State merit-based financial aid and postsecondary STEM enrollment and attainment: Evidence from Missouri

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Abstract

In this paper, we study the effect of the Missouri Bright Flight program, a highly targeted state-funded merit aid program, on postsecondary STEM enrollment and degree attainment. Our analytic sample is based on the administrative microdata, including about 130,000 college students from 11 cohorts (1996-2006) who enter 4-year Missouri public institutions. Using a fuzzy regression discontinuity design to estimate the treatment on treated, we find that this merit aid program has significant negative effects on engineering initial major choice and degree completion but insignificant negative effects on STEM subjects. Besides, the effects also vary by gender.

Keywords: Merit aid, STEM, enrollment and attainment, regression discontinuity

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With the rapid development in STEM (science, technology, engineering, and math) sector, STEM occupations have become more valuable on the labor market. Between May 2009 and May 2015, employment in STEM occupations grew 10.5% while non-STEM occupations increased only 5.2%. Moreover, 93% of STEM occupations had wages significantly above the national average wage for all occupations. Specifically, the national average wage for all STEM occupations was $87,570, compared with $45,700 for non-STEM occupations (Fayer, Lacey, & Watson, 2017).

Given the high demand and the wage premium in STEM occupations, a key question for policymakers in higher education is how to increase college enrollment and degree attainment in STEM fields. Financial cost remains an important barrier in the production of STEM degrees (*How much does it cost institutions to produce STEM degrees?* 2013). STEM courses are often the most expensive ones for colleges and universities to produce. According to the estimates of "cost per degree" for 28 disciplines, engineering, agriculture, computer, and science-related fields usually have higher than average production costs. Though the "cost per degree" of most STEM fields in public four-year institutions ranges between $65,000 and $80,000, the cost of engineering degree is even higher (nearly $100,000). As a result, institutions are increasingly implementing differential tuition policies which often increase the cost of STEM coursework (Stange, 2015). In 2010-2011, about 40% of public four-year institutions with doctoral programs have differential tuitions among different majors (Ehrenberg, 2011). This pricing strategy is shifting the financial burden onto students, potentially altering student major choice (Stange, 2015).

In this paper, we explore the role that financial aid plays in the decision to pursue a STEM major. Compared to other possible determinants examined in the literature, such as academic preparation/achievement, self-efficacy beliefs, identity, and peer influence (Griffith, 2010; Price, 2010; Wang, 2013), affordability in STEM majors is more feasible to be directly influenced by policies. For example, targeted financial aid and scholarship will reduce the financial cost and make higher education more affordable for students. Hence, we want to answer the following research question: what is the effect of receiving financial aid on STEM attainment, including initial major choice and degree completion?

Specifically, we examine the impact of the Missouri Bright Flight Program, a merit-based financial aid award, on initial STEM major choice and STEM degree completion. We evaluate the treatment effect of receiving the Missouri Bright Flight scholarship, a state-funded merit-based financial aid, on college students STEM initial major choice and degree completion in Missouri 4-year public universities.

Background

The Missouri Bright Flight Program

The Missouri Bright Flight Program was established in 1986. It is a merit-based program that encourages top-ranked high school graduates to enroll full-time at a participating Missouri institution, including 13 Missouri public 4-year universities and over 25 private institutions. The eligibility of this financial aid is established top 3% of all Missouri ACT takers. The amount of the Bright Flight scholarship was $2,000 per academic year without any adjustment for inflation until the 2007-2008 academic year. In 2007, the authorizing legislation was revised to add the top 4th and 5th percentiles as eligible for a lesser award, becoming a two-tier award structure. The first tier (top 3%) recipients can get $3,000 while the second tier (4%-5%) recipients are awarded only $1,000. However, that change did not become effective until the 2010-2011 academic year. It is also important to note that the second-tier award has never received funding through the program and the first-tier award was never fully funded (recipients could get the maximum amount of $3,000) until the 2015-2016 academic year. Recipients only got approximately $2,500 from 2008-2009 to 2014-2015 academic year. Before the 2008-2009 academic year, this program required initial students to have a composite ACT score of 30 or higher. To maintain the top 3% ACT requirement, the minimum ACT score has increased to 31 since the 2008-2009 academic year. Hence, we restrict our analytic sample who enrolled in Missouri public 4-year institutions from 1996-1997 to 2006-2007 academic year to avoid inconsistent policies after the 2007-2008 academic year.

To be eligible for this financial aid for the first time, initial applicants must achieve the qualifying score by the June test date immediately following the graduation from high school. Students can retake the ACT multiple times in high school and only their highest ACT score will be considered. Besides the qualifying ACT score, the eligibility also requires applicants to enroll full-time at a participating Missouri university and not to pursue a degree or certificate in theology or divinity. Students can renew this financial aid for up to 10 semesters or until completed a bachelor's degree (whichever occurs first) if they keep enrolled full-time and maintain a cumulative GPA over 2.5 and otherwise maintain satisfactory academic progress as defined by enrolled institutions.

Bright Flight in Missouri Public 4-year Universities

The University of Missouri-Columbia and Missouri University of Science and Technology (formerly University of Missouri-Rolla) are the two biggest STEM/engineering major providers among all 13 Missouri 4-year public institutions. Since these two institutions are very selective, admitted students usually have very high ACT scores and many of them are awarded by the Bright Flight program. For example, according to Missouri Department of Higher Education (*DHE financial assistance and outreach*, 2010), in the fiscal year 2007, the total number of Bright Flight recipients was 8,541, including 6,463 students (75.7%) from 13 public 4-year universities. Among 6,463 recipients, 2,381 students enrolled in the University of Missouri-Columbia and 919 students attended Missouri University of Science and Technology. The rest large recipients of the Bright Flight scholarship include institutions such as Truman State University (1,306) and Missouri State University (795). The majority of the recipients are probably enrolled in public 4-year institutions.

Differential Costs by Disciplines

Though Missouri institutions were not included on the list of institutions with differential tuitions (Ehrenberg, 2011), students enrolled in some institutions are still facing differential cost actually due to other enrollment fees. For example, in the 2006-2007 academic year, the highest course fees for per credit hour in the University of Missouri System (Columbia, Rolla, Saint Louis, Kansas City) were: architectural studies ($150), engineering ($50.5), and health ($49.3), which is at least 20% more expensive than many other courses (except nursing courses) (*University of Missouri System tuition rates (FY06-07)*, 2006). Besides, since the 2006-2007 academic year, Missouri University of Science and Technology began to charge an additional $50 supplemental fees for computer science, biological science, chemistry, and so on. Though claiming an initial major in STEM fields does not mean enrolling more expensive STEM courses immediately, the differential fees still increase the expected total cost of completing a degree in STEM fields, which may affect students' initial major choice.

Literature Review

State-funded merit-based financial aid has been widely established since 1990 (Dynarski, 2002), such as Helping Outstanding Pupils Educationally (HOPE) Scholarship (Georgia, since 1993) and Bright Future Scholarship (Florida, since 1997). One important rationale for merit aid adoption is the goal of keeping the best and brightest students in state (Heller & Marin, 2004). As a result, the evaluations of merit-based financial aid are usually looking at the following topics, including college enrollment (Cornwell, Mustard, & Sridhar, 2006; Singell, Waddell, & Curs, 2006; Zhang, 2011; Zhang, Hu, Sun, & Pu, 2016) and brain drain (Harrington, Muñoz, Curs, & Ehlert, 2016; Zhang & Ness, 2010). Generally, these studies typically find that merit aid has a significant positive effect on the probability of attending in-state institutions and keeps talents to study and work in state.

Because of the rapid demand in STEM occupations, evaluating state-funded merit aid programs with a focus on producing more STEM graduates becomes more and more necessary. However, unlike the topics mentioned above, the effect of merit aid on college major choice has not been fully examined. The following several empirical papers are considered as evaluating the effects of merit aid on college major choice and degree completion.

Cornwell, Lee, and Mustard (2006) explore the effect of Georgia HOPE merit aid on students from the University of Georgia through a difference in difference (DID) approach. They find that HOPE increased freshman GPA while reduced the number of credit hours completed in math and science core curriculum courses in their first year. They also find small significant effects for major choice. The HOPE increased the likelihood of a student choosing an education major by 1.7% but had no effect on other majors. A possible argument to explain the result is that the HOPE merit aid has a renewal requirement that students have to maintain a 3.0 GPA. In order to avoid losing HOPE in the future, students may strategically take less difficult courses or even choose some subjects which are easier to meet the required renewal GPA.

Stater (2011) examines the effect of student aid on the choice of the first-year major using individual-level data from three flagship public universities (Colorado, Indiana, and Oregon). He finds that loans and grants probably have small or insignificant effects on major choice while merit aid shows a large positive effect on claiming a major in humanities and science. However, though student characteristics are controlled, the manipulation to receive merit aid, as an endogeneity, is not considered. For example, students who want to receive merit aid may retake standardized exams or choose easier high school courses to maintain a high GPA. Those unobserved behaviors could affect major choice.

Zhang (2011) focuses on the effect of the Florida and Georgia merit aid on annual statewide conferred STEM degrees using the Integrated Postsecondary Education Data System's (IPEDS) Completion Survey. The empirical results show that HOPE (GA) and

Bright Future (FL) programs increased the number of both STEM and non-STEM baccalaureate degrees conferred by four-year institutions in Georgia and Florida. But no significant effect is found on the percentage of STEM majors, except a 1.6% increase in Florida private institutions. This study uses aggregated dataset instead of individual-level microdata, which may be problematic. Merit aid will attract students with a better academic background to stay in state for their higher education. The increased student quality may also affect students' major choice, which cannot be excluded without student-level information.

Sjoquist and Winters (2015a) investigate a national dataset from the American Community Survey (ACS) and evaluate the effect of state merit aids on students' major choice. Unlike previous studies with limited samples, they examine the individual-level data with a national-wide sample, making their results with stronger external validity. They also consider the different scales among different state merit aid programs. 9 states merit aid programs are defined as strong merit aid program according to the eligibility criteria, the number of recipients, and the size of the award. Their results suggest that adopting a strong merit aid program reduces the number of STEM graduates from the state by 6.5%. As a complementary to Sjoquist and Winters (2015a), Sjoquist and Winters (2015b) use administrative data from the University System of Georgia to examine whether Georgia's HOPE Scholarship has affected students' college major decisions. Similarly, they also find the negative effect of merit aid on STEM degree production.

As a conclusion, there are some points need to be noticed. First, many analytic samples of state-funded financial aid evaluation are derived from Georgia and Florida (Castleman, Long, & Mabel, 2018; Cornwell, Lee, & Mustard, 2006; Cornwell, Mustard, & Sridhar, 2006; Singell et al., 2006; Sjoquist & Winters, 2015a, 2015b; Zhang, 2011; Zhang et al., 2016). Though financial aid programs in Georgia and Florida have larger targeted subjects and make sizable impacts on students, as a supplementary to the literature, it is still necessary to have more studies including different state-funded financial aid programs.

Second, many studies focus on the difference between pre-aid and post-aid periods, using the difference in difference (DID) framework to estimate the treatment effect (Cornwell, Lee, & Mustard, 2006; Sjoquist & Winters, 2015a, 2015b; Zhang, 2011). Since many merit-based financial aid programs were introduced in the 1990s (Dynarski, 2002), the comparison between pre-aid and post-aid periods usually requires a sample with students enrolled in colleges more than 25 years ago, which may be a little be out-of-date when considering current demands in STEM occupations. Besides, under DID framework, we only know whether a merit aid program was implemented or not. Instead, it is not required to identify whether a student was eligible or received the merit aid. That could partially explain why researchers are more interested in large merit aid programs with sizable impacts. The effect of small merit aid programs may be easily disturbed by other policy changes and may not be observed widely from a state level. Last, improper control groups will create biased estimators under DID framework. Specifically, Sjoquist and Winters (2015b) argue that non-resident students are an imperfect control group. They also only use time difference estimates as a supplementary to DID estimates. Multiple robust checks have to be provided to make their results more convincing.

Our research of the Missouri Bright Flight program using a regression discontinuity (RD) approach will fill in the two gaps in the literature. First, unlike other state-funded merit aids, the Bright Flight program only targets a few Missouri students with very high ACT scores (30 or above). Other state-funded merit aids usually have a lower ACT requirement but a higher high school GPA (HS GPA) : Florida (two tiers: ACT 20, HS GPA 3.0; ACT 28, HS GPA 3.5); Georgia (HS GPA 3.0); Louisiana (three tiers: ACT 20, HS GPA 3.0; ACT 23, HS GPA 3.0; ACT 27, HS GPA 3.0); Mississippi (ACT 29, HS GPA 3.5) (Zhang & Ness, 2010). Second, because of the ACT eligibility, it is very proper to use an RD approach to evaluate the treatment effect on Missouri treated subjects. Our analytic sample could be students who enrolled from 1996-2006, a panel dataset with more recent observations. The RD design is also a strong quasi-experimental design and the similarities between control group and treatment group could be insured. Though the RD design becomes more and more popular in recent financial aid studies (Castleman et al., 2018; Denning & Turley, 2017; Evans, 2017; Zhang et al., 2016), many of them focus on the need-based aid programs, including the National SMART Grant (Denning & Turley, 2017; Evans, 2017). Hence, our evaluation of a state-funded merit aid on STEM attainment will be a good supplementary to the literature.

Conceptual Framework

The conceptual framework is developed from consumer choice theory. Castleman et al. (2018) argue that financial aid can impact attainment in colleges on either the extensive (e.g. enrollment) or intensive (e.g. major choice) margins. In this paper, focusing on all Missouri ACT takers, the extensive margin can be described as the total enrollment in Missouri 4-year public institutions and the intensive margin represents the proportion of students with different majors conditional on being enrolled in Missouri 4-year public institutions. We mainly examine the effect of the merit aid on the intensive margin. In other words, we evaluate the impact on major choice among students from Missouri 4-year public institutions. See discussion section for more detail discussion about the analysis of the extensive margin.

In order to choose the proper college major, m, assuming a student is facing the following utility maximization problem:

$$\underset{m=S,N}{U} = U_m(R_m, C_m) \tag{1}$$

subject to the constraint:

$$C_m + A + A_m = T_m \tag{2}$$

A student will choose a proper major (STEM, S, or non-STEM, N) to maximize his or her utility, which is a function of future revenue, R_m, and personal cost, C_m. The personal cost, C_m, major-unrelated aid, A, and major-related aid, A_m, cover the whole cost of major m, T_m. Besides, higher future income and lower personal cost will increase the utility, which means $\frac{\partial U_m}{\partial R_m} > 0$ and $\frac{\partial U_m}{\partial C_m} < 0$

To decide whether to choose a STEM major or not, the utility function can be rewritten like this:

$$\begin{aligned}\Delta U_S &= U_S(R_S, C_S) - U_N(R_N, C_N) \\ &= U_S(R_S, T_S - A - A_S) - U_N(R_N, T_N - A - A_N)\end{aligned} \tag{3}$$

If $\Delta U_S > 0$, a student is more likely to choose a STEM major otherwise he or she will choose a non-STEM major. Given R_m, T_m unchanged, Equation 3 can be simplified as:

$$\Delta U_S = U_S(A, A_S) - U_N(A, A_N) \tag{4}$$

The Missouri Bright Flight scholarship is likely to affect major choice through an income effect and a substitution effect. Generally, this scholarship is not major-targeted, which means receiving the merit aid will only increase major-unrelated aid A without changing major-related aid A_m, leading to an income effect. The income effect could be:

$$\frac{\partial \Delta U_S}{\partial A}\Delta A = \left(\frac{\partial U_S(A, A_S)}{\partial A} - \frac{\partial U_N(A, A_N)}{\partial A}\right)\Delta A \tag{5}$$

Because $\frac{\partial U_m}{\partial C_m} < 0$, both $\frac{\partial U_S(A,A_S)}{\partial A}$ and $\frac{\partial U_N(A,A_N)}{\partial A}$ are positive, making the income effect either positive or negative.

Empirically, on one side, the income effect could be positive on choosing STEM majors. The Bright Flight scholarship can cover additional costs of STEM majors, such as higher course fees, laboratory or material fees (*How much does it cost institutions to produce STEM degrees?* 2013; Stange, 2015). With a higher salary expectation in STEM occupations, the financial aid lowers the cost and makes STEM majors much more cost-effective. On the opposite side, receiving the Bright Flight scholarship will remove the pressure to pursue majors with higher expected earnings, such as STEM (Andrews & Stange, 2016; Rothstein & Rouse, 2011; Stater, 2011). This will result in a negative income effect on STEM major choice.

But we also notice that this scholarship has a renewal GPA requirement. the threat of losing the scholarship may make students choose a safer major (Cornwell, Lee, & Mustard, 2006; Sjoquist & Winters, 2015a). STEM courses are usually more difficult than non-STEM courses, making it harder to maintain a high GPA. Considering the eligibility of receiving the scholarship in the future, choosing a STEM major will reduce the total expected amount of the scholarship that a student can get in the next following years. In other words, the financial aid may decrease the major-related aid of STEM majors, A_S. The substitution effect could be:

$$\frac{\partial \Delta U_S}{\partial A_S}\Delta A_S = \frac{\partial U_S(A, A_S)}{\partial A_S}\Delta A_S \tag{6}$$

Because $\frac{\partial U_S(A,A_S)}{\partial A_S} > 0$ and $\Delta A_S < 0$, the substitution effect will be negative and may encourage students to choose non-STEM majors and decrease the probability of STEM attainment.

When combined, the predicted effect of the program on STEM major choice is ambiguous. Due to the uncertain effect of financial aid on STEM attainment, we want to test the following completing hypotheses:

1. Merit-based aid has a stronger positive income effect with weaker negative income

and substitution effects, making the combined effect on STEM attainment become positive.

2. Merit-based aid has stronger negative income and substitution effects with a weaker positive income effect, making the combined effect on STEM attainment become negative.

3. The combined effect is insignificant.

Research Design

Data

The analytic dataset is derived from three administrative datasets provided by the Missouri Department of Higher Education (MDHE). The first dataset contains first-time full-time degree-seeking students from Missouri public colleges and universities, which includes each student's demographic information, high school performance, and college information (major, credits, GPA, etc.). The second dataset has every Missouri ACT taker's records, including each one's highest ACT composite score and first-time ACT composite score. The third dataset provides the information about every recipient of the state's financial aid, such as which state grant he or she receives.

The analytic sample will be restricted to first-time full-time degree-seeking students with recent Missouri high school graduation from 1996 to 2006. Only students enrolled in 4-year public institutions are considered because many 2-year community colleges do not require ACT scores and the majority of the Bright Flight recipients are enrolled in 4-year institutions. The whole sample includes about 130,000 students. Table 1 shows the process of data construction.

STEM/Engineering Categories

Our analytic sample stores the Classification of Instructional Programs (CIP) code which is used to identify the specific program each student enrolls in. Engineering majors/degrees have three main categories: engineering, computer science, and technology. STEM majors/degrees have additional categories besides engineering, including agricultural & animal sciences, natural science, biological science, mathematics, military/security science, physical science, psychology, business, and social science, health science, etc. For more information about different STEM categories and CIP codes, please see Table 2.

Empirical Strategy

Treatment Effect. In the literature, estimating the effect of financial aid eligibility under the framework of intent to treat (ITT) is widely used (Castleman et al., 2018; Harrington et al., 2016). The eligibility usually creates a sharp discontinuity and subjects who pass certain criteria are eligible to receive the treatment. Hence, the framework of intent to treat helps researchers to construct a regression discontinuity (RD) design. With the strong assumptions from an RD framework, many unobserved sorting behaviors can be avoided. Differently, in our analytic sample, we include the state financial aid files. In order to utilize those records, we apply the framework of treatment on treated (TOT) to estimate the treatment effect of receiving the Bright Flight scholarship on STEM major choice and degree completion through an RD approach.

ACT as the Running Variable. ACT score is used as the main running variable. According to MDHE's policy, students with the highest ACT score above 30 will receive the Bright Flight scholarship. Figure 1 shows the proportion of Bright Flight recipients by different highest ACT composite score. The cut-off point is 29.5 because the ACT composite score is the average of four test scores (English, reading, math, and science), rounded to the nearest whole number. So students with an average score of 29.5 will be Bright Flight eligible. The composite score is recalculated without being rounded to the nearest whole number so that the interval of running variable would be reduced to 0.25 instead of 1, making the running variable more "continuous".

Manipulation of the Running Variable. To get an unbiased estimation through an RD design, the first key assumption is that the running variable cannot be manipulated. Unfortunately, in our context, the running variable, highest ACT composite score, can be easily controlled by retaking ACT exams multiple times. Students may retake the ACT if they cannot get enough points at the first attempt. The retaking behaviors will result in a manipulation of the running variable and create biased estimates. To exam the existence of manipulation, the following figures are provided for visual inspection (Harrington et al., 2016; McCrary, 2008). Figure 2 presents the average number of retakes by the first ACT score a student received. It implies that the average number of retakes increased until passing the cut-off point of Bright Flight eligibility and then subsequently declined. Figure 3 shows the density distribution of the highest ACT composite score. It is obvious to find a density increase around the cut-off point (29.5). Figure 4 shows the density distribution of first-time ACT composite score. As a comparison, there is no significant change around the cut-off point in the distribution of first-time ACT composite score and the density function is more likely to be continuous. To sum up, we can conclude that the highest ACT score is manipulated and cannot be used as the running variable in an RD design. Students who really want to get the financial aid would probably retake ACT exams multiple times, which creates an endogenous issue.

The first-time ACT score is better to be used as the running variable. Manipulation of a student's first ACT is unlikely because ACT is a standardized test and students are supposed to try to score as high as they can. But a sharp RD design would generate biased estimates because of the noncompliance displayed in Figure 3 (Lee & Lemieux, 2010). Figure 5 presents the proportion of Bright Flight recipients by different first-time ACT composite score. Though there is no sharp discontinuity, an increase of probability of receiving the Bright Flight scholarship around cut-off point still exists. In this case, a fuzzy RD framework is introduced and it can solve the noncompliance bias through a two-stage procedure.

2SLS Procedure. In the first stage, the probability of receiving Bright Flight (BF_treat_i) is estimated based on whether the subject is Bright Flight eligible on the first attempt ($BF\_eligible\_FT_i$), a flexible functional form of first-time ACT score (ACT_FT_i), and a set of control variables (X_i).

$$BF\_treat_i = \beta BF\_eligible\_FT_i + \gamma' f(ACT\_FT_i) + \theta' X_i + \epsilon_i \tag{7}$$

In the second stage, the predicted probability of receiving Bright Flight ($\widehat{BF\_treat_i}$) is substituted for receiving Bright Flight actually to estimate the effect of receiving Bright Flight on STEM/Engineering major choice/degree completion.

$$STEM/Engineering_i = \beta \widehat{BF\_treat}_i + \gamma' f(ACT\_FT_i) + \theta' X_i + \epsilon_i \tag{8}$$

The key coefficient β can be interpreted as the effect of the treatment on the treated, which is the effect of receiving Bright Flight for those who become Bright Flight eligible based on their first-time ACT composite score. The set of control variable X_i includes students' demographic information (race, gender), high school performance (class rank, math and science course taken), and the fixed effect of enrollment year.

Bandwidth Selection. To pick up a proper bandwidth in an RD design is very crucial. However, our running variable, ACT score, is not continuous, which means those commonly used bandwidth selection procedures (Calonico, Cattaneo, & Titiunik, 2014; Imbens & Kalyanaraman, 2012) can not be applied. In related literature, Harrington et al. (2016) choose ACT from 24 to 35 as a bandwidth, with 6 data points in both treatment group (30-35) and control group (24-29). Zhang et al. (2016) prefer ACT from 15 to 24, with 5 data points in both treatment group (15-19) and control group (20-24). Since our ACT score is not rounded, with a smaller interval of 0.25 instead of 1, we choose the bandwidth from 27 to 31.75, with 10 data points in each group.

Results

Summary Statistics

Table 3 presents descriptive statistics for our preferred analytic sample with first-time ACT between 27 and 31.75. Compared to the full sample, our selected sample has more students choosing STEM/engineering majors, higher STEM/engineering completion rates. In race and gender compositions, our selected sample has fewer minority and female students. Especially, the percentage of black students dropped from 7% to 1%. In high school performance, students in our analytic sample usually have finished more math and science courses with better class rank.

In the RD design, students around the cut-off point are usually assumed to have similar characteristics in order to be comparable. Table 4 compares the sample above the cut-off point and below the cut-off point. There are fewer black students and female students above the cut-off point. And students who pass the minimum ACT requirement are more likely to have more high school credits in math and science, which implies that students' high school course taken behaviors may not be affected by the Bright Flight program. Some merit aids in other states include a high school GPA requirement. As a result, high school students are more likely to choose easier courses to maintain a higher GPA. But in Missouri, the only requirement of ACT score may encourage students to do well in all four subjects instead of giving up more difficult math or science courses.

Though it is not necessary to add any control variables under the assumption of the RD design, the differences in gender, race, high school performance, and family income still exist between treatment and control groups. We will put those variables as control variables to get more precise estimates.

Fuzzy Regression Discontinuity Estimates

Figure 6 illustrates the regression discontinuity estimates for students enrolled Missouri 4-year institutions. Visually, students from treatment group are more likely to choose non-engineering majors and finish their college with non-engineering degrees in six years. However, as shown in Figure 5, choosing first-time ACT score as the running variable will bring fuzziness. Students below the cut-off point can still be treated through retaking ACT exams. A more precise estimate using the fuzzy RD approach is reported in Table 5.

Table 5[1] displays the fuzzy RD estimates with different bandwidths. Column 3 is our preferred regression model. In general, there is no significant positive effect among all four dependent variables. Moreover, negative effects on engineering major choice and degree completion are more significant while the effects on broader STEM subjects are not obvious, which is correspondent to Figure 6. in summary, receiving the merit aid will reduce the probability of choosing engineering major by 17.6% and completing engineering degree by 17.1%.

Alternative Functional Forms

In a parametric regression discontinuity design, the functional form of the relationship between outcome and running variable is also very important for valid estimates. Improper functional form can result in biased estimated effect of the treatment because of incorrect estimate of the counterfactual (Lee & Lemieux, 2010).

Table 6 reports estimations of the treatment effect and alternative functional forms for the relationship between major choice and ACT score. Our preferred model is Column 2. Column 1 and Column 3 present estimates with a linear function while Column 1 has slop restrictions before and after the cut-off. Column 2 and Column 4 present estimates with a quadratic function while Column 3 has slop restrictions before and after the cut-off. Generally, for all models presented, no significant positive effect is found. The effects on STEM outcomes, including STEM major choice and degree completion, are still negative

[1] In this paper, we only report robust standard errors instead of errors clustered by ACT. As Kolesár and Rothe (2018) point out recently, if the running variable is discrete, the commonly used confidence intervals based on standard errors that are clustered by the running variable have poor coverage properties. We believe our running variable with a quarter point is more “continuous” and has richer support than the rounded ACT used in previous papers (Harrington et al., 2016; Zhang et al., 2016). Hence, as suggested, we use a smaller bandwidth (about ± 2.375) with the robust standard error to make statistical inference.

but insignificant among all four models. For engineering outcomes, the coefficients of treatment in linear models are negative but insignificant. In quadratic models, the negative effect exists but not very significant. Visually, it is hard to choose a linear or quadratic model for a better fit. Besides, the fuzziness of the treatment also makes it more difficult to do a visual examination. Considering the flexibility of a quadratic model, we prefer the results in Column 2. As a conclusion, we believe that the financial aid has a general negative treatment effect on every outcome while it may have weak significant effect on engineering major choice and degree completion.

Robust Check for Covariates

Under the assumptions of the regression discontinuity, the covariates should be very similar around the cut-off point. We should not expect to see any jumps of other covariates at the cut-off point. Hence, we re-estimate the control variables as dependent variables using the same quadratic model in Table 5. Table 7 reports the fuzzy regression discontinuity estimates of receiving financial aid on control variables. Most control variables have no significant jump around cut-off point.

Discussion

Previous results implies that the merit-based financial aid has no positive effect on STEM/engineering major choice or degree completion. Students are not financially motivated to choose more expensive STEM/engineering majors. Besides our overall effect, policymakers or state agencies are more likely interested in some specific topics. As supplementary, we additionally evaluate the impact of the Bright Flight Scholarship in the following three aspects: differential effect by gender, public institution choice, and extensive margin.

Differential Effect by Gender

As noted by Griffith (2010) and Price (2010), female students are less engaged in STEM/engineering majors. It may be an alternative option to use merit-based financial aid to encourage female students to choose STEM/engineering majors. Similar to previous procedures, Figure 7 & 8 and Table 8 report the fuzzy RD results based on subsamples grouped by gender. Interestingly, the financial aid may have different effects on female and male students. Though it is not significant, the financial aid may have a positive effect on female students' STEM/engineering major choice and degree completion. Oppositely, the aid has a significant negative effect on male students' STEM/engineering major choice and degree completion, which probably contribute the most part of negative effects reported in Table 5.

Public Institution Choice

The previous analysis does not include the potential effect of financial aid on public institution choice. There are three selective public universities in Missouri, the University of Missouri-Columbia (UMC), Missouri University of Science and Technology (UMR), and Truman State University (Truman). Many Bright Flight recipients are enrolled in these three institutions. Noticed that the University of Missouri-Columbia and Missouri University of Science are the two biggest STEM/engineering providers in Missouri, receiving financial aid may encourage students to choose a different public institution, which finally impacts student's major choice due to the STEM/engineering availability. For example, Truman State University has an institutional competitive scholarship that awards students with Top 3% ACT score[2], which has a similar target group to Bright Flight recipients. If students choose Truman State University, they are more likely to choose non-engineering majors because of the programs that Truman State University can provide.

[2] See https://www.truman.edu/admission-cost/cost-aid/scholarships/competitive-scholarships/. However, the recent website implies that this scholarship only has twelve awards annually and we believe it may have little impacts on our previous analysis.

Those merit aids may create biased estimates of the Bright Flight Scholarship. To exam that, Table 9 reports the fuzzy RD estimates of the treatment effect on public institution choice. Though the estimates are not statistically significant, we still notice that receiving financial aid may encourage students to choose Truman State University instead of Missouri University of Science and Technology.

Extensive Margin

Besides the shifting in the proportion of STEM/engineering majors, producing more STEM/engineering graduates to meet the needs of the labor market is also crucial for policymakers. Even the proportion of STEM/engineering majors is decreasing, if the total enrollment increases because of the financial aid, it may still help the State government to produce more STEM/engineering graduates.

In our analytic sample, as mentioned, we have a focus on intensive margin instead of extensive margin. Only students who have already enrolled in Missouri public 4-year institutions are included. As a potential limitation, this restricted sample may result in a selection bias. Receiving financial aids can increase enrollment in public institutions (Zhang et al., 2016). Hence, we use all Missouri ACT takers to estimate whether the financial aid increases total enrollment in Missouri public 4-year institutions. Table 10 reports the estimates of extensive margin. The treatment effect is more positively significant with a larger bandwidth. Considering the negative coefficients in Table 5, the aggregated effect of intensive and extensive margins may still be unclear or insignificant, which means the financial aid could have no impact on producing more STEM/engineering graduates.

Conclusion

Our empirical result is similar to Sjoquist and Winters (2015a), the Bright Flight financial aid has no positive effect on STEM/engineering major choice or degree completion. Specifically, male students are more likely to be negatively impacted by the merit aid in choosing STEM/engineering majors. As Sjoquist and Winters (2015a) argued, the mechanism beyond merit-based financial aid and major choice is still unclear. Proper qualitative research is needed to explore the mechanism in detail.

Here are some caveats of our empirical results. First, our analytic sample is restricted and the estimates only measure the local treatment effect. Unlike merit aids in Georgia and Florida, the Missouri Bright Flight program is a highly targeted program, with a focus on top-ranked students. Usually, top-ranked students are probably from families with higher social economic status. These students often have clear career plans and their decisions of major choice may not be impacted by financial cost. They probably prefer majors they are interested in instead of considering too much about future income, cost of attendance, course difficulties, etc. Hence, the merit-based financial aid may have weak impacts on major choice. Second, since the extensive margin above is positive, the majority of the Bright Flight recipients are in public institutions, and the amount of financial aid is small, we believe that receiving financial aid may not specifically motivate students to enroll in Missouri private institutions. However, we cannot estimate the intensive margin in private institutions. The financial aid may have a different impact on students enrolled in private institutions. Third, compared to claiming a specific major, enrolled credits are more directly related to students' financial cost. Students, especially freshmen, can enroll as engineering students but choose less expensive non-engineering courses. Due to the data limitation, we cannot examine the effect of financial aid on students' course taken behaviors, which could be a better proxy that directly associated with the cost of attendance.

References

Andrews, R. & Stange, K. (2016). *Price regulation, price discrimination, and equality of opportunity in higher education: Evidence from Texas*, National Bureau of Economic Research. doi:10.3386/w22901

Calonico, S., Cattaneo, M. D., & Titiunik, R. (2014). Robust nonparametric confidence intervals for regression-discontinuity designs. *Econometrica*, *82*(6), 2295–2326. doi:10.3982/ECTA11757

Castleman, B. L., Long, B. T., & Mabel, Z. (2018). Can financial aid help to address the growing need for STEM education? The effects of need-based grants on the completion of science, technology, engineering, and math courses and degrees. *Journal of Policy Analysis and Management*, *37*(1), 136–166. doi:10.1002/pam.22039

Cornwell, C., Lee, K. H., & Mustard, D. B. (2006). *The effects of state-sponsored merit scholarships on course selection and major choice in college*. Retrieved from https://www.econstor.eu/bitstream/10419/33322/1/507466136.pdf

Cornwell, C., Mustard, D. B., & Sridhar, D. J. (2006). The enrollment effects of merit-based financial aid: Evidence from Georgia's HOPE Program. *Journal of Labor Economics*, *24*(4). Retrieved from http://www.journals.uchicago.edu/t-and-c

Denning, J. T. & Turley, P. (2017). Was that SMART? Institutional financial incentives and field of study. *Journal of Human Resources*, *52*(1), 152–186. doi:10.3368/jhr.52.1.0414-6340R1

DHE financial assistance and outreach. (2010). Missouri Department of Higher Education. Retrieved from https://dhe.mo.gov/files/research/statsum/table23_25_0910.pdf

Dynarski, S. (2002). *The consequences of merit aid*. Retrieved from http://www.nber.org/papers/w9400

Ehrenberg, R. G. (2011). *2011 survey of differential tuition at public higher education institutions*. Retrieved from https://www.ilr.cornell.edu/sites/ilr.cornell.edu/files/

2011%20Survey%20of%20Differential%20Tuition%20at%20Public%20Higher%20Education%20Institutions.pdf

Evans, B. J. (2017). SMART Money: Do Financial Incentives Encourage College Students to Study Science? *Education Finance and Policy*, *12*(3), 342–368. Retrieved from http://www.mitpressjournals.org/doi/abs/10.1162/EDFP_a_00199

Fayer, S., Lacey, A., & Watson, A. (2017). *STEM occupations: Past, present, and future.* U.S. Department of Labor, Bureau of Labor Statistics. Washington, DC. Retrieved from https://www.bls.gov/spotlight/2017/science-technology-engineering-and-mathematics-stem-occupations-past-present-and-future/pdf/science-technology-engineering-and-mathematics-stem-occupations-past-present-and-future.pdf

Griffith, A. L. (2010). Persistence of women and minorities in STEM field majors: Is it the school that matters? *Economics of Education Review*, *29*(6), 911–922. doi:10.1016/j.econedurev.2010.06.010

Harrington, J. R., Muñoz, J., Curs, B. R., & Ehlert, M. (2016). Examining the impact of a highly targeted state administered merit aid program on brain drain: Evidence from a regression discontinuity analysis of Missouri's Bright Flight program. *Research in Higher Education*, *57*, 423–447. doi:10.1007/s11162-015-9392-9

Heller, D. E. & Marin, P. (2004). *State merit scholarship programs and racial inequality.* Harvard University. Cambridge, MA. Retrieved from http://www.civilrightsproject.harvard.edu

How much does it cost institutions to produce STEM degrees? (2013). American Institutes for Research DATA. Ithaca, NY. Retrieved from https://deltacostproject.org/sites/default/files/products/Cost%20to%20Institutions%20of%20STEM%20Degrees.pdf

Imbens, G. W. & Kalyanaraman, K. (2012). Optimal bandwidth choice for the regression discontinuity estimator. *The Review of Economic Studies*, *79*(3), 933–959. doi:10.1017/CBO9781107415324.004

Kolesár, M. & Rothe, C. (2018). Inference in regression discontinuity designs with a discrete running variable. *American Economic Review*, *108*(8), 2277–2304. doi:10.1257/aer.20160945

Lee, D. S. & Lemieux, T. (2010). Regression discontinuity designs in economics. *Journal of Economic Literature*, *48*(2), 281–355. doi:10.1257/jel.48.2.281

McCrary, J. (2008). Manipulation of the running variable in the regression discontinuity design: A density test. *Journal of Econometrics*, *142*(2), 698–714. doi:10.1016/j.jeconom.2007.05.005

Price, J. (2010). The effect of instructor race and gender on student persistence in STEM fields. *Economics of Education Review*, *29*(6), 901–910. doi:10.1016/J.ECONEDUREV.2010.07.009

Rothstein, J. & Rouse, C. E. (2011). Constrained after college: Student loans and early-career occupational choices. *Journal of Public Economics*, *95*(1-2), 149–163. doi:10.1016/j.jpubeco.2010.09.015

Singell, L. D., Waddell, G. R., & Curs, B. R. (2006). HOPE for the Pell? Institutional effects in the intersection of merit-based and need-based aid. *Southern Economic Journal*, *73*(1), 79–99. doi:10.2307/20111875

Sjoquist, D. L. & Winters, J. V. (2015a). State merit aid programs and college major: A focus on STEM. *Journal of Labor Economics*, *33*(4), 973–1006. doi:10.1086/681108

Sjoquist, D. L. & Winters, J. V. (2015b). The effect of Georgia's HOPE scholarship on college major: a focus on STEM. *IZA Journal of Labor Economics*, *4*(1), 15. doi:10.1186/s40172-015-0032-6

Stange, K. (2015). Differential pricing in undergraduate education: Effects on degree production by field. *Journal of Policy Analysis and Management*, *34*(1), 107–135. doi:10.1002/pam.21803

Stater, M. (2011). Financial aid, student background, and the choice of first-year college major. *Eastern Economic Journal*, *37*(3), 321–343. doi:10.1057/eej.2009.41

University of Missouri System tuition rates (FY06-07). (2006). Retrieved from https://www.umsystem.edu/media/fa/budget/2007educfees.pdf

Wang, X. (2013). Why students choose STEM majors: Motivation, high school learning, and postsecondary context of support. *American Educational Research Journal*, *50*(5), 1081–1121. doi:10.3102/0002831213488622

Zhang, L. (2011). Does merit-based aid affect degree production in STEM fields? Evidence from Georgia and Florida. *The Journal of Higher Education*, *82*(4), 389–415. doi:10.1353/jhe.2011.0024

Zhang, L., Hu, S., Sun, L., & Pu, S. (2016). The effect of Florida's Bright Futures program on college choice: A regression discontinuity approach. *The Journal of Higher Education*, *87*(1), 115–146. doi:10.1353/jhe.2016.0003

Zhang, L. & Ness, E. C. (2010). Does State Merit-Based Aid Stem Brain Drain? *Educational Evaluation and Policy Analysis*, *32*(2), 143–165. doi:10.3102/0162373709359683

Table 1
Data construction

Sample	Total	Lost
First-time, degree-seeking students from Missouri 4-yr public institutions	148,654	
With historical ACT data matched	142,899	-5,755
With high school course taken and high school class rank	129,565	-13,334

Table 2
STEM and Engineering CIP codes

STEM	Engineering	CIP
Agricultural & animal science		010308; 010901; 010902; 010903; 010904; 010905; 010906; 010907; 010999; 011001; 011002; 011099; 011101; 011102; 011103; 011104; 011105; 011106; 011199; 011201; 011202; 011203; 011299;
Natural resource		030101; 030103; 030104; 030199; 030205; 030502; 030508; 030509;
Computer Science	X	CIP begins with 11
Engineering	X	CIP begins with 14
Technology	X	CIP begins with 15
Biological science		CIP begins with 26
Mathematics		CIP begins with 27
Military/security science		280501; 280502; 280505; 290201; 290202; 290203; 290204; 290205; 290206; 290207; 290299; 290301; 290302; 290303; 290304; 290305; 290306; 290307; 290399; 290401; 290402; 290403; 290404; 290405; 290406; 290407; 290408; 290409; 290499; 299999; 430106; 430116;
Physical science		CIP begins with 40
Psychology		422701; 422702; 422703; 422704; 422705; 422706; 422707; 422708; 422709; 422799;
Business and social science		450301; 450603; 450702; 521301; 521302; 521304; 521399;
Health science		511002; 511005; 511401; 512003; 512004; 512005; 512006; 512007; 512009; 512010; 512202; 512205; 512502; 512503; 512504; 512505; 512506; 512510; 512511; 512706;
Other STEM		040902; 090702; 100304; 130501; 130601; 130603; 300101; 300601; 300801; 301001; 301701; 301801; 301901; 302501; 302701; 303001; 303101; 303201; 303301; 410000; 410101; 410204; 410205; 410299; 410301; 410303; 410399; 419999; 490101;

Table 3
Descriptive statistics

	All sample		ACT27-31.75	
	Mean	SD	Mean	SD
Engineering major	0.11	0.31	0.21	0.41
STEM major	0.21	0.41	0.37	0.48
Major unclaimed	0.18	0.39	0.12	0.32
Engineering degree in 6 year	0.06	0.24	0.14	0.35
STEM degree in 6 year	0.12	0.32	0.26	0.44
Bright Flight recipient	0.11	0.32	0.66	0.47
Race & Gender				
Black	0.07	0.26	0.01	0.09
Hispanic	0.01	0.12	0.01	0.11
Asian	0.02	0.14	0.02	0.15
Others	0.03	0.17	0.04	0.19
Female	0.55	0.50	0.46	0.50
HS performance				
Math course taken	3.93	1.51	4.74	1.82
Science course taken	3.37	1.75	4.27	2.14
HS class rank	73.42	81.52	40.92	58.16
Family income				
Income Missing	0.16	0.36	0.17	0.37
Income zero	0.05	0.21	0.03	0.16
Less than $24,000	0.05	0.21	0.03	0.18
$24,000 to $36,000	0.05	0.23	0.04	0.20
$36,000 to $50,000	0.06	0.24	0.05	0.23
$50,000 to $60,000	0.07	0.26	0.07	0.25
$60,000 to $80,000	0.09	0.29	0.09	0.29
$80,000 to $100,000	0.11	0.31	0.11	0.31
$100,000 to $120,000	0.15	0.36	0.17	0.37
$120,000 to $150,000	0.10	0.30	0.11	0.31
Greater than $150,000	0.11	0.31	0.13	0.34
Observation	129,565		14,821	

Note: The ACT here is the first-time score.

Table 4
Sample Comparison

	ACT27-31.75		T-value
	Below (<29.5)	Above (>29.5)	
Engineering major	0.198	0.247	-6.50
STEM major	0.352	0.422	-7.81
Major unclaimed	0.123	0.101	3.64
Engineering degree in 6 year	0.129	0.168	-6.09
STEM degree in 6 year	0.237	0.304	-8.37
Bright Flight recipient	0.552	0.960	-50.91
Race & Gender			
Black	0.009	0.005	2.57
Hispanic	0.012	0.010	1.35
Asian	0.021	0.022	-0.40
Others	0.036	0.045	-2.50
Female	0.473	0.419	5.88
HS performance			
Math course taken	4.664	4.957	-8.75
Science course taken	4.179	4.516	-8.58
HS class rank	43.075	35.254	7.33
Family income			
Income Missing	0.163	0.181	-2.48
Income zero	0.027	0.024	0.82
Less than $24,000	0.034	0.031	0.83
$24,000 to $36,000	0.043	0.040	0.65
$36,000 to $50,000	0.054	0.054	0.05
$50,000 to $60,000	0.069	0.059	2.11
$60,000 to $80,000	0.092	0.090	0.45
$80,000 to $100,000	0.110	0.104	0.99
$100,000 to $120,000	0.168	0.169	-0.25
$120,000 to $150,000	0.113	0.104	1.49
Greater than $150,000	0.128	0.144	-2.44
Observation	10,738	4,083	

Note: The ACT here is the first-time score.

Table 5

Fuzzy RD Estimates with Different Bandwidth

	(1) ACT 24.5-34.25	(2) ACT 25.75-33	(3) ACT 27-31.75*	(4) ACT 28.25-30.5
First stage (Y=receiving Bright Flight)				
BF_eligibility_FT	0.177***	0.165***	0.149***	0.159***
	(0.008)	(0.009)	(0.011)	(0.016)
ACT_FT	0.729***	1.296***	2.103***	4.216***
	(0.019)	(0.035)	(0.093)	(0.540)
ACT_FT(sq)	-0.011***	-0.021***	-0.034***	-0.071***
	(0.000)	(0.001)	(0.002)	(0.009)
Control variables	X	X	X	X
N	35,169	24,079	14,821	6,927
R-squared	0.405	0.332	0.254	0.168
F-test	2029	848.6	265.6	50.78
p-value	0	0	0	0
Second stage (Y=engineering major choice)				
Receiving BF	-0.111*	-0.126*	-0.176*	-0.197
	(0.066)	(0.075)	(0.097)	(0.127)
ACT_FT	0.019	0.106	0.191	0.711
	(0.039)	(0.086)	(0.202)	(0.782)
ACT_FT(sq)	0.000	-0.001	-0.003	-0.011
	(0.001)	(0.001)	(0.003)	(0.013)
Control variables	X	X	X	X
N	35,169	24,079	14,821	6,927
R-squared	0.091	0.081	0.067	0.075
Second stage (Y=STEM major choice)				
Receiving BF	-0.085	-0.106	-0.099	-0.159
	(0.077)	(0.088)	(0.114)	(0.150)
ACT_FT	0.020	0.061	0.023	0.445
	(0.046)	(0.102)	(0.237)	(0.921)
ACT_FT(sq)	0.000	-0.000	0.000	-0.007
	(0.001)	(0.002)	(0.004)	(0.015)
Control variables	X	X	X	X
N	35,169	24,079	14,821	6,927
R-squared	0.083	0.070	0.075	0.059
Second stage (Y=engineering degree completion in 6 years)				
Receiving BF	-0.119**	-0.130*	-0.171**	-0.134
	(0.058)	(0.066)	(0.084)	(0.109)
ACT_FT	0.010	0.093	0.223	0.057
	(0.034)	(0.074)	(0.176)	(0.683)
ACT_FT(sq)	0.000	-0.001	-0.003	-0.001
	(0.001)	(0.001)	(0.003)	(0.011)
Control variables	X	X	X	X
N	35,169	24,079	14,821	6,927
R-squared	0.040	0.032	0.015	0.050
Second stage (Y=STEM degree completion in 6 years)				
Receiving BF	-0.106	-0.117	-0.141	-0.117
	(0.071)	(0.082)	(0.104)	(0.136)
ACT_FT	-0.016	0.072	-0.026	-0.172
	(0.042)	(0.093)	(0.217)	(0.833)
ACT_FT(sq)	0.001	-0.001	0.001	0.004
	(0.001)	(0.001)	(0.004)	(0.014)
Control variables	X	X	X	X
N	35,169	24,079	14,821	6,927
R-squared	0.053	0.045	0.038	0.056

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.10$

Table 6

Fuzzy RD Estimates with Different Function Forms

	(1) Linear1	(2) Quadratic1*	(3) Linear2	(4) Quadratic2
Second stage (Y=engineering major choice)				
Receiving BF	-0.254	-0.176*	0.382	-41.142*
	(0.190)	(0.097)	(0.514)	(21.246)
ACT_FT	0.055*	0.191	0.049**	-3.075
	(0.029)	(0.202)	(0.022)	(2.150)
ACT_FT(sq)		-0.003		0.056
		(0.003)		(0.039)
BF* ACT_FT			-0.018	2.981*
			(0.019)	(1.574)
BF* ACT_FT(sq)				-0.054*
				(0.029)
Control variables	X	X	X	X
N	14,821	14,821	14,821	14,821
R-squared	0.024	0.067	0.091	0.088
Second stage (Y=STEM major choice)				
Receiving BF	-0.093	-0.099	-0.077	-21.400
	(0.220)	(0.114)	(0.606)	(24.912)
ACT_FT	0.034	0.023	0.034	-1.802
	(0.033)	(0.237)	(0.026)	(2.479)
ACT_FT(sq)		0.000		0.033
		(0.004)		(0.045)
BF* ACT_FT			-0.000	1.563
			(0.023)	(1.842)
BF* ACT_FT(sq)				-0.029
				(0.034)
Control variables	X	X	X	X
N	14,821	14,821	14,821	14,821
R-squared	0.076	0.075	0.077	0.089
Second stage (Y=engineering degree completion in 6 years)				
Receiving BF	-0.269	-0.171**	0.443	-22.845
	(0.167)	(0.084)	(0.449)	(18.781)
ACT_FT	0.053**	0.223	0.046**	-1.360
	(0.025)	(0.176)	(0.019)	(1.900)
ACT_FT(sq)		-0.003		0.025
		(0.003)		(0.034)
BF* ACT_FT			-0.020	1.627
			(0.017)	(1.391)
BF* ACT_FT(sq)				-0.029
				(0.026)
Control variables	X	X	X	X
N	14,821	14,821	14,821	14,821
R-squared		0.015	0.046	0.012
Second stage (Y=STEM degree completion in 6 years)				
Receiving BF	-0.106	-0.141	-0.340	-0.390
	(0.200)	(0.104)	(0.559)	(23.029)
ACT_FT	0.036	-0.026	0.038	-0.134
	(0.030)	(0.217)	(0.024)	(2.299)
ACT_FT(sq)		0.001		0.003
		(0.004)		(0.041)
BF* ACT_FT			0.007	0.027
			(0.021)	(1.703)
BF* ACT_FT(sq)				-0.001
				(0.031)
Control variables	X	X	X	X
N	14,821	14,821	14,821	14,821
R-squared	0.052	0.038	0.031	0.046

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

Table 7
Treatment Effect on Control Variables

	(1) ACT 24.5-34.25	(2) ACT 25.75-33	(3) ACT 27-31.75*	(4) ACT 28.25-30.5
Black	-0.001	-0.000	-0.005	0.008
	(0.014)	(0.016)	(0.021)	(0.027)
Hispanic	-0.022	-0.019	0.004	-0.013
	(0.018)	(0.021)	(0.025)	(0.031)
Asian	-0.028	-0.040	-0.058*	-0.065
	(0.023)	(0.026)	(0.032)	(0.041)
Others	-0.014	-0.022	-0.045	-0.090
	(0.033)	(0.038)	(0.048)	(0.062)
Female	-0.045	-0.082	-0.151	-0.191
	(0.080)	(0.092)	(0.118)	(0.154)
Math course taken	0.399	0.250	0.582	0.155
	(0.301)	(0.352)	(0.440)	(0.572)
Science course taken	0.417	0.349	0.820	0.621
	(0.352)	(0.410)	(0.515)	(0.668)
HS class rank	0.539	2.395	3.211	1.537
	(9.070)	(10.356)	(13.308)	(17.401)
Income Missing	0.092	0.083	0.031	0.023
	(0.061)	(0.070)	(0.089)	(0.116)
Income zero	0.010	0.004	-0.007	0.001
	(0.025)	(0.029)	(0.038)	(0.049)
Less than $24,000	0.030	0.029	0.014	0.019
	(0.028)	(0.034)	(0.043)	(0.057)
$24,000 to $36,000	-0.009	-0.018	-0.028	-0.082
	(0.032)	(0.036)	(0.046)	(0.058)
$36,000 to $50,000	0.013	0.014	0.019	0.057
	(0.037)	(0.042)	(0.053)	(0.068)
$50,000 to $60,000	-0.074*	-0.051	-0.062	-0.056
	(0.041)	(0.046)	(0.059)	(0.076)
$60,000 to $80,000	0.003	0.021	0.041	0.108
	(0.047)	(0.054)	(0.069)	(0.090)
$80,000 to $100,000	-0.057	-0.093	-0.083	-0.046
	(0.050)	(0.059)	(0.074)	(0.097)
$100,000 to $120,000	-0.007	-0.008	-0.040	-0.032
	(0.060)	(0.069)	(0.088)	(0.114)
$120,000 to $150,000	-0.031	-0.040	0.012	-0.013
	(0.049)	(0.058)	(0.072)	(0.094)
Greater than $150,000	0.031	0.060	0.103	0.021
	(0.057)	(0.065)	(0.081)	(0.107)

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

Table 8

Fuzzy RD Estimates by Gender

	(1) ACT 24.5-34.25	(2) ACT 25.75-33	(3) ACT 27-31.75*	(4) ACT 28.25-30.5
Second stage (Y=engineering major choice)				
Receiving BF (Female)	0.060	0.009	0.054	0.064
	(0.075)	(0.082)	(0.100)	(0.130)
Receiving BF (Male)	-0.226**	-0.244**	-0.361**	-0.414*
	(0.102)	(0.120)	(0.160)	(0.212)
Second stage (Y=STEM major choice)				
Receiving BF (Female)	0.050	0.056	0.121	0.135
	(0.116)	(0.125)	(0.155)	(0.204)
Receiving BF (Male)	-0.169	-0.243*	-0.280*	-0.420*
	(0.105)	(0.125)	(0.166)	(0.224)
Second stage (Y=engineering degree completion in 6 years)				
Receiving BF (Female)	0.031	-0.012	0.010	-0.017
	(0.065)	(0.071)	(0.085)	(0.108)
Receiving BF (Male)	-0.229**	-0.232**	-0.314**	-0.224
	(0.091)	(0.106)	(0.140)	(0.181)
Second stage (Y=STEM degree completion in 6 years)				
Receiving BF (Female)	0.056	0.082	0.093	0.165
	(0.106)	(0.113)	(0.140)	(0.184)
Receiving BF (Male)	-0.221**	-0.281**	-0.343**	-0.358*
	(0.099)	(0.118)	(0.156)	(0.206)

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.10

Table 9

Treatment Effect on Public Institution Choice

	(1) ACT 24.5-34.25	(2) ACT 25.75-33	(3) ACT 27-31.75*	(4) ACT 28.25-30.5
Truman	0.040	0.026	0.014	0.058
	(0.041)	(0.047)	(0.061)	(0.079)
UMC	0.030	0.073	0.041	-0.012
	(0.079)	(0.090)	(0.116)	(0.152)
UMR	-0.090*	-0.092	-0.095	-0.079
	(0.053)	(0.060)	(0.077)	(0.100)

Robust standard errors in parentheses

*** $p<0.01$, ** $p<0.05$, * $p<0.10$

Table 10
Fuzzy RD Estimates of Extensive Margin

	(1) ACT 24.5-34.25	(2) ACT 25.75-33	(3) ACT 27-31.75*	(4) ACT 28.25-30.5
Receiving BF	0.184***	0.178**	0.060	-0.162
	(0.058)	(0.076)	(0.130)	(0.256)
ACT_FT	0.188***	0.163**	0.146	0.636
	(0.033)	(0.068)	(0.164)	(0.768)
ACT_FT(sq)	-0.004***	-0.003***	-0.003	-0.011
	(0.001)	(0.001)	(0.003)	(0.013)
Control variables	X	X	X	X
N	87,660	59,429	36,442	17,225
R-squared	0.131	0.169	0.083	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.10

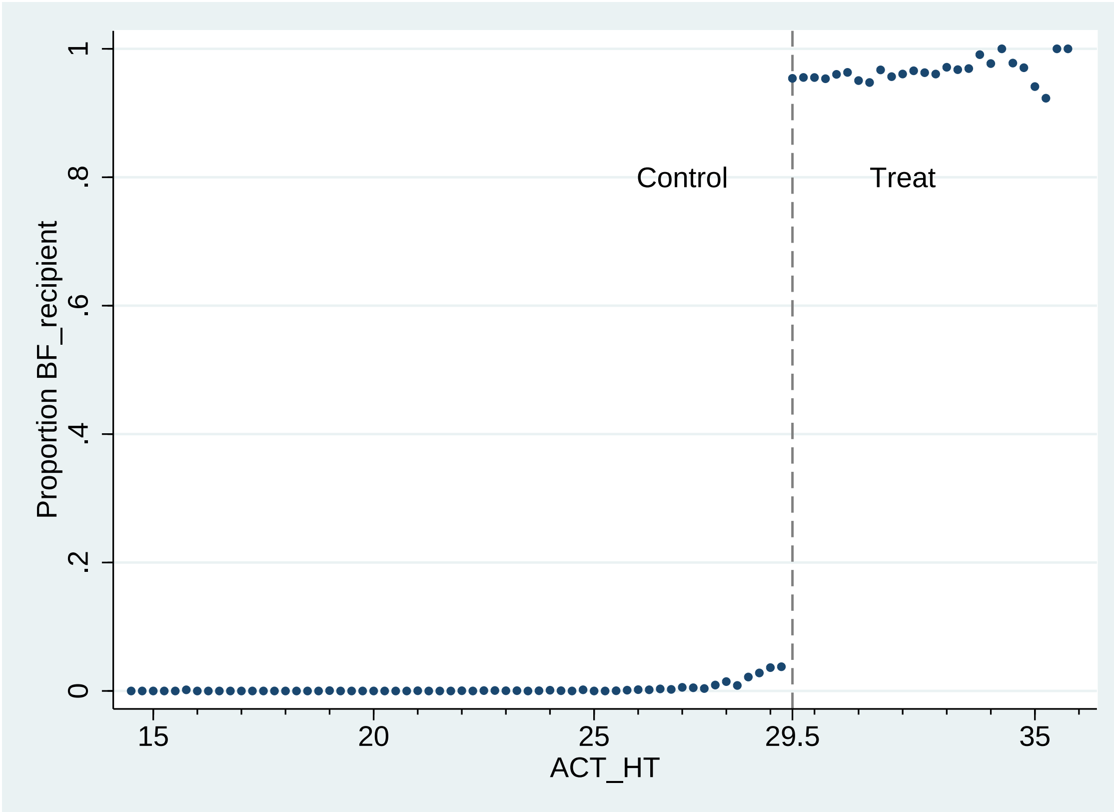

Figure 1. The proportion of Bright Flight recipient by highest ACT composite score

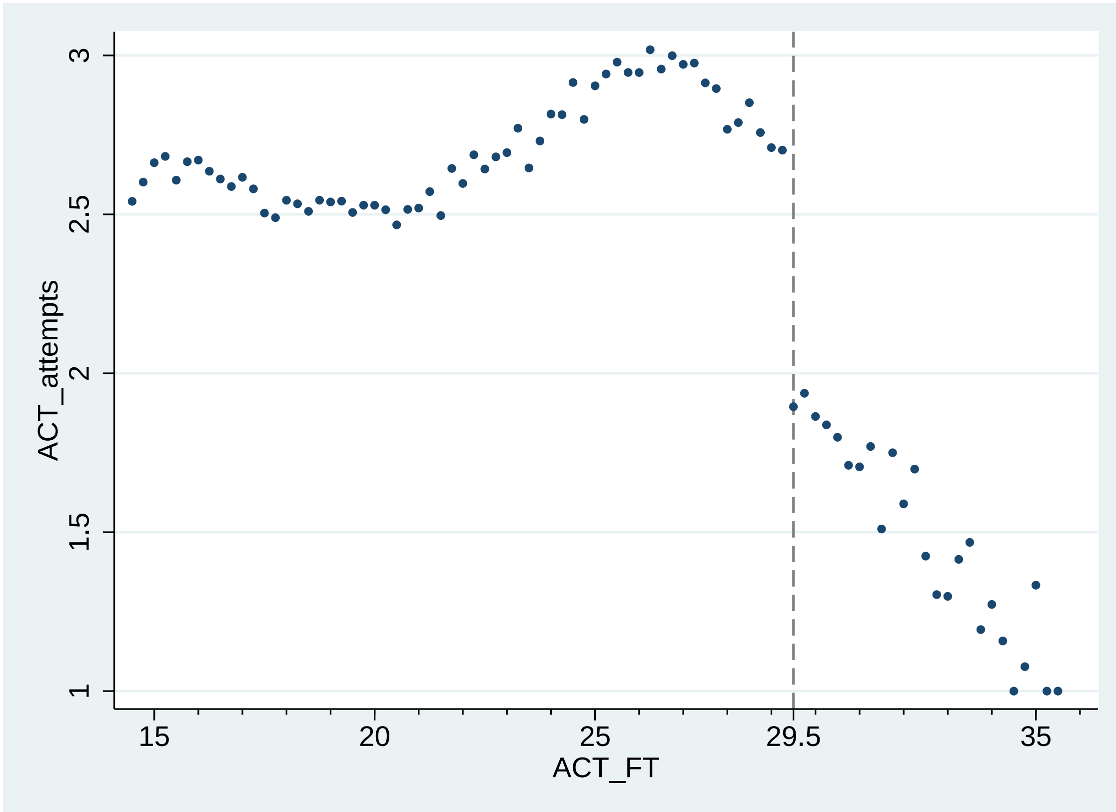

Figure 2. The average number of retakes by first-time ACT composite score

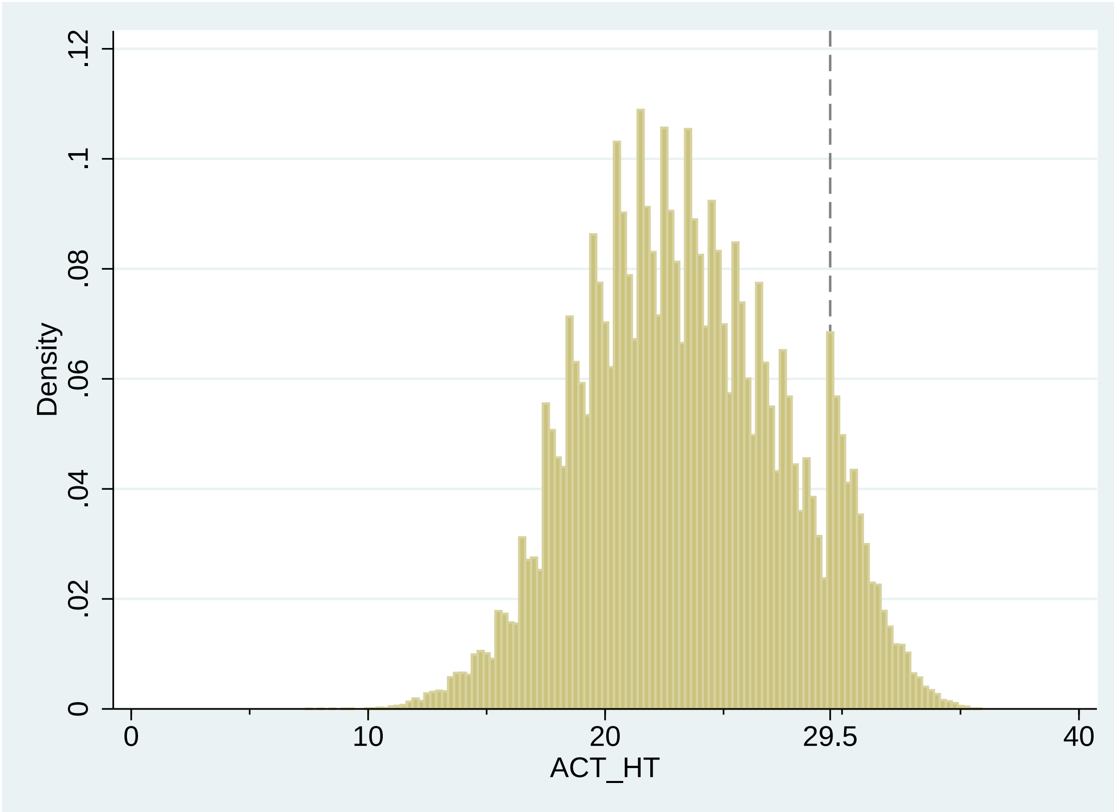

Figure 3. Histogram of highest ACT composite score

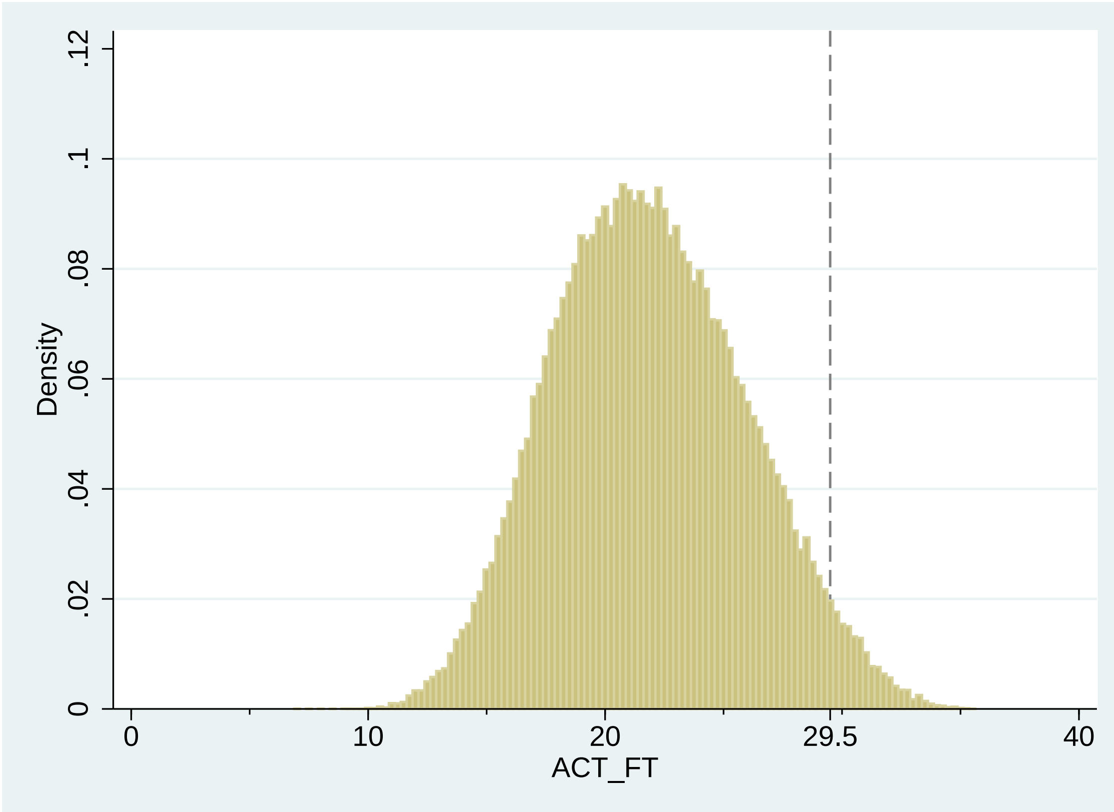

Figure 4. Histogram of first ACT composite score

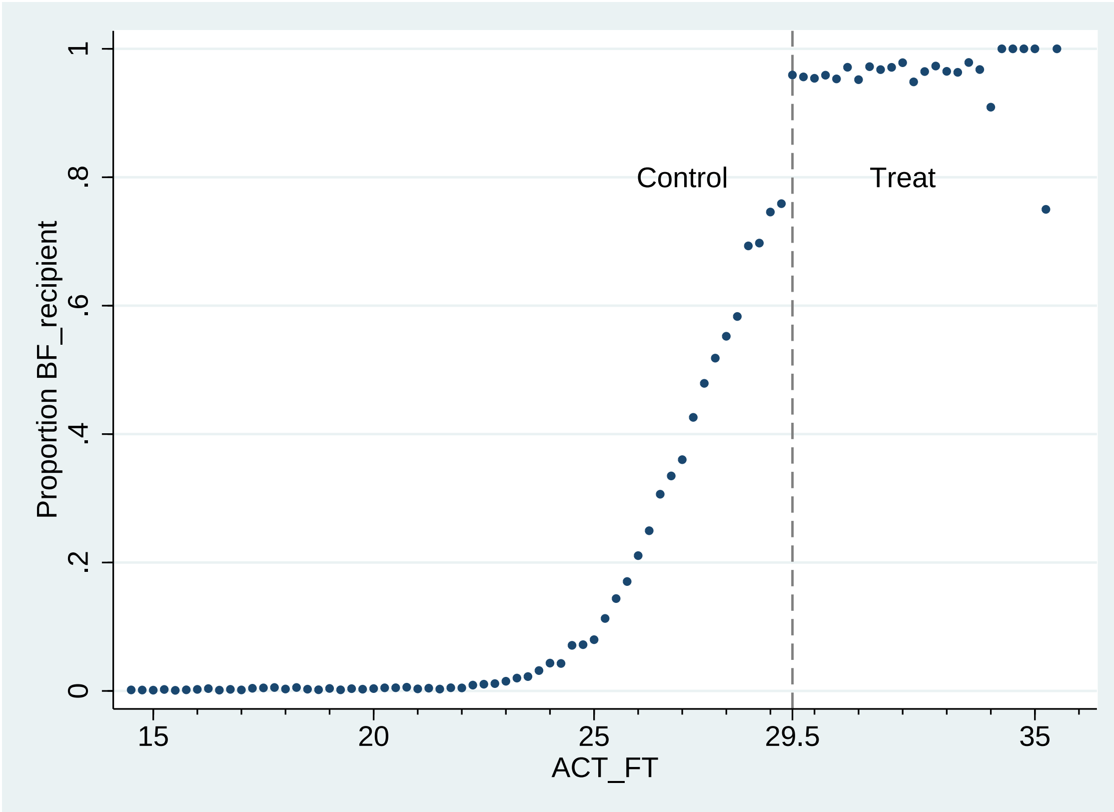

Figure 5. The proportion of Bright Flight recipient by first-time ACT composite score

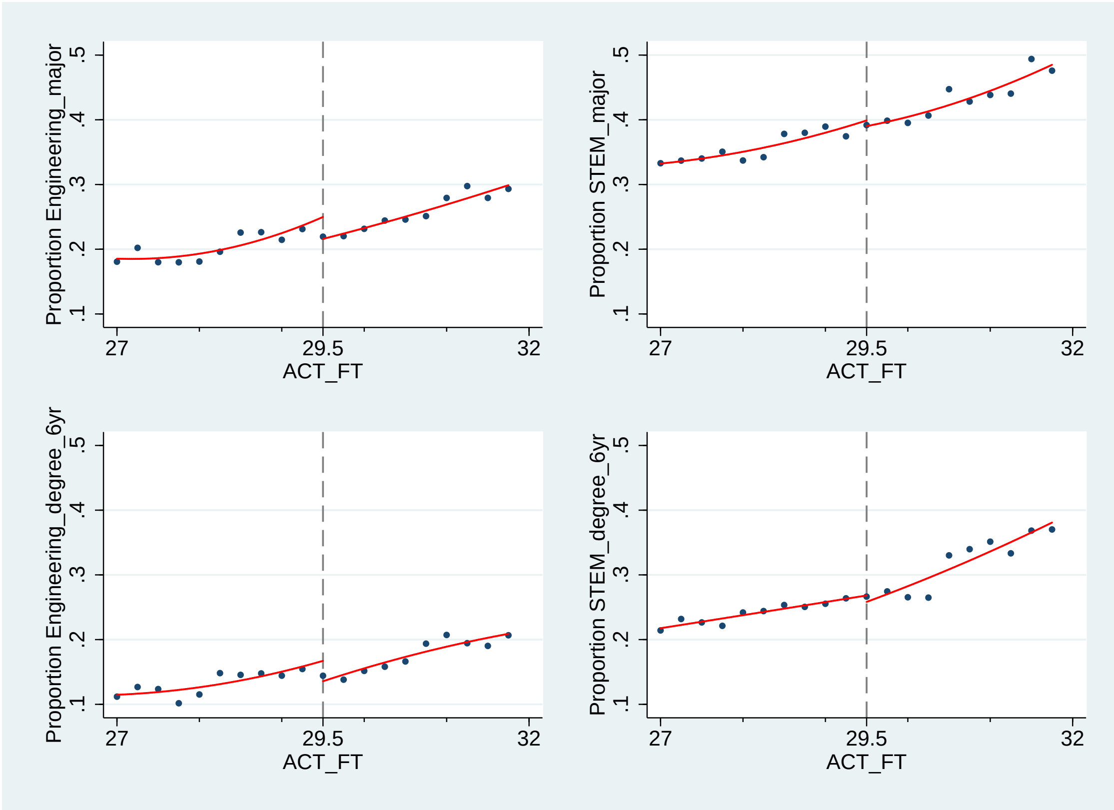

Figure 6. Regression Discontinuity Estimates (quadratic)

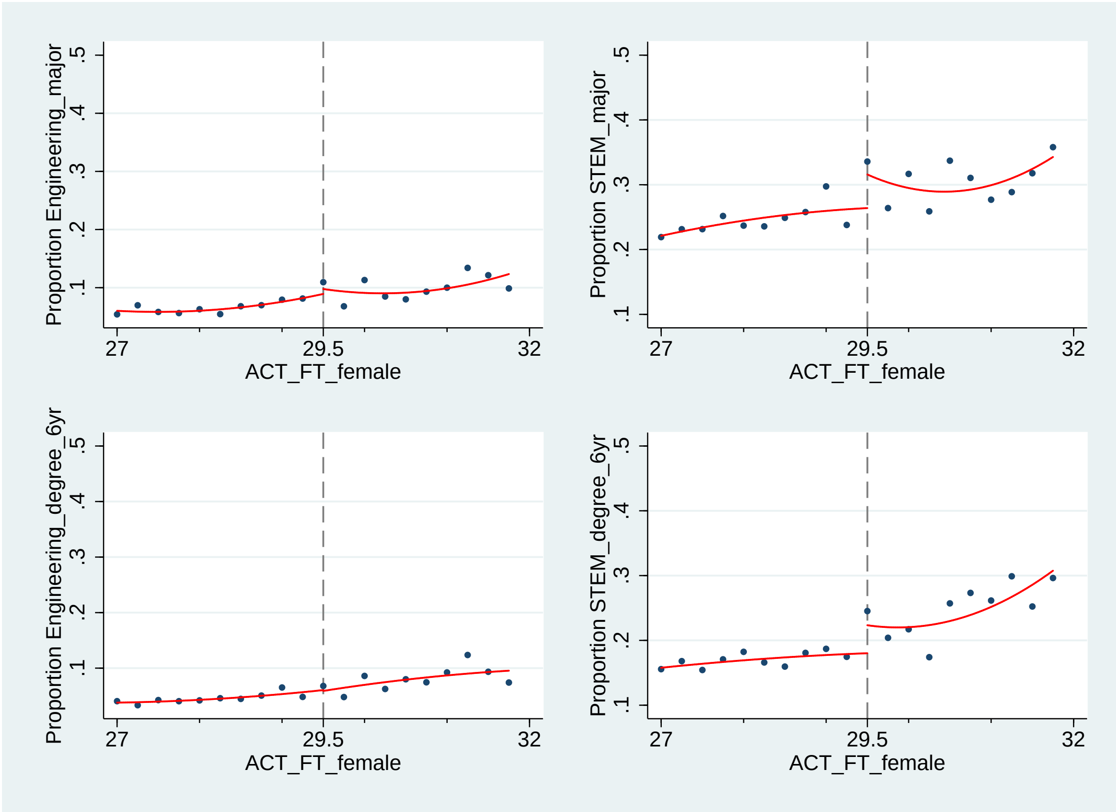

Figure 7. Regression Discontinuity Estimates of Female Students (quadratic)

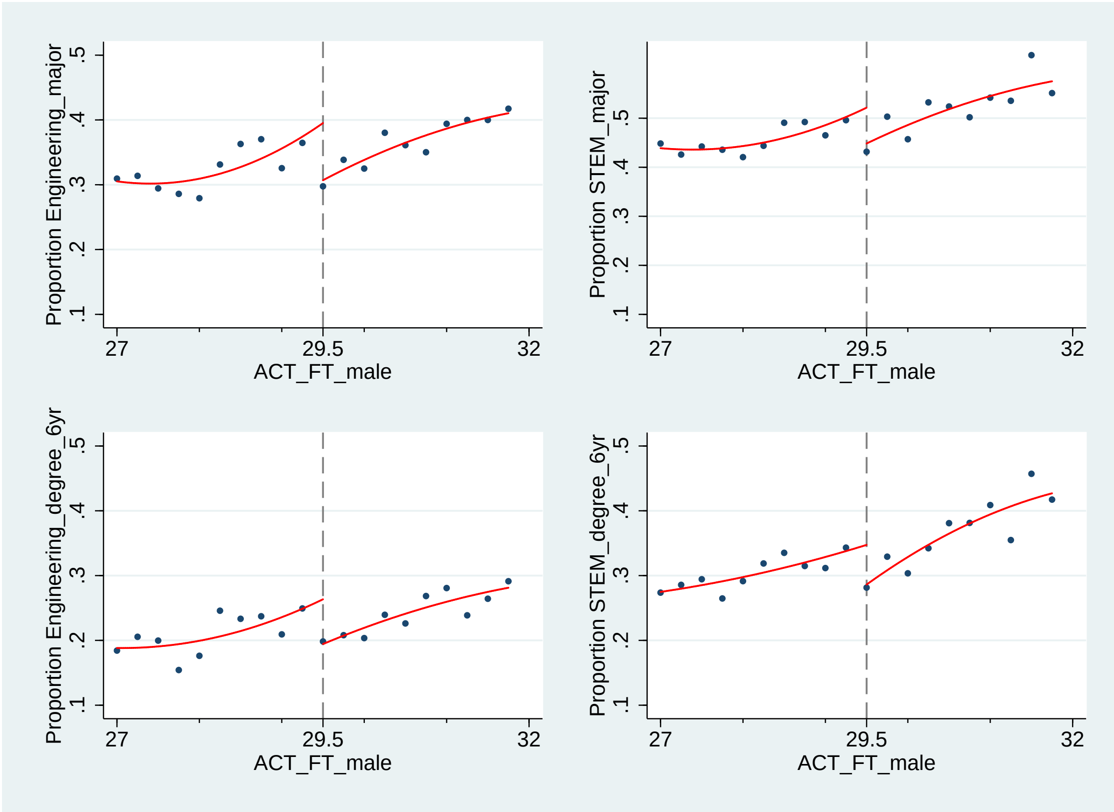

Figure 8. Regression Discontinuity Estimates of Male Students (quadratic)