**Abstract Title Page**
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**Title:** Financial barriers to STEM study in college: Causal effect estimates of need-based grants on the pursuit and completion of courses and degrees in STEM fields.

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## Abstract Body

*Limit 4 pages single-spaced.*

### Background / Context:

*Description of prior research and its intellectual context.*

The fastest growing supply of jobs in the United States today is in Science, Technology, Engineering, and Mathematics (STEM) fields. Yet despite the availability of work in STEM, there is not a sufficient supply of workers to fill open positions. Labor market projections indicate that the country will require one million *additional* STEM professionals over the next decade to retain our global competiveness in science and technology (PCAST, 2012).

While hiring foreign-trained professionals is one facet of a comprehensive investment strategy in the science and technology labor force, to meet current and future employment needs in STEM fields we also need to substantially increase the number of domestic STEM degree-holders. By some projections, the number of students earning undergraduate STEM degrees will need to increase 34 percent annually to fulfill employer demand over the next ten years (PCAST, 2012).

Amidst the growing demand for STEM workers, educational achievement and attainment in STEM fields in the United States are moving in the opposite direction. The achievement of secondary school students in mathematics and science is declining, with less than one-third of U.S. eighth graders now proficient in these subjects; there is a concurrent decline in interest in STEM fields among many middle and high school students (PCAST, 2010). Equally troubling, 60 percent of all college students and more than 75 percent of Black and Latino college students who indicate initial interest in pursuing STEM fields do not persist to the point of earning a STEM degree (PCAST, 2010).

### Purpose / Objective / Research Question / Focus of Study:

*Description of the focus of the research.*

An important policy question to consider is what role, if any, financial barriers play in dissuading students from pursuing or completing college study in STEM disciplines. In this paper we offer new evidence of the impact of need-based financial aid on whether students pursue and complete courses and degrees in STEM fields.

One possibility is that financially-needy high school graduates who have the aptitude and academic record to excel in STEM fields nonetheless fail to pursue postsecondary education because they perceive the cost of college to exceed the benefits. A related possibility is that students with potential to succeed in STEM fields do matriculate, but enroll at lower-cost colleges or universities where there are comparatively fewer or lower-quality STEM programs. Alternatively, students may enroll at colleges well-matched to their abilities or interests, but pursue non-STEM fields if they can complete their degree in a shorter amount of time or if they perceive the financial and psychic costs of completing a non-STEM degree to be lower. Finally, students may anticipate or come to find that they are unable to manage the demands of STEM courses given the hours they need to work to pay for college.

Each of these possibilities suggests that offering students additional need-based financial aid could have a positive impact on pursuing and persisting in STEM fields. Financial aid could reduce costs to the point where students decide to matriculate; induce students to attend institutions with more STEM offerings; encourage students to pursue or persist in STEM rather than a less costly (in terms of dollars or time) major; or limit the number of hours that students need to work, thereby allowing them to devote more time to STEM-related coursework. Research to date on the impact of financial barriers to STEM course selection, completion, and degree attainment has been sparse and inconclusive. In two recent studies, Evans (2013) finds that eligibility for the need-based National SMART Grant program did not impact students' likelihood of pursuing a STEM major, nor improve major persistence for initial STEM concentrators, while Stange (2013) finds that the adoption of differential university pricing policies by major decreased bachelor's degree completion in Engineering fields.

**Setting:**
*Description of the research location.*

Our analysis is based on high school graduates from the State of Florida. Florida offers many advantages as the geographic focus for our analysis. It is the fourth largest state in the country (U.S Census Bureau, 2011). Fourteen of the 100 largest school districts in the 2008-2009 academic year were located in Florida (National Center for Education Statistics, 2010). Florida also represents the increasing racial and ethnic diversity of the country as a whole: 16 percent of its residents are Black, and 23 percent of its residents are of Hispanic or Latino origin (U.S Census Bureau, 2011).

**Population / Participants / Subjects:**
*Description of the participants in the study: who, how many, key features, or characteristics.*

Our analysis focuses on a subset of Florida high school graduates in the 1999-2000 academic year. Of the 101,094 graduates in the State that year, we restricted the analytic sample to include only students who submitted a FAFSA application, since only they were eligible for both federal and state need-based aid. This restriction resulted in the exclusion of 55,309 students from our sample. Our main results are based on a subset of students whose Expected Family Contribution (EFC) falls between \$590 and \$2,590. This yields a sample of 6,921 students who fall within ±\$1,000 of the EFC cut-off which the State of Florida used to determine eligibility for the Florida Student Access Grant, a need-based grant we describe in more detail below.

Because one barrier to collegiate STEM achievement may be that students do not have sufficient academic preparation for those fields coming out of high school, we focus much of our analysis on a subset of the 6,921 students who demonstrate readiness for postsecondary study in STEM disciplines. We proxy for readiness in two ways: first, we condition on students who surpass college-ready math standards on the Florida College Placement Test in Math (CPT-M) or the SAT Math exams. Secondly, we condition the sample on students who completed trigonometry or higher in high school. These restrictions yield sub-samples of 2,834 and 1,283 low-income students, respectively, with higher math achievement among the latter sample (as measured by mean scores on the CPT-M exam). These samples allow us to explore the impact of grant eligibility for different groups of students.

**Intervention / Program / Practice:**
*Description of the intervention, program, or practice, including details of administration and duration.*

We focus on the impact of eligibility for the need-based Florida Student Access Grant (FSAG). In the early 2000s, colleges and universities in Florida determined eligibility for the

FSAG using the federal need analysis calculation. Applying for federal financial aid, and often for state and institutional aid, requires that students complete the Free Application for Federal Student Aid (FAFSA). The FAFSA collects information on family income and assets to determine the Expected Family Contribution (EFC), the amount a family is estimated to pay towards the cost of college.

For the Florida high school graduates in our study, students whose Expected Family Contribution (EFC) was less than or equal to $1,590 were eligible for a $1,300 FSAG award (in 2000 dollars); this roughly translates to families with incomes below $28,000 being eligible for a FSAG award in the 2000-2001 school year. The grant was sufficient to cover 57 percent of the cost of tuition and fees at an average public, four-year university in Florida. These students also qualified for at least a $1,750 Federal Pell Grant. Taken together, the FSAG and Pell awards were enough to pay for at least 28 percent of the average total cost of a four-year university in Florida (including tuition, room and board, and required fees). In contrast, students whose EFCs were just above $1,590 were not eligible for the FSAG but still received a Federal Pell Grant worth up to $1,750.

**Research Design:**

*Description of the research design.*

Exploiting this sharp EFC cut-off used to determine FSAG eligibility, we utilize a regression-discontinuity (RD) approach to estimate the causal effect of aid eligibility on whether students pursued and completed courses and degrees in STEM fields. Through this approach we compare the STEM outcomes for students just below the FSAG cut-off to students just above the eligibility cut-off. As we illustrate in Table 1, students on either side of the EFC cut-off appear equal in expectation on all baseline observable characteristics, differing only in that students just below the cut-off were eligible for an additional $1,300 in need-based aid and those just above the cut-off were not.[1] As a result, we can interpret outcome differences estimated on either side of the FSAG eligibility threshold as the causal effect of FSAG eligibility (Shadish, Cook, & Campbell, 2002; Murnane & Willett, 2010). Importantly, this design provides causal estimates relevant to marginal students around the cutoff who may not generalize to infra-marginal students further from the EFC eligibility threshold.

**Data Collection and Analysis:**

*Description of the methods for collecting and analyzing data.*

The data for this paper are from the Florida Department of Education K-20 Data Warehouse (KDW), which maintains longitudinal student-level records from primary school through postsecondary study at Florida public colleges and universities. We have data from KDW secondary-school records, including demographics, high school transcripts, and college entrance examination scores. These data are linked to KDW postsecondary data which provides the

[1] We reject differences on observables for all samples in a narrow window of the cut-off. When we expand the window to ±$1,000, differences emerge for the sample conditioned on completing trigonometry or higher in high school. Because equivalence is only required right at the cut-off in our RD design, the differences that emerge do not invalidate the causal interpretation of our results. In all models we also include a full set of covariates to account for average differences on either side of the cut-off within the analytic window.

financial information that families supplied when completing the FAFSA and any private, institutional, state, or federal financial-aid disbursements students received while enrolled. The postsecondary data also tracks students' enrollment and course-taking histories and degrees received. We therefore observe semester-by-semester STEM credits attempted and completed and examine credit accumulation over short-, medium-, and long-term intervals. We also observe whether students earned degrees and their field of study at the time of their degree receipt. These three measures – STEM credits attempted, STEM credits completed, and degree receipt in a STEM discipline – are our primary outcomes of interest.

While our data set does not include the postsecondary outcomes of students who attended out-of-state or private institutions, it captures college enrollment and completion records for a considerable majority of college-bound low-income Florida high school seniors. In the 2000-2001 academic year, 90 percent of first-time college students in Florida enrolled at in-state institutions (NCES, 2002). Low-income Florida residents may have been particularly unlikely to attend private or out-of-state colleges given that the average cost of attendance at these institutions was considerably higher than at Florida public colleges and universities.

**Findings / Results:**

*Description of the main findings with specific details.*

We find modest effects of FSAG eligibility on STEM credit completion in the unrestricted sample. Because our sample includes many high school graduates who did not pursue higher education, the absolute magnitude of the coefficients are small (for example, we estimate that FSAG-eligible students earn 1.6 additional STEM credits after three years); however, the magnitude of this estimate is a 22 percent increase relative to the control group, for which the mean number of STEM credits completed is 7.67.

We find larger effects among students in our two sub-samples of students ready for college-level STEM coursework. An FSAG award offer increases STEM course completion by 2.2 credits for students initially placed into college-level math on the basis of their entrance exam score. The largest effects are estimated for students who completed trigonometry or higher in high school. After three years, FSAG-eligible students earned 4.8 additional credits in STEM, representing a 33% increase relative to students just above the aid eligibility cut-off.

We also find small but significant effects with respect to STEM degree attainment. FSAG aid eligibility increased STEM degree attainment by 0.6 percentage points in our overall sample, which corresponds to a 30% increase over the control mean. While our estimates lack sufficient precision to achieve statistical significance in our samples of higher-achieving students, the magnitude of the coefficients suggests even more pronounced impacts on degree attainment for students who demonstrate readiness for postsecondary study in STEM fields.

**Conclusions:**

*Description of conclusions, recommendations, and limitations based on findings.*

Our results suggest that need-based aid has positive effects on STEM credit and degree completion, particularly for students who are ready for college-level STEM coursework at the end of high school. From a policy perspective, increasing the award amounts of current aid programs can play a critical role in addressing the growing mismatch in the United States between the degrees held by college graduates and the demands of employers in the domestic labor market.

## Appendices

*Not included in page count.*

### Appendix A. References

*References are to be in APA version 6 format.*

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## Appendix B. Tables and Figures

*Not included in page count.*

Our tables are attached, beginning on the next page.

**Table 1: Test for Baseline Equivalence around the FSAG Eligibility Cut-Off**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Unrestricted Sample | | College Entrance Score above College Math Placement Cut-Off | | Completed Trigonometry or Higher Math Course | |
| | EFCs window around the FSAG eligibility cut-off | | | | | |
| | ±$250 | ±$1,000 | ±$250 | ±$1,000 | ±$250 | ±$1,000 |
| Female | -0.024 | -0.009 | -0.051* | -0.003 | -0.047 | -0.011 |
| | [0.015] | [0.007] | [0.030] | [0.012] | [0.064] | [0.020] |
| Black | 0.014 | 0.001 | 0.011 | -0.013 | 0.106 | -0.035 |
| | [0.022] | [0.009] | [0.054] | [0.018] | [0.094] | [0.034] |
| Hispanic | 0.027 | -0.003 | -0.007 | -0.001 | 0.026 | -0.016 |
| | [0.025] | [0.011] | [0.046] | [0.018] | [0.100] | [0.036] |
| Other Race | 0.005 | -0.005 | -0.003 | 0.017 | 0.031 | -0.006 |
| | [0.038] | [0.017] | [0.060] | [0.022] | [0.113] | [0.035] |
| Age | 0.001 | 0.001 | 0.021 | 0.002 | -0.004 | -0.004 |
| | [0.015] | [0.006] | [0.035] | [0.011] | [0.070] | [0.020] |
| EFC (centered at FSAG cut-off) | -2.956*** | -0.759*** | -2.868*** | -0.761*** | -3.034*** | -0.771*** |
| | [0.036] | [0.004] | [0.075] | [0.008] | [0.195] | [0.013] |
| Parents' Adjusted Gross Income (AGI) | 0.001 | 0.000 | 0.001 | 0.001** | 0.001 | 0.002** |
| | [0.001] | [0.000] | [0.001] | [0.001] | [0.003] | [0.001] |
| Eligible for Bright Futures Scholarship | -0.020 | -0.006 | -0.037 | -0.011 | -0.082 | -0.053** |
| | [0.017] | [0.008] | [0.034] | [0.012] | [0.079] | [0.022] |
| Enrolled in Gifted/Talented Program | 0.038 | 0.046* | -0.023 | 0.032 | 0.065 | 0.008 |
| | [0.045] | [0.024] | [0.085] | [0.030] | [0.144] | [0.046] |
| High School Senior Year GPA | 0.014 | 0.006 | 0.040* | 0.016 | 0.033 | 0.050*** |
| | [0.012] | [0.005] | [0.024] | [0.010] | [0.074] | [0.019] |
| Observations | 1,758 | 6,921 | 739 | 2,834 | 346 | 1,283 |
| R-squared | 0.808 | 0.766 | 0.839 | 0.779 | 0.892 | 0.809 |
| P-value on F-test for Joint Significance | 0.556 | 0.512 | 0.563 | 0.375 | 0.959 | 0.031 |

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

Notes: Robust standard errors, clustered at the high school level, are shown in brackets. All models also include school fixed effects and a constant. The F-test for joint significance tests whether the explanatory variables in the model, excluding EFC, jointly explain variation in whether students were just above or below the FSAG cut-off.

**Table 2: The Effect of FSAG Eligibility on Cumulative STEM Credits Attempted and Completed, Full Sample (N = 6,921)**

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | Through Year 1 | | Through Year 3 | | Through Year 7 | |
| | STEM Credits Attempted | STEM Credits Completed | STEM Credits Attempted | STEM Credits Completed | STEM Credits Attempted | STEM Credits Completed |
| Eligible for FSAG | **0.451**** | **0.515***** | **1.464**** | **1.615***** | 1.760 | **2.051**** |
| | **[0.226]** | **[0.198]** | **[0.641]** | **[0.553]** | [1.074] | **[0.909]** |
| EFC (centered at FSAG cut-off) | 0.189 | 0.223 | 0.794 | 0.820 | 0.718 | 0.850 |
| | [0.297] | [0.249] | [0.801] | [0.673] | [1.300] | [1.070] |
| FSAG x EFC | 0.408 | 0.325 | 0.520 | 0.763 | 0.797 | 1.288 |
| | [0.379] | [0.333] | [1.032] | [0.895] | [1.660] | [1.385] |
| R-squared | 0.189 | 0.205 | 0.154 | 0.172 | 0.134 | 0.152 |
| Sample mean of outcome for students above FSAG cut-off | 3.39 | 2.50 | 10.28 | 7.67 | 15.62 | 11.67 |

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

Notes: Robust standard errors, clustered at the high school level, are shown in brackets. All models are estimated with an EFC window +/- $1,000 around the FSAG cut-off and include the following covariates: race dummy variables (Black, Hispanic, and Other race/ethnicity); female dummy variable; high school senior year GPA (weighted 4.5 scale); whether the student was in a gifted and talented program; parental adjusted gross income; student age, and whether the student was eligible for the Florida Bright Futures Scholarship. All models also include a constant.

## Table 3: The Effect of FSAG Eligibility on Cumulative STEM Credits Completed, Conditioned on Proxies for STEM Interest

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| | Unrestricted Sample | | | College Entrance Exam Math Score above College Math Placement Cut-Off | | | Completed Trigonometry or Higher Math Course | | |
| | Year 1 | Year 3 | Year 7 | Year 1 | Year 3 | Year 7 | Year 1 | Year 3 | Year 7 |
| Eligible for FSAG | **0.515*** ** | **1.615*** ** | **2.051** ** | **0.689* ** | **2.166** ** | **3.520** ** | **1.968** ** | **4.811** ** | **7.410** ** |
| | **[0.198]** | **[0.553]** | **[0.909]** | **[0.409]** | **[1.096]** | **[1.776]** | **[0.821]** | **[2.120]** | **[3.474]** |
| EFC (centered at FSAG cut-off) | 0.223 | 0.820 | 0.850 | 0.291 | 1.138 | 0.452 | 1.653 | 4.553 | 4.015 |
| | [0.249] | [0.673] | [1.070] | [0.488] | [1.290] | [2.024] | [1.069] | [2.911] | [4.312] |
| FSAG x EFC | 0.325 | 0.763 | 1.288 | 0.128 | 0.565 | 3.845 | -0.115 | -2.824 | 1.140 |
| | [0.333] | [0.895] | [1.385] | [0.671] | [1.827] | [2.789] | [1.424] | [3.783] | [5.693] |
| Observations | 6,921 | 6,921 | 6,921 | 2,834 | 2,834 | 2,834 | 1,283 | 1,283 | 1,283 |
| R-squared | 0.205 | 0.172 | 0.152 | 0.195 | 0.202 | 0.187 | 0.315 | 0.316 | 0.294 |
| Sample mean of outcome for students above FSAG cut-off | 2.50 | 7.67 | 11.67 | 4.31 | 12.41 | 18.27 | 5.28 | 14.44 | 20.98 |

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

Notes: Robust standard errors, clustered at the high school level, are shown in brackets. All results are from OLS specifications estimated with an EFC window +/- $1,000 around the FSAG cut-off and include the following covariates: race dummy variables (Black, Hispanic, and Other race/ethnicity); female dummy variable; high school senior year GPA (weighted 4.5 scale); whether the student was in a gifted and talented program; parental adjusted gross income; student age, and whether the student was eligible for the Florida Bright Futures Scholarship. All models also include school fixed effects and a constant.

**Table 4: The Effect of FSAG Eligibility on BA/BS Degree Completion In and Out of STEM, Conditioned on Proxies for STEM Interest**

| | Unrestricted Sample | | College Entrance Exam Math Score above College Math Placement Cut-Off | | Completed Trigonometry or Higher Math Course | |
|---|---|---|---|---|---|---|
| | Not STEM | STEM | Not STEM | STEM | Not STEM | STEM |
| Eligible for FSAG | **0.049**** | **0.006*** | 0.064 | 0.015 | 0.058 | 0.036 |
| | **[0.020]** | **[0.003]** | [0.039] | [0.010] | [0.052] | [0.022] |
| Observations | 6,921 | 6,921 | 2,834 | 2,834 | 1,283 | 1,283 |
| Pseudo R-Squared | 0.144 | 0.144 | 0.090 | 0.090 | 0.055 | 0.055 |
| Sample mean of outcome for students above FSAG cut-off | 0.22 | 0.02 | 0.37 | 0.04 | 0.43 | 0.06 |

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

Notes: Robust standard errors, clustered at the high school level, are shown in brackets. All results are from multinomial logit models estimated with an EFC window +/- $1,000 around the FSAG cut-off and include the following covariates: race dummy variables (Black, Hispanic, and Other race/ethnicity); female dummy variable; high school senior year GPA (weighted 4.5 scale); whether the student was in a gifted and talented program; parental adjusted gross income; student age, and whether the student was eligible for the Florida Bright Futures Scholarship. All models also include a constant. The results displayed are differences in predicted probabilities of degree completion estimated at the means of all covariates.