) and stands for first-year credit hours attempted by students. Y01GPA is an outcome variable in (2) and represents student's first-year GPA. In both (1) and (2), control variables include the interaction of resident indicator R_i and merit-based scholarship indicator M_i, SAT score, gender indicator G_i, engineering student indicator E_i, and academic year dummy variables Y_k ($k = 1, 2, \ldots, 9$). R_i is coded as 1 for in-state student and 0 for out-of-state student. M_i is coded as 1 if a merit-based scholarship is available in a specific year and coded as 0 otherwise. Gender indicator G_i is coded as 1 for male and 0 for female. Engineering indicator E_i is coded as 1 for engineering student and 0 for non-engineering student. Each dummy variable Y_k ($k = 1, 2, \ldots, 9$) represents academic year coded as 1 for the $k+1^{th}$ year and 0 for either other years or the first year. The scholarship effect is reflected in the coefficient

b_1 of the interaction between R_i and M_i. Additionally, we run multiple regression analyses for first-time engineering students using almost the same models except that E_i is deleted.

Logistic regression models are applied to study dichotomous outcome variables that measure first-time student course-taking behaviors. The form of logistic models differs from multiple regression models (1) and (2) only in the outcome variables:

$$Y01FRA = b_0 + b_1 \cdot R_i \cdot M_i + b_2 \cdot SAT + b_3 \cdot G_i + b_4 \cdot E_i + c_k \cdot Y_k \quad (3)$$
$$Y01W = b_0 + b_1 \cdot R_i \cdot M_i + b_2 \cdot SAT + b_3 \cdot G_i + b_4 \cdot E_i + c_k \cdot Y_k \quad (4)$$
$$Y01S = b_0 + b_1 \cdot R_i \cdot M_i + b_2 \cdot SAT + b_3 \cdot G_i + b_4 \cdot E_i + c_k \cdot Y_k \quad (5)$$

Y01FRA in (3) is an indicator of full course load which is coded as 1 for a student attempting at least 30 credit hours in the first year and coded as 0 otherwise. Y01W in (4) is an indication of course withdrawal that is coded as 1 for a student withdrawing from at least one course in the first year and coded as 0 otherwise. Y01S in (5) is an indicator of summer course-taking, coded as 1 for a student earning more than zero summer credit in the first year and coded as 0 otherwise.

We run regression models (1) to (5) for each of the five institutions that are located in three states with merit-based scholarships. Since we want to examine student academic behaviors and academic performance throughout the first year, we restrict the sample for regression analysis to TFS who enrolled continuously from fall to spring semester in the first academic year. Accordingly, the sample includes a total of 111,538 TFS with 20,768 being engineering students from 1988-1997 in Georgia, 1992-2001 in Florida, and 1993-2002 in South Carolina respectively.

Conducting multiple statistical tests, this study uses an adjusted alpha level to keep the experimentwise error rate at .05 level. The adjusted alpha level for each test is .001 based on calculation from the conservative Bonferroni adjustment[34].

Results and Discussion

The correlation between SAT score and measures of socioeconomic status

Before using Relative Peer SES as a measure of student's socioeconomic status, we calculate the Pearson's Correlations between SAT score and Peer SES, and between SAT score and Relative Peer SES respectively. We run tests on each institution located in Florida and South Carolina, and run tests on their corresponding comparison states. As shown in Table 2, all correlations are positive and statistically significant ($p < .005$). Notably, correlations between SAT and Relative Peer SES are universally stronger than the correlations between SAT and Peer SES. Although Relative Peer SES and Peer SES is highly correlated in each sample institutions, our results indicate that the former is a more appropriate measure of student's socioeconomic status regarding a higher correlation between Relative Peer SES and SAT.

Table 2. Pairwise Correlations of SAT, Peer SES, and Relative Peer SES for in-state Typical First-time Students

	Florida			Comparison states	South Carolina	Comparison states
	Institution A	Institution B	Institution C			
Academic year	1993-2000				1994-2001	
Sample size	20722	15401	6091	64907	10101	64091
Corr (SAT, Peer SES)	.06	.09	.08	.14	**.03**	.15
Corr (SAT, Relative Peer SES)	.12	.12	.09	.19	.04	.19
Corr (Peer SES, Relative Peer SES)	.98	.98	.99	.91	1.00	.91

Note: Almost all Pearson's Correlations are significant with $p < .001$, except the correlation between SAT and Peer SES in the institution located in South Carolina with $p < .005$ (bold-marked in Table 2).

Changes in academic preparedness and socioeconomic status of first-time resident students

Table 3 shows the means of SAT score and Relative Peer SES for in-state TFS in Florida, South Carolina, and their comparison states. In the three sample institutions in Florida, although average SAT score of total students increased by 47.67 in the post-scholarship period, the increase was smaller than the increase in comparison states, indicating that Florida's merit-based scholarship did not help improve the quality of first-time resident students—the effect was unrelated to the introduction of a merit-based scholarship. SAT scores of in-state engineering students grew steadily higher than those of non-engineering students in Florida as well as in its comparison states. But the gap between SAT of engineering and non-engineering students grew faster in Florida. In other words, the difference in academic preparedness between engineering and non-engineering students increased at a higher rate in Florida, suggesting that Florida's merit-based scholarship attracted better-prepared residents to engineering. While taking a closer look at institutional differences, changes of SAT scores in engineering followed a different pattern than changes in other fields. SAT of non-engineering students increased in all three Florida institutions, but SAT of engineering students decreased in one Florida institution which was less selective than the other two. Aiming at increasing student quality in resident institutions, Florida's merit-based scholarship might also intensify the stratification of resident institutions regarding incoming engineering student qualifications.

Changes of SAT score exhibited a distinct pattern in South Carolina. Compared to the gain of SAT in comparison states, gain of SAT in the sample institution in South Carolina was apparently larger. However, the increase of SAT score of engineering residents was smaller than that of non-engineering residents. Since only one sample institution is located in South Carolina, we are unable to determine whether the lower gain of SAT of engineering students was affected by merit-based scholarship or by institution selectivity within state.

Regarding changes of in-state student socioeconomic status, our results indicate that average Relative Peer SES increased in both Florida and its comparison states in post-scholarship period, with engineering experiencing a larger gain. Nevertheless, the difference in Relative Peer SES between engineering and non-engineering students increased faster in Florida, suggesting that engineering became less accessible to low-SES students than other fields after scholarship implementation. Moreover, Relative Peer SES of engineering students increased uniformly in three Florida institutions, whereas the Relative Peer SES changes of non-engineering students were inconsistent. Similarly, less-selective institutions became less attractive to students with higher SES.

Relative Peer SES decreased in South Carolina but increased in comparison states in post-scholarship period. It appears that South Carolina's merit-based scholarship did not impede college access for students with low SES. However, despite a decrease of Relative Peer SES in other disciplines, engineering experienced an increase in Relative Peer SES. Before South Carolina's merit-based scholarship established, average Relative Peer SES of engineering students was 0.83 smaller than that of non-engineering students in the sample institution. After scholarship implementation, Relative Peer SES of engineering students almost matched the Relative Peer SES of non-engineering students. The rate of improvement was faster than that of comparison states.

Overall, we find that merit-based scholarships did not help improve SAT scores of resident students in Florida, but was positively related to an increase of SAT in South Carolina. Our results for total resident students are consistent with previous study done by Cornwell and Mustard[23] where SAT scores of incoming students were found to decrease in Florida but increase in South Carolina. Besides, we discover that changes of SAT of engineering residents followed a different trend. The difference in academic preparedness between engineering and non-engineering students increased at a higher rate in Florida but increased slower in South Carolina, relative to the increase rates in their comparison states respectively. After scholarship programs went into effect, Relative Peer SES of resident students increased in Florida but decreased in South Carolina. Nevertheless, there is little evidence that merit-based scholarships raised the level of socioeconomic status of first-time resident students, because Relative Peer SES experienced larger increases in comparison states over the same periods. Engineering experienced universal increases of Relative Peer SES among resident students in all our sample institutions. Compared to engineering in comparisons states, engineering in both Florida and South Carolina became more attractive to high-SES residents (or less accessible to low-SES residents). As such, the scholarships disproportionately helped enrollment of students coming from wealthier environments to engineering. In other words, the socioeconomic diversity of engineering experienced a decline after the adoption of merit-based scholarships. Besides, we observe institutional differences within Florida. Consistent with the results of Cornwell and Mustard[23], we find that less-selective institutions became less appealing to residents with high SAT after merit-based scholarships were implemented. Moreover, less-selective institutions were less attractive to residents with high Relative Peer SES as well. Such stratification effects were more prominent in engineering than in other fields.

Table 3. Means of SAT and Relative Peer SES for in-state Typical First-time Students

Variable	State			Total student		Engineering student		Non-engineering student	
				Pre-period	Post-period	Pre-period	Post-period	Pre-period	Post-period
SAT	Florida	Institution A	Mean	1187.51	1256.82	1232.91	1301.00	1180.24	1246.93
			Increase		69.31		68.09		66.69
		Institution B	Mean	1104.06	1135.19	1133.88	1145.86	1102.54	1134.68
			Increase		31.13		11.98		32.14
		Institution C	Mean	917.66	939.09	1040.59	1032.82	910.39	933.34
			Increase		21.43		-7.77		22.95
		Total	Mean	1118.72	1166.39	1197.09	1259.74	1110.75	1154.12
			Increase		47.67		62.65		43.37
	Comparison states		Mean	1063.55	1115.81	1150.56	1218.40	1036.28	1091.15
			Increase		52.26		67.84		54.87
	South Carolina		Mean	964.46	1024.23	987.06	1035.19	955.81	1019.90
			Increase		59.77		48.13		64.09
	Comparison states		Mean	1079.59	1120.45	1169.96	1221.84	1053.77	1096.59
			Increase		40.86		51.88		42.82
Relative Peer SES	Florida	Institution A	Mean	19.90	20.69	19.15	20.57	20.03	20.72
			Increase		0.79		1.42		0.69
		Institution B	Mean	19.77	20.70	17.98	19.83	19.86	20.74
			Increase		0.93		1.85		0.88
		Institution C	Mean	13.35	12.50	13.40	13.53	13.35	12.44
			Increase		-0.85		0.13		-0.91
		Total	Mean	18.96	19.45	18.44	19.94	19.02	19.39
			Increase		0.49		1.50		0.37
	Comparison states		Mean	12.69	13.49	12.93	14.06	12.62	13.36
			Increase		0.80		1.13		0.74
	South Carolina		Mean	21.76	21.55	21.16	21.47	21.99	21.58
			Increase		-0.21		0.31		-0.41
	Comparison states		Mean	12.98	13.56	13.22	14.19	12.92	13.41
			Increase		0.58		0.97		0.49

Academic behaviors and academic performance of first-time resident students

We employ multiple regression and logistic regression models to examine first-year academic behaviors and academic performance of first-time resident students. Regression models are run separately on total first-time students and first-time engineering students. Test results are summarized in Appendix A-E.

First-year credit hours and full load attempted by students

Controlling for other factors that might have influences on first-year attempted credit hours, we find that the effect of merit-based scholarships was negative for engineering residents in Georgia, non-significant in Florida, and positive for both total and engineering residents in South Carolina. Direction and degree of course load adjustment were closely related to credit hour requirements in scholarship retention rules. In Georgia, where no minimum number of hours was required, in-state engineering students were more likely to attempt fewer credits in the first year. Conversely in South Carolina, total in-state students including those majoring in engineering attempted more credit hours after the scholarship was implemented, because scholarship recipients were required to enroll in at least 30 credit hours per academic year. The scholarship effect was non-significant in Florida where the scholarship required a more moderate enrollment of at least 12 credit hours per semester—the minimum required for full-time status, which is expected of recipients of most kinds of financial aid. Although engineering students attempted more credit hours than non-engineering students in general, the former were more sensitive to scholarship credit-hour requirements. In Georgia, engineering students became more likely to attempt fewer credits in the first year, while total students were unaffected by the scholarship.

While the number of credit hours represents a convenient continuous variable to measure the curricular progression of students, it is relevant to discuss student progression with respect to the "full load" threshold, since this threshold determines what fraction of students can graduate on time or early and which are falling behind the stated curriculum plan. Scholarship effects on first-year full load attempted by residents similarly varied based on credit hour requirements in scholarship rules. After the adoption of a merit-based scholarship, engineering residents in Georgia were less likely to attempt at least 30 credit hours per academic year. Conversely, total residents in South Carolina were more likely to attempt full load. In Florida, the scholarship effect was significant for total residents in only one institution where students were less likely to attempt full load. Our findings for course load adjustment suggest that tying scholarship rewards to course load may effectively reduce time-to-graduation.

Through an analysis of test results of first-year attempted credit hours and attempted full load, we find that engineering resident students were more prone to reduce first-year credit hours in response to merit-based scholarships, as compared to total residents. In Georgia where scholarship did not have credit hour requirement, engineering residents attempted significantly fewer credit hours and were less likely to attempt full load than prior engineering residents. The effects were non-significant for total residents. In South Carolina where scholarship required full load enrollment, the scholarship effect on attempted full load was non-significant for engineering residents while the likelihood for total resident students to attempt full load increased (engineering students would already have satisfied the 30-hour requirement to meet curricular expectations). According to interviews of engineering students done by Mobley et al. in a previous study, engineering students expressed their concern that engineering required much harder work than other disciplines in getting similar grades[15]. Our findings reinforce their research in a quantitative way: in response to the engineering students perception of higher per-course effort, they chose a lighter load to stay eligible for merit-based scholarships.

First-year course withdrawal and summer course enrollment

In post-scholarship period, the likelihood to withdraw from at least one course in the first academic year increased for total residents in two Florida institutions and in South Carolina. The scholarship effect was non-significant in Georgia. Interestingly in South Carolina, although scholarship required an enrollment of at least 30 credit hours per academic year, residents still became more likely to withdraw from a course. Since they also attempted more credit hours after the scholarship was implemented, it is possible that residents enrolled in more courses at the beginning and then withdrew from courses in which they performed poorly. As Dee and Jackson described, an unintended consequence is that merit-based scholarships might "discourage students from choosing curricula that present such increased risks for scholarship attrition"[28]. Notably, merit-based scholarships did not increase engineering residents' likelihood of course withdrawal. It seems that once engineering students enrolled in a course, they persisted anyway without being affected by scholarship requirements.

Merit-based scholarships increased the likelihood of taking at least one summer course for total resident students in all sample institutions. The effect was also significant for engineering residents except at two institutions located in Florida. Since scholarship programs in Georgia, Florida, and South Carolina accepted summer credits, residents including engineering students had the opportunity to improve their first-year GPAs by taking summer courses. Increases in the likelihood of course withdrawal and summer course-taking were highly correlated. Resident students became more likely to withdraw from courses probably because they perceived higher grades would be easier to earn during summer.

First-year GPA

Controlling for the positive effect of SAT score, merit-based scholarships were negatively correlated with total and engineering residents' first-year GPA in one institution in Florida, negative for total residents in South Carolina, and negative for total and engineering residents in Georgia. The negative effects of merit-based scholarships may be caused by the moderation of SAT scores in the regression models. However, as indicated previously in this study, increases of SAT scores in Florida and South Carolina did not keep pace with SAT increases in their comparison states, suggesting that scholarship programs did not help improve incoming student quality.

Conclusion

This study examines the effects of state-sponsored merit-based scholarships on first-time student characteristics, academic behaviors, and academic performance across states and institutions. We analyze student-level data through descriptive statistics and difference-in-differences regression models. Despite slight differences across states, we find that merit-based scholarships did not help improve SAT scores or first-year GPA of resident students including those majoring in engineering. There is little evidence that merit-based scholarships raised the level of socioeconomic status of first-time resident students, yet engineering became more attractive to students with high socioeconomic status, suggesting the socioeconomic diversity of engineering experienced a decline after scholarship adoption. Moreover, institutional differences existed in attracting students with high quality and high socioeconomic status. Less-selective institutions became less appealing to residents with high SAT or high socioeconomic status. Such stratification effects were more prominent in engineering.

Moreover, we find that resident students became more likely to withdraw from courses and enroll in summer classes after scholarships were implemented. It is possible that residents withdrew from difficult courses and then filled the credit gap by taking summer coursework at institutions where they believed higher grades would be easier to earn. Meanwhile, we find that merit-based scholarships had disproportionate effects on first-year course load across states. Scholarship effects varied based on credit hour requirements in scholarship retention policies, suggesting that tying rewards to course load may effectively reduce time-to-graduation. Compared to total residents, engineering residents were more prone to reduce first-year credit hours at the presence of merit-based scholarships, but their likelihood of withdrawing from a course did not increase. Consistent with the perception of engineering students that engineering courses require more effort, students chose a lighter load to maintain good grades. Once they took a course, they persisted anyhow without being influenced by scholarship retention rules.

Our study focuses on the impacts of merit-based scholarships on changes of student characteristics and academic choices, with specific focus on engineering students. Meanwhile, we thoroughly analyze the scholarship effects across states and institutions. In light of policymakers' concerns about engineering education and the large amount of state funding invested on merit-based scholarship programs, our findings can be used to inform legislators and state governors in understanding the range of effect of merit-based scholarships. We also provide information for the design of future government-sponsored financial aid programs. Moreover, results of this study will help engineering educators monitor students' academic progress to promote better academic achievement.

Limited by available data, this study only explores institutional differences within one state. Meanwhile, scholarship effects on academic behaviors beyond the first academic year are not yet studied. Future work will examine scholarship influences on retention and graduation. Qualitative approaches will be integrated to complement quantitative analysis in understanding student decision-making to meet scholarship requirements.

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Appendix A

Summary of multiple regression analysis for variables predicting first-year attempted credit hours of first-time in-state students

State		Predictor	First-time in-state total			First-time in-state engineering		
			B	*SE B*	*β*	*B*	*SE B*	*β*
Georgia		Scholarship	-.31	.11	-.03	-.53	.13	-.06*
		SAT	.01	.00	.28*	.01	.00	.22*
		Gender	-1.11	.08	-.11*	-.92	.11	-.09*
		Engineering	.36	.08	.04*			
		R^2		.09			.06	
		F for change in R^2		110.49*			50.51*	
Florida	Institution A	Scholarship	.00	.11	.00	-.06	.33	-.01
		SAT	.00	.00	.13*	.00	.00	.13*
		Gender	-.60	.05	-.06*	-.59	.17	-.05*
		Engineering	-.86	.08	-.06*			
		R^2		.02			.02	
		F for change in R^2		64.15*			8.93*	
	Institution B	Scholarship	-.27	.13	-.02	-2.01	.63	-.12
		SAT	.03	.00	.48*	.02	.00	.47*
		Gender	-1.14	.08	-.07*	-1.48	.47	-.08
		Engineering	.67	.20	.02*			
		R^2		.23			.24	
		F for change in R^2		647.06*			31.75*	
	Institution C	Scholarship	.29	.11	.02	.27	.35	.02
		SAT	.02	.00	.39*	.01	.00	.26*
		Gender	-.97	.08	-.07*	-.54	.25	-.05
		Engineering	-.38	.15	-.02			
		R^2		.46			.52	
		F for change in R^2		958.53*			99.47*	
South Carolina		Scholarship	.97	.17	.06*	1.64	.40	.09*
		SAT	.00	.00	.10*	.00	.00	.08*
		Gender	-1.50	.12	-.09*	-1.49	.32	-.07*
		Engineering	3.01	.14	.16*			
		R^2		.07			.04	
		F for change in R^2		116.06*			14.61*	

Note: Scholarship is the interaction of resident indicator and merit-based scholarship indicator, coded as 1 for in-state student in an institution with merit-based scholarship available in a specific year and coded as 0 otherwise. SAT stands for SAT score. Gender indicator coded as 1 for male and 0 for female. Engineering indicator coded as 1 for engineering student and 0 for non-engineering student.

*$p < .001$.

Appendix B
Summary of multiple regression analysis for variables predicting first-year GPA of first-time in-state students

			First-time in-state total			First-time in-state engineering		
State		Predictor	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Georgia		Scholarship	-.06	.02	-.04*	-.09	.02	-.06*
		SAT	.00	.00	.34*	.00	.00	.33*
		Gender	-.15	.01	-.10*	-.15	.02	-.09*
		Engineering	.06	.01	.04*			
		R^2		.13			.12	
		F for change in R^2		160.92*			100.25*	
Florida	Institution A	Scholarship	.02	.01	.02	-.03	.04	-.02
		SAT	.00	.00	.34*	.00	.00	.31*
		Gender	-.17	.01	-.13*	-.18	.02	-.11*
		Engineering	-.06	.01	-.03*			
		R^2		.14			.13	
		F for change in R^2		419.42*			55.30*	
	Institution B	Scholarship	-.01	.01	-.01	-.24	.06	-.16*
		SAT	.00	.00	.19*	.00	.00	.20*
		Gender	-.21	.01	-.16*	-.28	.05	-.16*
		Engineering	-.14	.02	-.04*			
		R^2		.07			.09	
		F for change in R^2		162.48*			9.57*	
	Institution C	Scholarship	-.16	.02	-.09*	-.16	.06	-.08
		SAT	.00	.00	.41*	.00	.00	.48*
		Gender	-.22	.01	-.14*	-.22	.04	-.13*
		Engineering	-.08	.02	-.03*			
		R^2		.21			.30	
		F for change in R^2		294.37*			40.47*	
South Carolina		Scholarship	-.07	.02	-.05*	-.07	.03	-.04
		SAT	.00	.00	.08*	.00	.00	.08*
		Gender	-.29	.01	-.20*	-.20	.03	-.10*
		Engineering	.03	.01	.02			
		R^2		.07			.03	
		F for change in R^2		113.13*			11.71*	

Note: Scholarship is the interaction of resident indicator and merit-based scholarship indicator, coded as 1 for in-state student in an institution with merit-based scholarship available in a specific year and coded as 0 otherwise. SAT stands for SAT score. Gender indicator coded as 1 for male and 0 for female. Engineering indicator coded as 1 for engineering student and 0 for non-engineering student.
*$p < .001$.

Appendix C
Summary of logistic regression analysis for variables predicting first-year full course load attempted by first-time in-state students

			First-time in-state total			First-time in-state engineering		
State		Predictor	*B*	*SE B*	*OR*	*B*	*SE B*	*OR*
Georgia		Scholarship	-.15	.05	.86	-.22*	.06	.81
		SAT	.00*	.00	1.01	.00*	.00	1.00
		Gender	-.35*	.04	.71	-.27*	.05	.76
		Engineering	.11	.04	1.12			
		Constant	-5.45			-4.69		
		χ^2	1176.68			674.50		
		df	13			12		
		% attempted full load	48.76			50.65		
Florida	Institution A	Scholarship	.16	.05	1.17	.01	.15	1.01
		SAT	.00*	.00	1.00	.00*	.00	1.00
		Gender	-.16*	.03	.85	-.00	.08	1.00
		Engineering	.18*	.04	1.20			
		Constant	-2.48			-2.29		
		χ^2	322.89			41.47		
		df	13			12		
		% attempted full load	26.20			29.65		
	Institution B	Scholarship	-.27*	.04	.76	-.72	.22	.49
		SAT	.01*	.00	1.01	.01*	.00	1.01
		Gender	-.30*	.03	.74	-.49	.16	.61
		Engineering	.27*	.07	1.31			
		Constant	-6.30			-6.44		
		χ^2	4177.46			221.34		
		df	13			12		
		% attempted full load	56.91			62.92		
	Institution C	Scholarship	-.04	.05	.96	-.04	.19	.96
		SAT	.01*	.00	1.01	.01*	.00	1.01
		Gender	-.36*	.04	.70	-.40	.14	.67
		Engineering	-.05	.07	.95			
		Constant	-5.51			-5.57		
		χ^2	3772.80			284.44		
		df	13			12		
		% attempted full load	47.20			56.50		
South Carolina		Scholarship	.33*	.06	1.39	.24	.12	1.27
		SAT	.00*	.00	1.00	.00	.00	1.00
		Gender	-.57*	.04	.56	-.50*	.11	.61
		Engineering	.51*	.05	1.67			
		Constant	1.04			2.03		
		χ^2	718.88			101.32		
		df	13			12		
		% attempted full load	78.16			82.41		

Note: OR = Odds Ratio. Scholarship is the interaction of resident indicator and merit-based scholarship indicator, coded as 1 for in-state student in an institution with merit-based scholarship available in a specific year and coded as 0 otherwise. SAT stands for SAT score. Gender indicator coded as 1 for male and 0 for female. Engineering indicator coded as 1 for engineering student and 0 for non-engineering student.
*$p < .001$.

Appendix D

Summary of logistic regression analysis for variables predicting first-year course withdrawal of first-time in-state students

			First-time in-state total			First-time in-state engineering		
State		Predictor	*B*	*SE B*	*OR*	*B*	*SE B*	*OR*
Georgia		Scholarship	.12	.05	1.13	.15	.07	1.17
		SAT	-.00*	.00	1.00	-.00*	.00	1.00
		Gender	.12	.04	1.13	.09	.06	1.10
		Engineering	-.38*	.04	.68			
		Constant	1.71			1.72		
		χ^2	454.43			231.21		
		df	13			12		
		% withdrew course	38.51			35.34		
Florida	Institution A	Scholarship	.23*	.05	1.26	.11	.14	1.11
		SAT	-.00*	.00	1.00	-.00*	.00	1.00
		Gender	.28*	.02	1.33	.28*	.08	1.32
		Engineering	-.15*	.03	.86			
		Constant	1.55			1.89		
		χ^2	882.87			144.93		
		df	13			12		
		% withdrew course	43.97			41.18		
	Institution B	Scholarship	.20	.08	1.22	.58	.47	1.78
		SAT	-.00*	.00	1.00	-.00	.00	1.00
		Gender	.02	.05	1.02	-.50	.27	.61
		Engineering	-.03	.13	.97			
		Constant	-1.83			-1.95		
		χ^2	63.63			9.32		
		df	13			12		
		% withdrew course	6.14			5.87		
	Institution C	Scholarship	.33*	.06	1.40	.29	.25	1.34
		SAT	-.00	.00	1.00	-.00	.00	1.00
		Gender	.26*	.05	1.29	.06	.18	1.07
		Engineering	-.25	.09	.78			
		Constant	-1.85			.13		
		χ^2	288.14			24.61		
		df	13			12		
		% withdrew course	16.91			13.88		
South Carolina		Scholarship	.18*	.05	1.19	.28	.10	1.32
		SAT	-.00*	.00	1.00	-.00	.00	1.00
		Gender	.52*	.03	1.69	.25	.08	1.29
		Engineering	-.33*	.04	.72			
		Constant	-.54			-.69		
		χ^2	388.22			43.47		
		df	13			12		
		% withdrew course	33.48			30.90		

Note: OR = Odds Ratio. Scholarship is the interaction of resident indicator and merit-based scholarship indicator, coded as 1 for in-state student in an institution with merit-based scholarship available in a specific year and coded as 0 otherwise. SAT stands for SAT score. Gender indicator coded as 1 for male and 0 for female. Engineering indicator coded as 1 for engineering student and 0 for non-engineering student.

*$p < .001$.

Appendix E

Summary of logistic regression analysis for variables predicting first-year summer course-taking of first-time in-state students

			First-time in-state total			First-time in-state engineering		
State		Predictor	*B*	*SE B*	*OR*	*B*	*SE B*	*OR*
Georgia		Scholarship	.45*	.06	1.57	.44*	.08	1.56
		SAT	-.00*	.00	1.00	-.00	.00	1.00
		Gender	-.53*	.05	.59	-.58*	.06	.56
		Engineering	-.07	.05	.93			
		Constant	-.64			-.69		
		χ^2	389.76			235.03		
		df	13			12		
		% took summer course	20.10			18.62		
Florida	Institution	Scholarship	.41*	.05	1.51	.32	.16	1.38
	A	SAT	-.00*	.00	1.00	-.00	.00	1.00
		Gender	-.08	.03	.93	.03	.08	1.04
		Engineering	-.00	.04	1.00			
		Constant	-.49			-.55		
		χ^2	586.98			75.14		
		df	13			12		
		% took summer course	28.27			27.91		
	Institution	Scholarship	.40*	.05	1.50	.20	.24	1.22
	B	SAT	-.00*	.00	1.00	-.00	.00	1.00
		Gender	-.08	.03	.93	-.14	.17	.87
		Engineering	.25*	.08	1.29			
		Constant	-.85			.15		
		χ^2	732.71			37.64		
		df	13			12		
		% took summer course	17.32			20.05		
	Institution	Scholarship	1.12*	.07	3.07	1.29*	.28	3.63
	C	SAT	-.00	.00	1.00	-.00	.00	1.00
		Gender	-.07	.05	.94	.16	.21	1.18
		Engineering	-.26	.10	.77			
		Constant	-1.43			-1.14		
		χ^2	416.86			45.22		
		df	13			12		
		% took summer course	15.10			10.52		
South		Scholarship	.68*	.06	1.97	.74*	.13	2.11
Carolina		SAT	-.00	.00	1.00	-.00	.00	1.00
		Gender	.00	.04	1.00	-.35*	.09	.70
		Engineering	.24*	.05	1.27			
		Constant	-2.03			-1.49		
		χ^2	306.28			103.56		
		df	13			12		
		% took summer course	15.40			17.93		

Note: OR = Odds Ratio. Scholarship is the interaction of resident indicator and merit-based scholarship indicator, coded as 1 for in-state student in an institution with merit-based scholarship available in a specific year and coded as 0 otherwise. SAT stands for SAT score. Gender indicator coded as 1 for male and 0 for female. Engineering indicator coded as 1 for engineering student and 0 for non-engineering student.

* $p < .001$.