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Achieving the Promise of Educational Opportunity: Graduate Student Debt for STEM vs. Non-STEM Students, 2012

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By Rachel Burns and Karen L. Webber

Using NPSAS 2012 data, this study examines graduate student debt for STEM versus non-STEM students who were enrolled in a master's or doctoral degree program in 2012. Findings showed significantly higher debt for those in non-STEM programs as well as differences by amount of undergraduate debt, race, and full- or part-time enrollment status. These differences may encourage more STEM participation, but may restrict some students from enrolling in graduate-level programs, particularly in non-STEM fields. The loss of a new generation of citizens with graduate level training may affect our national economy and productivity, and urges institution officials to consider means to offer financial aid to a larger number of graduate students.

Keywords: *Graduate students, graduate school debt, STEM, NPSAS*

Recent social, economic, and political forces influence trends in education and subsequently affect the promise of equal educational opportunity for students. However, a highly technical, global, and complex world does not diminish the need for graduate level education, but rather enhances it. While all academic disciplines contribute to national academic improvement (Sommers & Franklin, 2012), the calls for graduate degree production are particularly strong in science and engineering fields (NSF, 2012; COSEPUP, 2000). As the United States economy transitions away from industrial/manufacturing employment toward knowledge/technological employment, additional skills attained at the graduate level are essential. As an important indicator of achievement for all students, there is also a deliberate focus on the inclusion of women, minorities, and low-income students who have historically been underrepresented in graduate education, particularly in science, technology, engineering, and mathematics (STEM) fields. The educational attainment of underrepresented populations is important to address given the link between graduate education and socioeconomic mobility (Haskins, 2016). Recent research and policy activities have sought to determine the factors associated with graduate school enrollment and to expand access to graduate education, especially among these underrepresented groups.

Compared to what is known about factors that influence students' decision to enroll in an undergraduate degree program (e.g., Baum, McPherson, & Steele, 2008; Perna, 2010), we know relatively little about factors that contribute to graduate education enrollment and borrowing for graduate education. Given that about 70% of all students graduating from four-year colleges have student loan debt (TICAS, 2014 and confirmed in our data from NPSAS:2012) and proposed policy changes to limit graduate funding, an increasing number of students may choose to not pursue graduate education or could face debt loads that are difficult to repay in the years to come. This may contribute to students delaying or forgoing graduate education altogether. Moreover, since federal loans comprise over 60% of all graduate student aid (College Board,

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2017 and confirmed in NPSAS:2012), a better understanding of graduate student needs can inform possible legislative action and institutional policy changes. At a time when higher levels of educational attainment are increasingly in demand, additional research on why students choose to enroll (or not enroll) in graduate educate and how they finance this education can ensure more equitable access to educational programs and financial support.

From the limited studies available, we know that along with student ability and integration in one's undergraduate program (Baird, 1996; Ethington & Smart, 1986; Kallio, 1995; Malaney & Issac, 1988), the decision to seek and complete graduate studies is also based on the ability to finance advanced education (Ehrenberg & Mavros, 1995; Malcom & Dowd, 2012; Millet, 2003; Millet & Nettles, 2006; Nettles, 1987; Gross et al., 2010). Currently, about 40% of the $1 trillion in outstanding student loan debt belongs to students in graduate and professional degree programs (Delisle, 2014), thus the concerns about student debt are extremely relevant for students and policy makers focused on graduate education. Along with higher debt reported for underrepresented minority (URM) doctoral students compared to white peers, Zeiser et al. (2013) found that 38% of PhD recipients in social, behavioral, and economic fields accrued more than $30,000 in graduate student debt, compared to 11% of PhD recipients in STEM fields. For the proponents of increasing enrollment in STEM education, this is an encouraging statistic; however, lack of representation in the STEM fields among women and minorities (NSF, 2017) despite overall growth in the number of STEM degrees awarded temper these findings and suggest the need for additional attention and research.

Rapid changes in technology will likely continue the demand for advanced STEM graduates, but the nation's economic and cultural advances will be strengthened by the contributions of graduates with advanced skills in communication, critical thinking, and appreciation of aesthetics. If the students in both STEM and non-STEM fields accrue high levels of debt that reduce the likelihood of degree completion or make loan repayment more difficult, the national economy may suffer from an under-production of employable graduates. Moreover, the trends towards higher levels of loan debt to finance graduate education could deter future students from investing in additional years of schooling (Delisle, 2014).

Purpose of the Study

As an understudied topic, a better understanding of enrollment in graduate programs and graduate student debt is important because knowledge production and economic gains on a national level are deeply affected by graduate student education. Projections of PhD shortages exist in some fields (Jaschik, 2016; Ehrenberg & Mavros, 1992) and could have negative consequences for employment in critical areas of the economy, particularly in the health and medical fields (Cooper, Getzen, McKee, & Laud, 2002). If students cannot afford graduate level education, they may choose not to enroll after the attainment of an undergraduate degree, and the nation's knowledge production and economic strength may be jeopardized. Moreover, recent policy changes at the federal level due to budgetary concerns have limited graduate students' access to income-driven repayment plans and public service loan forgiveness (the proposed PROSPER Act and the College Cost Reduction and Access Act of 2007), which may increase the likelihood that students will confront financial barriers to repaying loans for graduate education (Friedman, et al., 2016). Moreover, many graduate students are unaware of these programs and participation remains historically low (Abraham, et al., 2018). Additional research on how students finance their postsecondary education, particularly for graduate school, can inform future policy decisions at the federal level (Hopkins, 2012; Hillman, 2015).

With a focus on differences between STEM and non-STEM graduates, this study seeks to fill this gap in the literature on graduate student enrollment and borrowing by examining the factors that contribute to graduate student debt in 2012. Delisle (2014) and Webber and Burns (2016) reported an increase in overall graduate student debt from 2008 to 2012 in real terms, due in part to rising costs of education and greater demand for graduate education. Webber and Burns found an average mean cumulative debt for doctoral student borrowers who completed their degree in 2012 to be over $73,000. According to reports from the Brookings Institution, this level of debt associated with graduate education constitutes a statistically significant increase from previous years and may signal a trend towards unsustainable growth in debt loads among professional and other doctoral students (Lee & Looney, 2018). The reasons for this growth may be manifold, including the rising costs of education, reduced state support for higher education, limited institutional resources, or changes in the availability of federal and private loans due to policy initiatives (Looney & Yannelis, 2015).

While we know that overall debt has increased in the past decade, less research has explicitly examined borrowing by disciplinary groups and degree programs. Increases in student loans for graduate school may prevent some from attending further education or may encourage students to change the major pursued based on the availability of graduate assistantships[1] or significant cost differentials across fields of study. The differences in both the cost of degree and the amount of funding available within a field may encourage students to pursue degrees based on purely financial rather than human-capital or social considerations. In addition, high levels of graduate debt could harm student persistence and further widen the gaps among high- and low-achieving students, minority and majority students, and high- and low-income students (Gururaj, Heilig, & Somers, 2010). As technological and intellectual changes demand increased levels of education and training, it is critical to ensure that students are able to complete their graduate education without high debt burdens. However, in order to develop policy that responds to the workforce needs of the country as well as the individual needs of specific student populations, additional information on the determinants of graduate borrowing is necessary.

In accordance with these aims, this study seeks to close the gap in the literature and focuses on three specific research questions:

1. What is the 2012 level of graduate student debt in U.S. colleges and universities for STEM and non-STEM students, and how does this compare to previous years of debt in terms of growth in debt and ability to repay debt?
2. Do individual characteristics (i.e., gender, race, and level of undergraduate borrowing) influence graduate debt differently for STEM and non-STEM students? and
3. To what extent do specific institutional characteristics (i.e., institution size or Carnegie classification, sector, and institutional reliance on tuition) influence graduate debt?

Relevant Literature

Although attention to educational debt for undergraduate students has resulted in prolific literature, few empirical studies to date have focused specifically on debt loads for graduate students. Funding has been found to be the most important factor in the doctoral experience (Millett, 2003; Millett & Nettles, 2006), and this debt can negatively affect enrollment in graduate programs, particularly for recent STEM baccalaureate recipients (Malcom & Dowd, 2012). Belasco, Trivette, and Webber (2014) used NPSAS data between 2000 and 2008 and found that compared to 2000, borrowing among graduate students increased in real terms in 2008, and differed by gender, race, and degree program. Kim and Otts (2010) also found significant differences in borrowing across degree type and level in the 2005 Survey of Earned Doctorates (SED). Specifically, doctoral students in engineering, physical science, and biological science were the least likely to rely on loans to finance their graduate education, whereas students in humanities and social sciences were the most likely to do so. Rapoport (1999) also used SED data and found that underrepresented minority students in doctoral programs incurred more graduate debt than their white peers. A previous study surprisingly found that doctoral recipients in science and engineering (S&E) fields incurred more debt

[1] Throughout this study, "assistantships" refer to research and teaching assistantships from the department or institution and do not include other forms of grants or scholarships.

between 1993 and 1996 than did students in other fields (Rapoport, 1998), but it did not account for other predictors of graduate borrowing.[2] Collectively, these studies highlight the importance of loan debt and funding in graduate school enrollment and suggest the need for additional research into the differences in borrowing for graduate school among students enrolled in different fields and degree programs.

Although the literature examining predictors of graduate student debt is limited, research on the consequences of educational borrowing is more extensive. Research suggests that the availability of financial resources can serve as an important predictor of student outcomes, and that undergraduate debt can affect decisions to enroll in graduate education. While many of these studies theorize that graduate degree enrollment is correlated with undergraduate debt levels, the findings are mixed. For instance, some researchers (Ekstrom, Goertz, Pollack, & Rok, 1991; Shapiro, O'Malley, & Litten, 1991; Weiler, 1995; English & Umbach, 2016) have found a limited connection between undergraduate debt and graduate degree enrollment, while others report that the correlation is significant (Malcom & Dowd, 2012 for recent STEM baccalaureate recipients; Fox, 1992; Zhang, 2013). The disagreement among authors on the extent to which undergraduate debt may affect graduate enrollment highlights the need for additional research on the determinants of graduate-level borrowing (including prior accumulation of debt) and the effects of debt loads at the graduate and undergraduate level on students' enrollment decisions.

Malcom and Dowd (2012) used propensity score matching to examine the effects of borrowing for undergraduate education among students in STEM fields and found that borrowing patterns varied by race/ethnicity and that higher levels of borrowing had a negative effect on graduate school enrollment within two years of completing a bachelor's degree. Other research focused on correlational rather than causal impacts; for instance, Fox (1992) identified a statistically significant and negative association between undergraduate debt and women's decisions to enroll in doctoral programs, while Zhang (2013) found that debt was negatively correlated with graduate school attendance for students in MBA, doctoral, and first professional programs. These studies and others underscore the necessity of understanding the student-level and institutional-level characteristics that are associated with distinctive borrowing patterns for graduate school to identify students with high levels of need and to develop research-based policy that addresses critical issues in graduate funding.

These negative consequences associated with debt burdens can extend beyond students' decisions to enroll in graduate education and can also affect persistence and completion. Graduate students relying on their own financial resources spend more time in graduate school and are less likely to complete their degrees (Bair & Haworth, 2004; Ehrenberg & Mavros, 1995). Students enrolled in programs lacking sufficient departmental or institutional funds to provide assistantships were also less likely to complete doctoral degrees due to the need to locate alternative forms of funding (Abedi & Benkin, 1987; Bowen & Rudenstein, 1992; Delisle, 2014; Dolph, 1983; Seigfried & Stock, 2001; Baird, 1990). According to NPSAS 2012 data, 38% of STEM students who graduated in 2012 received a teaching or research assistantship in 2012, compared to 14% of non-STEM students graduating in 2012. However, despite the fact that the average amount of grant aid per FTE students has increased for graduate students between 1990 and 2012, these increases have not kept pace with increases in tuition and fees; thus, more students turn to federal and non-federal loans to fund their graduate education (College Board, 2017).

In general, fewer federal financial aid funds are available for graduate programs than for undergraduates, particularly for the master's level and in non-STEM fields. Whereas doctoral students historically receive subsidized funding from the institution through participation in a research or teaching assistantship, few master's programs offer these benefits (Baird, 1990). In addition, recent initiatives at the federal level have

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[2] Moreover, the study included psychological and social sciences among S&E disciplines, a convention that other researchers do not follow.

attempted to promote enrollment in high-demand fields such as the STEM disciplines through the provision of additional funding (College Board, 2017). With recent changes in loan repayment rates, Delisle (2014) found that the largest changes in borrowing were at the graduate level. His review of the NPSAS dataset confirmed the need to differentiate graduate from undergraduate borrowing in the national discussion about student debt. Similarly, Zeiser et al. (2013) used data from the Survey of Earned Doctorates (SED) and found that student debt levels are larger at the graduate level, as are the differences in student debt between PhD recipients in STEM and those who major in social, business, and economics (SBE) fields. Overall, PhD recipients in SBE fields accrued higher levels of graduate student debt than PhD recipients in STEM fields, and more PhD recipients in SBE fields accrued debt (58%) than recipients of PhDs in STEM fields (28%). These discrepancies in debt accumulation may be attributable in part to the higher amount of extramural funding that faculty in STEM fields acquire for research, a portion of which may cover the tuition and assistantship of STEM graduate students (AAUS, 2017). This study builds upon and adds to this existing literature by investigating the differences in borrowing for graduate school among students in different graduate programs and fields using updated data from the nationally-representative NPSAS survey.

Producing more women and underrepresented minorities with advanced degrees in science and engineering is an important national goal that has led to several federal initiatives to support the presence of these populations in graduate education. While women have reached parity with men among degree recipients overall, they constitute disproportionally smaller percentages of employed scientists and engineers (NSF, 2017). In addition, Black/African American, Hispanic/Latino, and American Indian/Alaskan Native students have also increased their share of S&E degrees, but they remain underrepresented in graduate educational attainment and the S&E workforce. The "double bind" referred to by Malcom, Hall, & Brown (1976) for simultaneous sexism and racism in STEM careers might be further deepened if these students take on larger educational debt. Students' decisions to pursue graduate school are in part based on their knowledge of specific majors/disciplines, their potential career options, and the existence of institutions that offer desirable programs. Previous literature suggests that Black/African American and Hispanic/Latino students are less likely to have access to adequate information about college costs and financial aid (Freeman, 1997; Perna, 2000), and may consequently incur more educational debt than non-minority students in STEM fields (Malcom & Dowd, 2012). This interaction between socioeconomic status, gender, and race can serve as a doubly burdensome obstacle for students that could contribute to the gap in graduate degrees earned between majority and minority students or between historically high- and low-achieving groups.

Theoretical Framework

In seeking to fill the gap in the literature surrounding graduate students' borrowing decisions, this study is guided by the economic theories of human capital and rational choice, as both provide insight into the precursors of graduate school enrollment and borrowing. The human capital model posits that students will invest in their education to maximize utility, and that they conduct a cost-benefit analysis that determines their decisions to pursue further education (Elwood & Kane, 2000). These cost-benefit analyses include both monetary and non-monetary elements (Becker, 1993), and include direct financial considerations as well as psychological costs (Cunha, Heckman, & Navarro, 2005), such as the stress of "juggling" family and graduate school (Rice, Sorcinelli, & Austin, 2000) and the anxiety generated by additional loan burdens (Field, 2009).

Students with outstanding debt from undergraduate education, for instance, may be reluctant to accrue additional debt for graduate school (Millett, 2003). Individuals with a spouse or children, meanwhile, may opt against graduate education and the family-related sacrifices it would likely entail, regardless of financial considerations (Brus, 2006; Weiler, 1994). These perspectives warrant empirical attention to the influence that financial obligations and family circumstances may have on graduate school borrowing. More broadly, they suggest that decisions regarding education-related investments are rational yet varied (Manski & Wise, 1983; Manski, 1993), and depend considerably on personal preferences and circumstances (Perna, 2004).

In constructing rational decisions, DesJardins and Toutkoushian (2005) argue that rationality is not exclusive to those who make investments in schooling that are appropriate or that yield the most benefit. Individuals can act rationally yet make choices that may produce undesirable outcomes. The authors, along with other economic theorists (e.g., Becker, 1993; Elwood & Kane, 2000; Paulsen, 2001), purport that such behavior is consistent with the human capital model and can be attributed to personal preferences that derive from the attributes and experiences that shape how individuals perceive postsecondary education (De La Rosa & Hernandez-Gravelle, 2007; Rabin & Thaler, 2001) and gender (Alexitch, 2006; Roszkowski & Grable, 2010).

Other factors aside from personal preferences and experiences are likely to influence the level of borrowing for graduate school. The financial health of graduate programs, which serve as the primary sources of assistantship funding or tuition waivers, can impact the amount students borrow for their graduate education. Institutions and departments with large endowments or institutional budgets are more readily able to provide graduate scholarships and grants (Slaughter & Rhoades, 2004), while students pursuing graduate degrees at less wealthy institutions or in more professionalized fields rely more heavily on loans (Hoffer et al., 2006). Broader economic trends and institutional budgetary policies may also affect the ability of institutions to subsidize graduate education; institutions with declining public support or those with performance-based budgeting may confront difficulties allocating funding to graduate assistantships.

Method and Data

Data and Variables

Data for this study come from the 2012 National Postsecondary Student Aid Study (NPSAS), the Integrated Postsecondary Education Data System (IPEDS), and the Delta Cost Project (DCP). The 2012 update to NPSAS is the most recent update available at the time of this analysis. NPSAS respondents who were enrolled in a graduate or professional degree in 2012 were selected for analysis, and respondents in post-baccalaureate certificate programs and associate's institutions were omitted. The analytic sample for the 2012 cohort included 11,430 (rounded) graduate students, nationally representing 2,723,550 (rounded) students. Respondents from institutions with the parent-child flag in IPEDS were included in this analysis, as the results of the study did not vary when dropping these observations. Students were identified as enrolling in either a STEM or non-STEM program based on their field of degree; STEM programs include life sciences, math/engineering/computer science, and health; non-STEM programs include humanities, social/behavioral sciences, education, business/management, law, and others. Students were also classified as either master's or doctoral students.

The primary dependent variable used in our analyses was the cumulative amount borrowed for graduate school only, including all federal, private, and institutional loans graduate students had ever received for their graduate education.[3] The independent variables for institutional funding, graduate assistantship, and cumulative undergraduate borrowing were logged to assess the effects in terms of a percentage increase (rather than a dollar amount). The analysis includes four separate models: one for master's students, one for

[3] Students who earned master's degrees before earning doctoral degrees may have higher cumulative debt for graduate school. Some graduate programs may require students to attain master's degrees before pursuing doctoral education; thus, systematic differences in cumulative debt may exist across fields or programs. Future research could address this topic. For the purposes of this analysis, doctoral and master's degree students are analyzed separately and differences in graduate debt did not compromise the findings.

doctoral students, one for STEM students (both master's and doctoral), and one for non-STEM students (both master's and doctoral). In the models for master's and doctoral students, the primary independent variable of interest is a binary indicator of enrollment in a STEM or non-STEM program. In the models for STEM and non-STEM students, the primary variable of interest is a binary indicator of enrollment in a master's or doctoral program. Additional covariates include age, gender, race/ethnicity, marital status, enrollment intensity, number of dependents, amount of undergraduate borrowing, amount of graduate assistantship, student year of enrollment in graduate school, and institutional characteristics including institutional type, revenues, enrollment, and tuition reliance.[4]

The purpose of reporting four different models is to account for the differences among these categories of students. For instance, we hypothesize that non-STEM students and students in master's degree programs will accrue proportionately greater debt loads due to the lower incidence of graduate assistantships in non-STEM fields and master's programs. However, we also hypothesize that overall, doctoral students will accrue greater total debt for graduate school due to additional years of schooling required to complete a doctoral degree. The separations also aim to capture different academic pursuits and career interests of master's versus doctoral students and STEM versus non-STEM students.

Analytic Method

The analytic method employed for this analysis is a zero-censored Tobit model that accounts for the overdispersion of zeroes in the dataset pertaining to amount borrowed for graduate school. Data are weighted using NPSAS weights, and the balanced repeated replication approach was used to account for design effects. Because of the prevalence of financial assistance through scholarship, grants, and teaching or research assistantships, a large number of graduate students in both STEM and non-STEM fields do not borrow for graduate education. By censoring the data (at zero) and assigning weighted probability of each observation being above or below the threshold point, the model correctly estimates the linear relationships between the variables that would otherwise be distorted by the overdispersion of zeroes.

The Tobit model assumes that there is a latent (unobservable) variable, y_i^*, which depends linearly on a vector of independent variables, x_i, via a vector of parameter estimates, β. The observable variable, y_i, is equal to the latent variable, y_i^*, whenever the latent variable is above zero, and is zero otherwise. This is formally expressed as:

$$y_i = \begin{cases} y_i^* & \text{if } y_i^* > 0 \\ 0 & \text{if } y_i^* \leq 0 \end{cases} \qquad \text{Equation 1}$$

where y_i^* is a latent variable:

$$y_i = \beta x_i + u_i, u_i \sim N(0, \sigma^2) \qquad \text{Equation 2}$$

The interpretation of the β coefficient in a Tobit model is not the effect of x_i on y_i, but rather the combination of (1) the change in y_i of individuals above the limit (0), weighted by the probability of being above that limit; and (2) the change in the probability of being above the limit, weighted by the expected value of y_i if above the limit (McDonald & Moffitt, 1980). In order to ease interpretation of results, the reporting of regression coefficients and the effect on the outcome variable assumes: (1) the effect is for individuals above the limit of 0, weighted by the probability of being above that limit; and (2) the effect takes into account the change in probability of being above the limit of 0, weighted by the expected value of the outcome variable if it is above 0.

[4] School selectivity is not included in this model, as it is hypothesized to be highly colinear with sector and Carnegie classification. Student income (a proxy for socioeconomic status) is also not included as it is likely colinear with a combination of race, undergraduate borrowing, marital status, and other student characteristics.

Results

Following descriptive statistics (see Table 1), primary analyses examined predictive contributors to graduate debt. Tables 1 and 2 both use the weighted sample and report weighted descriptive statistics to provide nationally-representative estimates. Table 1 reports student-level and institutional-level descriptives for master's and doctoral students enrolled in STEM and non-STEM degree fields. Some differences between STEM and non-STEM enrollment appear among racial/ethnic categories: among Asian students, roughly half (48%) study STEM disciplines, while 52% study non-STEM disciplines (across both master's and doctoral students). Meanwhile, among African-American and Hispanic/Latino students, approximately one-fourth study STEM disciplines, while the remaining three-quarters study non-STEM disciplines (across both master's and doctoral students). White students and students who identify as "other" racial categories display similar enrollment patterns: 28% of white students enrolled in STEM fields (across master's and doctoral students), while 33% of students from "other" racial categories enrolled in STEM disciplines.

The rate of enrollment in STEM versus non-STEM fields is similar for men and women in master's and doctoral programs: almost one-third of men and women enroll in STEM fields (32% and 30%, respectively), while over two-thirds enroll in non-STEM fields (68% and 70%, respectively). Regarding institutional characteristics, 37% of students at public institutions enrolled in STEM disciplines, while 27% of students at private not-for-profits and 21% of students at private for-profits did so (across both master's and doctoral students). When compared across basic Carnegie group, 37% of students enrolled at doctoral/research institutions, 22% of students as master's institutions, 15% of students at baccalaureate institutions, and 38% of student at "other" institution types enrolled in STEM rather than non-STEM disciplines.

Table 1

General Descriptives for Master's and Doctoral Students in 2012[5]

STEM

	Master's		Doctoral	
	N	%	N	%
Male	255600	38.33	98100	57.70
Female	411290	61.67	71920	42.30
White	403680	60.53	88660	52.12
Black	76870	11.53	9860	5.80
Hispanic/Latino	50220	7.53	8880	5.22
Asian	114680	17.20	57030	33.54
Other Race	21450	3.22	5600	3.29
Single	397710	59.64	104830	61.66
Married	256820	38.51	64180	37.75
Separated	12360	1.85	1010	0.60
Public	337180	50.56	117420	69.06
Private NFP	250150	37.51	48840	28.72
Private for Profit	79570	11.93	3760	2.21
Doctoral/Research	391820	58.75	155000	91.17
Master's	201430	30.20	4970	2.92
Bachelor's	14290	2.14	780	0.46
Other	59350	8.90	9270	5.45
Year 1	301610	45.23	40510	23.82
Year 2	246450	36.95	33150	19.50
Year 3	79730	11.96	29400	17.29
Year 4+	39110	5.86	66960	39.39
	Mean	SD	Mean	SD
Age	32.06	9.68	30.53	7.95
No. of dependents	0.69	1.14	0.46	0.94

Non-STEM

	Master's		Doctoral	
	N	%	N	%
Male	631200	38.26	106220	44.84
Female	1018600	61.74	130660	55.16
White	1078130	65.35	137990	58.25
Black	221110	13.40	35610	15.03
Hispanic/Latino	153380	9.30	18640	7.87
Asian	147110	8.92	39070	16.49
Other Race	49970	3.03	5570	2.35
Single	921010	55.83	123430	52.10
Married	694320	42.09	109150	46.08
Separated	34420	2.09	4310	1.82
Public	654210	39.66	128440	54.22
Private NFP	719900	43.64	75780	31.99
Private for Profit	275640	16.71	32660	13.79
Doctoral/Research	743340	45.06	205530	86.76
Master's	716310	43.42	19560	8.26
Bachelor's	85170	5.16	3370	1.42
Other	104940	6.36	8430	3.56
Year 1	730690	44.29	51020	21.54
Year 2	627280	38.02	43650	18.42
Year 3	179260	10.87	45870	19.37
Year 4+	112520	6.82	96340	40.67
	Mean	SD	Mean	SD
Age	32.70	9.28	35.07	9.94
No. of dependents	0.77	1.17	0.75	1.21

[5] N rounded to the nearest 10. Weighted samples used to provide nationally-representative figures.

Table 2 reports graduate students' borrowing for their undergraduate degree, graduate degree, cumulative amount of debt accumulated for all postsecondary education, and amount of graduate assistantship. These average amounts are reported for both master's and doctoral students in STEM and non-STEM degree programs and are reported separately for students in each year of their graduate program, from students in their first, second, third, or fourth year and beyond. As shown in Table 2 and Appendix A, differences in graduate, undergraduate, and cumulative debt are found for STEM versus non-STEM students and for master's versus doctoral students. Among doctoral students in non-STEM disciplines, borrowing for graduate education and cumulative borrowing amounts are significantly larger ($p<0.01$ for all comparisons) across all years of enrollment than borrowing for graduate education and cumulative borrowing among non-STEM master's students. Alternatively, doctoral students in STEM programs borrow significantly less for graduate education and cumulative borrowing than master's students in STEM programs ($p<0.01$).[6] In comparing STEM versus non-STEM students, master's students in non-STEM programs borrow significantly more for graduate education and cumulative borrowing across most years of enrollment than do master's students in STEM programs. Similarly, doctoral students in non-STEM programs borrow a significant amount more for education and cumulative borrowing than doctoral students in STEM disciplines.[7]

Table 2 confirms that the average amount of graduate assistantship also varies across degree level and field, which likely contributes to the differences observed in borrowing patterns. In both STEM and non-STEM fields, graduate and cumulative debt rise during the first three years, and then drop in the fourth year, likely due to students who complete the program (and are no longer in the sample) and the fact that many master's students in their fourth year are enrolled part-time and thus borrow less each year. Not surprisingly, doctoral students receive higher (as much as 10 times higher) graduate assistantships than master's students, and STEM students, particularly those in doctoral programs, receive assistantships that are about twice as large as non-STEM peers. The average amounts reported include students that did receive assistantships as well as those that did not, including part-time students who do not typically receive any assistantship funding.[8]

[6] Difference in means tests between the two samples for each year of enrollment show significant differences. These results are not reflected in the table due to space considerations, but appear in Appendix A.

[7] See footnote 6 and reference Appendix A.

[8] Because students are divided and analyzed by year of enrollment, it is also possible that cohort effects could appear in the results. For instance, the class of students that entered graduate education in 2010 (and are measured in their second year) may have had disproportionally high rates of borrowing due economic conditions in comparison to other cohorts of students.

Table 2

Trends in Undergraduate and Graduate Borrowing for Master's and Doctoral Students in 2012 by Year [9] [10]

STEM			Non-STEM							
	Master's Mean	Doctoral Mean		Master's Mean	Doctoral Mean		Master's Mean	Doctoral Mean	STEM Mean	Non-STEM Mean
Undergraduate Debt			Undergraduate Debt			Undergraduate Debt				
Year 1	$11,348	$7,117	Year 1	$14,929	$9,961	Year 1	--	--	--	--
Year 2	$14,529	$9,499	Year 2	$16,098	$13,212	Year 2	--	--	--	--
Year 3	$11,948	$8,450	Year 3	$11,069	$13,032	Year 3	--	--	--	--
Year 4+	$10,484	$6,449	Year 4+	$12,278	$9,833	Year 4+	--	--	--	--
All	$12,544	$7,548	All	$14,773	$11,103	All	$14,131	$9,618	$11,529	$14,312
Graduate Debt			Graduate Debt			Graduate Debt				
Year 1	$14,243	$8,779	Year 1	$15,423	$22,857	Year 1	--	--	--	--
Year 2	$25,031	$11,843	Year 2	$25,138	$34,885	Year 2	--	--	--	--
Year 3	$30,769	$14,890	Year 3	$22,067	$42,523	Year 3	--	--	--	--
Year 4+	$17,031	$14,637	Year 4+	$21,964	$36,824	Year 4+	--	--	--	--
All	$20,369	$12,740	All	$20,285	$34,562	All	$20,309	$25,444	$18,819	$22,078
Cumulative Debt			Cumulative Debt			Cumulative Debt				
Year 1	$25,591	$15,896	Year 1	$30,352	$32,818	Year 1	--	--	--	--
Year 2	$39,560	$21,342	Year 2	$41,236	$48,096	Year 2	--	--	--	--
Year 3	$42,717	$23,340	Year 3	$33,136	$55,556	Year 3	--	--	--	--
Year 4+	$27,515	$21,086	Year 4+	$34,242	$46,656	Year 4+	--	--	--	--
All	$32,913	$20,289	All	$35,058	$45,664	All	$34,441	$35,061	$30,348	$36,390
Graduate Assistantship			Graduate Assistantship			Graduate Assistantship				
Year 1	$860	$10,585	Year 1	$723	$6,261	Year 1	--	--	--	--
Year 2	$1,465	$12,362	Year 2	$991	$7,767	Year 2	--	--	--	--
Year 3	$1,040	$13,178	Year 3	$716	$8,052	Year 3	--	--	--	--
Year 4+	$1,887	$12,152	Year 4+	$349	$6,852	Year 4+	--	--	--	--
All	$1,165	$11,997	All	$798	$7,126	All	$904	$9,161	$3,366	$1,593

[9] N rounded to nearest 10. Weighted samples used to provide nationally-representative figures.
[10] Year refers to the student's enrollment status, with Year 1 corresponding to the first year of graduate enrollment, and year 4+ corresponding to the fourth year.

Model 1: Master's Students

To examine the contribution of individual and institutional characteristics to graduate debt, Table 3 shows results from the four Tobit models censored at zero.[11] Column 1 reports the outcomes for model 1 (master's students only), and reveals significant associations for race/ethnicity, marital status, enrollment intensity, institutional control and type, institutional finances and size, undergraduate borrowing, amount of graduate assistantship, and completing a degree in 2012 (the graduate degree recipients in the sample). Although the direction of the relationship between graduate student debt and enrollment in a STEM program is positive, the model does not indicate any significant differences between STEM and non-STEM master's students in the amount of borrowing for graduate school.

All else equal, master's students who were married and who borrowed for graduate school borrowed $5,650 less for graduate school than single students who borrowed, and those enrolled part-time borrowed $6,348 less than full-time students.[12] Black/African-American students borrowed $9,915 more than white students, while Asian students borrowed $14,119 less than white peers. Students who borrowed and who were attending specialty institutions such as medical or professional schools borrowed $13,838 more for graduate school than students at doctoral/research institutions, while students at master's institutions borrowed $6,385 less. Students attending institutions with higher total current funds revenues borrowed $375 more for every 10% increase in total current funds revenues at the institution. Master's students attending private non-profits borrowed $10,899 more than students at public institutions, while students at private for-profits borrowed $9,853 more than public-school peers, all else equal. Students at larger institutions borrowed $42 less for every 1,000-student increase in the full-time equivalent enrollment.

There was a strong and significant relationship between the amount of undergraduate borrowing and subsequent graduate borrowing, with master's students borrowing on average $347 more in graduate school for every 10% increase in undergraduate borrowing. With master's students borrowing on average $14,130 for undergraduate education, this finding indicates that for every $1,413 increase in borrowing for undergraduate education, these students borrow $347 more for graduate education. Students who received assistantships, alternatively, were much less likely to borrow, with these students borrowing $112 less for each 10% increase in graduate assistantship. With an average assistantship amount of $904 for master's students, this finding suggests that a $90 increase in graduate assistantship reduces borrowing by a greater amount, or $112. Unsurprisingly, students who graduated in 2012 (versus those who were still completing their degrees) borrowed $8,801 more than students who had additional years remaining to complete their program.

Model 2: Doctoral Students

Column 2 in Table 3 reports the results of model 2 (doctoral students only) and shows significant associations between the amount of borrowing for graduate school and students' race/ethnicity and marital status, as well as institutional control, institutional finances and size, undergraduate borrowing, level of graduate assistantship, year in school, and whether they graduated in 2012. In addition, and unlike results for master's students, there was a significant difference in the amount of graduate debt for STEM versus non-STEM students ($p<0.01$). Controlling for all other variables in the model, results in model 2 show that doctoral students in non-STEM programs borrowed $20,013 more than STEM peers.

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[11] The models are censored due to the left skew of values for the cumulative amount of graduate borrowing.
[12] These results, and all results throughout, account for the change in the outcome for individuals above the lower limit, the probability of being above the lower limit, and the expected value of the outcome variable if above the lower limit.

Among doctoral students who borrowed, race and marital status were associated with graduate borrowing. Black/African American or students from "other" racial backgrounds borrowed $17,466 more and $11,976 more, respectively, than their white peers, and Asian students borrowed $39,335 less. Married doctoral students borrowed $17,421 less than single students. Some institution characteristics also proved significant: borrowing was $12,844 lower among students at private non-profit institutions in comparison to public institutions, but $18,641 higher at private for-profit institutions. Findings from the tobit regression in Table 3 showed that students borrowed $5,796 more for each 0.1-unit increase in an institution's reliance on tuition to cover operational expenditures,[13] and $24 less for each 1,000-student increase in the institution's FTE enrollment. Students also borrowed $425 less for each 10% increase in the institution's total funds revenues.

Regarding graduate program borrowing, students who took loans for their undergraduate degree borrowed $479 more for each 10% increase in undergraduate borrowing (or roughly $962 dollars in undergraduate debt, based on the average undergraduate debt for doctoral students). Alternatively, students with graduate assistantships borrowed $166 less for each 10% increase in the amount of graduate assistantship (or a $916 increase in graduate assistantship, based on the average graduate assistantship for doctoral students). Not surprisingly, doctoral students enrolled in their first year of their graduate program borrowed $21,253 less than peers in their fourth year, while students who completed a degree in 2012 borrowed $6,929 more than students who were still enrolled.

Model 3: STEM Students

Column 3 in Table 3 reports the results of model 3 (STEM students only) and shows significant associations between the amount borrowed for graduate school and a student's gender, race/ethnicity, marital status, enrollment intensity, institutional type and finances, undergraduate borrowing, amount of graduate assistantship, grade level, and whether they graduated in 2012.

Results showed that female students in STEM programs borrowed $9,437 more than male students, and part-time students borrowed $11,287 less than full-time students. Consistent with previous models, Asian students borrowed $23,236 less than white students, while married students borrowed $10,052 less than single students. Students enrolled at "other" institutional types borrowed $14,778 more than students at doctoral/research institutions, and students borrowed $328 more for every 10% increase in the institution's total funds revenues. As expected, students who borrowed for their undergraduate degrees also borrowed more for their graduate degrees, or about $400 for each 10% increase in undergraduate borrowing. Based on the average amount borrowed by STEM students, this finding suggests that students borrowed $400 more for graduate education for every $1,153 increase in undergraduate borrowing. Students who received graduate assistantships borrowed less, all else equal, at a rate of $198 less for each 10% increase in graduate assistantship (or an increase of $337 in graduate assistantship based on the average assistantship amount for all STEM students). Students in the third year of their graduate program borrowed $14,406 more than students in their fourth year, and students who graduated in 2012 borrowed $11,212 more than students still enrolled in the program.

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[13] A 0.1-unit increase in an institution's reliance on tuition to cover operational expenditures corresponds to a 10% increase in the proportion of total expenditures that an institution covers using tuition and fees revenues. Institutions with a value of 1 rely entirely on tuition and fees (100%), while institutions with a value of 0 do not rely at all on tuition and fees (0%).

Model 4: Non-STEM Students

Column 4 in Table 3 reports the results of model 4 (non-STEM students only) and shows significant associations between the student's degree program (master's versus doctoral), race/ethnicity, marital status, institutional control type, institutional finances and enrollment, undergraduate borrowing, amount of graduate assistantship amount, grade level, and graduation in 2012.

All else equal, non-STEM master's students borrowed $27,568 less than doctoral students. Compared to white peers, Black/African American students borrowed $14,255 more, while Asian students borrowed $15,726 less, all else equal. Married non-STEM students borrowed $7,727 less than single peers, and those enrolled at private-nonprofit and private for-profit institutions borrowed $5,023 and $12,229 more, respectively, than non-STEM peers at public institutions. Also shown in column 4, non-STEM students in master's, bachelor's, and "other" institutions borrowed $12,545 less, $15,340 less, and $12,296 more, respectively, than peers at doctoral/research universities. Non-STEM students borrowed $1,472 more for each 0.1-unit (or 10%) increase in the institution's reliance on tuition to cover operational expenditures, and $59 less for each 1,000-student increase in FTE enrollment.

As with previous models, undergraduate borrowing and graduate assistantship were strongly correlated with graduate borrowing. Students who borrowed for both graduate and undergraduate degrees borrowed $364 more for each 10% increase in undergraduate debt (or an increase of $1,431 in undergraduate debt, based on the average for non-STEM students), while students with graduate assistantships borrowed $197 less for every 10% increase in the amount of graduate assistantship received (or an increase of $159 in graduate assistantship, based on the average amount for non-STEM students). As expected, first-year students borrowed $8,003 less than fourth-year students, and students who graduated in 2012 borrowed $9,857 than students who were still enrolled, all else equal.

Table 3

Tobit Regression Results

	Graduate Program Borrowing			
	Model 1: Master's	Model 2: Doctoral	Model 3: STEM	Model 4: Non-STEM
STEM	61.17	-20012.7***		
	(0.03)	(-5.03)		
Master's			-1340.7	-27567.8***
			(-0.31)	(-10.36)
Age	36.83	164.7	312.4	-57.77
	(0.35)	(0.91)	(1.82)	(-0.44)
No. Dependents	1536	2006.5	3348.4	1143.2
	(1.69)	(1.72)	(1.67)	(1.34)
Female	3494	5535.9	9347.1*	1896.5
	(1.79)	(1.77)	(2.55)	(0.96)
Black	9914.5***	17465.6***	7591.4	14254.7***
	(4.24)	(4.43)	(1.67)	(6.02)
Hispanic	5015.6	4065.8	-514	6753.3
	(1.67)	(0.73)	(-0.09)	(1.83)
Asian	-14119.2***	-39334.8***	-23236.3***	-15725.6***
	(-3.56)	(-7.99)	(-3.92)	(-4.35)
Other Race	1272.3	11976.0*	-1246.2	5047.4
	(0.23)	(2.16)	(-0.2)	(0.64)
Married	-5649.8**	-17421.0***	-10052.0**	-7726.7***
	(-3)	(-6.03)	(-2.86)	(-3.61)
Separated	2228.4	5215.5	4930.4	-1175.3
	(0.42)	(0.66)	(0.55)	(-0.21)
Part-Time	-6348.3***	1290.2	-11287.0***	-3894
	(-3.46)	(0.33)	(-3.69)	(-1.8)
Private	10898.8***	-12844.2**	5948.9	5022.7*
Non-Profit	(4.07)	(-3.15)	(1.54)	(2)
Private	9853.1*	18640.9*	-297	12229.1*
For-Profit	(2.11)	(2.14)	(-0.04)	(2.38)
Master's	-6385.1**	-14259.6	-3878.8	-12545.2***
Institution	(-2.98)	(-1.74)	(-1.15)	(-4.38)
Bachelor's	-8357.3	-6517.4	5588.4	-15340.2**
Institution	(-1.87)	(-0.47)	(1.06)	(-3.04)
Other Institution	13838.4***	13143.5	14777.7*	12295.9*
	(3.35)	(1.03)	(2.02)	(2.23)
Total Funds	3745.2***	-4246.7*	3284.1*	1976.1
Revenues (ln)	(4.03)	(-2.24)	(2.1)	(1.67)
Tuition	4855.4	57958.5***	22135.5	14720.9*
Reliance	(0.77)	(5.2)	(1.9)	(2.21)
FTE Enrollment	-42.47*	-24.22	-19.94	-58.53***
(thousands)	(-2.48)	(-0.57)	(-0.71)	(-3.44)
Undergraduate	3467.0***	4788.0***	3997.7***	3637.4***
Borrowing (ln)	(16)	(13.72)	(13.64)	(15.06)
Graduate	-1116.8***	-1662.4***	-1983.7***	-1973.1***

Assistantship (ln)	(-3.67)	(-4.21)	(-5.24)	(-6.57)
First Year	-4469.3	-21253.2***	-3515.7	-8003.0*
	(-1.06)	(-4.89)	(-0.84)	(-2.42)
Second Year	6408.8	-7935.5	7274.8	3327.7
	(1.47)	(-1.92)	(1.92)	(0.99)
Third Year	8309.8	-870.1	14406.3*	3702.4
	(1.59)	(-0.22)	(2.28)	(0.91)
Graduated in 2012	8800.5***	6929.4*	11211.6**	9857.0***
	(4.2)	(1.98)	(2.66)	(4.25)
Constant	-96620.0***	58195.1	-113334.7**	-30721.9
	(-4.89)	(1.36)	(-3.13)	(-1.21)
N	2315940	456960	740070	2032840
F-Statistic	32.54	54.61	13.91	49.88

N rounded to nearest 10. Weighted samples are used to provide nationally-representative figures.
Standard error in parentheses.
*p<.05 **p<.01 ***p<.001
Reference for categorical variables

1. STEM: non-STEM
2. Master's: doctoral
3. Race: white
4. Gender: male
5. Attendance intensity: full-time
6. Institution type: doctoral/research
7. Control: public non-profit
8. Marital status: single
9. Grade level: 4th year or higher

Discussion

This study provides a needed update on prior research that explicitly examines graduate student decision-making and borrowing patterns for graduate education, particularly as it pertains to differences among students in STEM and non-STEM disciplines. Findings in this study suggest that the recent graduate students' level of educational debt is correlated with several individual and institutional characteristics. Overall, the difference in borrowing between STEM and non-STEM students is not evident at the master's level, likely due in part to the small number of graduate assistantships offered to master's students in general – regardless of discipline. However, among doctoral students, those in a non-STEM field incur on average an additional $20,000 more in debt than their doctoral-level peers in STEM fields. In addition to discipline and program, results overall found that female graduate students in STEM programs borrowed more than women in non-STEM programs, married students borrowed less than single peers, Black/African American students borrowed more than white peers, and students at private institutions borrowed more than public-school peers.

These differences in borrowing along ethnic/racial demarcations may be due to differential access to adequate information regarding financing options for graduate education. Prior research suggests that students from underrepresented minority or low-income populations may be less aware of grant funding opportunities, particularly in STEM disciplines (Freeman, 1997; Perna, 2000; Malcom & Dowd, 2012). This could potentially explain the higher rate of borrowing among African American students compared to their white peers. It is also possible that white or Asian students may be more academically prepared upon enrollment and thus receive more assistantships or study in fields that provide more grant funding and reduce the cost of tuition, thus lowering their overall amount of borrowing. In the framework of rational choice and human capital theory, it is possible that students from less-affluent economic backgrounds (usually underrepresented minority students) are making seemingly non-rational choices in the decision to borrow more for undergraduate education (thus increasing their cumulative debt load), with the expectation that their large investment in postsecondary education will eventually reap economic benefits. From an economic perspective, this decision may appear non-rational due to the large accumulation of debt. However, the long-term outcomes of the decision to invest in graduate education may reap additional financial and economic returns, particularly for underrepresented minority students.[14]

The lower rates of borrowing among married students may be attributable to additional support from a spouse or reliance on personal savings. Married students may also be older or have more dependents and may thus be more cognizant of the potential long-term consequences of educational debt and therefore less willing to accumulate additional debt burdens (Rice, Sorcinelli, & Austin, 2000). This is consistent with the theoretical framework of human capital theory and rational choice, which posits that students will make investment decisions to maximize utility and balance other economic considerations. Older, married students with dependents may also be more likely to enroll in graduate programs on a part-time basis and may work throughout graduate school, thus lowering the total amount of debt these students incur.

Not surprisingly, both master's and doctoral students who held a graduate assistantship incurred significantly less debt. Assistantships include both teaching and research positions that allow students to offset the cost of tuition and fees while also receiving remuneration for living expenses. The contribution of select institutional indicators showed mixed findings; for example, tuition reliance was positively associated with debt for doctoral students but not for master's students. This suggests that institutions that rely more heavily on tuition to cover operational expenditures may have limited resources to provide assistantships to students in doctoral programs. However, institutional size was consistently a factor in all analyses, suggesting

[14] While this study did not explicitly include covariates for students' socioeconomic status or academic preparation, future studies could incorporate these measures into a more comprehensive model of students' postsecondary borrowing decisions.

that graduate students in larger institutions (based on FTE enrollment) incurred less debt. Institutions with larger undergraduate enrollments may have the additional institutional funds necessary to subsidize graduate student education through tuition waivers, assistantships, and other forms of institutional funding that preclude the need for graduate loans.

Findings herein highlight the importance of broadly examining rising tuition costs for graduate degrees and whether the investment will result in a positive return on investment for the student, the institution, and for the economy. Since workers in non-STEM fields typically earn a lower salary than peers in STEM fields, educational debt may take longer to pay off without the assistance of loan forgiveness or repayment plans. Lower salaries combined with higher debt amounts and longer payment timelines will likely translate into lower human capital gains and fewer personal funds for other living expenses. Although some loan repayment and default programs are becoming more popular, they are still not widespread among recent graduates and their effectiveness is unknown (Perna, Kvaal, & Ruiz, 2017). From the human capital and rational choice framework, these negative consequences of debt from graduate education may discourage students from enrolling or may discourage enrollment in certain high-cost programs, such as the STEM disciplines. Although the results of this study suggest that graduate students in STEM disciplines borrow less than graduate students in non-STEM disciplines (due in part to the presence of graduate assistantships), many potential students may be unaware of these funding opportunities and may instead be dissuaded by the "sticker-shock" associated with STEM programs that often charge high tuition (AIR, 2013).

Findings herein also highlight the need to revisit financial aid policies and practices at the graduate level, particularly by program level and by discipline (STEM versus non-STEM). While employees with advanced STEM skills will be needed in the future, our nation's economy and cultural improvements will benefit from non-STEM graduates as well. Skills in communication, creativity, and critical thinking are valued by employers and are particularly relevant in today's global world (Christ, 2012). In addition, institutional officials may wish to consider more graduate assistantships for master's level students and for students in critically important or underrepresented fields. The significant difference in debt that is accrued for non-STEM doctoral students and master's students may prompt some students to not enroll in high-debt programs or to not attend graduate school at all based on rational decision-making that may indeed prove irrational (DesJardins & Toutkoushian, 2005). The loss of future citizens with the necessary graduate level training to prosper in the knowledge economy may affect our national economy; thus, institutional officials are encouraged to consider creative mechanisms to provide more financial aid to a larger number of graduate students.

An additional area of concern is the underrepresentation of women and minorities in STEM-related fields, and the subsequently lower rates of employment among these individuals in STEM careers. Because results show consistent differences by race and gender, considerations are merited for debt relief for Black/African-Americans and women in STEM programs, particularly in light of the recent initiatives to increase participation among underrepresented populations. One hypothesized driver of this low rate of enrollment and completion is the high cost of STEM programs and the possibility that women and minority students may be less likely to have access to grant funding opportunities in STEM disciplines (Malcolm & Dowd, 2012). In addition to lower rates of enrollment due to lower interest (Astin et al., 1997), studies have also found that women are more likely than men to switch out of STEM programs at the postsecondary undergraduate level (Seymour & Hewitt, 1997). Even in employment, women are less likely than men to persist in STEM careers, partially due to family obligations (Xie & Shauman, 2003). Although underrepresented minority beginning postsecondary students are equally as likely to enroll in STEM fields as their white peers (Anderson & Kim, 2006), they are more likely to switch to non-STEM fields prior to degree completion (Chubin & Babco, 2003).

This study is significant in that it expounds upon these findings at the undergraduate level and suggests possible links to persistence and attainment in STEM programs at the graduate level based on financial considerations. While it is difficult to speculate on the causes of degree changes, it is possible that some students' choices to leave their field of study are driven by the high costs of STEM graduate degrees and the subsequent long-term debt obligations for students during graduate school and following degree completion. When Hall (1981) surveyed minority female professionals in STEM fields asking what they recommended to retain women of color in graduate STEM programs, the most common response was to increase financial aid. A review of the literature from Ong et al. (2010) found that women are underrepresented in STEM fields and thus represent a missed opportunity to take advantage of human capital. They find, moreover, that multiple factors influence the decisions of women of color to pursue and persist in STEM fields, including mentoring, funding, training, and family obligations.

Findings herein also show concerning differences in graduate education debt by institutional characteristics and undergraduate borrowing patterns. Larger institutions (defined by FTE enrollment) generally have substantial budgets and general funds that may allow for more academic support to graduate students via assistantships or perhaps hourly work. In addition, larger institutions generally support a strong research infrastructure that may generate more opportunities for graduate students to become engaged in research projects that are critical to the development of academic skills and employment preparation. While smaller institutions may lack the research grants and additional funding to support their graduate students, institutional officials are encouraged to seek alternative mechanisms for providing additional graduate level funding through initiatives targeted to small institutions or partnerships with private foundations and potential employers.

The results in Table 3 of this study suggest that doctoral students in private non-profit institutions incur $12,000 less in educational debt than do their master's-level peers in private non-profit institutions. This finding may signal the strong mission of private institutions to support doctoral-level studies, seeking to affirm the goals of human capital and generate a more robust academic market and knowledge economy. Although their missions and funding structures differ, public institutions could look to their private-sector peers to develop models for further supporting graduate education, particularly at the doctoral level. Initiatives such as fund-raising, partnerships with non-partisan foundations focused on increasing attainment, or implementation of training programs could provide these necessary funds to support graduate students at public institutions.

Findings also emphasize the need to effectively communicate with prospective students about various options for financing their graduate education so that they can choose the program of highest preference and make informed decisions when they receive offers for graduate program admission. Additional policies and financial aid programs for special populations may encourage women and minority students to continue with advanced study. From the NPSAS data available, we do not know if or how many students did not enroll due to the need to accumulate loans. As the U.S. economy began to recover after 2008 and unemployment rates declined, it is possible that some students chose to forego graduate education in part because employment was somewhat more available. Additional inquiry into the decision to not enroll is warranted.

Nexus

Several practical implications emerge from this analysis and summarize the discussion above. First, institutional officials and higher education policymakers are encouraged to examine rising tuition costs for graduate degrees, particularly in fields that may not provide a positive return on investment for students, institutions, and employers. Officials and policymakers are encouraged to find mechanisms for reducing these high tuition costs through partnerships with organizations and stakeholders, including fellowships, cooperative arrangements, or internships for students with prospective employers. Second, policymakers and officials should consider such costs and returns when revisiting financial aid policies and practices, perhaps treating different program levels and disciplines differently. Institutions could consider charging differential tuition prices in order to encourage or discourage enrollment in particular programs with the highest returns on investment for students, institutions, and employers. Third, when possible, institutional officials should seek to provide additional assistantships and funding opportunities for students enrolled in master's degree programs, particularly in non-STEM fields. Although this remains a perennial problem, officials are encouraged to consider external sources of funding, internal fundraising campaigns, and creative arrangements for graduate employment.

Fourth, institution officials are encouraged to provide adequate mentoring, funding, and training for at-risk populations such as women and minorities, particularly in light of the disparities that persist among different racial/ethnic groups in regard to graduate degree enrollment and completion (Ong et al., 2010). Fifth, public institutions should seek to adapt some of the practices of private institutions, which have successfully provided sufficient funding to graduate students despite high tuition costs, particularly at the doctoral level. Institutions can achieve these outcomes through new approaches to appealing to alumni, local businesses, potential employers, athletic boosters, and other stakeholders. Finally, institutional officials must communicate effectively with prospective students regarding the financing options available to ensure that students make informed decisions. New approaches to presenting options among financial aid packages as well as more informative financial aid materials can assist students with making these critical decisions.

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Appendix A. Significance Tests for Borrowing Patterns

STEM Students	Master's			Doctoral			Two-Sample Difference in Means Test		
Undergraduate Debt	Mean	SD	N	Mean	SD	N	Difference	SE	t-stat.
Year 1	$11,348	$18,355	301610	$7,117	$10,972	40510	$4,231	93.36	45.32
Year 2	$14,529	$21,196	246450	$9,499	$13,373	33150	$5,030	119.49	42.09
Year 3	$11,948	$16,347	79730	$8,450	$12,569	29400	$3,498	105.22	33.24
Year 4+	$10,484	$19,492	39110	$6,449	$11,339	66960	$4,035	94.66	42.62
Graduate Debt									
Year 1	$14,243	$23,941	301610	$8,779	$13,511	40510	$5,464	121.47	44.98
Year 2	$25,031	$32,510	246450	$11,843	$14,900	33150	$13,188	181.06	72.84
Year 3	$30,769	$45,657	79730	$14,890	$19,370	29400	$15,879	274.97	57.75
Year 4+	$17,031	$30,859	39110	$14,637	$22,976	66960	$2,394	166.49	14.38
Cumulative Debt									
Year 1	$25,591	$34,101	301610	$15,896	$19,970	40510	$9,695	173.29	55.95
Year 2	$39,560	$43,411	246450	$21,342	$22,914	33150	$18,218	242.85	75.02
Year 3	$42,717	$51,087	79730	$23,340	$26,338	29400	$19,377	312.21	62.06
Year 4+	$27,515	$39,534	39110	$21,086	$27,961	66960	$6,429	208.16	30.88
Graduate Assistantship									
Year 1	$860	$3,593	301610	$10,585	$30,422	40510	($9,725)	58.20	-167.10
Year 2	$1,465	$5,022	246450	$12,362	$30,674	33150	($10,897)	67.66	-161.05
Year 3	$1,040	$3,613	79730	$13,178	$32,249	29400	($12,138)	116.14	-104.52
Year 4+	$1,887	$6,683	39110	$12,152	$33,566	66960	($10,265)	171.68	-59.79

Non-STEM Students	Master's			Doctoral			Two Sample Difference In Means Test		
Undergraduate Debt	Mean	SD	N	Mean	SD	N	Difference	SE	t-stat.
Year 1	$14,929	$19,533	730690	$9,961	$17,681	51020	$4,968	88.92	55.87
Year 2	$16,098	$19,661	627280	$13,212	$21,083	43650	$2,886	97.80	29.51
Year 3	$11,069	$16,709	179260	$13,032	$20,901	45870	($1,963)	92.32	-21.26
Year 4+	$12,278	$18,420	112520	$9,833	$19,593	96340	$2,445	83.27	29.36

Graduate Debt									
Year 1	$15,423	$22,604	730690	$22,857	$34,012	51020	($7,434)	107.69	-69.03
Year 2	$25,138	$30,135	627280	$34,885	$44,706	43650	($9,747)	154.89	-62.93
Year 3	$22,067	$27,235	179260	$42,523	$51,735	45870	($20,456)	176.36	-115.99
Year 4+	$21,964	$33,585	112520	$36,824	$52,212	96340	($14,860)	189.57	-78.39
Cumulative Debt									
Year 1	$30,352	$34,055	730690	$32,818	$43,976	51020	($2,466)	159.30	-15.48
Year 2	$41,236	$42,242	627280	$48,096	$53,045	43650	($6,860)	212.99	-32.21
Year 3	$33,136	$35,980	179260	$55,556	$61,632	45870	($22,420)	222.29	-100.86
Year 4+	$34,242	$42,197	112520	$46,656	$61,801	96340	($12,414)	228.97	-54.22
Graduate Assistantship									
Year 1	$723	$3,783	730690	$6,261	$10,208	51020	($5,538)	20.57	-269.21
Year 2	$991	$4,457	627280	$7,767	$11,176	43650	($6,776)	25.58	-264.92
Year 3	$716	$3,442	179260	$8,052	$11,029	45870	($7,336)	30.61	-239.68
Year 4+	$349	$2,120	112520	$6,852	$10,721	96340	($6,503)	32.68	-198.98

Master's Students	STEM			Non-STEM			Two-Sample Difference In Means Test		
Undergraduate Debt	Mean	SD	N	Mean	SD	N	Difference	SE	t-stat.
Year 1	$11,348	$18,355	301610	$14,929	$19,533	730690	($3,581)	41.55	-86.19
Year 2	$14,529	$21,196	246450	$16,098	$19,661	627280	($1,569)	47.80	-32.82
Year 3	$11,948	$16,347	79730	$11,069	$16,709	179260	$879	70.66	12.44
Year 4+	$10,484	$19,492	39110	$12,278	$18,420	112520	($1,794)	109.78	-16.34
Graduate Debt									
Year 1	$14,243	$23,941	301610	$15,423	$22,604	730690	($1,180)	49.78	-23.70
Year 2	$25,031	$32,510	246450	$25,138	$30,135	627280	($107)	73.28	-1.46
Year 3	$30,769	$45,657	79730	$22,067	$27,235	179260	$8,702	144.68	60.15
Year 4+	$17,031	$30,859	39110	$21,964	$33,585	112520	($4,933)	193.14	-25.54
Cumulative Debt									
Year 1	$25,591	$34,101	301610	$30,352	$34,055	730690	($4,761)	73.73	-64.57
Year 2	$39,560	$43,411	246450	$41,236	$42,242	627280	($1,676)	101.22	-16.56
Year 3	$42,717	$51,087	79730	$33,136	$35,980	179260	$9,581	175.49	54.60

Year 4+	$27,515	$39,534	39110	$34,242	$42,197	112520	($6,727)	243.76	-27.60
Graduate Assistantship									
Year 1	$860	$3,593	301610	$723	$3,783	730690	$137	8.07	16.98
Year 2	$1,465	$5,022	246450	$991	$4,457	627280	$474	10.99	43.12
Year 3	$1,040	$3,613	79730	$716	$3,442	179260	$324	14.88	21.77
Year 4+	$1,887	$6,683	39110	$349	$2,120	112520	$1,538	22.62	67.98

Doctoral Students	STEM			Non-STEM			Two-Sample Difference In Means Test		
Undergraduate Debt	Mean	SD	N	Mean	SD	N	Difference	SE	t-stat.
Year 1	$7,117	10972.11	40510	$9,961	$17,681	51020	($2,844)	100.38	-28.33
Year 2	$9,499	13373.33	33150	$13,212	$21,083	43650	($3,713)	132.31	-28.06
Year 3	$8,450	12569.13	29400	$13,032	$20,901	45870	($4,582)	135.29	-33.87
Year 4+	$6,449	11338.65	66960	$9,833	$19,593	96340	($3,384)	84.07	-40.25
Graduate Debt									
Year 1	$8,779	13511.38	40510	$22,857	$34,012	51020	($14,078)	179.26	-78.53
Year 2	$11,843	14900.27	33150	$34,885	$44,706	43650	($23,042)	255.69	-90.12
Year 3	$14,890	19370.48	29400	$42,523	$51,735	45870	($27,633)	314.99	-87.73
Year 4+	$14,637	22976.01	66960	$36,824	$52,212	96340	($22,187)	214.92	-103.23
Cumulative Debt									
Year 1	$15,896	19969.94	40510	$32,818	$43,976	51020	($16,922)	235.70	-71.79
Year 2	$21,342	22914.03	33150	$48,096	$53,045	43650	($26,754)	311.30	-85.94
Year 3	$23,340	26337.78	29400	$55,556	$61,632	45870	($32,216)	379.90	-84.80
Year 4+	$21,086	27960.68	66960	$46,656	$61,801	96340	($25,570)	255.25	-100.18
Graduate Assistantship									
Year 1	$10,585	30421.88	40510	$6,261	$10,208	51020	$4,324	143.92	30.05
Year 2	$12,362	30673.73	33150	$7,767	$11,176	43650	$4,595	159.13	28.88
Year 3	$13,178	32248.66	29400	$8,052	$11,029	45870	$5,126	163.74	31.31
Year 4+	$12,152	33566.14	66960	$6,852	$10,721	96340	$5,300	115.81	45.77