Seeking STEM:
The Causal Impact of Need-Based Grant Aid on Undergraduates' Field of Study

Katharine M. Broton*
University of Iowa

David B. Monaghan
Shippensburg University of Pennsylvania

July 2018

Abstract

Increasing the number of science, technology, engineering, and mathematics (STEM) degrees is a national priority and one way to promote the socioeconomic mobility of students from low-income families. Prior research examining why demand for STEM majors outstrips supply often points to students' lack of academic preparation, preferences for non-STEM majors, or a lack of information. This paper draws on a randomized experiment to investigate an alternative explanation related to resource constraints. Findings indicate that university students from low-income families who were offered additional need-based grant aid were 7.87 percentage points more likely to declare a STEM major than similar peers, representing a 42% increase. There is no evidence that the grant offer influenced the share of students who declared a major; rather, it reduced the likelihood of majoring in a non-STEM field. Need-based grants thus appears to be one avenue for increasing the share of low-income students studying STEM.

Acknowledgments

The authors thank Sara Goldrick-Rab, Peter Kinsley, Alison Bowman and the Wisconsin Scholars Longitudinal Study research team for advice and support. We also thank participants at the 2018 Institute for Higher Education Law and Governance Higher Education Finance Roundtable for constructive feedback. The study was funded by The Bill and Melinda Gates Foundation, Great Lakes Higher Education Guaranty Corporation, Institute for Research on Poverty, Spencer Foundation, William T. Grant Foundation, Center for the Advancement of Postsecondary Education, and an anonymous donor. It was conducted in partnership with the Fund for Wisconsin Scholars, the Higher Educational Aids Board, the University of Wisconsin System, and the Wisconsin Technical College System under the direction of Dr. Sara Goldrick-Rab. All errors are omissions are those of the authors alone.

* Corresponding author: katharine-broton@uiowa.edu

INTRODUCTION

Increasing the number of skilled science and technology workers is a national priority with support from a diverse group of government, business, academic, and philanthropic leaders (Business Roundtable 2017; Handelsman and Smith 2016; National Research Council 2015; The White House 2017). Each year, public and private organizations spend billions of dollars on initiatives designed to increase flow through the nation's STEM pipeline (Altonji, Arcidiacono, and Maurel 2016; American Institute of Physics 2017).

Increased funding and attention may have begun to pay off, as the proportion of U.S. undergraduates planning to major in science and engineering has risen in recent years (National Science Board 2016). In 2014, nearly a third of bachelor's degrees were awarded in STEM (Science, Technology, Engineering, and Math) fields, which represents a 25% increase over 2001 (National Student Clearinghouse Research Center 2015; Snyder, de Brey, and Dillow 2018). This suggests that the U.S. is on a path to reach the Obama administration's ambitious goal of adding a million STEM graduates between 2010 and 2020 (Mervis 2014).

Concerns remain, however. First, attrition rates from STEM majors are still high. Of those who begin studying STEM fields, only about half earn a degree in those fields within six years (Chen 2013). Second, STEM degree production is highly inequitable. Females, low-income students and non-Asian minorities are considerably underrepresented among STEM graduates (Camera 2017; National Science Board 2016). Students who attend high schools where the majority of students come from low-income families are half as likely to earn a STEM degree compared to those who attend schools with smaller shares of low-income students (National Student Clearinghouse Research Center 2016). Since STEM fields are associated with higher pay and status, these differential participation rates undermine socioeconomic mobility and perpetuate social inequality (Choy and Badburn 2008; Kim, Tamborini, and Sakamoto 2015). Third, STEM fields include a diverse array of occupations and there are a number of areas — such as software development, computer engineering, petroleum engineering, and data science — for which the demand for workers substantially outstrips supply (Xue and Larson 2015). Finally, the proportion of college graduates with degrees in STEM fields is lower in the United States than in most comparably wealthy countries (Organisation for Economic Co-operation and Development 2017).

The national discussion about increasing STEM production is taking place against a backdrop of increased austerity in public higher education. Public spending on higher education has failed to increase proportionately with rising participation rates and has fallen in many cases. As a result, on a per-student basis, public resources allocated to higher education are far lower today than they were in the past (State Higher Education Executive Officers Association 2018). As a consequence, the burden for paying for college has been shifted progressively onto students and their families (Goldrick-Rab 2016). Today's college students, even in the public sector, are meeting funding shortfalls through working, taking out loans – or both – and so choose what to study under considerable constraints. That such a context may be impacting, and perhaps undermining, efforts to increase STEM production is little discussed.

In this paper, we bring these two conversations together by investigating the impact of need-based financial aid on university students' choice of college major. We tap a unique dataset tracking the results of a randomly assigned grant, permitting us to establish *causal* evidence regarding this relationship. To our knowledge, this paper presents the first experimental evidence regarding the impact of grant aid on field of study. We find that need-based grant aid induced students to major in STEM fields, suggesting that grant aid is an effective intervention for increasing the share of low-income students who pursue STEM fields of study.

THEORY AND PRIOR RESEARCH

Theories of Major Choice

Economic and psychological theories of how students choose majors dominate research on undergraduate field of study. Economists typically begin with two insights: 1) graduates' earnings vary dramatically by major and 2) some majors are more academically taxing than others (Altonji, Arcidiacono, and Maurel 2016; Altonji, Blom, and Meghir 2012). It is then noted that the likely earnings accruing to a field of study is positively correlated to the demands it makes upon a student, particularly in terms of mathematics (Arcidiacono 2004). Therefore, a student's quantitative "ability" determines the relative cost of a more difficult, more remunerative major. Based on this rational-actor framework, students maximize utility by considering a major's eventual monetary worth relative to its current "cost" in terms of effort. Indeed, there is some evidence that fluctuation in earnings streams over time impacts cohorts' major decisions (Berger 1988; Montmarquette, Cannings, and Mahseredjian 2002), and that students tend to pick majors that they *believe* (perhaps incorrectly) will maximize their earnings (Arcidiacono, Hotz, and Kang 2012). Meanwhile, attrition from math and science majors has been linked to students updating beliefs about their capacity to perform in these fields given prior performance (Stinebricker and Stinebricker 2013).

Those who employ rational-actor frameworks acknowledge that ability and likely financial rewards do not fully explain major selection, but consign student “tastes” and “preferences” to the error term. Empirical research, however, suggests that such preferences are quite consequential. For instance, a study of students at an elite university found that “consumption values” are equal in importance to pecuniary concerns for male students, and substantially more so for females. Moreover, those who switched majors were more likely to report doing so because of shifting interests rather than because of concerns over academic performance (Zafar 2011, 2013).

Psychologists—and many education researchers—commonly apply personality-based models of career choice to college major selection, utilizing either Holland’s “person-environment fit” model (Johnson & Muse 2017; Porter and Umbach 2006) or the “big five” personality trait model (Balsamo, Lauriola, and Saggino 2012). Other researchers working in this tradition trace major choice to student interests or values, such as the importance of material success, social activism, or making an artistic contribution (Astin 1993; Easterlin 1995; Fiorito and Dauffenbach 1982). In both the rational-actor framework, which acknowledges the existence of preferences but otherwise ignores them, and the psychological approach, which foregrounds them, tastes and inclinations are considered sovereign and fixed in the short-run and therefore simply given as data.

Sociology provides several insights that disrupt these conceptions of major selection. First, sociologists question the sovereignty of preferences and tastes.

Sociologists have long noted that students' overall orientation to higher education varies by social class (Clark and Trow 1966; Katchedourian and Boli 1985), and a Bourdieusian framework helps explain this variation. Specifically, there are fields which primarily teach practical skills exchangeable on the market for wages, and others whose rewards are primarily symbolic – prestige, intellectual achievement, and so on. Students more likely to recognize and desire such symbolic rewards, which can be captured by "playing the game," are those whose family capital is more densely cultural than economic (Bourdieu 1984). Working-class students, as well as the children of the economic elite, tend to value education for extrinsic reasons (Ma 2009; Mullen 2010, 2014). Empirical research indicates that socioeconomic status positively predicts the choice of academic (versus applied) majors (Goyette and Mullen 2006; Leppel, Williams, and Waldauer 2001) and less remunerative majors (Monaghan and Jang 2017), and negatively predicts the choice of technical and vocational majors (Ma 2009).

Beyond class differences, sociologists note that major-choice "preferences" vary by gender, race/ethnicity, and prior academic preparation (e.g., Goyette and Mullen 2006). The gender gap is particularly large, with females selecting into fields associated with caring (education, nursing, psychology), aesthetics (art, English), or communication, and males into fields associated with instrumental competence, financial acumen, and socio-political power (Charles and Bradley 2009; Dickson 2010; England and Li 2006; Jacobs 1989, 1995; Mann and DiPrete 2013). Because this gap persists after accounting for academic preparation (Riegle-Crumb et al. 2012), sociologists attribute such tendencies to deeply-ingrained cultural schemata suggesting what each gender is “good at” and to which social virtues it ought to aspire (Correll 2001, 2004).

Next, sociologists note that major choice takes place within an impactful institutional order. First, majors on offer vary systematically across institutions. The prestige and selectivity of institutions correlates with the academic prestige of available majors, with newer “vocational” majors clustered at lower-tier institutions and largely missing from elite schools (Brint et al. 2011). Indeed, business, as an undergraduate major, is not offered at most elite private colleges and universities despite being the most common major nationally (Snyder, et al. 2018). Second, for some—mostly vocational-technical—majors, there are *institutional links* to specific occupations, but for others—mostly academic—such links are nonexistent until after graduate school. Therefore, the selection of *most* academic majors is de facto a choice to either continue schooling past the baccalaureate or to struggle in the labor market (Monaghan and Jang 2017; Mullen, Goyette, and Soares 2003; Roksa and Levey 2010). Accordingly, students with less of a financial buffer or who gain less intrinsic enjoyment from schooling may avoid academic majors (Goyette and Mullen 2006).

But irrespective of discipline, both rational actor and personality models rarely account for how financial considerations may constrain students’ educational decision-making – which we consider below.

Financial Constraints and Major Choice

Driven by dramatic declines in per-student state appropriations for higher education, the total price of college attendance (including tuition and fees, room and board, books and supplies, and personal expenses) at public four-year colleges and universities has increased substantially while the average family's income has stagnated (College Board 2017; Goldrick-Rab 2016). Need-based financial aid, including the Pell grant, was created to ensure students could pursue college regardless of family economic background, but the "purchasing power" of that aid has declined and now covers just 30% of the total price of attendance at the average public four-year institution (Goldrick-Rab 2016). In 2015-16, over half of students in the public four-year sector faced college net prices (full cost of attendance minus grant aid) greater than 25% of their family income, including 20% who faced net prices greater than their total family income (Kelchen 2018).

Given this reality, most students and families have three options for meeting the net price of college attendance. First, they can reduce up-front expenses through living at home, going without textbooks or other needs, enrolling part-time, or taking semesters off. Second, students can buttress family contributions with their own earnings from work. Third, students and families can defer expenses into the future by taking out loans.

All three solutions have drawbacks. There is a scholarly consensus that off-campus residence, part-time enrollment, and intermittent attendance lower the odds of eventual completion (Attewell, Heil, and Reisel 2011; Bozick 2007; Goldrick-Rab 2006; Schudde 2011). The relationship with work hours is more complex as the timing and quality of work – not just the total number of hours worked – matters for student success (Broton, Goldrick-Rab, and Benson 2016; Goldrick-Rab 2016). Working during college is associated with lower levels of academic achievement, especially when students work off-campus or more than 20 hours per week (Bozick 2007; Dadgar 2012; DeSimone 2008; Riggert et al. 2006; Scott-Clayton 2011; Scott-Clayton and Minaya 2016; Sinebrickner and Stinebrickner 2003). High-quality work experiences, however – including those located on-campus or related to students' interests – can enhance academic outcomes (Ehrenberg and Sherman 1987; McCormick, Moore, and Kuh 2010; Scott-Clayton and Minaya 2016).

Most research has found that average returns to a college degree are large enough to make taking out loans economically rational (Avery and Turner 2012; Barrow and Malamud 2015). There are, however, four considerations that render loans problematic. First, there is ample evidence that debt-aversion among students, and particularly lower-income students, is considerable (Boatman and Evans 2017; Evans, Boatman, and Soliz 2018; Goldrick-Rab and Kelchen 2015). Second, calculations about loans' economic rationality presume college *completion*, which is a bold assumption given that six-year completion rates hover around 60% and are lower for historically underserved groups (Webber 2016). Those who do not earn a degree must meet loan payments on a non-college salary, which explains why default rates are high among non-completers (Hillman 2014, 2015). Third, while loans are generally positively associated with completion, this relationship reverses at particularly high loan amounts, and loans may be negatively associated with completion among lower-income students (Baker and Doyle 2017; Dwyer, McCloud, and Hodson 2012; Herzog 2018; McKinney and Burridge 2015). Finally, student loans may be insufficient to meet students' actual educational and living expenses. Federal policies cap the amount students may borrow through regulated-rate programs (e.g., Stafford). When these caps are set below the actual price of college attendance, students have few choices but to work more, go without basic material goods, or turn to the high-interest private loan market (Broton and Goldrick-Rab 2018; Kelchen, Goldrick-Rab and Hosch 2017).

Financial constraints may impact the selection of college major in at least two ways. First, if constrained students respond by increasing work hours (Scott-Clayton 2012), they may have fewer hours per day and less energy to devote to academics. Accordingly, they may select a less demanding major than they would otherwise prefer in order to improve their odds of degree completion. Secondly, if constrained students respond by taking out larger loans, they may feel the need to select a major that links readily to a high-paying job. There is already a growing body of research that demonstrates that student loans constrain decisions after graduation, impacting occupational choice (Rothstein and Rouse 2011), reducing graduate school attendance (Zhang 2013), delaying marriage (Addo 2014; Bozick and Estacion 2014; Gicheva 2016), and increasing post-college co-residence with parents (Dettling and Hsu 2017). Quadlin (2017) examined major selection during students' first term of study and found that those who meet more of their college expenses through loans are more likely to select majors in applied non-STEM fields, which entail high salaries and low unemployment. Similarly, students facing higher net costs are more likely to select vocational majors and less likely to select arts and sciences fields (Stater 2011).

Hypotheses

Drawing on Quadlin (2017), we specify two axes according to which majors may be arrayed: STEM/non-STEM and academic/applied. The first is self-explanatory. The second refers to the division in the academy between the “old liberal arts and sciences” core and “newer” majors which are constituted as technical training for given occupations (Brint et al. 2005).[1] Students who major in “newer” applied fields have higher average rates of pay, are more likely to be employed, and less likely to attend graduate school than those who major in academic fields of study (Choy and Bradburn 2008; Horn and Zahn 2001; Quadlin, 2017). Since grant aid – including the Wisconsin Scholars Grant we study here – reduces students’ need to take out loans, it may reduce the pressure to pursue a degree in an applied field for the remunerative benefits loans (Angrist, Hudson, and Pallais 2014; DesJardins and McCall 2014; Goldrick-Rab 2016). That is, students may feel freer to pursue lower paying fields in the liberal arts, for which graduate school is often necessary (e.g., the humanities and natural and social sciences) (Quadlin 2017).

H1: Grant award will increase the probability of selecting an academic major relative to an applied major.

On the other hand, grant aid may reduce out-of-pocket costs such that students are able to cut work hours and focus more on academic effort. Prior research on the grant we study indicates that students offered the grant were less likely to work and worked fewer hours than otherwise similar students (Broton et al. 2016), as has an evaluation of the Gates Millennial Scholars grant (DesJardins and McCall 2014). As a result, students may select more *academically challenging* fields, such as those in STEM. Moreover, the grant aid may enable students to purchase expensive textbooks or lab equipment associated with STEM majors. Indeed, prior quasi-experimental

[1] For more information on these categorization axes, see the measures section below.

research on the need-based Florida Student Assistance Grant indicates that grant aid shifts students into STEM-heavy course loads (Castleman, Long, and Mabel 2018).

H2: Grant award will increase the probability of selecting a STEM major.

Many grants, including the one we focus on here, however, require students to maintain a given GPA and credit accumulation rate in order to keep receiving the grant. Such grants can have the unintended consequence of incentivizing students to take less demanding courses and to gravitate toward less-demanding majors (Cornwall, Lee, and Mustard 2006; Sjoquist and Winters 2015; but see Zhang 2016). Prior research on the grant we study indicates that students near the threshold of losing the grant also changed their behavior by lowering their enrollment intensity as a way to “make the grade” (Kinsley and Goldrick-Rab 2016; Goldrick-Rab 2016).

H3: Grant award will decrease the probability of selecting a STEM major.

Finally, the impact of the grant on field of study may be indistinguishable from zero, as Evans (2017) reports in related work. He used a regression-discontinuity design to investigate the impact of eligibility for the national SMART grant during students’ junior and senior years of college on choosing a STEM major. Even though the SMART grant was reasonably generous, specifically designed to incentivize choosing STEM, and automatically awarded to eligible students who completed the FAFSA (Free Application for Federal Student Aid), there was no detectable impact on STEM field of study. Our study builds on this prior work by studying the effects of a renewable need-based grant program administered to students at the start of their college career, observing students’ declared major, and using data from a randomized control trial designed to identify causal relationships.

Research Questions

Can offering additional grant aid to undergraduates from low-income families influence their field of study choices? We consider average impacts and investigate variation by pre-treatment factors likely to influence field of study decisions. Since STEM fields of study are associated with both higher pay and more academically challenging coursework, we conduct two additional analyses to explore these potential mechanisms behind any shifts in major selection.

DATA AND EMPIRICAL APPROACH

Data

The Wisconsin Scholars Grant (WSG) is a privately funded grant for undergraduates from low-income families in Wisconsin. Launched in 2008 and administered by the Fund for Wisconsin Scholars, it offers eligible university students $3,500 per year, renewable for up to five years.[2] To be eligible, students must be Wisconsin residents who graduated from a state public high school or earned a Wisconsin High School Equivalency Diploma within three years of matriculating to one of the state's 42 public colleges and universities. Additionally, they must have enrolled for at least 12 credits in their first semester, completed the FAFSA, and qualified for a federal Pell Grant while still possessing unmet need (excluding loans).

[2] To renew the grant, students must maintain Pell Grant eligibility, enroll full time, and meet satisfactory academic progress. The grant is transferable among all public two- and four-year colleges and universities in Wisconsin. The Fund for Wisconsin Scholars offers eligible students attending two-year colleges $1,800 per year. The WSG program is ongoing; as of 2012, students did not need to maintain Pell eligibility to renew the grant and as of 2016, the fund offers university students $4,000. More information is available at www.ffws.org.

The Fund for Wisconsin Scholars works with the Higher Educational Aids Board to identify eligible students from college administrative records and selects recipients via a lottery conducted early in students' first postsecondary semester. Recipients are notified of the grant offer through an award letter that they must sign and return; 92% of university students in the first cohort did so (Goldrick-Rab et al. 2016). The grant is then disbursed through students' financial aid offices.

Two aspects of the WSG make it appealing for studying effects of financial aid. First, because students do not apply for the grant, those who are offered the grant are representative of the population from which they are drawn. Second, since students are chosen randomly, internally valid estimates of causal effects may be calculated by comparing those offered the grant to those who were eligible, but not selected to receive an offer of the WSG. Researchers from the Wisconsin Scholars Longitudinal Study team have studied the WSG's impacts on academic performance and completion using administrative data from several cohorts. Specifically, Goldrick-Rab and colleagues (2016) demonstrated that the grant improved on-time bachelor's degree completion among four-year college students while results were mixed, though largely null, among two-year college students (Anderson & Goldrick-Rab, 2018).

In academic year 2008-09, 1,200 students were chosen to receive the WSG, divided equally between two- and four-year institutions. Researchers also randomly selected 1,800 non-recipients from the pool of eligible students to serve as a comparison group; these will be referred to hereafter as "experimental" or "treatment" and "control" groups, respectively. In creating the control group, researchers oversampled students attending racially/ethnically diverse colleges and developed survey weights to account for this research design. The research team sought active consent to access students' records and 46% of subjects completed and returned consent forms (596 recipients and 797 control). For these subjects, researchers obtained academic and demographic data from students' colleges and financial aid data from Wisconsin's Higher Education Aid Board. Researchers also surveyed study participants annually between 2008 and 2011.

For the purposes of studying major selection in this paper, we only consider the 600 treatment students and 900 control students who were in the four-year college randomization pool in 2008 and track them over their first three academic years. Our analytic sample includes the 619 students who initially enrolled at a four-year college, consented to the linkage of their administrative data records, and declared a major within three years of starting college. Those who did not declare a major within this period (n=125) were not on pace to graduate in six years.[3] Because both consenting to give access to records and major declaration occur after assignment to treatment, restricting our sample according to these factors could introduce endogenous selection bias (Elwert and Winship 2014). However, the difference between experimental and control groups in the probability of inclusion in the analytic sample is statistically indistinguishable from zero (p>.10).

---

[3] Analyses that include an undeclared category are statistically and substantively similar. Since the grant offer did not impact the probability of declaring a major, we eliminate the undeclared category for a more concise presentation of results.

Outcomes

Students in these data selected 128 institution-specific majors, which we classify along two axes—STEM/non-STEM and academic/applied—using Classification of Instructional Programs (CIP) codes used by the University of Wisconsin system. *STEM majors* are those whose two-digit CIP code contains engineering; biological sciences; mathematics; physical sciences; or related fields involving development of technologies using engineering, mathematics, computer science, or natural sciences (these majors are designated using 6-digit CIP codes according to the STEM regulatory definition (Department of Homeland Security 2016)); all others are *non-STEM*. Following Brint and colleagues (2005), we categorize the following as *academic majors:* area studies, biological or life sciences, English and cultural studies, ethnic studies, foreign languages and literatures, history, legal studies, liberal studies, mathematics, multi- or interdisciplinary studies, philosophy, physical sciences, psychology, religious studies, social sciences, and visual and performing arts. The remaining *applied majors* include agriculture, business, communications, computer science, education, engineering, health professions, industrial technology, parks and recreation, public administration, social services, and religious vocations. Additionally, we combine these dichotomies into a four-category scheme; see Appendix (Table A1) for a full classification. We select the last observed major for those who changed majors over time and the primary major for those with multiple majors.

Independent Variables

The independent variable of interest is a dichotomous measure for WSG offer. We include a number of pre-treatment control variables, mostly taken from administrative records. Information on students' economic standing comes from the FAFSA, completed prior to college entry. We include measures of parents' and student's adjusted gross income, expected family contribution (dichotomous; equal to 1 if EFC=0), financial dependency status (dichotomous; equal to 1 if independent), and a dummy equal to 1 if the student qualifies for the FAFSA's simplified needs test.[4] With the exception of race/ethnicity, which is drawn from responses to a survey administered in Fall 2008, demographic information also comes from the FAFSA. We include sex (female or male), age in years, parental status indicating if the student has at least one dependent child (dichotomous), and race/ethnicity. The University of Wisconsin classes as "underrepresented minorities" those identifying as African American, Latino/a, American Indian, Southeast Asian, or multiracial; our dichotomous measure of race/ethnicity follows this scheme. We measure academic preparation through ACT composite scores and conduct robustness checks using science and math sub-scores.[5] For eight students missing ACT composite scores, we imputed using their institutions' median scores. Finally, we include dummy variables for students' first-semester

[4] The EFC is an estimation of a students' or parents' ability to contribute to the financial costs of a college education and is used in determining applicants' eligibility for need-based federal student aid, including the Pell Grant. The EFC is minimized at zero, indicating that a family is not expected to contribute anything to the cost of college. Students can be considered financially independent for several reasons including if they are over age 23, married, or have dependent children. Students qualify for a simplified needs test when calculating the EFC if they reside in a household that receives certain means-tested public benefits (e.g., Supplemental Nutrition Assistance Program (SNAP) or Free and Reduced-Price School Lunch), they satisfy a low-income criterion, or the parent is a dislocated worker.

[5] ACT sub-scores are only available for a subsection of the analytic sample.

institutions.

Mechanisms

To explore potential mechanisms, we link via student majors to two external data sources. First, we measure the income associated with majors by calculating median incomes by bachelor's degree subject from the 2009-2012 American Community Survey (ACS), accessed through the Minnesota Population Center's IPUMS (Ruggles et al. 2017). The ACS samples over 3 million respondents yearly, providing a sample of over 12 million, including 2.5 million for whom college major is identified. The ACS's detailed field of study variable has 176 response categories, allowing for close matches to respondents' majors.

Second, we obtained, from the University of Wisconsin System's Office of Policy Analysis and Research (UW-OPAR), the mean entering ACT scores of 2015-16 bachelor's earners for each major (CIP subarea) at each college in the UW system. We matched students in our sample to their major's average ACT score in their first-semester institution. UW-OPAR did not calculate statistics for college-major combinations with fewer than 10 graduates, rendering 26 cases unmatchable in this manner. For these, we substituted their major's weighted average ACT score across the UW system. We employ resulting major-associated ACT scores as proxies for majors' relative difficulty, given measurement challenges associated with this concept.

Analytic Strategy

Randomized control trials (RCTs) have long been recognized as the gold standard for obtaining unbiased causal estimates (Morgan and Winship 2015). Because its recipients were selected through lottery, the WSG is, for purposes of analysis, an RCT. We estimate experimental impacts of grant aid on major choice through intent-to-treat (ITT) analyses. Because grant take-up was over 90%, ITT estimates are near-identical with complier average causal effects.

We calculate regression-adjusted treatment impacts, which are more efficient than unadjusted impacts and equally unbiased (What Works Clearinghouse 2017). We include unadjusted impact estimates in the appendix as a reference for the reader (Table A2). The equation for adjusted impacts is:

$$y_i=\alpha+\beta(WSG_i)+\gamma X_i+\varepsilon_i, \quad (1)$$

where y_i is the college major chosen by student i; WSG_i is an indicator of WSG offer; X_i is a vector of individual-level pre-treatment characteristics; and ε_i is an error term. For our two dichotomous major-choice outcomes—STEM/non-STEM and academic/applied—we employ logistic regression. When examining major choice in terms of our four-class scheme, we use multinomial logistic regression, varying the base category to demonstrate different contrasts. Finally, when examining major choice in terms of associated income or difficulty, we employ ordinary least squares regression as these measures are normally distributed.[6] We use sampling weights in all analyses to adjust for varying odds of sample inclusion across institutions. In tables, we report

[6] For all continuous outcomes, skewness is between 0 and 1 and kurtosis between 3 and 4. We obtain substantively similar results when regressing on the log of major-associated income.

treatment impacts as percentage point differences and in the text, we also report percent changes by dividing percentage point difference by control group share.

To test for heterogeneous treatment impacts by pre-treatment characteristics, we introduce interaction terms. The equation is

$$y_i = \alpha + \beta(WSG_i) + \gamma X_i + \delta Z_i + \theta(WSG_i \times Z_i) + \varepsilon_i \tag{2}$$

where y_i is major choice, WSG_i is an indicator of WSG offer; X_i a vector of pre-treatment characteristics; Z_i is a vector of pre-treatment individual-level characteristics hypothesized to influence major selection; $WSG_i \times Z_i$ is an interaction of grant offer and a pre-treatment variable, and ε_i is an error term. We examine interactions of WSG receipt with each of the following dichotomous variables: sex, underrepresented minority status, zero-EFC status, and dummy variable equal to 1 if composite ACT is equal to or greater than 25, which represents a score in the 80th percentile, nationally, and suggests that students are academically well prepared (Seigel 2015). Each interaction is examined in a separate regression predicting major choice in terms of one of our two dichotomous outcomes; small cell sizes prevent us from examining heterogeneous treatment impacts in terms of our four-class scheme. We consider these analyses exploratory in nature, given the number of comparisons and research design.

Limitations

There are several limitations in this study. First, our sample is not nationally representative nor representative of the full study sample, limiting generalizability. Second, our data only covers students' first three years of college, preventing us from examining impacts on degree fields. Third, we limit analysis to students' last recorded major decision. Rules for major declaration vary across the UW system, with some requiring students to declare at entry and others allowing students to remain undeclared for a number of semesters. However, typically students are required to declare by the end of their sophomore year. In supplementary analyses (not included), there is no evidence that the grant increased the probability of changing majors. Finally, our analyses are limited to intent-to-treat analyses, which exploits exogenous variation from random assignment, but may result in more conservative estimates of treatment impacts.

RESULTS

Internal Validity and Descriptive Statistics

First, we examined 12 pre-treatment baseline measures for differences by treatment status and found no statistically significant differences. The treatment and control groups are balanced on demographic characteristics; student and parent income; expected family contribution; and financial (in)dependence status ($p > .05$), meeting What Works Clearinghouse (2017) benchmarks for high internal validity (Table 1).

Table 1. Baseline Characteristics of Analytic Sample by Treatment Status

Characteristic	Control Group	Treatment Group	*p* Value
Female (%)	59.97	65.67	0.168
Targeted racial/ethnic minority (%) [a]	21.15	21.90	0.827
Average age (years)	18.26	18.27	0.711
Married (%)	0.40	1.07	0.389
Has dependent child (%)	0.65	0.72	0.911
Financially dependent on parents (%)	97.29	97.40	0.932
Average expected family contribution (US$)	1,742.62	1,825.39	0.685
Zero expected family contribution (%)	31.23	24.64	0.086
Parent(s)' adjusted gross income (US$)	28,914.17	31,069.70	0.172
Student's adjusted gross income (US$)	2,777.72	3,041.39	0.407
Simplified needs test (%)	54.92	47.21	0.072
ACT score (composite)	21.89	21.86	0.935
Sample size	353	266	

Note: Data come from students' 2008 FAFSA except for race/ethnicity, which are self-reported on a survey. We imputed ACT score (composite) using the institutions' median composite ACT score for eight students. No other imputation was performed.

[a] Targeted minority groups include African American, Latino, Southeast Asian, Native American, and multiracial. "Targeted" refers to a policy of the University of Wisconsin System.

In the analytic sample, 62% of undergraduates identify as female and according to University of Wisconsin System policy, 21% are underrepresented racial/ethnic minorities. The average age is 18 years and 97% are financially dependent on their parents according to the financial aid system. Their parents earn $29,800 per year and are expected to contribution nearly $1,800, on average, to support their students' college expenses though 28% are not expected to contribute financially to their students' college expenses. Less than 1% are married or have dependent children. The average composite ACT score is nearly 22, which is similar to the national average (Seigel 2015) (Table 2).

The analytic sample is not representative of the full study sample. It contains a greater share of females (62% analytic vs. 57% full) and a smaller share of racial/ethnic minorities (21% analytic vs. 25% full) (p<.05). The average expected family contribution is higher in the analytic sample ($1,777 analytic vs. $1,631 full), indicating that students come from families with more resources (p<.05). Finally, students in the analytic sample scored approximately one-third of one point lower on the composite ACT exam (21.88 analytic vs. 22.22 full) (p<.05). Thus, the results may not be generalizable to the population of Wisconsin students described above (Table 2).

Table 2. Baseline Characteristics of Full and Analytic Samples

Characteristic	Full Study Sample	Analytic Sample	*p* Value
Wisconsin Scholars Grant (%)	40.00	42.00	0.202
Female (%)	57.30	62.45	0.001
Targeted racial/ethnic minority (%) [a]	25.13	21.46	0.002
Average age (years)	18.25	18.26	0.649
Married (%)	0.71	0.68	0.908
Has dependent child (%)	0.94	0.68	0.346
Financially dependent on parents (%)	97.18	97.34	0.760
Average expected family contribution (US$)	1,631.08	1,777.38	0.043
Zero expected family contribution (%)	30.62	28.46	0.148
Parent(s)' adjusted gross income (US$)	29,218.23	29,819.48	0.313
Student's adjusted gross income (US$)	2,768.26	2,888.46	0.280
Eligible for Simplified Needs Test (%)	53.87	51.68	0.177
ACT score (composite)	22.22	21.88	0.000
Sample size	1500	619	

Note: Data come from students' 2008 FAFSA except for race/ethnicity, which are self-reported on a survey. We imputed ACT score (composite) using the institutions' median composite ACT score for eight students. No other imputation was performed.

[a] Targeted minority groups include African American, Latino, Southeast Asian, Native American, and multiracial. "Targeted" refers to a policy of the University of Wisconsin System.

WSG Impact on Field of Study

Among students who were eligible but not offered the WSG, nearly one-fifth majored in a STEM field and more than one-third majored in an academic field. Just over half of students in the control group majored in an applied non-STEM field (54%), 27% selected an academic non-STEM major, 11% selected an applied STEM major, and 8% selected an academic STEM major (Table 3).

Table 3. Wisconsin Scholars Grant Adjusted Impact on Field of Study

Field of Study	Control	Treatment Impact	*p* Value (alternative base categories)	*p* Value (alternative base categories)
STEM (%)	18.66	7.87	0.016*	na
Academic (%)	35.16	2.76	0.496	na
Detailed Field of Study				
Applied STEM (%)	10.56	3.31	0.106	0.756
Academic STEM (%)	8.16	4.36	0.043*	(base)
Applied Non-STEM (%)	54.19	-5.82	(base)	0.043*
Academic Non-STEM (%)	27.09	-1.85	0.799	0.089+

N=619

Notes: Reference category for STEM is non-STEM. Reference category for academic is applied. Outcome models adjusted for sex, racial/ethnic minority, age, has dependent child, financially dependent on parents, zero expected family contribution, parent(s)' adjusted gross income, student's adjusted gross income, simplified needs test, ACT score, and institution. We did not include married or average expected family contribution in the outcome models due to multicollinearity.

+ $p<.10$, * $p<.05$, ** $p<.01$, *** $p<.001$

Students offered the WSG were 7.87 percentage points more likely than students in the control group to major in a STEM field, representing a 42% increase (p<.05). The impact was concentrated among the academic STEM subfields, though there was also a smaller, statistically non-significant increase in the share of treatment students pursuing majors in an applied STEM subfield. Treatments students were 4.36 percentage points, or 53%, more likely to major in an academic STEM field, such as biology or chemistry (p<.05) and 3.31 percentage points, or 31%, more likely to major in an applied STEM field like engineering. Though only the treatment impact on academic STEM is statistically significant at the p<.05 level, the impacts on academic STEM and applied STEM are not statistically different from one another (Table 3).

The WSG did not influence the probability of majoring in an academic, rather than an applied, field of study (p>.10). Specifically, students offered the WSG were 5.82 percentage points (11%) less likely to major in an applied non-STEM field (p<.05) and 1.85 percentage points (7%) less likely to major in an academic non-STEM field (p<.10). Substantively, the grant induced students away from applied non-STEM fields and towards academic STEM fields though there were also smaller shifts away from academic non-STEM fields and towards applied STEM fields (Table 3).

Potential Mechanisms

There are multiple explanations for the causal relationship between need-based grant aid and STEM fields of study. As noted above, those who major in STEM fields have higher average annual pay than those in non-STEM fields (Choy and Badburn 2008; Quadlin 2017), but we hypothesized that the grant offer would *reduce* students' desire to seek a high-paying career given the relaxation in financial constraints. To investigate this potential mechanism, we estimate the treatment impact on major-associated median income, both for individuals with exactly a bachelor's degree and for the full population. Our point estimates in both cases are positive but statistically non-significant (p>.05). In other words, there is no evidence that a desire to pursue less lucrative careers is the underlying mechanism influencing students' major selection in this sample (Table 4).

We also hypothesized that the grant offer may have enabled students to pursue more academically challenging majors. A major's relative difficulty is challenging to measure, but we employ average ACT scores of those who earn degrees in the major from various institutions as a proxy. Point estimates indicate that students offered the WSG selected majors associated with higher average composite ACT scores; for the math score the difference amounted to 0.215 points or just under 10% of a standard deviation. The consistency of the point estimates is suggestive, and in accordance with theory. However, none of these differences are larger than one-quarter point on the ACT, nor are they statistically significant at p<.05 (Table 4), and so we cannot conclude that this is a primary mechanism for how the grant impacted major choice.

Table 4. Potential Mechanisms for Wisconsin Scholars Grant Impact on STEM Field of Study

College Major Characteristics	Control	Treatment Impact	*p* Value
Median Income ($) (BA degree holders only)	38,686	387.21	0.643
Median Income ($) (full population)	46,042	904.92	0.274
Average Composite ACT Score (points)	23.24	0.173	0.119
Average Math ACT Sub-score (points)	23.09	0.215	0.126
Average Science ACT Sub-score (points)	23.24	0.170	0.101
Average Reading ACT Sub-score (points)	23.29	0.217	0.104
Average English ACT Sub-score (points)	22.78	0.073	0.574

N=619

Note: Outcome models adjusted for sex, racial/ethnic minority, age, has dependent child, financially dependent on parents, zero expected family contribution, parent(s)' adjusted gross income, student's adjusted gross income, simplified needs test, ACT score, and institution. We did not include married or average expected family contribution in the outcome models due to multicollinearity.

+ p<.10, * p<.05, ** p<.01, *** p<.001

Treatment Effect Heterogeneity

Additional exploratory analyses suggest that the average treatment impact may vary by expected family contribution (EFC), a composite measure of a family's financial resources. Those with the fewest financial resources are not expected to contribute to their students' college expenses and have an EFC of $0, whereas families with more resources have a greater than $0 EFC. Results indicate a marginally significant interaction between EFC and WSG offer on the probability of declaring a STEM major ($p<.06$). In the control group, the chances of declaring a STEM major do not differ by EFC (~18%), but among the treatment group, 16% of students with a $0 EFC and 31% of students with a greater than $0 EFC declared a STEM major. The WSG impacts on STEM majors appear to be concentrated among students who come from families that have a positive EFC, indicating more family financial resources. There is no evidence of heterogeneous impacts by sex, underrepresented racial/ethnic minority status, or ACT score[7] (Table 5).

[7] Treatment impacts do not vary by a continuous measure of composite ACT nor alternative specifications comparing those with particularly high or low composite scores who may be better or less prepared to successfully engage in STEM coursework. For a subsection of the analytic sample for which we have math and science sub-scores, treatment impact does not vary by students' STEM readiness, as defined by ACT, Inc. as 27 or higher in math and 25 or higher in Science. Analyses not presented.

Table 5. Heterogeneous Impacts of Wisconsin Scholars Grant on Field of Study

	Control		Treatment		
A. Expected Family Contribution	**$0 EFC**	**Greater than $0 EFC**	**$0 EFC**	**Greater than $0 EFC**	**Interaction Term *p* Value**
STEM (%)	18.81	18.48	15.54	30.70	0.054+
Academic (%)	29.37	37.60	36.12	38.84	0.521
N	115	238	66	200	

	Control		Treatment		
B. Sex	**Female**	**Male**	**Female**	**Male**	**Interaction Term *p* Value**
STEM (%)	16.07	22.52	24.15	30.19	0.788
Academic (%)	37.36	31.37	42.52	30.08	0.452
N	218	135	173	93	

Continued on next page…

Table 5 continued...

C. Race/ Ethnicity	Control: Underrepresented Racial/Ethnic Minority	Control: Not Racial/Ethnic Minority	Treatment: Underrepresented Racial/Ethnic Minority	Treatment: Not Racial/Ethnic Minority	Interaction Term *p* *V*alue
STEM (%)	18.94	18.60	37.68	24.20	0.216
Academic (%)	39.44	34.08	50.44	34.74	0.321
N	90	263	58	208	

D. Composite ACT score	Control: Less than 25	Control: 25 or Higher	Treatment: Less than 25	Treatment: 25 or Higher	Interaction Term *p* *V*alue
STEM (%)	14.70	31.10	24.49	33.95	0.255
Academic (%)	14.70	31.10	24.49	33.95	0.255
N	273	80	211	55	

Notes: Reference category for STEM is non-STEM. Reference category for academic is applied.

Outcome models adjusted for sex, racial/ethnic minority, age, has dependent child, financially dependent on parents, zero expected family contribution, parent(s)' adjusted gross income, student's adjusted gross income, simplified needs test, ACT score, and institution. We did not include married or average expected family contribution in the outcome models due to multicollinearity.

Treatment impacts do not vary by a continuous measure of expected family contribution, a continuous measure of composite ACT score nor alternative specifications comparing those with particularly high or low composite ACT scores. For a subsection of the analytic sample for which we have math and science sub-scores, treatment impact does not vary by students' STEM readiness, as defined by ACT, Inc., as 27 or higher in math and 25 or higher in Science. Results not shown.

+ p<.10, * p<.05, ** p<.01, *** p<.001

DISCUSSION

Fields of study shape students' college experiences and contribute to stratification in occupational and socioeconomic attainment (Kim et al. 2015). Whether and how financial aid impacts what college students choose to study, however, is little understood. Leveraging a randomized experiment, we find that offer of a need-based grant increased the share of students majoring in a STEM field. These findings contribute to the growing body of literature showing that college funding matters for major selection (e.g., Quadlin 2017). Moreover, our results mirror extant quasi-experimental research indicating that eligibility for need-based grant aid shifted students into STEM-heavy course loads (Castleman et al. 2018). Students may believe that pursuing a STEM major requires additional resources – such as time to study or money to purchase expensive textbooks – and the additional need-based grant aid reduced students' resource constraints. This explanation is consistent with prior research indicating that those offered the Wisconsin Scholars Grant were less likely to work and worked fewer hours than similar peers (Broton et al. 2016). Our supplementary analyses suggest that the grant may have enabled students to pursue slightly more academically challenging majors on average, but do not provide sufficient evidence to conclude that this is the primary mechanism through which grant aid affects STEM major selection.

In particular, students who were offered additional grant aid were substantively more likely to major in academic STEM fields, like biology, and high-demand applied STEM fields, like engineering, though only the former is statistically significant at traditional levels. The grant offer reduced the share of students majoring in applied non-STEM fields, such as business or education, and to a smaller extent, shifted students away from academic non-STEM fields, such as sociology.

Although those offered additional grant aid had less student debt than their peers (Goldrick-Rab et al. 2016), the treatment did not appear to induce students to select lower-paying majors, on average. Indeed, point estimates for impacts on major choice in terms of associated earnings were positive, but substantively small. This is most likely because STEM fields are generally quite lucrative, and the non-STEM fields that treated students took up less frequently vary in their associated earnings—some, like Education, are relatively low and others, like Business, are quite high. Broadly, we reject the hypothesis that the grant offer induced students to pursue less remunerative fields of study.

Both “mechanisms” we investigated presumed that grant aid “freed” students to pursue underlying preferences. The two proposed mechanisms simply varied in what we assumed students’ underlying preferences might be. Our null findings for these mechanisms might suggest that we were wrong about the underlying preferences of undergraduates in general; or of those of our study population (lower-income students in public Wisconsin institutions); that the grant was insufficient to allow students to follow these particular preferences; or that our theoretical mechanisms were poorly measured. Additional research that “unpacks the black box” of experimental and quasi-experimental studies, including this one, is important for better understanding processes through which grant aid influences STEM major selection.

Exploratory analyses suggest that students may have responded to the grant differently, based on the financial aid system's calculation of their expected family contribution. However, due to the number of interactions tested, this marginally significant difference may have occurred by chance. Findings indicate that the grant induced students from families with more financial resources to major in a STEM field of study whereas there was no substantive impact on those from families with the fewest resources. Due to the research design, it is not clear if these differences are driven by EFC or highly correlated, but unmeasured factors, such as social and cultural capital. Regardless of the exact causal mechanism, the grant offer may have exacerbated socioeconomic differences in STEM major selection among students from low-income families. To minimize potential unintended consequences, those seeking to increase the share of STEM majors from low-income families may want to consider how financial, social, and cultural capital jointly influence major selection.

Though need-based grant aid is not formally designed to increase the share of students pursuing STEM fields of study, it appears to be one approach to doing so. Back-of-the-envelope analyses suggest that the grant induced 21 more students to major in STEM at a cost of $1,944,250 or approximately $93,000 per student.[8] This per-student cost is very similar to prior quasi-experimental estimates. Castleman and

[8] We calculated total direct costs by multiplying the number of students in the treatment group that actually received the grant in each semester of the study period by $1750. We calculated that 21 students were induced to major in STEM fields by multiplying the number of students in the treatment group by the proportion those in the treatment and control groups majoring in STEM and taking the difference: [(266* .2657) - (266*.1863)].

colleagues (2018) studied a similar need-based grant program in Florida and report that it costs $106,000 for each additional STEM graduate. Following their calculation of a $10,000 annual wage premium for entry-level college-educated workers (Carnevale, Cheah, and Hanson 2015), and assuming that these upperclassmen attain degrees, it would take 10 years for the benefits of the WSG to outweigh the costs. These estimates are likely conservative, however, since they ignore the non-pecuniary benefits of a STEM career and the fact that “the average earnings of STEM majors grow more quickly than other majors over the course of a career” (Castleman et al. 2018:162). Furthermore, future research examining the cost-effectiveness of need-based grant aid must also consider STEM-associated gains in the labor market to avoid understating the long-run impacts of financial aid (e.g., Bettinger et al. 2016).

Conclusion

Our findings indicate that need-based grant aid is one way to promote the national priority of increasing the share of STEM majors needed to contribute to a competitive and prosperous workforce (Handelsman and Smith 2016; The White House 2017). At an individual-level, need-based grant aid appears to promote economic mobility and reduce social inequality by helping low-income students earn a bachelor's degree *and* inducing them to pursue a STEM field, which is associated with higher pay, lower employment rates, and greater access to health and retirement benefits (Choy and Badburn 2008; Goldrick-Rab et al. 2016). While lack of academic preparation, individual preferences for non-STEM majors, or a lack of information may impede some students' pursuit of a STEM major, our study indicates that resource constraints are also a barrier for students from low-income families. Policies and practices that increase the price of STEM majors – such as differential tuition pricing or additional program fees – may be hampering the production of STEM degrees. Moreover, STEM initiatives that ignore financial constraints – such as informational campaigns – may be more effective if they also address students' financial challenges. Overall, need-based grant aid appears to be one avenue for increasing the share of undergraduates pursuing STEM fields and promoting the socioeconomic mobility of students from low-income families.

REFERENCES

Addo, Fenaba R. 2014. “Debt, Cohabitation, and Marriage in Young Adulthood.” *Demography 51* (5): 1677–1701.

Altonji, Joseph. G., Peter Arcidiacono, and Arnaud Maurel. 2016 “The Analysis of Field Choice in College and Graduate School: Determinants and Wage Effects,” Pp. 305-396 in *Handbook of the Economics of Education, Volume 5*, edited by E. A. Hanushek, S. Machin, and L. Woessmann. Oxford, UK: Elsevier.

Altonji, Joseph G., Erica Blom, and Costas Meghir. 2012. "Heterogeneity in Human Capital Investments: High School Curriculum, College Major, and Careers." *Annual Review of Economics. 4*(1): 185-223.

American Institute of Physics. 2017. “Senate Appropriators Spotlight STEM Education Funding”*. Science Policy News from AIP*. Retrieved July 9, 2018 (https://www.aip.org/fyi/2017/senate-appropriators-spotlight-stem-education-funding).

Anderson, Drew. M., and Sara Goldrick-Rab. 2018. *Aid After Enrollment: Impacts of a Statewide Grant Program at Public Two-Year Colleges* (Working Paper). Madison, WI: Wisconsin HOPE Lab.

Angrist, Joshua, Sally Hudson, and Amanda Pallais. 2014. *Leveling Up: Early Results from A Randomized Evaluation of Post-Secondary Aid* (NBER Working Paper No. 20800). Cambridge, MA: National Bureau of Economic Research.

Arcidiacono, Peter. 2004. “Ability Sorting and the Returns to College Major.” *Journal of Econometrics 121*(1): 343-375.

Arcidiacono, Peter, V. Joseph Hotz, and Songman Kang. 2012. "Modeling College Major Choices Using Elicited Measures of Expectations and Counterfactuals." *Journal of Econometrics 166*(1): 3-16.

Astin, Alexander W. 1993. *What Matters in College: Four Critical Years Revisited*. San Francisco: Jossey-Bass.

Attewell, Paul, Scott Heil, and Liza Reisel. 2011. “Competing Explanations of Undergraduate Noncompletion.” *American Educational Research Journal 48*(3): 536-559.

Avery, Christopher, and Sarah Turner. 2012. “Student Loans: Do College Students Borrow Too Much—Or Not Enough?” *The Journal of Economic Perspectives 26*(1): 165-192.

Baker, Dominique J., and William R. Doyle. 2017. "Impact of Community College Student Debt Levels on Credit Accumulation." *The ANNALS of the American Academy of Political and Social Science 671*(1): 132-153.

Balsamo, Michela, Marco Lauriola, and Aristide Saggino. 2012. "Personality and College Major Choice: Which Come First?" *Psychology* 3(5): 399-405.

Barrow, Lisa, and Ofer Malamud. 2015. “Is College a Worthwhile Investment?” *Annual Review of Economics 7*(1): 519-555.

Berger, Mark C. 1988. “Predicted Future Earnings and Choice of College Major.” *ILR Review 41*(3): 418-429.

Bettinger, Eric, Oded Gurantz, Laura Kawano, and Bruce Sacerdote. 2016. *The Long Run Impacts of Merit Aid: Evidence from California’s Cal Grant* (NBER Working Paper No. 22347). Cambridge, MA: National Bureau of Economic Research.

Boatman, Angela, and Brent J. Evans. 2017. “How Financial Literacy, Federal Aid Knowledge, and Credit Market Experience Predict Loan Aversion for Education.” *The ANNALS of the American Academy of Political and Social Science 671*(1): 49-68.

Bourdieu, Pierre. 1984. *Distinction: A Social Critique of the Judgement of Taste.* London: Routledge.

Bozick, Robert. 2007. “Making it Through the First Year of College: The Role of Students' Economic Resources, Employment, and Living arrangements.” *Sociology of Education 80*(3): 261-285.

Bozick, Robert, and Angela Estacion. 2014. “Do Student Loans Delay Marriage? Debt Repayment and Family Formation in Young Adulthood.” *Demographic Research 30*(69): 1865-1891.

Brint, Steven, Kristopher Proctor, Robert A. Hanneman, Kerry Mulligan, Matthew B. Rotondi, and Scott P. Murphy. 2011. “Who Are the Early Adopters of New Academic Fields? Comparing Four Perspectives on The Institutionalization of Degree Granting Programs in US Four-Year Colleges and Universities, 1970–2005.” *Higher Education 61*(5): 563-585.

Brint, Steven, Mark Riddle, Lori Turk-Bicakci, and Charles S. Levy. 2005. “From the Liberal to the Practical Arts in American Colleges and Universities: Organizational Analysis and Curricular Change.” *The Journal of Higher Education 76*(2): 151-180.

Broton, Katharine. M., and Sara Goldrick-Rab. 2018. “Going Without: An Exploration of Food and Housing Insecurity among Undergraduates.” *Educational Researcher 47*(2): 121-133.

Broton, Katharine M., Sara Goldrick-Rab, and James Benson. 2016. “Working for College: The Causal Impacts of Financial Grants on Undergraduate Employment.” *Educational Evaluation and Policy Analysis 38*(3): 477–494.

Business Roundtable. 2017. "Business Roundtable Welcomes Administration's Focus on STEM Education, Computer Science". Retrieved July 9, 2018 (https://www.businessroundtable.org/media/news-releases/business-roundtable-welcomes-administration%E2%80%99s-focus-stem-education-computer).

Camera, Lauren. 2017. "Low-Income Students Nowhere to Be Found in STEM: A Dearth of Low-Income Students in STEM Has College Officials 'Terrified.'" *U.S. News and World Report*, May 25*.* Retrieved July 10, 2018 (https://www.usnews.com/news/stem-solutions/articles/2017-05-25/low-income-students-nowhere-to-be-found-in-stem).

Carnevale, Anthony P., Ban Cheah, and Andrew R. Hanson. 2015. *The Economic Value of College Majors.* Washington, D.C.: Center on Education and the Workforce, Georgetown University.

Castleman, Benjamin L., Bridget Terry Long, and Zachary Mabel. 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.

Charles, Maria, and Karen Bradley. 2009. "Indulging our Gendered Selves? Sex Segregation by Field of Study In 44 Countries." *American Journal of Sociology 114*(4): 924-976.

Chen, Xianglei. 2013. *STEM Attrition: Paths into and out of STEM Fields: Statistical Analysis Report*. Washington, D.C.: National Center for Education Statistics, U.S. Department of Education.

Choy, Susan P., and Ellen M. Badburn. 2008. *Ten Years After College: Comparing the Employment Experiences of 1992–93 Bachelor's Degree Recipients with Academic and Career-Oriented Majors.* Washington, D.C.: National Center for Education Statistics, U.S. Department of Education.

Clark, Burton R., and Martin Trow. 1966. "Determinants of the Subculture of College Students: The Organizational Context," Pp. 17-70 in *College Peer Groups: Problems and Prospects for Research*, edited by T. Newcomb and E. Wilson. Chicago, IL: Aldine.

College Board. 2017. *Trends in College Pricing 2016*. Washington, DC: College Board.

Cornwell, Christopher, Kyung H. Lee, and David B. Mustard. 2006. *The Effects of State-Sponsored Merit Scholarships on Course Selection and Major Choice in College* (IZA Discussion Paper No. 1953)*.* Bonn, Germany: Institute of Labor Economics.

Correll, Shelley J. 2001. "Gender and the Career Choice Process: The Role of Biased Self-Assessments." *American Journal of Sociology 106*(6): 1691-1730.

Correll, Shelley J. 2004. "Constraints into Preferences: Gender, Status, and Emerging Career Aspirations." *American Sociological Review 69*(1): 93-113.

Dadgar, Mina. 2012. *The Academic Consequences of Employment for Students Enrolled in Community College* (CCRC Working Paper No. 46). New York, NY: Community College Research Center, Columbia University.

Department of Homeland Security. 2016. *STEM Designated Program List.* Washington, D.C.: Department of Homeland Security. Retrieved July 10, 2018 (https://www.ice.gov/sites/default/files/documents/Document/2016/stem-list.pdf).

DeSimone, Jeffrey S. 2008. *The Impact of Employment During School on College Student Academic Performance* (NBER Working Paper No. 14006). Cambridge, MA: National Bureau of Economic Research.

DesJardins, Stephen L., and Brian P. McCall. 2014. "The Impact of The Gates Millennium Scholars Program on College and Post-College Related Choices of High Ability, Low-Income Minority Students." *Economics of Education Review 38*: 124-138.

Dettling, Lisa J., and Joanne W. Hsu. 2017. "Returning to the Nest: Debt and Parental Co-Residence Among Young Adults." *Labour Economics* (Online, Print Forthcoming).

Dickson, Lisa. 2010. “Race and Gender Differences in College Major Choice.” *The ANNALS of the American Academy of Political and Social Science 627*(1): 108–124.

Dwyer, Rachel E., Laura McCloud, and Randy Hodson. 2012. "Debt and Graduation from American Universities." *Social Forces 90*(4): 1133-1155.

Easterlin, Richard A. 1995. "Preferences and Prices in Choice of Career: The Switch to Business, 1972–1987." *Journal of Economic Behavior & Organization 27*(1): 1-34.

Ehrenberg, Ronald G., and Daniel R. Sherman. 1987. "Employment While in College, Academic Achievement, and Postcollege Outcomes: A Summary of Results." *The Journal of Human Resources 22*: 1–23.

Elwert, Felix, and Christopher Winship. 2014. "Endogenous Selection Bias: The Problem of Conditioning on a Collider Variable." *Annual Review of Sociology 40*(1): 31-53.

England, Paula, and Su Li. 2006. "Desegregation Stalled: The Changing Gender Composition of College Majors, 1971-2002." *Gender and Society 20*(5): 657-677.

Evans, Brent J. 2017. "SMART Money: Do Financial Incentives Encourage College Students to Study Science?." *Education Finance and Policy 12*(3): 342-368.

Evans, Brent J., Angela Boatman, and Adela Soliz. 2018. "Framing and Labelling Effects in Preferences for Borrowing for College: An Experimental Analysis." *Research in Higher Education*, (Online, print forthcoming).

Fiorito, Jack, and Robert C. Dauffenbach. 1982. "Market and Nonmarket Influences on Curriculum Choice by College Students." *ILR Review 36*(1): 88-101.

Gicheva, Dora. 2016. "Student Loans or Marriage? A Look at The Highly Educated." *Economics of Education Review 53*: 207-216.

Goldrick-Rab, Sara. 2006. "Following Their Every Move: An Investigation of Social-Class Differences in College Pathways." *Sociology of Education 79*(1): 61-79.

Goldrick-Rab, Sara. 2016. *Paying the Price: College Costs, Financial Aid, and the Betrayal of the American Dream*. Chicago, IL: The University of Chicago Press.

Goldrick-Rab, Sara, and Robert Kelchen. 2015. "Making Sense of Loan Aversion: Evidence from Wisconsin," Pp. 317-378 in *Student Loans and the Dynamics of Debt*, edited by B. Hershbein and K. M. Hollenbeck. Kalamazoo, MI: W.E. Upjohn Institute for Employment Research.

Goldrick-Rab, Sara, Robert Kelchen, Douglas N. Harris, and James Benson. 2016. "Reducing Income Inequality in Educational Attainment: Experimental Evidence on the Impact of Financial Aid on College Completion." *American Journal of Sociology 121*(6): 1762–1817.

Goyette, Kimberly A., and Ann L. Mullen. 2006. "Who Studies the Arts and Sciences? Social Background and The Choice and Consequences of Undergraduate Field of Study." *The Journal of Higher Education 77*(3): 497-538.

Handelsman, Jo and Megan Smith. 2016. "STEM for All". *Obama White House Blog*, February 11. Retrieved July 10, 2018 (https://obamawhitehouse.archives.gov/blog/2016/02/11/stem-all).

Herzog, Serge. 2018. "Financial Aid and College Persistence: Do Student Loans Help or Hurt?" *Research in Higher Education 59*(3): 273-301.

Hillman, Nicholas W. 2014. "College on Credit: A Multi-Level Analysis of Student Loan Default." *Review of Higher Education* 37(2): 169-195.

Hillman, Nicholas W. 2015. "Borrowing and Repaying Federal Student Loans." *Journal of Student Financial Aid 45*(3): 35-48.

Horn, Laura J. and Lisa Zahn. 2001. *From Bachelor's Degree to Work: Major Field of Study and Employment Outcomes of 1992-93 Bachelor's Degree Recipients Who Did Not Enroll in Graduate Education by 1997.* Washington, D.C.: National Center for Education Statistics, U.S. Department of Education.

Jacobs, Jerry A. 1989. *Revolving Doors: Sex Segregation and Women's Careers*. Stanford, CA: Stanford University Press.

Jacobs, Jerry A. 1995. "Gender and Academic Specialties: Trends among Recipients of College Degrees in the 1980s." *Sociology of Education 68*(2): 81-98.

Johnson, Iryna Y., and William B. Muse. 2017. "Choice of Academic Major at a Public Research University: The Role of Gender and Self-Efficacy." *Research in Higher Education 58*(4): 365-394.

Katchadourian, Herant. A., and John Boli. 1985. *Careerism and Intellectualism Among College Students*. San Francisco: Jossey-Bass Pub.

Kelchen, Robert. 2018. "Trends in Net Price by Family Income." *Kelchen on Education Blog*, June 6. Retrieved July 10, 2018 (https://robertkelchen.com/kelchen-on-education/).

Kelchen, Robert, Sara Goldrick-Rab, and Braden Hosch. 2017. " The Costs of College Attendance: Examining Variation and Consistency in Institutional Living Cost Allowances." *The Journal of Higher Education 88* (6): 947–971.

Kim, ChangHwan, Christopher R. Tamborini, and Arthur Sakamoto. 2015. “Field of Study in College and Lifetime Earnings in the United States.” *Sociology of Education* 88(4): 320–339.

Kinsley, Peter and Sara Goldrick-Rab. 2016. "Making the Grade: The Academic Side of College Life Among Financial Aid Recipients." Chapter 5 in *The Working Classes and Higher Education: Inequality of Access, Opportunity and Outcome*, edited by A. E. Stich and C. Freie. New York, NY: Routledge.

Leppel, Karen, Mary L. Williams, and Charles Waldauer. 2001. "The Impact of Parental Occupation and Socioeconomic Status on Choice of College Major." *Journal of Family and Economic issues 22*(4): 373-394.

Ma, Yingyi. 2009. "Family Socioeconomic Status, Parental Involvement, and College Major Choices—Gender, Race/Ethnic, and Nativity Patterns." *Sociological Perspectives 52*(2): 211-234.

Mann, Allison, and Thomas A. DiPrete. 2013. "Trends in Gender Segregation in The Choice of Science and Engineering Majors." *Social Science Research 42*(6): 1519-1541.

McCormick, A., J. Moore, and G. Kuh. 2010. "Working During College: Its Relationship to Student Engagement and Educational Outcomes," Pp. 179-212 in *Understanding the Working College Student: New Research and Its Implications for Policy and Practice*, edited by L. W. Perna. Sterling, VA: Stylus.

McKinney, Lyle, and Andrea Backscheider Burridge. 2015. "Helping or Hindering? The Effects of Loans on Community College Student Persistence." *Research in Higher Education 56*(4): 299-324.

Mervis, Jeffrey. 2014. “Data check: U.S. Producing More STEM Graduates Even Without Proposed Initiatives.” *Science*, June 30. Retrieved July 10, 2018 (http://www.sciencemag.org/news/2014/06/data-check-us-producing-more-stem-graduates-even-without-proposed-initiatives).

Monaghan, David, and Sou Hyun Jang. 2017. "Major Payoffs: Postcollege Income, Graduate School, and the Choice of “Risky” Undergraduate Majors." *Sociological Perspectives 60*(4): 722-746.

Montmarquette, Claude, Kathy Cannings, and Sophie Mahseredjian. 2002. "How do Young People Choose College Majors?" *Economics of Education Review 21*(6): 543-556.

Morgan, Stephen. L., and Christopher Winship. 2015. *Counterfactuals and Causal Inference*. Cambridge: University Press.

Mullen, Ann L. 2010. *Degrees of Inequality: Culture, Class, and Gender in American Higher Education*. Baltimore: Johns Hopkins University Press.

Mullen, Ann L. 2014. "Gender, Social Background, and the Choice of College Major in a Liberal Arts Context." *Gender & Society 28*(2): 289-312.

Mullen, Ann L., Kimberly A. Goyette, and Joseph A. Soares. 2003. "Who Goes to Graduate School? Social and Academic Correlates of Educational Continuation After College." *Sociology of Education 76*(2): 143-169.

National Research Council. 2015. *Identifying and Supporting Productive STEM Programs in Out-of-School Settings.* Washington, DC: The National Academies Press.

National Science Board. 2016. *Science and Engineering Indicators 2016*. Washington, D.C.: National Science Board.

National Student Clearinghouse Research Center. 2015. *Snapshot Report: Degree Attainment*. Washington, D.C.: National Student Clearinghouse. Retrieved July 10, 2018 (https://nscresearchcenter.org/wp-content/uploads/SnapshotReport15-DegreeAttainment.pdf).

National Student Clearinghouse Research Center. 2016. *High School Benchmarks 2016.* Washington, D.C.: National Student Clearinghouse. Retrieved July 10, 2018 (https://nscresearchcenter.org/wp-content/uploads/HighSchoolBenchmarks2016.pdf).

Organisation for Economic Co-operation and Development. 2017. *Education at a Glance 2017: OECD Indicators.* Paris: OECD.

Porter, Stephen R., and Paul D. Umbach. 2006. "College Major Choice: An Analysis of Person–Environment Fit." *Research in Higher Education 47*(4): 429-449.

Quadlin, Natasha. 2017. "Funding Sources, Family Income, and Fields of Study in College." *Social Forces 96*(1): 91–120.

Riegle-Crumb, Catherine, Barbara King, Eric Grodsky, and Chandra Muller. 2012. "The More Things Change, The More They Stay the Same? Prior Achievement Fails to Explain Gender Inequality in Entry into STEM College Majors Over Time." *American Educational Research Journal 49*(6): 1048-1073.

Riggert, Steven C., Mike Boyle, Joseph M. Petrosko, Daniel Ash, and Carolyn Rude-Parkins. 2006."Student Employment and Higher Education: Empiricism and Contradiction." *Review of Educational Research 76*(1): 63-92.

Roksa, Josipa, and Tania Levey. 2010. "What Can You Do with That Degree? College Major and Occupational Status of College Graduates over Time." *Social Forces 89*(2):389-415.

Rothstein, Jesse, and Cecilia Elena Rouse. 2011. "Constrained after College: Student Loans and Early-Career Occupational Choices." *Journal of Public Economics 95*(1): 149-163.

Ruggles, Steven, Katie Genadek, Ronald Goeken, Josiah Grover, and Matthew Sobek. 2017. *Integrated Public Use Microdata Series*: Version 7.0 [dataset]. Minneapolis: University of Minnesota. Retrieved May 22, 2018 (https://doi.org/10.18128/D010.V7.0).

Schudde, Lauren T. 2011. "The Causal Effect of Campus Residency on College Student Retention." *The Review of Higher Education 34*(4): 581-610.

Scott-Clayton, Judith. 2011. "The Causal Effect of Federal Work-Study Participation: Quasi-Experimental Evidence From West Virginia." *Educational Evaluation and Policy Analysis 33*(4): 506–527.

Scott-Clayton, Judith. 2012. "What Explains Trends in Labor Supply Among U.S. Undergraduates?" *National Tax Journal 65*(1): 181–210.

Scott-Clayton, Judith, and Veronica Minaya. 2016. "Should Student Employment Be Subsidized? Conditional Counterfactuals and The Outcomes of Work-Study Participation." *Economics of Education Review 52*: 1-18.

Seigel, Dora. 2015. "Historical ACT Percentiles for 2010, 2009, and 2008." *Prep Scholar Blog*, December 4. Retrieved July 10, 2018 (https://blog.prepscholar.com/historical-act-percentiles-2010-2009-2008).

Sjoquist, David L., and John V. Winters. 2015. "State Merit Aid Programs and College Major: A Focus on STEM." *Journal of Labor Economics 33*(4): 973-1006.

Snyder, Thomas D., Cristobal de Brey, and Sally A. Dillow. 2018. *Digest of Education Statistics 2016*. Washington, D.C.: National Center for Education Statistics, U.S. Department of Education.

State Higher Education Executive Officers Association. 2018. *State Higher Education Finance 2017*. Boulder, CO: State Higher Education Executive Officers.

Stater, Mark. 2011. "Financial Aid, Student Background, and the Choice of First-Year College Major." *Eastern Economic Journal 37*(3): 321-343.

Stinebrickner, Ralph, and Todd R. Stinebrickner. 2003. "Working During School and Academic Performance." *Journal of Labor Economics 21*(2): 473–491.

Stinebrickner, Ralph, and Todd R. Stinebrickner. 2013. "A Major in Science? Initial Beliefs and Final Outcomes for College Major And Dropout." *Review of Economic Studies 81*(1): 426-472.

Webber, Douglas A. 2016. "Are College Costs Worth It? How Ability, Major, and Debt Affect the Returns to Schooling." *Economics of Education Review 53*: 296-310.

What Works Clearinghouse. 2017. *Procedures and Standards Handbooks Version 4.0.* Washington, D.C.: U.S. Department of Education.

The White House. 2017. *National Security Strategy of the United States of America*. Washington, D.C.: The White House. Retrieved July 10, 2018 (https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905.pdf).

Xue, Yi, and Richard Larson. "STEM Crisis or STEM Surplus? Yes and Yes." *Monthly Labor Review,* U.S. Bureau of Labor Statistics, May. Retrieved July 10, 2018 (https://www.bls.gov/opub/mlr/2015/article/stem-crisis-or-stem-surplus-yes-and-yes.htm).

Zafar, Basit. 2011. "How Do College Students Form Expectations?" *Journal of Labor Economics 29*(2): 301-348.

Zafar, Basit. 2013. "College Major Choice and the Gender Gap." *Journal of Human Resources 48*(3): 545-595.

Zhang, Lei. 2013. "Effects of College Educational Debt on Graduate School Attendance and Early Career and Lifestyle Choices." *Education Economics 21*(2): 154-175.

Zhang, Liang. 2016. "Does Merit-Based Aid Affect Degree Production in STEM Fields? Evidence from Georgia and Florida." *Journal of Higher Education 82*(4): 389-415.

APPENDIX

Table A1. Categorization of Majors in Four-category Scheme (may appear online)

	Academic	Applied
STEM	Biological or Life Sciences Biochemistry Biology Genetics Zoology Mathematics Mathematics Physical Sciences Chemistry Geology Physics	Agriculture & Environmental Studies Animal Science Conservation & Environmental Sciences Crop & Soil Science Dairy Science Environmental Horticulture Environmental Policy & Planning Environmental Sciences Wildlife Ecology & Management Computer & Information Sciences Computer Science Information Science & Technology Engineering & Engineering Technologies Biological Systems Engineering Chemical Engineering Civil Engineering Computer Engineering Electrical Engineering Engineering Industrial Technology and Management Manufacturing Engineering Mechanical Engineering Interdisciplinary Sciences, Applied Applied Science Biomedical Science Biotechnology Cartography and Geographic Information Systems Chemistry with Business Emphasis Human Biology Human Development Nutritional Science

Table continued on next page…

Table A1 continued…

	Academic	Applied	
Non-STEM	Humanities & Liberal Arts English Gender & Women's Studies Global Studies History Humanistic Studies Interdisciplinary Arts Interdisciplinary Studies International Studies Japanese Legal Studies Liberal Studies Philosophy Spanish Social Sciences Anthropology Geography Political Science Psychology Sociology Visual & Performing Arts Art Art History Dance Design Arts Fine Arts Graphic Design Music Music, Applied Performance Stage & Screen Arts Theatre & Drama	Agriculture & Environmental Studies Agricultural Business Agricultural Engineering Technology Fisheries & Water Resources Life Sciences Communication Resource Management Architecture Architectural Studies Business Accounting Business Administration Business Management Finance General Business Hotel, Restaurant & Tourism Management Human Resource Management Information Technology Management Marketing Personal Finance Retail Merchandising & Management Transportation & Logistics Management	Communications Communication Communication Studies Cross-media Graphics Management Journalism Marketing Communication Media Studies Radio, TV & Film Education Agriculture Education Art Education Early Childhood Education Education Elementary Education Family & Consumer Sciences Education Marketing & Business Education Music Education Physical Education Physical Science Education Social Science for Teacher Certification Special Education Family & Consumer Sciences Human Development & Family Studies Food Science & Technology Textile & Fashion Design

Table continued on next page…

Table A1 continued…

	Academic	Applied	
Non-STEM		<u>Health</u> Applied Health Sciences Athletic Training Communication Sciences & Disorders Communicative Disorders Dietetics Healthcare Administration Imaging Nuclear Medicine Technology Nursing Therapeutic Recreation	<u>Parks, Fitness & Leisure Studies</u> Health Promotion & Wellness Kinesiology Recreation Management Sport Management <u>Public Administration, Social Service & Protective Professions</u> Criminal Justice Human Services Leadership Public Administration Social Work

Note: We present the major names used by each institution and organize the classification by CIP Code or Field as explained in Brint and colleagues (2005) and the Department of Homeland Security (2016). Institution major names do not necessarily match CIP major names, nor are they consistent across institutions (i.e., two institutions may have different major names though use the same UW System and CIP codes to classify that major). We removed duplicate names for a more concise presentation and so display fewer than the 128 institution-specific majors represented in the analytic sample.

Table A2. Wisconsin Scholars Grant Unadjusted Impact on Field of Study

	Analytic Sample	Control	Treatment	*p* Value	*p* Value
				(alternative base categories)	
Field of Study					
STEM (%)	21.96	18.63	26.57	0.026*	na
Non-STEM (%)	78.04	81.37	73.43		
Academic (%)	36.32	34.91	38.26	0.416	na
Applied (%)	63.68	65.09	61.74		
Detailed Field of Study					
Applied STEM (%)	11.94	10.59	13.81	0.585	0.157
Academic STEM (%)	10.02	8.04	12.76	(base)	0.038*
Applied Non-STEM (%)	51.74	54.50	47.93	0.038*	(base)
Academic Non-STEM (%)	26.30	26.87	25.50	0.095+	0.713
N	619	353	266		

+ p<.10, * p<.05, ** p<.01, *** p<.001