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The Impact of Undergraduate Debt on the Graduate School Enrollment of STEM Baccalaureates

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How much student loan debt is too much, too little, or just right? One way of answering this question is by looking at standards for loan repayment. Current federal policy enacted July 1, 2009, as Income-Based Repayment (IBR) recognizes that a "financial hardship" exists when monthly student loan payments exceed 10% of discretionary income (Kittredge, 2010). Beyond that threshold, borrowers may apply to request smaller monthly payments. IBR was designed for those with high debt-to-income ratios persisting over a long period of time and also includes provisions for loan forgiveness, particularly for people in public service occupations.

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Income-based repayment policies aim to support several social goals. They address the concern, in the face of high debt burden, that college graduates will not take public service positions in teaching, law, medicine, engineering, and science, gravitating instead to private sector employment where salaries tend to be higher. Second, they reduce the risk of loan default, which is detrimental to the borrowers who stop repaying their debt as well as to the lending agencies and student loan system as a whole. Third, they retain the role of loans as a central feature of college financing in the United States, which has a cost-sharing design based on the expectation of human capital and other benefits accruing to individuals and society. Through cost sharing the federal government subsidizes students who would not otherwise have the financial capital to make optimal investments in higher education.

IBR was instituted after a decade of rapid expansion in college borrowing, both for undergraduate and graduate study (College Board, 2006; Hoffer et al., 2006). Average debt varies in magnitude in expected ways by institutional type, with those graduating from higher-priced institutions typically carrying more debt (College Board, 2009). Debt burden, meaning the ratio of repayment amounts to income, falls more heavily on lower income graduates. Despite attending less costly institutions, on average, low-income borrowers still accrue sizeable debt (Price, 2004; The Institute for College Access and Success [TICAS], 2010) and more often fall into default (Knapp & Seaks, 1992; Woo, 2002). The "right" amount of debt clearly depends on future salary prospects. Those graduating from prestigious institutions and with degrees in high-demand fields can afford to borrow more, given the expectation of high earnings.

By 2005, however, several indicators suggested that cumulative debt (the absolute magnitude of the dollars borrowed by college graduates) as well as typical debt burden (repayments relative to graduates' discretionary income) were becoming excessive. Twenty percent of students who borrowed a total of $15,000 or more in federal Stafford loans defaulted, compared to only 7% among students who borrowed $5,000 or less (Choy & Li, 2005). Recent graduates with earnings in the bottom quartile were more likely to default (17.4%) than those in the high-middle (7.6%) and highest (4.2%) quartiles (Choy & Li, 2005). These figures on debt burden and default signaled an overreliance on borrowing to fund higher education. In response, the federal government invested more in the means-tested Pell grant program to offset the need for borrowing among low-income students and in loan repayment provisions to mitigate the negative impacts of high debt burden.

In addition to promoting economically efficient investments in human capital, federal financial aid policy also aims to promote equity in access to higher education, i.e., to create a level playing field for participation by less affluent families. Increases in college participation among low-income

students and students from underrepresented racial-ethnic minority groups in the second half of the 20th century indicate that the federal role in promoting equity has been a partial success. Increases in enrollment among African Americans, Latinas, and Latinos represent important gains in access. However, entire fields of study continue to have minimal participation by underrepresented minority groups, and equity gaps remain at the postbaccalaureate level, with students from White and some Asian ethnic groups outpacing others in graduate and professional degree completion (National Center for Education Statistics [NCES], 2010).

As highlighted during a March 2010 Congressional hearing on "Broadening Participation in STEM," these equity gaps are particularly acute in science, technology, engineering, and mathematics (STEM) fields. (The National Science Foundation defines biological sciences, physical sciences, engineering, mathematics, computer science, and the social and behavioral sciences as STEM fields.) Comparing the representation of minorities in the general population (37%) with the proportion among STEM bachelor's degree holders (17%) and those with doctorates (11%), the hearing charter emphasized the need for greater representation of minority groups at the doctoral level, particularly at the top 100 research universities, and in the STEM faculty (*Hearing Charter*, 2010). Depending on the field of study, the proportion of underrepresented minorities on the faculty ranges between 3% and 6%, aggregated numbers that only get smaller when considering specific racial-ethnic groups. These equity gaps reflect the loss of an "untapped talent pool" (p. 3) as well as the ongoing and socially unconscionable exclusion of minority students from STEM fields of study.

In light of these inequities in STEM fields and the central role of borrowing in college financing, this study investigates the impact of undergraduate debt on graduate and professional school enrollment among STEM bachelor's degree holders. It informs a deeper understanding of the differential impact of borrowing on students of different racial-ethnic backgrounds, based on the concern that financial aid policies have not been sufficient to improve equity in participation and degree attainment in STEM. African Americans, American Indians, Latina and Latino students, and members of some Asian ethnic groups continue to be underrepresented in STEM fields, and these enrollment gaps are particularly substantial at the postbaccalaureate level. Therefore, it is important to consider whether the reliance on loans as a central feature of financial aid policy is reducing investments in graduate and professional study in STEM, particularly among students from underrepresented minority groups.

With historically disadvantaged groups comprising a growing share of the U.S. population, diversity in the STEM workforce is a necessary condition for remaining competitive in the modern economy (Kelly, 2005). There is some

evidence that African Americans, Latinas, and Latinos are more negatively impacted in their college investment decisions by debt or the fear of debt than their Asian and Caucasian counterparts (Linsenmeier, Rosen, & Rouse, 2006). This finding reflects the association between race and income in the United States and the fact that African American and Latino families tend to be less affluent, reducing the assets available to help pay college costs. In part due to a greater reliance on working during college (NCES, 2009), African Americans, Latinas, and Latinos are less likely to complete their bachelor's degrees, leaving an onerous debt burden for those with debt unmatched by higher earnings. In a related manner, default rates are also higher for these groups (Gladieux & Perna, 2005).

The relationship between borrowing and graduate/professional school enrollment in STEM fields, and variation in that relationship among racial-ethnic groups, is not well understood, however. This lack of understanding is due to limitations in the available data and in the statistical models that have typically been used. Therefore, this study uses data and statistical techniques still relatively new to the financial aid literature and informs policy-making by answering the following research questions:

1. To what extent does reliance on debt vary by race and ethnicity among recent STEM bachelor's degree holders?

2. What is the effect of relative debt level on graduate and professional school enrollment among recent STEM bachelor's degree earners?

3. Are there differences in the effect of relative debt by race/ethnicity?

We measure debt in relative terms—as a ratio of a baccalaureate's cumulative undergraduate debt compared to the typical debt load of other graduates of the same bachelor's-degree-granting institution—because debt burden, and its concomitant influences on workforce and quality of life choices, is a relative construct. For example, an individual with high debt in absolute dollar terms and high earnings is in a better position than one with moderate debt (in absolute terms) and low earnings. It is the latter who is more likely to face the financial hardship targeted for amelioration by the Income-Based Repayment policy. This relative debt metric (explained in detail in the Methods section) differs from the measures used in prior studies. Its use is substantiated by the growing awareness both in financial aid policy and in studies of financial aid, borrowing, and debt that the "meaning of money" is relative (McDonough & Calderone, 2006). This means that interpretations of the risks and rewards of borrowing are shaped by a student's social location (e.g. as a minoritized[1] group member or a dominant group member) and by the educational context of the educational setting in which the student studies.

[1]Following Gillborn (2005), we use "minoritized" rather than "minority" to emphasize that groups acquire minority status due to the marginalizing acts of dominant groups.

By using propensity score matching (PSM) analysis, we estimate both the factual and counterfactual results—in other words, determining the effects of debt not only on those students who opted to borrow but also on those who did not. Most studies of the consequences of borrowing have not estimated the effect of debt among nonborrowers (i.e., the counterfactual), but those effects are certainly also relevant in evaluating how to structure the financial aid system to stimulate human capital investments in the critical occupations where STEM graduates find employment.

Literature Review

Previous studies of the effect of loans on graduate school enrollment using statistical methods offer mixed findings concerning the relationship between debt and graduate education, with the estimate of effects ranging from negative to positive or insignificant (Bedard & Herman, 2005, 2008; Choy & Gies, 1997; Kim & Eyermann, 2006; Millett, 2003; Murphy, 1994; Nettles, 1989; Perna, 2004; Tsapogas & Cahalan, 1996; Weiler, 1991). Typically, the authors of these studies use a rational choice framework and conceptualize the significance or insignificance of debt in the graduate school decision-making process as the ability of debt to become salient enough to drive students' cost-benefit analyses. However, like researchers using qualitative methods and socio-cultural perspectives, statistical analysts are increasingly recognizing that multiple factors in an individual student's environment will shape his or her expectations, preferences, and enrollment choices. Decision-making processes are not only unique but dynamic (Dowd, 2008), in the sense that educational decisions rely upon knowledge and interpretation of the costs and benefits which are contextually dependent—that is, they are shaped in large part by interactions with faculty, counselors, and peers, as well as by the resources, academic options, and financial aid available in those environments.

Under these conditions, the nonrandom assignment of students to various cumulative debt levels complicates the statistical modeling of the effects of debt on educational outcomes, including graduate and professional school enrollment (Alon, 2005; Dowd, 2008; Dowd & Coury, 2006; DesJardins, Ahlburg, & McCall, 2006; Titus, 2007). Most studies regarding the impact of undergraduate debt burden on graduate school enrollment were conducted before substantial attention was given to these issues. Therefore they, and even more recent studies, do not typically use methods to address endogeneity and self-selection bias. Therefore, as a whole, the literature provides no clear assessment of the nature of this relationship. The findings offer multiple, sometimes contradictory, interpretations of the potential effects of debt on educational decision making.

Although the magnitude and direction of effects found through biased methods of estimation are unconvincing, the interpretations of prior analysts inform current understanding of the impacts of debt. Studies that find a negative relationship between debt and graduate school enrollment posit that students who have accumulated high levels of debt as undergraduates might be resistant to accumulating additional debt in graduate school, leading them to forgo postbaccalaureate study (Choy & Gies, 1997; Heller, 2001; Millett, 2003; Tsapogas & Cahalan, 1996). Students with unsubsidized federal loan or private loan debt, aware of the continuing accrual of interest, may want to begin paying off that debt as soon as possible. Although graduate study is likely to bring increased earnings in the future, forgoing the chance for full-time employment to attend graduate school may be an opportunity cost too large for some to bear.

In contrast, another group of scholars finds that debt either has a small positive association with graduate school enrollment or no relationship, which is interpreted in a positive manner because indebtedness did not deter graduate school enrollment (Bedard & Herman, 2005, 2008; Kim & Eyermann, 2006; Murphy, 1994; Perna, 2004; Weiler, 1991). The positive effects of debt are generally attributed to the assumption that heavy borrowing reflects a deeper understanding of the relationship between finances and educational investment decisions, including the long-term financial benefits of obtaining a graduate degree (Kim & Eyermann, 2006). Authors who find insignificant effects offer several interpretations for the lack of significance. As a result, the weighing of costs and benefits is a highly individualized process dependent on characteristics such as ability, aspirations, and expectations (Bedard & Herman, 2008; Murphy, 1994; Weiler, 1991). They suggest that other factors come into play as well—for example, the policy context (Kim & Eyermann, 2006), economic climate (Bedard & Herman, 2005, 2008), and social location (Millett, 2003; Perna, 2004). These larger trends and forces are thought to obscure or mitigate a generalized effect of debt.

The aforementioned studies demonstrate the difficulty associated with modeling the effect of debt on graduate school enrollment. As the findings and as our interpretations reveal, perceptions of debt and, by extension, the effects of debt are highly contextualized.

Theoretical Framework

The analysis for this study draws on economic theories of human capital and rational choice. Decision makers (in this case, college students) are viewed as investing in education to maximize their utility (or satisfaction). That goal is subject to financial and nonfinancial constraints, including tuition costs, the opportunity costs of forgone earnings, and the psychic costs of academic

pursuits in different fields of study. In deciding to attend graduate school, a student weighs the costs against the expected benefits and enrolls in graduate education if the net effect is positive (DesJardins & Toutkoushian, 2005; Manski & Wise, 1983; Paulsen & Toutkoushian, 2008; Perna, 2004).

Rational, utility-maximizing choices about graduate school, like other decisions, are made based on incomplete or imperfect information about the true nature of the costs and benefits of various educational and financing options (DesJardins & Toutkoushian, 2005; Ehrenberg, 1991; Paulsen & Toutkoushian, 2008; Perna, 2004). This uncertainty, including uncertainty about whether investments of time, money, and effort will in fact lead to successful completion of a degree, is recognized as a form of risk in educational decision-making. Individuals may have different tastes for risk, but these preferences are taken as given at the individual level. Although a person's taste for education and for risk may change with new information and experiences, preferences are expected to be consistent over time in the rank ordering of comparable choices. This assumption of stable individual preferences is made in order to focus on constraints, rather than preferences, as the source of explanatory power in economic analysis (DesJardins & Toutkoushian, 2005).

In using an economic perspective, our approach is like many studies of college student choice. Unlike prior studies, however, we emphasize two additional assumptions that lead us to adopt a different modeling strategy in estimating the effects of undergraduate debt on graduate school enrollment: (a) the information students *receive* varies in nonrandom ways by their racial-ethnic characteristics and (b) the way that students *interpret* information varies in nonrandom ways associated with their racial-ethnic characteristics. The first of these assumptions follows from the racial-ethnic stratification of access to college, which concentrates Latinas and Latinos in community colleges and Hispanic-serving institutions (HSIs), African Americans in historically Black colleges and universities (HBCUs) (particularly in the sciences) and nonselective traditionally White institutions (TWIs), and (disproportionately) Asian and White students in selective research universities. As we discuss below, students in these settings have access to different types of information about graduate and professional schools.

The second assumption follows from the history of racial discrimination in the United States, including institutionalized discrimination that outright barred access to many institutions of higher education for minoritized groups; structural discrimination that provided and still provides unequal quality of education across the educational spectrum (see, e.g., Harper, Patton, & Wooden, 2009; Olivas, 2005); and discrimination in financial institutions, including lending agencies of various types (Powell & Roberts, 2009). This history matters because, for individuals from groups that have been subject to discrimination, the cost-benefit calculus involved in maximizing

utility has an additional element of uncertainty. The fear of discrimination in education and employment is not randomly distributed; it is correlated with racial-ethnic characteristics. As Trent, Lee, and Owens-Nicholson (2006) point out, the fear or expectation of discrimination is rational for individuals of racial-ethnic groups that have experienced discrimination. This discriminatory context is particularly relevant to the decision to borrow because, once debt is incurred, repayment depends on success in college and the labor market.

In contrast to some analysts (De La Rosa & Hernandez-Gravelle, 2007; Monaghan, 2001) who have posited that race and ethnicity are associated with risk aversion, or a reluctance to invest in spite of expected returns on investment (Rabin & Thaler, 2001), we assume that tolerance for risk is identically distributed among individuals of different racial-ethnic groups. Racial-ethnic variation occurs systematically in the information that students of different racial-ethnic groups receive and the way that information is interpreted in the presence or fear of discrimination. Therefore, we estimate the effects of debt on graduate school enrollment separately for African Americans, Asian Americans, Caucasians, and Latinos. (The number of Native Americans or of ethnic subgroups was too small to disaggregate.)

Recognizing that contextual forces "mediate" students' rational decision-making is not novel (see, e.g., McDonough, 1997; Perna, 2006; Tierney & Venegas, 2007, p. 13), and a few analysts have previously acknowledged the racial dimensions of college financing decisions. Our approach is supported by the findings of sociocultural studies that show that the "meaning of money" (McDonough & Calderone, 2006), perceptions of cost, and attitudes toward borrowing and debt are relative to one's social status and familial experiences with formal financial systems (Archer & Hutchings, 2000; Burdman, 2005; Christie & Munro, 2003; McDonough, 2004; McDonough & Calderone, 2006; St. John, 2003; Trent, Lee, & Owens-Nicholson, 2006). These studies demonstrate that perceptions of college affordability are relative in nature and depend on a student's social context and social status. Low-income students and those who advise them may view even a small amount of borrowing as leading to "insurmountable debt" (McDonough & Calderone, 2006, p. 1714), thus foreclosing opportunities for graduate school enrollment.

The higher education literature points to several sources of variation in the way information about graduate school enrollment and financing is shared with, interpreted by, and ultimately used by underrepresented minorities (Perna, 2004). First, previous research has demonstrated that the information provided to students regarding postsecondary educational opportunities and financial aid varies by institutional type (McDonough, 1997; Perna, 2006; Tierney & Venegas, 2007). Enrollment in an elite undergraduate program is very likely to increase a student's opportunity for graduate study, particu-

larly in those fields where fellowships, teaching assistantships, or research assistantships are available (Eide & Waehrer, 1998). Further, students at highly selective institutions and research universities tend to have more opportunities to interact with faculty and engage in research—activities that increase the chances of attending graduate school (Foertsch, Alexander, & Penberthy, 1997; Kardash, 2000; Kinkead, 2003; Sabatini, 1997; Seymour, Hunter, Laursen, & Deantoni, 2004). Indeed, students who graduate from research universities are more likely to attend graduate school, controlling for individual characteristics.

African American, Latino, and Native American STEM undergraduates have disparate access to these advantaging institutional types; they are less likely to earn their degrees from a highly selective institution or a research university. Latino STEM undergraduates, in particular, are most likely to follow what are thought to be "unconventional" pathways to STEM, first earning an associate's degree at a community college prior to transferring to a four-year university (Malcom, 2008; NSF, 2009). Traversing this route to the bachelor's degree further limits access to elite institutions and research universities (Malcom, 2008).

The information and counseling that students receive about financial aid also depend on the perceptions of information providers about students' income status (Linnehan, Weer, & Stonely, 2006; McDonough & Calderone, 2006). Because race and socioeconomic status are highly correlated, due to historic opportunity denial and the resulting disparities in accumulated wealth (Keister & Moller, 2000; Krivo & Kaufman, 2004; Smith, 1995), these differences in information based on SES likely have a disproportionate impact on underrepresented minority students, potentially limiting the information they receive about sources of financial support for graduate school.

Differences in the ways that students access and interpret information about graduate school financing are also likely to vary systematically by racial-ethnic status. There are socioculturally based differences in "attitudes toward seeking help and help-seeking behavior" (Alexitch, 2006). Students who are members of minoritized racial-ethnic groups, particularly those attending predominantly or traditionally White institutions, may feel uncomfortable seeking assistance to secure financial aid for graduate school from knowledgeable faculty and staff because of perceived or real cultural differences between the student and prospective help providers (Gloria, Hird, & Navarro, 2001).

Further, feelings of academic inferiority or fears of reinforcing negative racial-ethnic stereotypes (Gloria, Hird, & Navarro, 2001; Rendón, Jalomo, & Nora, 2000; Steele, 1997) can prevent minority students from seeking advice about academic decision-making. Behavioral economists emphasize that individuals who sense a lack of fit or social exclusion in educational settings experience a loss of self-image, or identity, which leads to a higher

cost of participation in that setting (Akerlof & Kranton, 2000, 2002). Such marginalizing experiences have been well documented in STEM fields, in particular, which are less diverse than other fields of study (Martin, 2009; Sevo, 2009; Tuitt, 2009).

The scant numbers of faculty of color in STEM fields only increase the likelihood that minoritized students would have difficulty reaching out to a knowledgeable mentor (NSF, 2009). Students who lack mentors, instead, often rely on peer groups for information about academic decision-making and financial aid (Bensimon & Dowd, 2009; Stanton-Salazar, 2000; Tierney & Venegas, 2006; Venegas, 2006). This peer-to-peer information sharing can limit the quality and breadth of information to which underrepresented minority students in STEM fields have access, as well as a student's ability to act on pertinent information.

METHODS

Data Sources and Sample

We analyzed student-level data from the 2003 National Survey of Recent College Graduates (NSRCG) merged with institutional-level data from several sources, including the 2002–2003 College Board Annual Survey of Colleges and Universities, the Institute for College Access and Success (TICAS) student debt database,[2] the Integrated Postsecondary Education Data System (IPEDS), and Barron's Profiles of American Colleges. The National Science Foundation (NSF) administers the NSRCG every two years to a nationally representative sample of recently graduated STEM bachelor's and master's degree holders.

Key institutional-level variables added from these sources included selectivity (from the Barron's Profiles); mean per-borrower cumulative indebtedness for the 2001 and 2002 graduating classes; the percentage of students who borrowed; selectivity; and 2001 and 2002 in-state and out-of-state tuition levels (from the College Board). The TICAS dataset also provided a student loan usage variable, "mean cumulative per borrower indebtedness," that we used to supplement institutional cases missing this information in the College Board data. The population of interest in our study consisted of U.S. citizens who earned a bachelor's degree in the mainland United States AY 2000–2001 or 2001–2002.[3] We excluded degrees earned in Puerto Rico

[2]The student debt data made publicly available by TICAS were derived from the Peterson's Undergraduate Financial Aid and Undergraduate Databases.

[3]The NSRCG data contain records for individuals who earned a STEM bachelor's *or* master's degree in 2000–2001 or 2001–2002. We eliminated those who earned the B.S. before AY 2000–2001 to achieve a more consistent interpretation of debt to college costs and financial aid policies at the time of undergraduate study.

because Latinos in Puerto Rico and in the mainland United States experience a different cultural and higher education context, and our analysis entails making comparisons among racial ethnic groups with characteristics salient in the mainland States.

We omitted baccalaureate institutional codes from the analysis, and dropped from analysis individual records that did not include a valid institutional code for the baccalaureate-granting institution; however, we retained them in the database to accurately account for the NSRCG's complex sampling design effects. These procedures resulted in an analytical sample of $n = 7{,}700$ (99.3% of cases in the data representing the population of interest). The racial-ethnic composition of the final analytical sample was: $n_{\text{Latino}} = 1{,}065$; $n_{\text{Black}} = 1{,}062$; $n_{\text{Asian}} = 534$; $n_{\text{White}} = 4{,}765$; the remaining 274 respondents included Native Americans, Pacific Islanders, and those classified as "Other." This racial-ethnic composition reflects oversampling underrepresented minority groups during NSF's NSRCG data collection.

Analytical Strategy

The analysis relied on propensity score matching (PSM), a quasi-experimental method applied in educational policy research to reduce bias in the estimate of program effects due to self-selection into and out of social programs (see Dowd, 2008; Riegg, 2008; Titus, 2007, for in-depth descriptions of propensity score matching). The PSM analysis generates propensity scores (probabilities) for each case in the data, which represents an individual's propensity to engage in the treatment offered by the program—in this case, borrowing. As noted above, PSM analysis also generates the counterfactual estimate of the effects of program participation on those who did not participate, which gives a fuller picture of program effects because those who do not participate may anticipate—and may in fact be likely to receive—a lesser benefit from participation than those who do participate. We defined two treatment conditions, "heavy borrowing" and "typical borrowing," and compared them with a control group who had not borrowed at all. Students were assigned to one of these three groups empirically, based on their actual borrowing behavior. Then those in the treatment groups were matched to others in the control group, based on their propensity to borrow and on their racial-ethnic designation, in order to estimate the effect of debt on graduate enrollment among different racial-ethnic groups.

Heavy and typical borrowing levels were defined relative to the average cumulative undergraduate debt at a student's baccalaureate institution. This operationalization of the magnitude of debt as relative follows from the literature review above, demonstrating that a borrower's interpretation of and willingness to incur debt depends on his or her social location, the likelihood

of success in college, and the prospects of future earnings sufficient to repay college loans. These expectations vary systematically (i.e., are not randomly distributed) by racial-ethnic status and type of institution attended.

In addition, the magnitude of debt incurred by those with associate's degrees is typically lower due to lower tuition charges at community colleges (TICAS, 2009; Santiago & Cunningham, 2005). However, even these lower levels of borrowing can be viewed as a high debt burden by those with lower earnings expectations. In this modeling strategy, the average debt of peers graduating from the same institution at the same time serves as a benchmark for typical debt amounts and the normative use of debt in different institutional contexts. Those with higher debt than is typical for students attending similar types of institutions on the way to the STEM baccalaureate are viewed as using loans more aggressively as a college financing strategy (i.e., as being "heavy borrowers").

Propensity scores, or the probability of accumulating relative debt at a given level, were estimated for each case in the data using constrained multinomial probit regression. To retain the representativeness of the sample, the cases were weighted in the probit analysis by the sampling weights of the NSRCG's complex survey design (Jang & Lin, 2007). In estimating the propensity scores, the constrained model takes into account the fact that institutional-level covariates (such as institutional control, type, and selectivity) impact the likelihood of borrowing versus not borrowing. In this model, it is individual-level characteristics, not these institutional characteristics, that determine the probability of heavy or typical borrowing as an individual decides how much to borrow relative to the costs of study at his or her institution and earnings expectations. This approach controls for the expected differences in the effect of debt on graduate enrollment among racial-ethnic groups that is attributable to the racial-ethnic stratification of enrollment by institutional type.

The probit model predicting the propensity scores controlled for variables known to be associated with borrowing, with the exception of other financial aid variables, such as need- or non-need-based grants. Following Caliendo and Kopeinig (2005), we omitted these variables because they are correlated with borrowing and "only variables unaffected by participation [in the treatment] (*or the anticipation of it*) should be included" (p. 6, emphasis ours). Following our theoretical framework, control variables entered into the probit model that generated the propensity scores included measures of institutional context, social location, and human capital. These independent variables were student demographic characteristics (gender, national origin, parental education, and nontraditional student status) postsecondary educational experiences (community college attendance, associate degree attainment, undergraduate GPA, STEM major field), and baccalaureate-granting institu-

Table 1

Demographic, Educational, Institutional,[1] and Financial Support: Characteristics of Analytical Sample: Summary Statistics

Variable	*Means*			
	Latino	*African American*	*Asian*	*White*
Demographic Variables				
Age at time of survey	25.182 (.301)	26.857 (.373)	23.409 (.306)	24.930 (.241)
Gender				
Female	0.583 (.018)	0.682 (.020)	0.467 (.023)	0.567 (.012)
National origin				
Mexican American	0.476 (.027)			
Cuban	0.064 (.014)			
Puerto Rican	0.126 (.016)			
Other Latina/o	0.334 (.020)			
Highest parental education level				
Less than high school	0.159 (.016)	0.068 (.012)	0.065 (.015)	0.019 (.004)
High school diploma or equivalent	0.200 (.015)	0.224 (.023)	0.169 (.017)	0.158 (.009)
Some college, vocational, or trade school	0.265 (.018)	0.299 (.019)	0.132 (.015)	0.212 (.009)
Bachelor's degree	0.157 (.014)	0.175 (.015)	0.241 (.019)	0.268 (.009)
Master's degree	0.134 (.013)	0.146 (.013)	0.186 (.017)	0.213 (.009)
Professional degree (e.g., JD, LLB, MD, DDS)	0.048 (.008)	0.037 (.008)	0.118 (.015)	0.070 (.005)
Doctorate	0.036 (.006)	0.043 (.008)	0.081 (.014)	0.061 (.004)

Table 1, cont.

Variable	*Means*			
	Latino	*African American*	*Asian*	*White*
Educational Variables				
Associate degree from community college	0.198 (.020)	0.164 (.018)	0.112 (.018)	0.153 (.012)
Associate degree from any institution	0.219 (.021)	0.191 (.019)	0.117 (.018)	0.172 (.013)
Community college attendance	0.620 (.021)	0.533 (.024)	0.482 (.026)	0.486 (.014)
Nontraditional student status	0.307 (.020)	0.396 (.024)	0.174 (.022)	0.250 (.015)
Field of Study				
Computer and mathematical science	0.097 (.008)	0.099 (.010)	0.254 (.024)	0.095 (.005)
Biological, agricultural, and environmental science	0.127 (.012)	0.116 (.013)	0.200 (.018)	0.163 (.007)
Physical and related sciences	0.024 (.004)	0.025 (.003)	0.037 (.004)	0.042 (.002)
Social and related sciences	0.573 (.019)	0.500 (.026)	0.279 (.022)	0.428 (.013)
Engineering	0.100 (.008)	0.066 (.007)	0.197 (.014)	0.112 (.006)
S&E-related fields	0.078 (.015)	0.195 (.027)	0.033 (.013)	0.158 (.015)
Non S&E fields	0.001 (<.001)	<0.001 (<.001)	NO VALUES	<0.001 (<.001)
Undergraduate Grade Point Average				
3.75–4.00 (Mostly A's)	0.160 (.017)	0.057 (.010)	0.149 (.016)	0.203 (.010)
3.25–3.74 (About half A's, half B's)	0.356 (.018)	0.248 (.019)	0.367 (.022)	0.408 (.011)
2.75–3.24 (Mostly B's)	0.351 (.018)	0.473 (.020)	0.380 (.020)	0.299 (.010)
2.25–2.74 (About half B's, half C's)	0.119 (.011)	0.195 (.018)	0.079 (.010)	0.077 (.004)
Less than 2.24 (Mostly C's)	0.014 (.005)	0.027 (.005)	0.018 (.006)	0.013 (.002)
Did not take courses for grades	<0.001 (<.001)	<0.001 (<.001)	0.006 (.001)	<0.001 (<.001)

Table 1, cont.

Variable	*Means*			
	Latino	*African American*	*Asian*	*White*
Graduate Degree Enrollment/Attainment				
Earned graduate degree or currently enrolled in graduate school	0.325 (.018)	0.286 (.018)	0.383 (.023)	0.337 (.009)
Baccalaureate-Granting Institutional Characteristics				
Control				
Private	0.331 (.033)	0.318 (.039)	0.310 (.032)	0.399 (.026)
Carnegie Classification				
Research university	0.399 (.032)	0.284 (.026)	0.603 (.034)	0.365 (.021)
Doctoral university	0.138 (.029)	0.184 (.036)	0.115 (.022)	0.114 (.015)
Master's college or university	0.340 (.038)	0.395 (.040)	0.211 (.035)	0.358 (.027)
Liberal arts institution	0.114 (.023)	0.106 (.029)	0.066 (.017)	0.140 (.021)
Specialized institution	0.009 (.006)	0.032 (.016)	0.005 (.005)	0.022 (.008)
Selectivity				
Noncompetitive	0.090 (.018)	0.066 (.023)	0.074 (.019)	0.045 (.016)
Less competitive	0.084 (.026)	0.142 (.037)	0.013 (.005)	0.067 (.017)
Competitive	0.225 (.034)	0.293 (.035)	0.109 (.016)	0.289 (.023)
Competitive plus	0.044 (.024)	0.039 (.020)	0.040 (.022)	0.023 (.007)
Very competitive	0.231 (.029)	0.220 (.035)	0.233 (.028)	0.290 (.022)
Very competitive plus	0.011 (.008)	0.036 (.014)	0.046 (.020)	0.042 (.010)
Highly competitive	0.128 (.027)	0.093 (.013)	0.162 (.021)	0.117 (.015)
Highly competitive plus	0.019 (.005)	0.020 (.005)	0.039 (.012)	0.031 (.008)

Table 1, cont.

Variable	*Means*			
	Latino	*African American*	*Asian*	*White*
Most competitive	0.163 (.016)	0.089 (.014)	0.284 (.025)	0.094 (.011)
Special	0.004 (.004)	0.002 (.002)	NO VALUES	0.001 (.001)
State				
California	0.340 (.035)	0.065 (.011)	0.343 (.028)	0.092 (.012)
Florida	0.097 (.028)	0.038 (.014)	0.035 (.005)	0.030 (.003)
Illinois	0.034 (.008)	0.060 (.015)	0.051 (.018)	0.042 (.011)
New York	0.108 (.026)	0.108 (.024)	0.149 (.033)	0.094 (.018)
Texas	0.118 (.029)	0.037 (.012)	0.023 (.010)	0.040 (.010)
Other state	0.303 (.029)	0.692 (.033)	0.398 (.030)	0.702 (.023)
Financial Support/Aid Variables				
Sources of financial aid				
Earnings	0.599 (.020)	0.536 (.021)	0.487 (.024)	0.591 (.011)
Employer support	0.088 (.012)	0.136 (.016)	0.041 (.008)	0.091 (.009)
Grants or scholarships	0.652 (.018)	0.719 (.019)	0.589 (.022)	0.626 (.012)
Loans from government, banks, & institutional sources	0.661 (.019)	0.779 (.017)	0.507 (.024)	0.596 (.011)
Loans from parents or other relatives	0.075 (.009)	0.057 (.009)	0.123 (.015)	0.085 (.006)
Gifts from parents or other relatives not to be repaid	0.557 (.020)	0.522 (.023)	0.752 (.021)	0.689 (.013)
Work study	0.278 (.019)	0.324 (.022)	0.235 (.020)	0.224 (.012)
Other source	0.017 (.005)	0.021 (.005)	0.031 (.014)	0.024 (.004)

Table 1, cont.

Variable	*Means*			
	Latino	*African American*	*Asian*	*White*
Financial Support/Aid Variables				
Amount borrowed to finance undergraduate degree				
None	0.279 (.018)	0.202 (.016)	0.415 (.024)	0.356 (.011)
$1–5,000	0.094 (.014)	0.076 (.009)	0.103 (.014)	0.062 (.005)
$5,001–10,000	0.113 (.011)	0.095 (.013)	0.102 (.015)	0.081 (.005)
$10,001–15,000	0.137 (.013)	0.120 (.015)	0.088 (.012)	0.102 (.006)
$15,001–20,000	0.137 (.013)	0.159 (.015)	0.104 (.014)	0.144 (.008)
$20,001–25,000	0.077 (.009)	0.087 (.009)	0.072 (.014)	0.075 (.005)
$25,001–30,000	0.074 (.010)	0.086 (.012)	0.042 (.008)	0.053 (.004)
$30,001–35,000	0.026 (.006)	0.054 (.013)	0.017 (.005)	0.037 (.004)
$35,001 or more	0.063 (.008)	0.121 (.021)	0.058 (.010)	0.089 (.007)
Relative debt level				
No debt	0.279 (.018)	0.202 (.016)	0.415 (.024)	0.355 (.011)
Low debt	0.513 (.019)	0.479 (.024)	0.450 (.023)	0.425 (.012)
High debt	0.208 (.017)	0.319 (.024)	0.136 (.014)	0.220 (.012)

Note: Robust standard errors, which take into account the clustered (by undergraduate institution) and stratified (by race/ethnicity, gender, and field of study) sample design of the NSRCG, are reported in parentheses below mean estimates. *Source:* NSF 2003 National Survey of Recent College Graduates (NSRCG), using final survey weight (WTSURVY) and Barron's *Profiles of American Colleges* (2004).
[a]Baccalaureate degree-granting institution.

tional characteristics (control, Carnegie classification, selectivity, minority-serving status, tuition, and percentage of undergraduates who borrowed to finance college). Table 1 provides the means and standard deviations of the control variables listed above, disaggregated by race and ethnicity. (Results of the constrained multinomial probit model used to derive individual propensity scores are available upon request.)

The effects of the heavy and typical debt treatments on graduate and professional school enrollment were estimated using the PSMATCH2 module in Stata 10 (Leuven & Sianesi, 2003; Sianesi, 2001). This function creates the "treatment" and "control" groups, checks for a balanced number of cases in these groups, and matches cases with similar propensities to borrow (e.g., heavy-heavy, and typical-typical). Following Titus (2007), we used a narrow kernel matching bandwidth (0.06) to avoid matching cases with large differences in propensity scores. This step increases the quality of matches by identifying the best counterfactual comparison (Titus, 2007). After the matching of cases in the "treatment" and "control" groups, PSMATCH2 estimates the average effects of cumulative relative debt level on the dependent variable of graduate and professional school attendance, measured dichotomously to indicate whether respondents enrolled in graduate school (by which we mean master's, doctoral, or professional programs) within two years of earning a STEM bachelor's degree. We classified as "enrolled in graduate school" individuals who indicated that they were enrolled in a master's, doctoral or professional degree program at the time of the survey and/or who indicated that they had already earned a graduate degree. All other individuals in the sample were identified as not having enrolled in graduate school.

We note that 29.5% of individuals determined to have enrolled in graduate school were in non-STEM fields. Though this is a large proportion of graduate school enrollees, we left these individuals in our sample because we have no basis for determining that individuals enrolled in such non-STEM degree programs as business or education will be employed outside of the STEM workforce. Nearly half of graduate school enrollees in non-STEM fields were pursuing business or education graduate degrees, with the other portion in other non-STEM fields.

Just above one-third of the sample (33.5%) enrolled in graduate school. There were significant racial-ethnic differences in graduate school enrollment; 37.9% of Asian STEM baccalaureates enrolled in graduate school compared to 28.6% of African Americans, 32.5% of Latinos, and 33.7% of Whites. We estimated the effect of relative debt on graduate school enrollment separately for each racial-ethnic group in our analysis. It is not possible to incorporate interaction terms to calculate separate estimates by racial-ethnic group because the PSM technique returns average treatment effects, which must be based on all the cases in the sample.

The NSRCG variable (UGLOANR) measuring cumulative undergraduate student loan debt was categorical and included borrowing from any source. The response categories ranged from "none" to "$35,001 or more" and increased in increments of $5,000, such as "$1–5,000," "$5,001–10,000," etc. (See Table 1 for all response categories.) The "dosage" of the treatment (i.e., heavy, typical, or no borrowing) was determined, using the formula below, using the average cumulative undergraduate debt ($debt_k$) of the graduating class in the year of interest (i.e., 2000–2001 or 2001–2002) as the benchmark for typical debt:

$$Dose = \frac{1}{2}\left(\frac{(UGLOAN_{\text{min value}})_i + (UGLOAN_{\text{max value}})_i}{\overline{\text{debt}}_k}\right) \quad (1)$$

We selected two sets of cut points for the heavy borrowing and typical borrowing categories, based on a review of the distribution of cumulative undergraduate debt among students who had earned associate degrees and those who had not. Within both groups, we assigned the value of zero (0.0) to students who had no debt and the value of one (1.0) to the amount equal to the average per borrower cumulative debt at each individual respondent's baccalaureate-granting institution.

It was during assignment to the heavy and typical debt categories that we distinguished between associate and non-associate degree holders. We selected different cut points based on the empirical distribution of cumulative debt in these two groups (established by reviewing histograms and descriptive statistics). A cut point of 1.0 differentiated the typical and heavy debt categories for those with associate's degrees, whereas a cut point of 1.5 was used for those who did not have associate's degrees. In other words, associate degree holders who had average amounts of debt compared to students in their bachelor's degree graduating class were categorized as heavy borrowers, while those without associate's degrees who had average amounts of debt were characterized as typical borrowers. We then used the relative debt level as established by these cut points for each case as the treatment variable in the propensity score-matching analyses, which estimate the treatment effects of borrowing at heavy or typical levels of relative debt on graduate school enrollment.

Missing Data

The cases in the analytical sample were complete with the exception of the variables indicating the 2001 and 2002 mean per-borrower cumulative indebtedness of the baccalaureate-granting institution. These values were missing at random (MAR), meaning that they were not randomly distributed across all the observations, but were missing randomly within more than one subsample of institutions (Allison, 2002). Due to the MAR condition, imputation of the missing values was an appropriate step to take.

We imputed missing values for the key variables "2001 mean per borrower cumulative undergraduate debt" (17% missing) and "2002 mean per borrower cumulative undergraduate debt" (29% missing) using random regression imputation (i.e., predictive regression imputation with the addition of a stochastic component through the residual terms). The imputation of the variable "2001 mean debt" involved modeling this continuous variable as a linear function of tuition, institutional selectivity, geographical location of the institution (i.e., state), and control. We replaced missing values with the predicted values plus a randomly selected residual term from those cases with non-missing values for 2001 mean debt. For the variable 2002 average debt, we used the same model, with the addition of the 2001 average debt as a predictor.

Interpretation

PSM analysis in PSMATCH2 in Stata calculates the average treatment effect (ATE), average treatment effect on the treated (ATT), and the average treatment effect on the untreated (ATU) (Leuven & Sianesi, 2003; Sianesi, 2001). The ATE represents the average treatment effect for the entire population, whether or not a particular individual has been treated, and corresponds to the mean effects estimated by regression analysis. The ATT represents the average impact of the treatment among those who have been exposed to it, and the ATU indicates the expected impact of treatment among those who have not been treated. The average treatment effect (ATE), treatment effect on the treated (ATT), and treatment effect on the untreated (ATU) resulting from the PSM analysis of STEM bachelor's degree holders are presented below.

As noted, almost all cases (greater than 99%) were matched (i.e., "fell within the common support area") (Caliendo & Kopeinig, 2005), indicating that nearly the entire analytical sample was included in the calculation of the treatment effects. We tested the statistical significance of difference among the estimates generated for each racial-ethnic groups using statistics calculated as the quotient of the difference in effect size between groups and the standard error of the difference between those groups. The standard errors were calculated using bootstrap repetition (Efron & Tibshirani, 1993). The conventional alpha value of .05 was adjusted in determining statistical significance to .0125 to account for multiple comparisons (Holm, 1979).

Given the mixed results of prior studies concerning the effects of debt on graduate school enrollment, we used a two-sided test of the null hypothesis of no difference. We interpret significant differences in estimates as having an "effect" on graduate school enrollment, keeping in mind that, strictly speaking, causality is not demonstrated by PSM analysis because it is not possible to fully control for unobservable factors affecting the outcome of interest (Rosenbaum & Rubin, 1983). We tested the robustness of the estimated treatment effects derived from PSM using the Stata module MHBOUNDS

(Becker & Caliendo, 2007), which introduces different levels of bias that could be caused by unobserved variables and tests how large the hidden bias would have to be to render the PSM results insignificant. The result of this sensitivity analysis indicated that any hidden bias due to unobserved characteristics would have to alter the odds of selection of treatment by nearly double. These results indicate an adequately robust PSM model.

To test the robustness of the estimated treatment effects to model misspecification, we conducted a second sensitivity analysis in which we systematically excluded selected variables from the actual model, reporting the change in treatment effects caused by these alterations. The results indicated that the direction of the effect remained negative across all models. The range of the estimates in the models remained within one standard error of the actual model's treatment effect estimates. Goodness-of-fit tests for the constrained multinomial probit models that we used to calculate the propensity scores indicated that the probit models were a good fit.

Limitations

This study has a number of data limitations. Ideally, the data would have allowed further disaggregation of the racial-ethnic categories of Latino and Asian, which both incorporate a wide range of national and ethnic groups with disparate histories and experiences in the United States. However, there were too few cases in these data for this type of disaggregation to be possible.

Measures of early educational aspirations, indicators of academic and social activities, high school grades or course-taking patterns, which affect college choice, were lacking. The absence of aspiration measures required us to treat graduate school as an outcome by all students, when likely it was not. On a related note, the career aspirations of graduate school enrollees were not included in the dataset. This factor prevented us from differentiating those individuals in non-STEM graduate degree programs (e.g., business, education) who planned to enter the STEM workforce from those who did not. As a result, our findings reflect the relationship between debt and the graduate school enrollment of STEM baccalaureates in any graduate degree program.

Further, the variables related to financial aid are less than ideal. For example, the NSRCG does not provide aid amounts for non-loan financial aid. Instead, students simply indicate whether they received the specified forms of financial aid. The NSRCG also does not provide the students' debt levels disaggregated by loan type (e.g., subsidized versus unsubsidized), a reporting pattern that prohibited us from determining whether the effects of debt vary based on the type of loan.

Additionally, the NSRCG data measured indebtedness in nine categories. While this approach has its merits (for example, graduates are not always

likely to know the exact amount of their student loans), it obscured finer observations of variation in borrowing, including thresholds where borrowing may drop off among students at different types of institutions and of different racial-ethnic groups. Ideally, we would have derived indebtedness from a continuous variable.

FINDINGS

Racial-Ethnic Differences in Borrowing

The first research question of our study pertained to the prevalence of borrowing among STEM bachelor's degree holders and the variation in borrowing patterns among racial-ethnic groups. Our results show that African American and White STEM bachelor's degree holders were most likely to be heavy borrowers, Latinos were most likely to be typical borrowers, while Asians were the group most likely to avoid borrowing altogether. Table 2 illustrates that the majority of STEM bachelor's degree holders borrowed some amount to finance college. As one might suspect, the largest proportion of these borrowers accumulated typical debt. However, a sizable proportion—more than one-fifth—of STEM bachelor's degree holders were heavy borrowers.

Key differences in the patterns of borrowing by race/ethnicity emerged from our analysis. More than 40% of Asian STEM bachelor's degree holders did not borrow at all; those who did rarely exceeded "typical" borrowing levels. Just 13.3% of Asians borrowed heavily—by far the smallest proportion of any racial-ethnic group. Slightly more than a third (35.5%) of White STEM bachelor's degree holders accumulated no debt, 42.5% accumulated typical debt levels, and 22.1% borrowed heavily. More than half of Latinos (51.3%) were typical borrowers, 27.9% were non-borrowers and the remainder (20.8%) accumulated heavy debt. Nearly 80% of African American STEM bachelor's degree holders borrowed to pay for college (31.9% heavy debt; 47.9% typical debt).

These patterns are mirrored in the data on absolute debt. (See Table 1.) Fewer than 12% of Asian STEM bachelor's degree holders accumulated more than $25,000 in debt, compared to 17.9% of whites, 16.3% of Latinos, and 26.1% of African Americans. The racial-ethnic disparities in absolute and relative debt loads led us to further examine the respondents' self-reported means of college financing. As shown in Table 1, drawing on parental and/or familial support (not to be repaid) to finance college was most common among Asian STEM bachelor's degree holders (75.2%). Similarly, Asians most commonly reported receiving loans from their parents and/or other relatives (12.3%).

Table 2

Estimates of the Average Treatment Effect (ATE), Average Treatment on the Treated (ATT), and Average Treatment on the Untreated (ATU) Effect of Relative Level of Indebtedness (Low, High) on 2000-2001/2001-2002 STEM Bachelor's Degree Recipients' Graduate School Enrollment, by Race/Ethnicity

		Low Relative Debt			*High Relative Debt*		
		ATE	*ATT*	*ATU*	*ATE*	*ATT*	*ATU*
Latinos	Kernel matching estimates	−0.141***	−0.138**	−0.156***	−0.185***	−0.171***	−0.198***
	S.E.	0.0403	0.0370	0.0351	0.0507	0.0445	0.0383
	Percent of cases matched	100			99.2		
African Americans	Kernel matching estimates	−0.096*	−0.100**	−0.088*	−0.071	−0.057	−0.088*
	S.E.	0.0396	0.0384	0.0437	0.0384	0.0421	0.0377
	Percent of cases matched	99.7			100		
Asians	Kernel matching estimates	−0.139**	−0.102*	−0.175**	−0.032	−0.056	−0.022
	S.E.	0.0502	0.0495	0.0522	0.0680	0.0679	0.0706
	Percent of cases matched	99.5			99.0		

Table 2, cont.

		Low Relative Debt			*High Relative Debt*		
		ATE	*ATT*	*ATU*	*ATE*	*ATT*	*ATU*
Whites	Kernel matching estimates	−0.052**	−0.055***	−0.049**	−0.063**	−0.060**	−0.065**
	S.E.	0.0154	0.0143	0.0144	0.0201	0.0212	0.0194
	Percent of cases matched	100			99.9		

Note: Standard errors were generated using bootstrap replications.
Source: Analyses of the 2003 NSF NSRCG, using propensity scores generated from a multinomial probit model and weighted data (WTSURVY).
*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

Debt and Graduate School Enrollment among Borrowers

Our second research question pertained to the effect of debt on graduate school enrollment within two years of receiving the STEM baccalaureate, and the third considered variations in those effects among racial-ethnic groups. We found that borrowing at typical debt levels had a negative effect on graduate school enrollment for students of every racial-ethnic group in our study. (See Table 3). The effect of heavy borrowing, however, was mixed. Latino and White students experienced a negative effect (compared to non-borrowers), but African Americans and Asians experienced no effect.

The estimates of the negative effect of typical debt, as measured by the ATT, ranged between 13.8% and 10.0% among Latinos, African Americans, and Asians, who were all less likely to enroll in graduate school than their counterparts who did not borrow (Table 3, column 2). White students with typical debt were 5.5% less likely to enroll in graduate school than their White counterparts who shared similar characteristics and did not borrow. While this estimate of the negative effect of typical debt on White students is roughly half as large as the effect on other racial-ethnic groups, the differences in the estimates between groups are not statistically significant.

The estimates of the negative effects of heavy borrowing are greater than the estimates of the negative effects of typical borrowing among Latinos and White students (17.1% and 6.0%, respectively) (Table 3, column 5). However, these effects of heavy borrowing are not statistically significantly different from the effects of typical debt in either group. In addition, although the magnitude of this negative effect on the probability of graduate school enrollment among Latinos is estimated at more than two-and-a-half times the negative effect among White students, this difference between the two groups is not statistically significant.

Debt and Graduate School Enrollment among Non-Borrowers

The two columns denoted ATU in Table 3 provide estimates of the (counterfactual) average effects of typical and heavy debt on graduate school enrollment among non-borrowers (if those individuals had instead borrowed). As with borrowers, these effects are negative at typical debt levels among all racial-ethnic groups, with the magnitude of effects ranging between 17.5% among Asian students and 4.9% among Whites. While the negative magnitude of effect tends to be larger among non-borrowers than among borrowers, these within-group differences in the magnitude of the decomposed treatment effect are not statistically significant.

TABLE 3

ESTIMATES OF THE AVERAGE TREATMENT EFFECT (ATE), AVERAGE TREATMENT ON THE TREATED (ATT), AND AVERAGE TREATMENT ON THE UNTREATED (ATU) EFFECT OF RELATIVE LEVEL OF INDEBTEDNESS (LOW, HIGH) ON 2000-2001/2001-2002 STEM BACHELOR'S DEGREE RECIPIENTS' GRADUATE SCHOOL ENROLLMENT, BY RACE/ETHNICITY

		Low Relative Debt			*High Relative Debt*		
		ATE	*ATT*	*ATU*	*ATE*	*ATT*	*ATU*
Latinos	Kernel matching estimates	−0.141***	−0.138**	−0.156***	−0.185***	−0.171****	−0.198***
	S.E.	0.0403	0.0370	0.0351	0.0507	0.0445	0.0383
	Percent of cases matched	100			99.2		
African Americans	Kernel matching estimates	−0.096*	−0.100**	−0.088*	−0.071	−0.057	−0.088*
	S.E.	0.0396	0.0384	0.0437	0.0384	0.0421	0.0377
	Percent of cases matched	99.7			100		
Asians	Kernel matching estimates	−0.139**	−0.102*	−0.175**	−0.032	−0.056	−0.022
	S.E.	0.0502	0.0495	0.0522	0.0680	0.0679	0.0706
	Percent of cases matched	99.5			99.0		

Whites	Kernel matching estimates	−0.052**	−0.055***	−0.049**	−0.063**	−0.060**	−0.065**
	S.E.	0.0154	0.0143	0.0144	0.0201	0.0212	0.0194
	Percent of cases matched	100			99.9		

Note: Standard errors were generated using bootstrap replications.
Source: Analyses of the 2003 NSF NSRCG, using propensity scores generated from a multinomial probit model and weighted data (WTSURVY).
*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

The effects of heavy borrowing compared to not borrowing at all are again mixed in the population of non-borrowers, as they were in the population of borrowers. A very large negative effect of heavy debt is estimated for Latino non-borrowers (-19.8%), and more moderate negative effects are estimated for African Americans (-8.8%) and Whites (-6.5%). Negative effects are not estimated for Asian non-borrowers, however, where the estimate is statistically insignificant. As with the estimated effects of typical debt among non-borrowers compared to borrowers, these within-group differences in the magnitude of the treatment effect are not statistically significant.

Discussion

The results of our study reveal that, while the majority of Asian, African American, Latino, and White recent STEM bachelor's degree holders relied on loans to finance college, the degree of borrowing was not uniform across race and ethnicity. We also found that, generally, each racial-ethnic group experiences a negative effect of debt, measured in relative terms, on graduate school enrollment within two years of completing a bachelor's degree. When measured against the goal of graduate school enrollment immediately after bachelor's degree completion, the amount of borrowing that is "just right" is no debt at all. For all racial groups and Latinos in our study, borrowing reduces the chances of attending graduate school. And, with the exception of African Americans and Asians with heavy debt, the likelihood of post-baccalaureate enrollment declines as the relative debt level increases.

Patterns of Borrowing by Race and Ethnicity

The high frequency at which recent STEM bachelor's degree holders borrowed to pay for college indicates the oft-discussed growing prominence of student loans (College Board, 2007; St. John, 2003). In that sense, we expected these findings. However, the differences revealed by our analysis in accumulated relative debt by race/ethnicity—i.e., whether students were heavy or typical borrowers—were striking. The racial-ethnic differences in the prevalence of borrowing are consistent with previous studies of student debt measured by the magnitude of debt (Price, 2004).). More important, our findings demonstrate that disparate borrowing patterns also exist when measured in terms of relative debt. Independent of variation in institutional costs (which is controlled for through the relative debt measure), African Americans were most likely to be heavy borrowers, a greater proportion of Latinos than of other groups borrowed at typical levels, and Asian graduates were the most likely to have no debt.

Asian STEM bachelor's degree holders were less often borrowers and accumulated lower relative debt. Asian graduates were also most likely to draw on parental and/or familial support to pay for college. African Americans,

in contrast, borrowed most heavily and were least likely to rely upon familial support. Thus, we conclude that Asian STEM bachelor's degree holders and their African American counterparts employ distinct college financing strategies, which appear to be rooted in well-documented differences in accumulated family wealth (Keister & Moller, 2000; Krivo & Kaufman, 2004; Smith, 1995).

The Negative Effects of Debt

With the exception of Asian and African Americans who were heavy borrowers, the estimated negative effects of debt on graduate school enrollment are statistically significant among borrowers and non-borrowers. In other words, STEM bachelor's degree holders are susceptible to the negative effects of typical and heavy borrowing, regardless of race and ethnicity. Our results also indicate that, for Latinos, the negative effect of heavy borrowing on graduate school enrollment is larger than the effect of typical borrowing.

We argued that it is important to model the effects of debt in ways that recognize that members of different racial-ethnic groups are stratified in different types of institutions, receive different information about graduate opportunities and financing, and also interpret similar information differently. The use of the relative debt construct partially controlled for these differences by estimating the effects not of the absolute value of debt but of students acting as typical or heavy borrowers across the whole range of institutions that grant bachelor's degrees.

That students who attend different types of institutions are likely to receive different information is controlled for by the comparison of the treatment and control groups constructed with reference to institutional characteristics, i.e., control, type, and selectivity. Our model, however, is unable to account for the variation in the interpersonal experiences that students of different racial-ethnic backgrounds might have while attending the same institutional type. We are also unable to account for differences in minoritized students' perceptions of the returns on investing in graduate education and students' anticipation of discrimination when entering the labor market.

Our findings do not fully support the expectation of variation in the effects of debt on graduate school enrollment by race and ethnicity, as differences in the effect size across racial-ethnic groups were not statistically significant. However, the patterns of our results are consistent with the expectation that racial-ethnic differences in the effects of debt exist. Generally, the estimated "debt penalty" was smallest for White STEM baccalaureate and largest for Latinos with Asians and African Americans falling between these two groups. Despite the lack of statistical significance, these patterns of effects of debt warrant further investigation.

Other researchers (Bedard & Herman, 2008; Kim & Eyermann, 2006; Murphy, 1994; Weiler, 1991) have interpreted a lack of significance in the

effect of debt on graduate enrollment as a sign that debt has become "normalized." However, this argument rests upon the assumption that students with sufficient ability and clear-minded aspirations are capable of accurately forecasting the positive returns on educational investments that borrowing enables. Our findings do not support this interpretation. Differences between our findings and those of previous studies may be attributable in part to changes in the financial aid policy context, the economic climate, and labor market. However, our analysis reveals that, in spite of the emphasis placed on loans in the shared cost model of higher education finance, debt can stifle post-baccalaureate educational opportunity. We conclude that relative to non-borrowers of the same race or ethnicity, debt disadvantages borrowers who may aspire to professional status and leadership in STEM fields.

Our results indicate that heavy borrowing has a large negative effect on graduate school enrollment for Latinos and Whites, but no significant effect for African American and Asian STEM bachelor's degree holders. Several factors, including data limitations, may contribute to the observed variation in the effect of heavy borrowing among STEM bachelor's degree holders.

Our measure of debt originates from a categorical variable of absolute debt, the highest category of which is $35,001 or more. This category limited our ability to distinguish between those students who engaged in the heaviest borrowing, i.e., borrowed several times the mean cumulative debt of graduates from their baccalaureate-granting institutions, from those who borrowed right at the cut point between typical and heavy borrowing, (i.e., 150% of the mean cumulative debt). This lack of precision may have resulted in the unintentional grouping of STEM bachelor's degree holders with distinct borrowing patterns.

If for any reason the distribution of African American and Asian STEM bachelor's degree holders within the heavy borrowing category differed from that of Latinos and Whites, we might expect to see different patterns of the estimated effect sizes. However, the insignificance of heavy borrowing on graduate school enrollment among Asian and African American STEM bachelor's degree holders may in fact, indicate a student's aspirations. Previous research has shown that students in general, and those who plan to pursue STEM in particular, enter college with high graduate degree aspirations (Hurtado, Saenz, Santos, & Cabrera, 2008; Pryor, Hurtado, DeAngelo, Palucki Blake, & Tran, 2010). The insignificant effect of heavy debt among African Americans and Asian could provide evidence that graduate degree aspirations can endure heavy borrowing for students who have concrete career plans and are willing to borrow to the extent necessary to realize those plans.

Alternatively, the insignificant relationship between heavy borrowing and graduate school enrollment may reflect systemic differences in the information available to students regarding graduate school funding. If a large

proportion of heavy borrowers graduate from more selective institutions or attend institutions at which there are graduate programs and a culture of research coupled with undergraduate research opportunities, the insignificant relationship may indicate those institutions' ability to effectively provide information about graduate funding sources and articulate the advantages of investing in graduate education to STEM students.

These interpretations point to areas for further study that may explain the differences between African American and Asian STEM bachelor's degree holders and their Latino and White counterparts.

Directions for Future Research

While the findings of this study characterize the effect of relative debt on graduate and professional school enrollment, this relationship warrants further study. Future explorations of the effects of debt on educational outcomes would benefit from large datasets containing multiple attitudinal, aspirational, and cognitive measures. Including such variables will help to reduce (but not eradicate) uncertainty in the estimated effects of debt that is introduced by selection on unobservables. Larger sample sizes, particularly for minoritized students, will also allow disaggregation of minority sub-groups and reduce the possibility of Type I and Type II error.

Several factors deserve further consideration in future research on patterns of borrowing and the effects of debt. Though our findings identify a negative consequence of student debt, we understand that borrowing may have been a necessary means to attain the STEM baccalaureate.

The need for and utility of borrowing to finance college ought not be understated. Nonetheless, our findings also highlight the need to broaden the field's understanding about which groups of students face greater disadvantages related to debt and the origins of such disadvantages. Do these disparate effects stem from within—and between—institutional differences in the information that STEM majors receive about attending and financing graduate school? These variations in information may mediate students' perceptions of the costs and benefits of obtaining a graduate degree in substantially different ways.

The negative effects of debt also highlight the need to bring a more critical approach to research focusing on student opportunity and success in STEM fields. Much of the previous research on student participation in STEM emphasizes the barriers faced by African American, Latina/o, and Native Americans, while Asian American students are characterized as successful to the point of being overrepresented in STEM fields. Our findings, however, reveal that Asian American STEM bachelor's degree holders experience negative effects of debt that are similar to those of members of

underrepresented minority groups. Though we do find that borrowing is less prevalent among Asians, those who do borrow are harmed by that debt in terms of graduate school enrollment. Despite the overrepresentation of Asian Americans among STEM degree holders, our findings suggest the need for more nuanced studies of the experiences of Asian Americans of different national and ethnic groups in STEM fields.

We find mixed results regarding the effects of heavy borrowing among African American and Asian STEM bachelor's degree holders, complicating our understanding of the negative effects of debt. The absence of a significant relationship between heavy borrowing and graduate school enrollment for these two groups highlights the importance of understanding the interaction of debt at different thresholds. Are these findings indicative of a unique decision-making process regarding investment in graduate education? These heavy borrowers may receive different information about graduate school that reduces the prominence of debt in the decision to attend graduate school.

Future studies should also consider how differences in the patterns of college attendance of racial-ethnic groups, which are shaped by the regional distribution of students and the appeal of particular institutional types (e.g., historically Black colleges and universities), influence the patterns of debt accumulation and the effect of debt on graduate school enrollment. Previous research demonstrates that African Americans at HBCUs have higher educational aspirations (Allen, 1992; Allen, Epps, & Haniff, 1991). HBCUs are also the baccalaureate origin institutions for a disproportionately high number of African American graduate degree holders (NSF, 2009). Do the unique experiences of African Americans at HBCUs mitigate the negative effects of debt among heavy borrowers? Are there certain institutional environments that provide the same benefit to Asian STEM bachelor's degree holders? Further research is needed to understand the roles that geographical location and institutional type play in structuring the patterns of borrowing and the effects of debt on graduate school enrollment.

Conclusion

Much of the literature on educational borrowing frames debt aversion, or the unwillingness to borrow to invest in human capital in spite of likely returns to investment (Eckel, Johnson, Montmarquette, & Rojas, 2007), as a negative characteristic of students that constrains their educational options. Debt aversion among historically disadvantaged students has been attributed to a lack of information about student loans or cultural barriers to accumulating debt. Multiple researchers (Admon, 2006; De La Rosa & Hernandez-Gravelle, 2007; ECMC Group Foundation, 2003; Monaghan, 2001; Cunningham & Santiago, 2008) have pointed out several potential

drawbacks to avoiding debt: being forced to attend lower-cost institutions, working while in school, or even stopping out to save more money to pay for school.

While an unwillingness to borrow to finance college may result in these negative effects, few have explored the possible benefits of not borrowing. The findings of this study suggest that perhaps students hold additional information about the marginal utility of borrowing that is not observable in the data. We propose that some of this additional information is derived from the unique contexts in which historically disadvantaged students make their college-going choices and their accompanying experiences. Despite our inability in this study to identify the particular contexts and mechanisms through which debt negatively affects minoritized groups, the results of this study support the need for further research to understand how loans can best serve the finance goals of equity and efficiency in promoting higher education.

Although we focused specifically on the relationship between indebtedness and decision-making about graduate education among STEM bachelor's degree holders, we are also addressing the larger issue of increasing the educational attainment of and broadening access to STEM fields for minoritized students. In response to the persistent race-based inequities in postsecondary degree attainment and the calls for the diversification of the STEM workforce, numerous studies have been conducted to understand what factors lead to student success for the historically disadvantaged in STEM fields. A large portion of these studies worked to identify student characteristics associated with retention and degree attainment (e.g., Bonous-Hammarth, 2006; Cole & Espinoza, 2008; Grandy, 1998; Hurtado et al., 2006; Seymour & Hewitt, 1997), while others have focused on the characteristics of institutional environments (e.g., Chang, Cerna, Han, & Saenz, 2008) that lead to success for STEM majors from minoritized groups. Indeed, this body of literature has increased our understanding of the type of academic preparation and institutional support that can lead to better outcomes for African Americans, Latinos, and Native American students in the STEM fields.

However, research on minoritized students in STEM ought to also include in-depth examination of the structural barriers imposed by state and federal policy, particularly by financial aid policy. Our study, drawing on the extensive work on the relationship between financial aid and student outcomes, expands the field's understanding of the ways in which debt can represent opportunity and disadvantage for all students, particularly minoritized students in science-related fields.

Graduate and professional education is a critically important component of diversifying the STEM workforce. In order to increase the occupational attainment of minorities and to reduce economic disparities between minoritized groups and Whites, the inequities of participation and postbac-

calaureate attainment in STEM fields need to be redressed. Without larger numbers of minoritized groups earning STEM master's and doctoral degrees, we will continue to see the stark underrepresentation of African Americans, Latinos, Native Americans, and Asian Americans in the ranks of higher education faculty and corporate leaders in science, technology, and engineering fields. We note that a significant proportion of the STEM bachelor's degree holders in our sample attended non-STEM graduate or professional degree programs. Though earning a graduate degree in a non-STEM field may move these individuals out of the STEM workforce, we concede that business and education graduate degrees may ultimately be used for STEM-related purposes. Nonetheless, our results show that undergraduate debt constrains immediate post-baccalaureate investments in graduate study among STEM bachelor's degree holders.

The negative relationship between debt and graduate school enrollment highlights the need to create pathways to graduate and professional education without an overreliance on loans. Our finding that debt deters STEM bachelor's degree holders from investing in graduate education soon after completing the baccalaureate supports the importance of financial aid policy reform, such as the Student Aid and Fiscal Responsibility Act (SAFRA) enacted in March 2010. SAFRA contains several provisions that could mitigate the negative effects of debt. In addition to strengthening Income-Based Repayment (IBR) programs by reducing the debt burden ceiling and increasing means-tested grant aid, the bill provides an infusion of funds to help state and local agencies, in partnership with philanthropic organizations, increase students' financial literacy and debt management skills (U.S. Department of Education, 2011). These resources could also be used to help students develop reasonable expectations about potential earnings and debt burden by academic field, institutional type, and location. The funds can also help institutions better inform underrepresented students in STEM fields about graduate fellowship opportunities and other sources of non-loan support.

Though our findings support the creation of debt-free pathways by showing the greater likelihood of graduate and professional degree enrollment among STEM bachelor's degree holders with no debt, we recognize the fiscal challenge of implementing a "no debt" financial aid reform. However, recent legislation aimed at reducing the prevalence of borrowing, limiting students' debt burdens, and increasing minority-serving institutions' capacity to educate students, particularly those in STEM fields, about debt management are welcome changes. Similar efforts that acknowledge the relationship between degree attainment and postsecondary financial aid will further the development of a larger, more diverse, STEM talent pool.

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