AC 2012-4215: THE EFFECT OF COLLEGE COST AND FINANCIAL AID ON ACCESS TO ENGINEERING

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The Effect of College Costs and Financial Aid on Access to Engineering

Abstract

Financial factors such as tuition costs and financial aid have substantial influences on college access. Prior studies have examined how financial factors influence cohort patterns of incoming students. Our study adds to that body of work by studying institutional differences in the effect of college costs and financial aid on access. We particularly focus on engineering students and explore access of an important underrepresented group in engineering—students of low socioeconomic status. We utilize two large databases: the Integrated Postsecondary Education Data System (IPEDS) and the Multiple Institution Database for Investigation of Engineering Longitudinal Development (MIDFIELD). We employ descriptive statistics, nonparametric test, and a difference-in-difference regression model to determine the relationship between financial factors and engineering cohort patterns. We demonstrate the inability of grant aid to match the pace of rising tuition and fees, and identify different trends between institutions with and without merit-based scholarships. The adoption of merit-based scholarship was positively correlated to in-state student enrollment, engineering first-time student enrollment, and the fraction of students with high socioeconomic status. Compared to the overall institutional effect of merit-based scholarships, engineering experienced a larger increase in the fraction of students with high socioeconomic status. The scholarship effect was not consistently related to in-state students' SAT scores. Variations in significance and direction exist in the results across institutions.

Introduction

Promoting access to engineering has been a central concern in engineering education for decades. Many of the challenges, such as developing student interest and competency in engineering, have been identified and addressed by engineering educators, researchers, and policy makers. However, constraints exist for potential students who cannot afford college costs. The enlarging gap between financial aid (especially grants) and college costs is central to the discussion of student access to engineering[1].

State-supported public institutions charge lower tuition and fees for in-state students and higher costs for out-of-state students who do not meet the state's or institution's residency requirements. In contrast, private institutions usually do not price discriminate among in-state or out-of-state students[2]. Despite variations in tuition and fees, college costs have risen continuously at a higher rate than inflation and family incomes over the past two decades[3]. The large tuition surcharges for out-of-state students as well as the inflation of college costs have led to a high percentage of in-state students in public institutions[4]. The increase in tuition and fees has caused decline in college enrollment and changes in the type of institutions that students attend[5, 6]. This is particularly true for students with low socioeconomic status (SES) who are more sensitive to tuition changes[7].

Besides tuition and fees, the accessibility of financial aid also affects prospective students' decision to attend college. Since the mid-1990s, various states have replaced need-based scholarships with merit-based scholarships to ensure students attend in-state colleges, promote academic achievement, and retain graduates work in state. In the 2009-10 academic year, thirty states had identified merit-based scholarships that provided funding on the basis of academic qualifications. A combined $3.4 billion with a merit component was awarded to college students, with $1.78 billion awarded based solely on merit[8]. Unlike traditional merit programs, state-funded merit-based scholarships require relatively modest academic performance and therefore are attainable to a majority of in-state college students. Although scholarship requirements differ among states and specific scholarship programs, a merit-based scholarship recipient must generally be a state resident and graduated from an eligible in-state high school with a 3.0 or better high school grade point average (GPA). The recipient must pursue a first-time bachelor's degree at eligible public or private in-state institutions. To retain the scholarship, a student generally needs to earn a minimum amount of credit hours per academic year and reach a minimum standard of GPA in college. Prior studies indicate that merit-based scholarships increase college enrollment rate and high school graduates' academic performance within state[9, 10], which are among the goals of such scholarship programs. An unintended consequence is that middle- and high-income students are the primary beneficiaries[11].

Considering the diverse effects of college costs and merit-based scholarship in college enrollment, this study adds to the conversation by studying institutional and state differences in the effect of college costs and financial aid on access. This study particularly focuses on engineering students to explore access of an important underrepresented group in engineering—students of low socioeconomic status. Therefore, this study aims to answer the following research questions:

1) To what extent do college costs and financial aid (especially merit-based scholarships) interact to affect the fraction of in-state students and access to engineering?
2) To what extent do merit-based scholarships affect the demographics of first-time in-state engineering students?
3) How do these effects vary by state and by institution?

To answer these questions, we analyze two large-scale databases: the Integrated Postsecondary Education Data System (IPEDS)[12], and the Multiple Institution Database for Investigation of Engineering Longitudinal Development (MIDFIELD)[13]. The timeline of the introduction of state-wide merit-based scholarship was gathered by Mobley, Brawney, and Ohland in earlier research[14] from the websites of state scholarship grant programs and university catalogs. Currently, there are eleven public four-year institutions in MIDFIELD. Five institutions locate in three states that have introduced merit-based scholarships, and the other six institutions locate in four states without merit-based scholarships. Table 1 summarizes characteristics of merit-based scholarships in the three MIDFIELD states: Florida, Georgia, and South Carolina.

Table 1. Characteristics of state-funded merit-based scholarship in Florida, Georgia, and South Carolina

State	Scholarship	Year	Threshold Criterion	Award Amount	Eligibility
Florida	Bright Futures-Florida Academic Scholars (FAS)	1997	1) 3.5 GPA 2) 1270 SAT or 28 ACT	Full tuition up to 120 credit hours (up to 132 credit hours before 2010)	1) First-time bachelor's degree at in-state public or private college or university or technical college 2) U.S. citizen or eligible non-citizen 3) Florida residency
	Bright Futures-Florida Medallion Scholars (FMS) (renamed from Florida Merit Scholarship)	1997	1) 3.0 GPA 2) 970 SAT or 20 ACT	75% tuition up to 120 credit hours (up to 132 credit hours before 2010)	
	Bright Futures-Gold Seal Vocational Scholars (GSV)	1997	1) 3.0 GPA 2) 440 Critical reading + 440 Math SAT or 17 English + 18 Reading + 19 Math ACT	75% tuition up to 90 credit hours	
Georgia	Helping Outstanding Pupils Educationally (HOPE)	1993	3.0 GPA	Full tuition up to 127 credit hours	1) First-time bachelor's degree at in-state public or private college or university or technical college 2) U.S. citizen or eligible non-citizen 3) Georgia residency
South Carolina	Palmetto Fellows	2001	2001-2003: 1) 3.5 GPA 2) 1200 SAT or 27 ACT 3) 5% high school class rank 2004-2010: 1) 3.5 GPA 2) 1200 SAT or 27 ACT 3) 6% high school class rank	2001: $5,000 up to 8 terms 2002-2010: $6,700 for first year and $7,500 for three consecutive years	1) First-time full-time bachelor's degree at in-state public or private college or university or technical college 2) U.S. citizen or eligible non-citizen 3) South Carolina residency
	Legislative Incentive for Future Excellence (LIFE)	1998	1998-1999: 1) 3.0 GPA 2) 1000 SAT or 21 ACT 2000-2001: 1) 3.0 GPA 2) 1050 SAT or 22 ACT 2002-2010 (meet two of the following criteria): 1) 3.0 GPA 2) 1100 SAT or 24 ACT 3) 30% high school class rank	1998-1999: $2,000 up to 8 terms 2000-2001: $3,000 up to 8 terms 2002-2010: The lesser of full tuition and $5,000 up to 8 terms	
	HOPE	2002	3.0 GPA	2002-2006: $2,650 for first year 2007-2010: $2,800 for first year	

Literature review

Financial factors have long been recognized to have substantial influences on college access. To understand how college costs and financial aid (including merit-based scholarships) affect the cohort pattern of entering engineering students, we review studies examining the effects of financial factors on: student migration and major choice, socioeconomic status (SES), and student quality.

Student migration and major choice

The fraction of in-state students in an institution is part of the picture of student migration within and across states. Tuckman[15] employed a linear regression model to examine the influence of college costs and financial aid on interstate student migration without differentiating between need- and merit-based aid. Results showed that student migration was affected by tuition levels at both in-state and out-of-state institutions, but was not influenced by financial aid. Students attending out-of-state institutions were found to be more concerned with the quality of academic programs and regional economic factors than tuition[6, 16]. Nevertheless, the rates of in-state students in public institutions had been constant and high because of the huge difference in tuition charge between in-state and out-of-state students[4].

Merit-based scholarships have attracted researchers' attention since Georgia offered the first state-funded merit-based scholarship HOPE in 1993. Dynarski[11] employed a difference-in-differences model and revealed that the college attendance rate in Georgia was increased by 7.0-7.9 percentage points because of HOPE. In her later study[17], she found consistent increases in enrollment in other southeast states that offered merit-based scholarships. Meanwhile, student out-migration was reduced in Georgia, which was consistent with the results in Bugler's report[18]. Cornwell, Mustard, and Sridhar[9] further proposed that the increase in enrollment was concentrated in four-year institutions. Zhang and Ness[19] extended the scale to 13 states and found that both enrollment rates and in-state student percentages were increased since merit-based scholarships began.

The effect of financial factors on major choice is not as clear as the effect on student migration. Specifically, inconsistent results have been found regarding the effect of merit-based scholarships on students choosing engineering-related majors. Using student-level data in Kentucky, Delaney[20] found that students were more likely to major in science, technology, engineering, and mathematics (STEM) after the adoption of merit-based scholarship. In contrast, Hu[21] revealed a significant drop in the percentage of STEM students since Florida initiated the Bright Futures merit-based scholarship. Mobley et al.[14] adopted a qualitative approach through interview of 16 engineering students at a four-year institution in South Carolina. They concluded that merit-based scholarship had little influence on students' decision to major in engineering.

Socioeconomic status

Tuition fees, financial aid, and socioeconomic status (SES) affect the type of institutions students choose to attend[6]. Students with low SES were more sensitive than high-SES students to college price changes[22, 23]. Estimating the impact of rising tuition and financial aid, a report for higher education policy[1] presented that the fraction of first-year students with low SES decreased at most types of four-year institutions during 1989-1999, whereas the percentage of first-year students with high SES increased at selective four-year institutions. Perna and Titus[6] discovered that low-SES students were more likely than high-SES students to enroll at in-state public two-year institutions, while high-SES students were more likely than low-SES students to attend out-of-state institutions. They attributed the percentage decrease of low-SES students in public four-year institutions to those students' fewer chances to receive merit-based scholarship. Since SES has been shown to be positively correlated with academic performance[6], merit-based scholarship has been criticized for placing low-SES students at a disadvantage in college enrollment. In fact, such criticism was supported by research findings. Dynarski[11] estimated the impact of Georgia's HOPE scholarship on first-time students with different income levels. She recognized a positive relationship between SES and high school GPA, suggesting that students with high SES were more likely to be awarded. Meanwhile, a significant increase in enrollment for high-SES students was found since HOPE began, whereas the effect was not significant for low-SES students.

Student quality

SAT or ACT score, high school rank, and high school GPA are conventional measures of first-time student quality. Increases in these student quality indicators were found by researchers studying merit-based scholarship effects. Bugler and colleagues[18] found that average SAT scores and high school GPA for college-bound seniors in Georgia were higher after the adoption of HOPE. Cornwell and Mustard[24] confirmed the scholarship effect in Georgia public universities and found similar increases in SAT and high school ranks in six other merit-based scholarship states, except for Florida and Louisiana. They attributed the mixed effects in Florida (reduced SAT scores but improved high school class ranks) and negative effects in Louisiana (reduced SAT scores and high school class ranks) to changing and less rigorous scholarship requirements.

Prior studies have examined how college costs and financial aid affect first-time student pattern such as the fraction of in-state students, socioeconomic status, and student quality. However, little is known about how financial factors affect the cohort pattern in engineering fields. Our study is unique in that we study first-time engineering student pattern changes with specific focus on students with low socioeconomic status. Exploring student-level data across institutions and states, we are able to compare first-time engineering enrollment with the entire cohort and examine both institution and state differences.

Data and variables

Two large-scale databases constitute the main data sources of this study: (1) The Integrated Postsecondary Education Data System (IPEDS)[12] conducted by the National Center for Education Statistics (NCES), which contains over 3,000 variables on enrollments, completions, finances, and other attributes for all institutions in the U.S. (2) The Multiple Institution Database for Investigation of Engineering Longitudinal Development (MIDFIELD)[13], which includes student record data at eleven public institutions and represents approximately 1/10th of all U.S. engineering graduates. In this study, we analyze eleven institutions with available data in MIDFIELD and IPEDS. Among these institutions, five are located in three states that have state-funded merit-based scholarships, and the rest six are located in four states without merit-based scholarship.

Both financial indicators and enrollment variables for incoming students are drawn from IPEDS. Specifically, tuition and fees are drawn from the table of institutional characteristics. Total grant aid and the number of first-time full-time undergraduate students are drawn from the table of student financial aid. The fraction of first-time in-state students of an institution is calculated from the table of enrollment. Grand aid per student is estimated by dividing the number of first-time full-time undergraduate students by total grant aid. To eliminate the effect of inflation or deflation, we use the Consumer Price Index (CPI)[25] to calculate constant dollars of tuition fees and grant aid. The baseline for CPI indexes is CPI(1982-1984) = 100.

Enrollment variables for first-time engineering students, academic variables, and SES indicator are drawn from MIDFIELD. We use aggregate SAT scores to measure quality of incoming students. When SAT scores are missing and ACT scores are available, ACT scores are converted to SAT scores using a SAT-ACT concordance table provided by the College Board[26]. We measure SES by peer SES—the percentage of students not eligible for free meals of the National School Lunch Program at high school[27]. Though peer SES is not a direct measurement of the socioeconomic status of a student or his/her family, it indicates the poverty status of an academic environment in which a student attended high school. Orr, Ramirez, and Ohland[28] presented that peer SES was correlated with the enrollment and academic achievement of engineering students. In this study, we do not use peer SES directly to study scholarship effects on in-state students. Since 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 in which the high school is located (state SES), we control for state influences by subtracting state SES from peer SES. The new variable is called relative peer SES, which measures the gap between the poverty status of a high school and that of a state where the high school is located. To illustrate, a positive relative peer SES score indicates that a student came from a high school with socioeconomic status above the state level. Peer SES scores are available in MIDFIELD, while state SES scores are drawn from NCES Common Core of Data[29]. Computing relative peer SES in this way focuses our attention on to what extent each state institution is serving its population.

Methods

We employ descriptive statistics to describe the growth of tuition fees and grant aid, and to show the changes in the demographics of first-time in-state students and engineering students. We compare five institutions with merit-based scholarships to six institutions without scholarship. We anticipate that the amount and trend of grant aid per student differ between the two groups of institutions.

We calculate the fraction of first-time in-state students in an institution from IPEDS data. The data are available in 1988, in even years from 1992 to 1998, and annually from 2000-2009 for most institutions. Missing data in the IPEDS database resulted in the exclusion of a Georgia institution from some parts of this study. Because of the sparse availability of data on in-state enrollments, we include 10 years both before and after the adoption of merit-based scholarship. The multiple MIDFIELD partner institutions within Florida form one scholarship group. There is only one participating institution located in South Carolina, so institution and state are confounded, forming a separate scholarship group. The remaining six institutions located in non-merit-based scholarship states form a comparison group for both scholarship groups. Comparisons are made during pre- and post-scholarship periods. For example, Florida introduced merit-based scholarship in 1997, so the pre-period is from 1987 to 1996 with available data in 1988, 1992, 1994, and 1996. The post-period is from 1997 to 2006 with available data in 1998, and 2000-2006. We calculate the average fraction of first-time in-state students for both pre- and post-period in each Florida institution, and then calculate the percentage change from pre- to post-period averaging across three Florida institutions. Similarly, we calculate the percentage change in the comparison group from 1987-1996 to 1997-2006 averaging across six institutions.

We calculate the fraction of first-time students enrolled in engineering in an institution from MIDFIELD data. Since data are available each year from 1988 to 2004 for most institutions, we use a common strategy to compare three years before and three years after the adoption of a merit-based scholarship[19]. Institutions with merit-based scholarships are categorized into three scholarship groups based on states. For each scholarship group, a comparison group consists of institutions without merit-based scholarship during both pre- and post-period of the scholarship group. For example, the state of Georgia offered merit-based scholarship in 1993. Its comparison group consists of ten institutions, none of which had merit-based scholarship during 1990-1995. To calculate the percentage change of the fraction of first-time engineering students, we use the same formulas as we calculate the percentage change of total first-time in-state students.

By analyzing student-level data, we depict the changes of relative peer SES of first-time in-state students from pre- to post-scholarship period. Furthermore, we employ Kruskal-Wallis test to determine the significance of such changes. Relative peer SES scores of first-time in-state students including engineering students are calculated from MIDFIELD data. We only evaluate the scholarship effect in Florida because peer SES data are unavailable for institutions in Georgia or South Carolina before they adopted merit-based scholarships. We compare relative peer SES of in-state students in Florida with those in non-merit-based scholarship states (consist of six institutions). Again, we use data from 1994-1996 to 1997-1999 to allow three years of observation both before and after scholarship began. To show the change of relative peer SES, we use the percentage distribution of relative peer SES rather than the original distribution of relative peer SES to control for size differences of student populations between pre- and post-period. Meanwhile, since relative peer SES scores are not normally distributed, we conduct the Kruskal-Wallis test, a common nonparametric alternative test for one-way ANOVA, to evaluate differences between pre- and post-period on median change in relative peer SES.

The difference-in-differences method has been widely used by researchers to study scholarship effects[9, 11, 19]. In this study, we employ a difference-in-differences regression model to investigate the relationship between merit-based scholarship and change of student quality. We compare three years before and after scholarship began in each state that has merit-based scholarship. We regress aggregate SAT scores on scholarship indicator, including a gender dummy variable to control for gender differences and including 'Year' to control for the effect of grade inflation. Institutional dummy variables are also included to represent comparison institutions. We do not group institutions by states because SAT scores vary greatly among institutions of different levels in the same state. Instead, we group institutions that have scholarship by state first, and then generate smaller groups within a state based on institutional similarities according to the following criteria: ranking of undergraduate engineering programs[30], the percentage and total number of engineering first-time students. Accordingly, we derive four groups of scholarship institutions. Afterwards, we match each group with comparison institutions chosen based on the criteria mentioned above. One institution is excluded from the analysis for insufficient data on SAT scores. Finally, we derive the following difference-in-differences model:

$$SAT = b_0 + b_1\cdot(\text{Scholarship indicator}) + b_2\cdot(\text{Gender}) + b_3\cdot(\text{Year}) + c_k\cdot(\text{Institution dummy } k) \qquad (1)$$

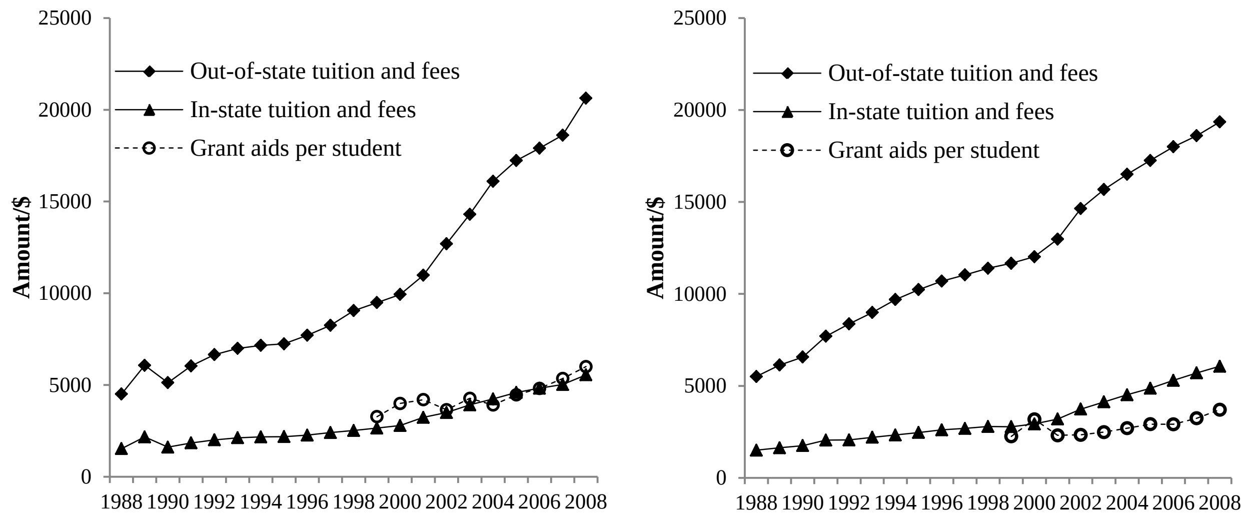
where SAT is the dependent variable. Scholarship indicator is a dummy variable coded as 1 for an institution with merit-based scholarship and 0 for an institution without merit-based scholarship in a specific year. Gender is coded as 1 for male and 0 for female. Each institution dummy k (k = 1, 2, 3, 4) represents each of the comparison institution coded as 1 for comparison institution k and 0 for other comparison institutions or the reference institution.

Since we conduct multiple statistical tests, we use an adjusted alpha level for each test to keep the experimentwise error rate at .05 level. Calculated from Bonferroni adjustment[31], the adjusted alpha level for each test is .004 (≈ .05/12).

Results

Trends in tuition and fees, grant aid

Figure 1a plots out-of-state tuition and fees, in-state tuition and fees, and grant aid per student averaging across five institutions with merit-based scholarships adopted before 1999. Figure 1b plots the same indexes averaging across six institutions without merit-based scholarship. The data of tuition and fees are available between 1988 and 2008, while the data of total grant aid are only available between 1999 and 2008. Table 2 shows the rising paces of out-of-state tuition and fees, in-state tuition and fees, and grant aid per student in both nominal value and constant dollar. We can see from Figure 1 and Table 2 that tuition and fees rose steadily during 1988-1998 and escaladed even faster during 1999-2008, especially for out-of-state tuition and fees. Compared with the growth of in-state tuition and fees, the growth of out-of-state tuition and fees was much faster during 1999-2008 than during the whole period. During 1999-2008, the increase in grant aid per student had not kept pace with tuition increases, while the trends break down differently between institutions with and without merit-based scholarships. At institutions with scholarships, the pace of grant aid per student almost caught up with that of in-state tuition fees. At institutions without merit-based scholarships, the rate of increase of grant aid per student was less than half of the rate of increase of in-state tuition and fees. Institutions without merit-based scholarships had about half the grant aid per student than institutions with merit-based scholarships. At institutions with merit-based scholarships, however, out-of-state tuition fees rose at a speed almost 1.5 times faster than at institutions without merit-based scholarship during 1999-2008.



a, with merit-based scholarships *b*, without merit-based scholarships

Figure 1. Out-of-state tuition and fees, in-state tuition and fees, and grant aid per student.
a, averaging across five MIDFIELD institutions with merit-based scholarships;
b, averaging across six MIDFIELD institutions without merit-based scholarships.

Table 2. Average annual increase in tuition and fees and grant aid per student in nominal value and constant dollar

States included	Comparison interval	Growth rate, nominal value (USD/year)			Growth rate, constant dollar (USD/year)		
		Out-of-state tuition and fees	In-state tuition and fees	Grant aid per student	Out-of-state tuition and fees	In-state tuition and fees	Grant aid per student
States with merit-based scholarship	1988-2008	806.27	201.38		288.67	64.48	
	1999-2008	1238.16	322.62	303.06	431.93	109.87	91.39
States without merit-based scholarship	1988-2008	692.12	227.96		216.55	77.24	
	1999-2008	853.98	365.15	161.11	220.65	127.71	40.79

Trends in the population fraction of students who are in-state

Figure 2 plots percentage change of the fraction of first-time in-state students in states with merit-based scholarships vs. comparison states between pre- and post-scholarship period. The fraction of first-time students who were in-state increased in states with merit-based scholarships, but decreased in states without merit-based scholarship. Meanwhile, the degree of percentage changes varied across states with merit-based scholarships. The differences in percentage change between Florida, South Carolina and their comparison states were 6.48 and 1.61 respectively.

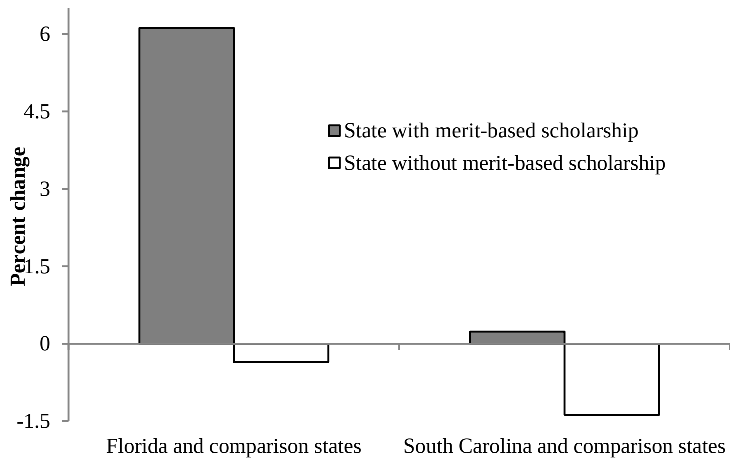


Figure 2. Percent change of the fraction of first-time students classified as in-state.

Trends in the population fraction of students who choose engineering

Figure 3 shows percentage change of the fraction of first-time students enrolled in engineering in states with merit-based scholarships vs. comparison states between pre- and post-scholarship period. The fraction of first-time students enrolled in engineering increased in Florida and South Carolina, but decreased in comparison states from pre- to post-period. The fraction of first-time students enrolled in engineering decreased in both Georgia and comparison states, with a smaller decrease in Georgia. The differences in percentage change between Florida, South Carolina, Georgia and their comparison states were 6.03, 5.01, and 3.54 respectively.

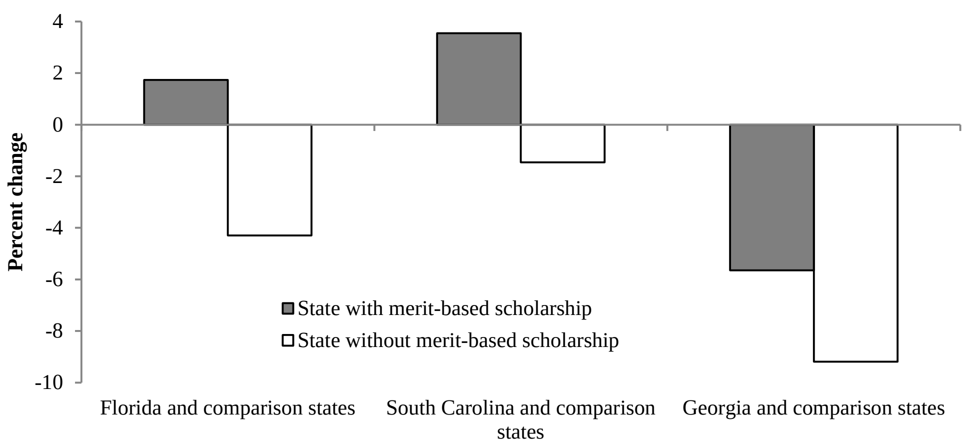
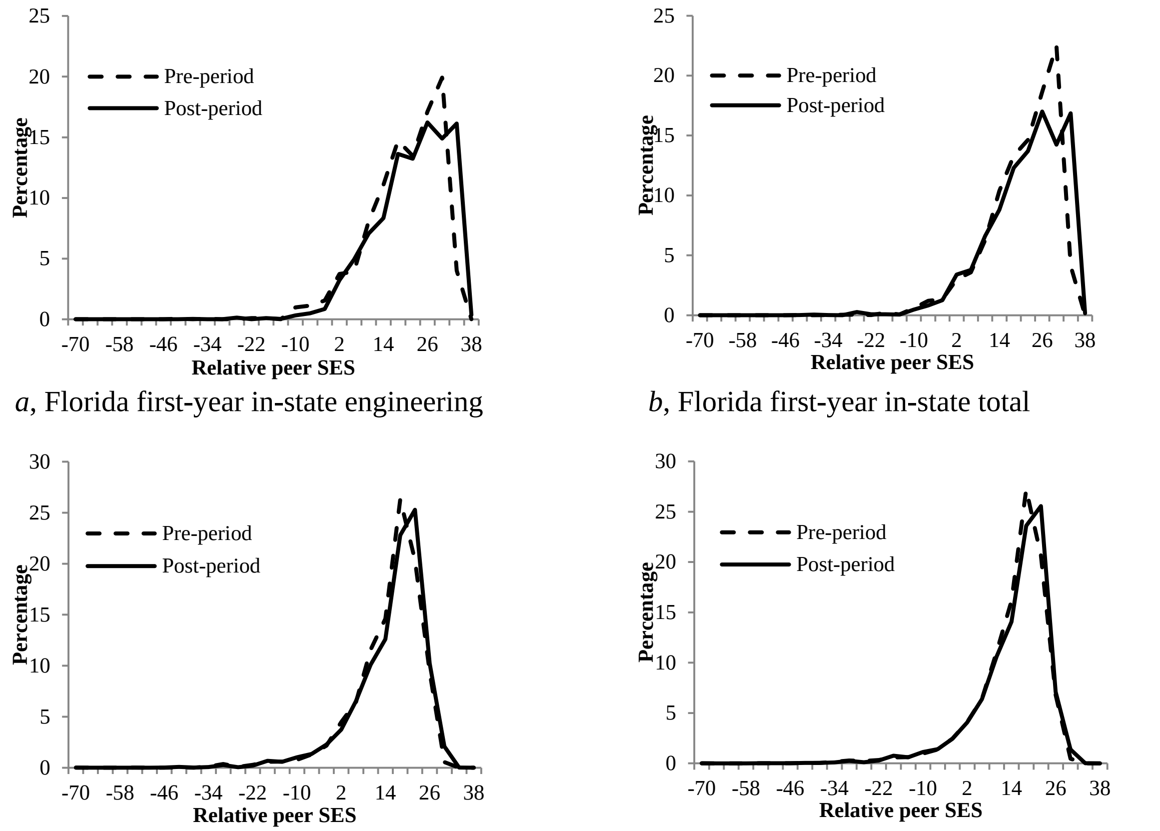


Figure 3. Percent change of the fraction of first-time students enrolled in engineering.

Trends in the population distribution of relative peer SES

Figure 4 shows the population distribution of relative peer SES of in-state students during pre- and post-scholarship periods. To illustrate the percentage distribution of relative peer SES, in Figure 4a, the highest point in the dotted line denotes that 19.92% of Florida in-state engineering students' relative peer SES scores fell within the range of (26, 30] during 1994-1996. We can see from Figure 4a and 4b that for both engieering and total incoming students in Florida, the percentage of students with high relative peer SES increased after merit-based scholarship was adopted. In comparison states, the percentage distribution of relative peer SES did not change much except a slight shift of the peak from interval (14, 18] to (18, 22], as shown in Figure 4c and 4d.



a, Florida first-year in-state engineering   *b*, Florida first-year in-state total

c, Comparison states first-year in-state engineering   *d*, Comparison states first-year in-state total

Figure 4. Percentage distribution of relative peer SES for first-year in-state students.

Modeling relative peer SES for in-state students

In the examination of relative peer SES differences between pre- and post-period, Kruskal-Wallis tests were all significant. For first-time in-state engineering students in Florida, $\chi^2(1, N = 5207) = 52.95$, $p < .001$; for total first-time in-state students in Florida, $\chi^2(1, N = 56721) = 189.23$, $p < .001$; for first-time in-state engineering students in comparison states, $\chi^2(1, N = 15082) = 53.66$, $p < .001$; and for total first-time in-state students in comparison states, $\chi^2(1, N = 83734) = 163.93$, $p < .001$. For in-state engineering students in Florida, relative peer SES score in post-period (M =

19.81, *SD* = 9.80) was 1.88 higher than that in pre-period (*M* = 17.93, *SD* = 9.80). For total in-state students in Florida, relative peer SES score in post-period (*M* = 19.67, *SD* = 10.35) was 0.81 higher than that in pre-period (*M* = 18.86, *SD* = 9.56). For in-state engineering students in comparison states, relative peer SES in post-period (*M* = 13.51, *SD* = 9.53) was 0.69 higher than that in pre-period (*M* = 12.82, *SD* = 9.17). For total in-state students in comparison states, relative peer SES in post-period (*M* = 12.92, *SD* = 9.57) was 0.5 higher than that in pre-period (*M* = 12.42, *SD* = 9.36). Figure 5 plots the change of relative peer SES from pre- to post-period for both first-time in-state engineering students and total students in Florida and comparison states. The increase in relative peer SES was larger for first-time in-state engineering students than that for total first-time in-state students. Meanwhile, Florida had larger increases in relative peer SES scores than comparison states for both first-time in-state engineering students and total first-time in-state students. A brief review indicates that both tuition fees and merit-based scholarship were positively related to relative peer SES scores for students majoring in engineering, while the scholarship effects were either less significant or non-significant for students in other majors. A more comprehensive analysis will be considered in future work.

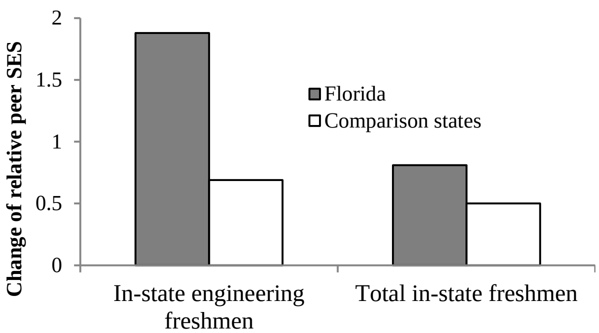


Figure 5. Change of relative peer SES of first-time in-state engineering students and total first-time in-state students from pre-period to post-period.

The correlation between merit-based scholarship and aggregate SAT scores

To investigate the relationship between merit-based scholarship and aggregate SAT scores, difference-in-differences model (1) was used. Regression assumptions were met, and test results for the four groups were statistically significant (the adjusted alpha level for each test was .004). Table 3 summarizes test results for first-time in-state engineering students and total first-time in-state students respectively. The effect of merit-based scholarship varied across states and across institutions of different levels. Specifically, the implementation of merit-based scholarship was positively related to SAT scores in Georgia, with stronger effect for engineering students. Scholarship adoption had mixed effects in Florida depending on the level of the institution. Group 2 includes institutions at a higher level than that in group 3. However, the adoption of scholarship was negatively associated with SAT scores in group 2, with less negative effect for engineering students. Scholarship adoption was positively related to SAT in group 3 for total students, but was non-significant for engineering students. Meanwhile, the effect was non-significant in South Carolina. Gender was a significant predictor for all groups except for group 3. Men had higher SAT scores than women. Significant institutional differences existed in all groups except for first-time in-state engineering students in group 3.

Table 3. Summary of multiple regression analysis for variables predicting aggregate SAT scores for first-time in-state engineering students and total first-time in-state students

		First-time in-state engineering			First-time in-state total		
Group	Predictor	*B*	*SE B*	*β*	*B*	*SE B*	*β*
Group 1 Georgia	Scholarship indicator	22.98	4.00	.06***	14.69	3.63	.02***
	Gender	15.81	2.36	.05***	51.28	1.14	.14***
	Year	-1.69	.63	-.02	2.16	.34	.02***
	Institution dummy 1	-116.44	3.08	-.40***	-248.58	2.70	-.67***
	Institution dummy 2	-97.51	3.30	-.30***	-197.97	2.74	-.50***
	Institution dummy 3	-42.61	3.71	-.10***	-135.48	2.76	-.33***
	R^2		.16			.22	
	F for change in R^2		545.15***			3623.91***	
Group 2 Florida	Scholarship indicator	-13.45	4.06	-.03***	-21.15	1.49	-.06***
	Gender	16.54	2.17	.05***	43.94	.79	.14***
	Year	22.17	.56	.27***	18.49	.27	.20***
	Institution dummy 1	-20.84	3.44	-.06***	-99.65	1.33	-.25***
	Institution dummy 2	-26.89	3.54	-.08***	-42.90	1.43	-.10***
	Institution dummy 3	22.10	4.15	.05***	-10.51	1.46	-.02***
	Institution dummy 4	-35.77	3.49	-.11***	-25.36	1.57	-.05***
	R^2		.09			.10	
	F for change in R^2		320.00***			2269.24***	
Group 3 Florida	Scholarship indicator	-24.91	12.80	-.08	13.94	3.44	.05***
	Gender	1.18	6.80	.00	2.44	1.91	.01
	Year	9.10	2.19	.14***	1.49	.73	.02
	Institution dummy 1	-17.43	9.30	-.07	71.14	2.65	.29***
	R^2		.01			.07	
	F for change in R^2		4.51**			294.27***	
Group 4 South Carolina	Scholarship indicator	-12.50	6.39	-.02	-6.14	3.27	-.01
	Gender	13.16	2.90	.03***	41.95	1.09	.11***
	Year	16.23	.73	.15***	14.93	.33	.14***
	Institution dummy 1	192.69	5.00	.46***	70.73	2.51	.18***
	Institution dummy 2	189.17	5.06	.44***	131.61	2.58	.30***
	Institution dummy 3	226.32	5.73	.38***	150.04	2.61	.33***
	Institution dummy 4	182.82	5.08	.43***	151.69	2.70	.30***
	R^2		.18			.11	
	F for change in R^2		622.22***			1850.55***	

Note: Scholarship indicator coded as 1 for *an institution with merit-based scholarship in a specific year* and 0 for *an institution without merit-based scholarship in a specific year*. Gender coded as 1 for *male* and 0 for *female*. Institution dummy k (k = 1, 2, 3, 4) coded as 1 for *comparison institution k* and 0 for *other comparison institutions* or *the reference institution*.
** $p < .003$. *** $p < .001$.

Discussion

This study demonstrates the apparent inability of grant aid to match the pace of rising tuition and fees over 1999-2008, especially in states without merit-based scholarship (Figure 1 and Table 2). The availability of funds and a relatively lower tuition costs for in-state students attracted high school graduates to attend in-state institutions. Meanwhile, tuition and fees for out-of-state students increased much more quickly in institutions with merit-based scholarships, making these institutions less attractive to students from other states. This pattern of financial factors provides a reasonable explanation of why the fraction of in-state students increased in institutions after the adoption of merit-based scholarships (Figure 2). Variation in the increase rates across states may be due to regional economic factors and institutional characteristics[19].

The adoption of merit-based scholarship seemed to be positively related to the enrollment of engineering students (Figure 3). Though the fraction of first-time students enrolled in engineering increased in Florida and South Carolina but decreased in Georgia, in all three cases these states were more successful at attracting or maintaining the fraction of first-time students enrolled in engineering compared to states without merit-based scholarship.

In addition, for institutions with merit-based scholarships, there were significant increases in the percentage of first-time in-state students with high relative peer SES—an indicator of an individual's socioeconomic status (Figure 4). Meanwhile, a larger change in relative peer SES was found among engineering students compared to all in-state students (Figure 5), indicating the shift in access toward high-SES students was more prominent in engineering. Though relative peer SES also increased in institutions without merit-based scholarship, the increases were apparently larger in institutions with scholarships, which was consistent with Dynarski's results[11].

Although merit-based scholarship eligibility emphasizes academic performance, we find inconsistent relationships between the adoption of merit-based scholarships and first-time in-state students' SAT scores across states and across institutions of different levels. Variations in significance and direction existed in the results, suggesting that student qualities in the institutions that we study were affected by some other factors, such as institutional characteristics, rather than by merit-based scholarship.

Conclusion and future work

In this work, we study the effects of college costs and financial aid (especially merit-based scholarship) in college enrollment with specific focus on engineering students. Our results suggest that the pace of grant aid failed to match the pace of rising tuition and fees especially in institutions without merit-based scholarship. In-state students as a proportion of total enrollment, the proportion of enrolled students choosing engineering, and the proportion of students with high socioeconomic status increased in 4-year public institutions after merit-based scholarships were adopted in the states where those institutions located. The effect of higher SES among incoming students was more prominent in engineering fields, indicating that merit-based scholarship may have bigger impact on engineering enrollments. Finally, inconsistent results were found regarding the effect of merit-based scholarship on SAT scores for in-state students.

We suggest that incoming student quality in the institutions that we study, as indicated by SAT scores, was affected by other factors rather than by merit-based scholarship.

We explore student-level data across institutions and states, and therefore expect some generalizability for our conclusions. Findings of this study have significant implications for policy makers and engineering educators by informing decisions regarding scholarship program evaluation, recruitment, advising, and financial assistance. In light of policy makers' concerns about engineering education and the large amount of state funding invested on merit-based programs, it is essential to understand policy implications of these programs with respect to student enrollment pattern changes. The increase of enrollment rates of in-state students and engineering students meet the program goals in retaining better-qualified students within states. However, students with high socioeconomic status seem to benefit the most. Noting that the proportion of students with low socioeconomic status decreased after merit-based scholarships were adopted, engineering educators should pay specific attention to support systems for socioeconomically disadvantaged students. At the state level, need-based scholarships might complement merit-based scholarships to avoid further restricting access to low-SES students.

Future work will use more comprehensive analysis to explore how relative peer SES relates to financial factors and to determine whether the scholarship effects are unique for engineering students. Beyond the enrollment effects of merit-based scholarship, future work will examine scholarship influences on student academic decisions such as course choice behavior, retention, and graduation. Besides quantitative analysis of student-level data, qualitative approaches will be adopted to understand students' learning experiences and strategies to meet scholarship requirements. A theoretical framework will also be developed to guide future study and help engineering educators identify effective ways to motivate students in studying engineering.

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