



Money Matters: The Influence of Financial Factors on Graduate Student Persistence

By Terrell L. Strayhorn



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MANUSCRIPT SUBMISSION: Submit manuscripts to Joe Paul Case, Editor, Journal of Student Financial Aid, Office of Financial Aid, P.O. Box 5000, B-5 Converse Hall, Amherst, MA 01002-5000; e-mail jpcase@amherst.edu.

NASFAA MEMBERSHIP: Membership in the National Association of Student Financial Aid Administrators includes receiving the Journal of Student Financial Aid. For further information, please contact NASFAA, 1101 Connecticut Avenue, NW, Suite 1100, Washington, DC 20036-4374; phone (202) 785-0453 ext.1; fax (202) 785-1487; e-mail membership@nasfaa.org.

SUBSCRIPTIONS: \$45.00/year. For information or subscription orders write NASFAA, Journal of Student Financial Aid, 1101 Connecticut Avenue, NW, Suite 1100, Washington, DC 20036-4374 or e-mail membership@nasfaa.org.

CHANGE OF ADDRESS: Notices should be sent to NASFAA, Journal of Student Financial Aid, 1101 Connecticut Avenue, NW, Suite 1100, Washington, DC 20036-4374 or via e-mail membership@nasfaa.org.

REPRINTS: Reprints of articles can be obtained in lots of not less than fifty. Back issues of the Journal may be ordered for \$15.00 from NASFAA, 1101 Connecticut Avenue, NW, Suite 1100, Washington, DC 20036-4374. The Journal is also available on microfilm from University Microfilms International, 300 North Zeeb Road, Ann Arbor, Michigan 48106. The Journal is indexed and abstracted in the ERIC monthly bibliographic journal, Current Index to Journals in Education.

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The Journal is published three times a year by the National Association of Student Financial Aid Administrators, 1101 Connecticut Avenue, NW, Suite 1100, Washington, DC 20036-4374.

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Cover photograph by Nikolay Mamluke.

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Journal of Student Financial Aid

Volume 40, Number 3

2010

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Editor's Column:

On Keeping the Need Principle Principal

Aid administrators are often called on to perform a precarious balancing act between the financial interests of their students and their institutions. They feel pressures from enrollment managers, budget officers, and students and their families. There are imperatives in enrollment management: recruiting enough students to fill the classrooms and dormitories and produce needed revenue; matriculating a quality class that helps meet objectives for racial, ethnic, and socioeconomic diversity; and fulfilling the institution's academic, athletics, talent, and leadership aspirations. Meanwhile aid administrators are expected to stay within aid budget limits, perhaps working with strictures on staffing and operating budgets, and coping with new federal regulations that deal with anything from textbook prices to fire safety. And the current national economic situation adds perplexities in dealing with students and their families, especially those experiencing new financial straits, while in many cases awarding limited institutional dollars and reduced state appropriations for student aid and public institutions' operating budgets.

As one aid administrator once put it, "All financial aid is need-based – it's a question of whether you're meeting the students' needs or the institution's needs." Trying to find the right balance between competing needs is basic to the aid administrator's job. Ultimately, the question may boil down to how the aid administrator achieves a fair distribution of aid resources and simultaneously tends to the institution's budgetary restraints and enrollment desires.

Access has become the mantra of postsecondary education in the decades since the Higher Education Act became law in 1965. Marshalling federal, state, institutional, and private resources to help students enter college and persist is fundamental to our enterprise and essential to our national wellbeing in personal, societal, and economic terms. As important as institutional objectives may be, the aid professional is called on to focus on the student and to keep the need principle principal.

The principles of need analysis are rooted in the philosophical concepts of fairness and distributive justice. These form the theoretical basis of need analysis and its role in helping our society toward equal educational opportunity.

Because justice or fairness is a relative term, it is necessary to define it a particular context. There are several ways of doing so.

Egalitarianism is fundamental to our understanding of fairness; each person has an equal vote, equal pay for equal work, or equal size pieces of the pie. But an egalitarian approach to distributing financial aid leaves some with more than enough and others with too little.

A meritocratic approach to distribution is attractive, in that it recognizes achievement of some kind, though in other situations it may be seen as

preserving privilege and class. It provides opportunity for the select few, but falls short of effectively ministering to the needs of the many.

Utilitarian advocates advance the idea of distributing a good with an eye to the usefulness of the end result. For example, it may be utile to an institution to increase the number of scholarly students, to the end of enhancing the school's reputation. This is seen as benefiting the faculty, current students, and alumni. Federal aid programs, including the GI Bill, National Defense Education Act, and current SMART Grant program, have had similar utilitarian purposes, aimed, for example, at easing the return of veterans to the workforce or recruiting educators in sciences and foreign languages. Although distribution based on utilitarianism can be beneficial to many, the receipt of help among students may be somewhat scattershot.

The notion of distributing financial aid on the basis of financial need arose in the early 1950's. Interestingly, it had a utilitarian benefit for institutions, in that awarding need-based aid maximized use of the schools' resources while achieving broader, egalitarian societal goals. John Rawls, the late Harvard philosopher, promoted the idea of "justice as fairness" in his book *A Theory of Justice*, first published in 1971. Rawls contended that a just system for distributing a good is one that is most beneficial to the least-advantaged members of society, and that the rules for distribution should be devised by free persons who are unaware of their place in society.

Our need analysis schemas – Congressional misadventures notwithstanding – attempt to achieve a fairness of distribution. Families are taken in their current setting. Their income, expenses, assets, and debts are weighed along with necessary basic support of their families, whatever the size. The resulting calculated contribution is shared among the children enrolled in college. One can certainly dispute the allowance levels and assessment rates, which are all matters of judgment. This issue of the *Journal of Student Financial Aid* provides three perspectives on tuition discounting, need, and awarding student aid. But the basic structure of need analysis remains an attempt to achieve distributive justice.

In *The Nicomachean Ethics*, Aristotle described the virtues of the "liberal man" – one who chooses how best to distribute goods in a fair way, while being neither miserly nor profligate. He wrote,

... [I]t is no easy task to be good. ... For in everything it is no easy task to find the middle.... [A]nyone can ... give or spend money; but to do this to the right person, to the right extent, at the right time, with the right motive, and in the right way, that is not for everyone, nor is it easy; wherefore goodness is both rare and laudable and noble. (II, 9, David Ross, tr.)

Aid administrators are called upon to find that "middle" and keep the need principle principal.

Joe Paul Case
Editor

Money Matters: The Influence of Financial Factors on Graduate Student Persistence

By Terrell L. Strayhorn

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National statistics indicate that approximately 50 percent of all graduate students fail to complete their degree; thus, understanding the factors that influence their persistence is an important research objective. Using data from a nationally representative sample of bachelor's degree recipients, the study aimed to answer three questions: What proportion of 1992-1993 bachelor's degree recipients enrolled in graduate school by 2003? Of those, what proportion persisted in graduate school? Controlling for background and academic differences, what effect do financial factors have on persistence in graduate school? Descriptive and hierarchical binomial logistic regression results suggest that 36 percent of bachelor's degree recipients has enrolled in a graduate program by 2003; 74 percent of initial enrollees has persisted by 2003, and financial factors (e.g., total loan, tuition reduction, deferment status) were related to persistence. Implications for future policy, practice, and research are highlighted.

Research in higher education largely focuses on undergraduate education and, in contrast, has devoted comparatively little attention to post-baccalaureate (post-BA) or graduate education (Burgess, 1997). In fact, as Burton Clark (1993) commented:

The first degree level has historical primacy, predominates numerically and possesses a deep hold on traditional thought and practice. It comes first in budget determination, public attention and the concerns of governments. Graduate or advanced education is then prone to develop at the margin as an add-on of a few more years of unstructured work for a few students. (p. 356)

Perhaps related to the inattention to graduate education in the research literature, national statistics consistently indicate that approximately 50% of all graduate students fail to complete their degree (Berelson, 1960; Bowen & Rudenstein, 1992; Lovitts, 1996), whereas only 30-50% of undergraduates leave their institution before earning their bachelor's (BA) degree. Graduate attrition rates can be higher among women and historically underrepresented minority groups (Lovitts, 2001).

Despite these alarming "drop out" rates, relatively few studies have been conducted to examine the factors that influence persistence in graduate school. Instead the literature focuses almost exclusively on undergraduate students' persistence at 2- and 4-year institutions (McGrath & Braunstein, 1997; Perna, 1998; Tinto, 1993; Williamson & Creamer, 1988). Such information has limited applicability to post-BA contexts (Baird, 1993b). We know from prior research that significant differences exist between undergraduate and graduate education. For instance, the costs associated with attending graduate school tend to be significantly higher than the average cost of tuition for undergraduate study (Choy & Li, 2006). Federal student aid formulas generally assume that undergraduates are financially dependent on parents or guardians until the age of 24 years; graduate students are usually considered independent

regardless of age. And while this may make graduate students eligible for more financial aid than undergraduates, there are no major federal grant programs for graduate students, which limits the type of aid awarded; various studies have found that the *type* of aid—not the amount—is most strongly related to graduate attrition (Lovitts, 2001). Additionally, there are significant differences in the undergraduate “general education” curriculum and the highly specialized, technical focus of graduate education (Golde & Walker, 2006). Therefore, it is reasonable to suspect that there may be differences in the factors that influence or inhibit student persistence in graduate school. Specifically, financial aid and related variables may be more or less influential on graduate student persistence and it is out of this context that the need for the present study grew.

The purpose of this study was to examine the influence of financial aid and other related variables on graduate student persistence. Using data from the National Center for Education Statistics’ *Baccalaureate and Beyond Longitudinal Study* (B&B:1993/2003) database, the following research questions were explored:

- (a) What proportion of 1992-1993 bachelor’s degree recipients enrolled in graduate school by 2003?
- (b) Of those, what proportion persisted in graduate school?
- (c) Controlling for background and academic differences, what effect do financial factors have on persistence in graduate school?

This study is intended to add to our knowledge about student persistence in general and the body of knowledge relative to graduate student persistence, in particular. Indeed, graduate student persistence is an area of critical need according to the Council of Graduate Schools and several leading scholars on post-BA education (Baird, 1993a; DePauw, 2004; Nyquist & Woodford, 2000). As Baird (1993b) noted:

Whether measured in budget, increases in enrollment, or attention from administrators, graduate education is assuming a large role at most institutions...[it is] the most expensive area of higher education...[and] the training ground for some of the most valued graduates of our universities... Thus, for reasons of both cost and social importance, the progress of students in graduate education becomes a critical matter. (p.1)

Brief Literature Review

The literature on graduate education and graduate students can be organized into three categories: theoretical essays on the nature and quality of graduate education in the United States; research studies on graduate student experiences in graduate school; and a handful of empirical studies that estimate the influence of variables related to graduate student retention. Most scholarship on graduate education is of the first-order—that is, essays about the process of post-baccalaureate education (Borkowski, 2006; Golde & Walker, 2006; Kohl & LaPidus, 2000; LaPidus, 2000). The weight of evidence suggests that “graduate education is a major part of American higher education...” (Baird, 1993b, p. 3).

A second set of studies focus on graduate students’ experiences while enrolled in graduate school such as their involvement (Gardner & Barnes, 2007), research collaborations (Saddler, 2008), and degree progress (Abedi &

Benkin, 1987; Girves & Wemmerus, 1988). For example, Girves and Wemmerus analyzed data from 324 masters and 158 doctoral students to determine the most significant influences on graduate degree progress, which was operationalized as time-to-degree (in years). They found differences by degree level and enrollment status; involvement in the academic department through a teaching- or research assistantship was important to timely degree progress.

Representing a related but smaller line of inquiry, several studies focus on determinants of graduate student attrition or, conversely, persistence to degree attainment (Andrieu, 1991; Asker, 2001; Langlois, 1972; Luan & Fenske, 1996; Lyn, 1998; Strayhorn, 2009). Langlois surveyed 10,000 students who dropped out of graduate school at the University of California at Berkeley and found that financial factors were the most frequently cited reason for not completing the degree. And in one of the first national studies on graduate student persistence, Andrieu analyzed *National Postsecondary Student Aid Study* (NPSAS) data to study within-year persistence of graduate students. She found that financial factors, along with background and program-related variables, influenced persistence within-year.

While useful, the existing literature is limited in a number of ways. Most research on graduate student persistence is based on single-institution or relatively small cohort-based samples (e.g., Vaquera, 2007-2008) rather than nationally representative samples. Second, some previous researchers combined masters, doctoral, and first-professional students (e.g., Luan & Fenske, 1996) while others combine or aggregate all graduate programs and majors (Asker, 2001). Clearly, not all graduate degree programs or degrees are the same as they attract different types of students and may be governed by different norms or paths for socialization to the profession (LaPibus, 2000). Thus, studies are needed that account for such nuances. This is the gap addressed by the present study.

Method

The purpose of this study, which is part of a larger research program on graduate education, was to examine the influence of financial variables on graduate student persistence using a nationally representative sample of students. Using a conceptual frame consisting of background, academic, and financial variables proposed elsewhere (Strayhorn, 2005), this research was designed to assess the relationship between financial factors and student persistence in graduate school, controlling for an array of confounding influences. This section describes the methodology used to achieve these purposes. It begins by providing an overview of the database, including the study's sample, main variables, and the analytical techniques employed.

Data Source

Data were drawn from the National Center for Education Statistics' *Baccalaureate & Beyond Longitudinal Study* (B&B:1993/2003). The B&B:1993/2003 longitudinal study follows baccalaureate degree completers over time to provide information on work experiences after college and on progress and persistence at the graduate level. In fact, using the 1993 *National Postsecondary Student Aid Study* (NPSAS:93) as the base year, the B&B:93/03 longitudinal study follows baccalaureate degree completers nine to ten years beyond their undergraduate graduation. This is particularly useful given the fact that graduate programs vary in length and time-to-degree (Baird, 1993b).

The third-year follow-up survey provides a unique opportunity to gather information concerning delayed entry into graduate education, graduate school aspirations, progress and persistence to degree, and the interaction between work and education beyond obtaining a bachelor's degree. These data were deemed appropriate for this investigation by the National Center for Education Statistics (P. Knepper, personal communication, July 1, 2006) and, thus, a restricted database was licensed to the principal investigator for a period of five years. All analyses were based on the restricted-use data.

Sample

The analytic sample was drawn from the total pool of respondents to the B&B:1993/2003 survey. Of all 1992=93 bachelor's degree recipients (see Table 1), 52% reported "no additional degree program" by 2003 while 31% had enrolled in a masters degree program and 5% had enrolled in a doctoral degree program. Additionally, 5% of BA recipients had enrolled in a first professional degree program. However, given differences found between masters, doctoral, and first-professional students—one of which is related to the cost of education and amount/type of aid awarded generally—this analysis only includes those individuals who enrolled in either a masters or doctoral degree program. Excluding first-professional students from subsequent analyses also makes sense because it costs much more to train first-professional students (e.g., doctors and lawyers) than traditional graduate students; and, conversely, it usually takes longer to educate a doctoral student than a first-professionals student (LaPidus, 2000). Academic qualifications for first-professional students can also be markedly different from other graduate student groups (e.g., MCAT vs. GRE).

Thus, the analytic sample consisted of graduate students (persons pursuing masters and doctoral degrees; excluding first-professional students, including MBA students) who responded to the B&B:93/03 third-year follow-up study. The weighted sample size was approximately 1.2 million participants. Of these, the majority (55%) were women and those seeking masters degrees (86%). Eighty-three percent described themselves as Caucasian/White, 6 percent as African American/Black, 5 percent as Hispanic, 5 percent as Asian/Pacific Islander, and 1 percent as American Indian/Alaska Native. Table 2 presents additional information about the analytic sample.

Table 1: Percent Distribution of 1992-93 Bachelor's Degree Recipients' Graduate and Non-graduate Enrollment, by Selected Student Characteristics, 2003

Variables	No Addtl. Degree Program	Non-Graduate Degree or Certificate	Masters Degree	Doctoral Degree	First Professional Degree
Total	52.1	7.2	31.2	4.5	5.0
<i>Gender</i>					
Male	54.4	6.3	27.4	5.7	6.2
Female	50.2	7.9	34.4	3.5	4.0
<i>Race</i>					
White	53.0	7.0	31.1	4.4	4.5
Black	46.4	7.5	35.7	5.4	5.1
Hispanic	48.6	7.9	33.0	5.9	4.6
Asian/Pacific Islander	50.0	7.5	25.7	3.4	13.4
American Indian/ Alaska Native	49.7	20.4	23.3	3.8	2.8
<i>Parent's highest education</i>					
HS or less	58.5	6.6	29.4	2.5	3.1
Some post-secondary education	52.9	7.3	32.3	3.3	4.3
Bachelor's	52.4	7.4	29.7	5.3	5.2
Advanced degree	43.4	7.4	34.5	7.3	7.5
<i>Age at receipt of bachelor's t</i>					
24 or younger	49.8	6.7	31.6	5.6	6.2
25-29	62.2	8.4	25.6	2.0	1.8
30 or older	55.5	7.8	33.0	1.8	1.9
<i>Amount borrowed (undergraduate)</i>					
None	52.9	6.6	30.3	4.8	5.4
Less than \$5,000	52.5	8.1	31.6	4.1	3.7
\$5,000-9,999	51.0	7.0	34.0	3.8	4.2
\$10,000-14,999	51.0	9.3	30.0	4.8	4.8
\$15,000 or more	51.9	6.2	32.1	4.6	5.3

Table 2: Description of Those Enrolling in Graduate School, B&B:93/03

Characteristic	Percent
<i>Graduate Program</i>	
Masters	86
Doctoral	14
<i>Gender</i>	
Male	45
Female	55
<i>Race/Ethnicity</i>	
White	83
Black	6
Hispanic	5
Asian/Pacific Islander	5
American Indian/Alaskan Native	1
Other	low n
<i>Undergraduate Grade Point Average</i>	
2.9 or less	33
3.0 to 3.3	30
3.4 to 3.6	21
3.7 to 4.0	16
<i>Marital Status</i>	
Married	67
Single, never married	21
Cohabiting/living with partner	5
Separated	1
Divorced	6
Widowed	low n
<i>Parental highest education</i>	
High school or less	30
Some college	18
Bachelor's degree	23
Advanced degree	25
<i>Age at receipt of bachelor's degree</i>	
24 or younger	72
25-29 years	12
30 or older	16
<i>Amount borrowed (undergraduate)</i>	
Did not borrow	48
Less than \$5,000	15
\$5,000 to \$9,999	13
\$10,000 to \$14,999	10
\$15,000 or more	12

Variables

The dependent variable reflects respondent's persistence status in graduate school by 2003. The variable was constructed using responses to several items from the longitudinal database. First, the researcher restricted the B&B:1993/2003 sample to only respondents who reported being enrolled in a masters or doctoral degree program after receiving their bachelor's degree. Then, of those, all who had earned their graduate degree by 2003 or remained enrolled in their graduate degree program were considered "persisters." All those who had enrolled in graduate school since receiving their BA degree but did not remain enrolled by 2003 were coded "non-persisters." Thus, the dependent variable was coded dichotomously ranging from 0 ("non-persisters") to 1 ("persisters").

Three sets of independent variables were included in this analysis in consonance with the conceptual model. For instance, several background and demographic variables were included such as age, race, gender, parent's level of education, students' educational expectations (Carter, 2001), and expected family contribution (EFC) which served as a proxy for the student's financial situation. It is important to note that the EFC of independent students does not include parental information; rather it consists primarily of the contribution expected from the students themselves. Thus, the measure is useful for modeling students' financial circumstances, which has been done in prior research (Choy & Bobbitt, 2000), and their ability to pay for graduate school. Parent's level of education was measured using 4 levels ranging from 0 ("high school or less") to 3 ("advanced degree").

Academic factors included undergraduate grade point average (GPA), performance on the Scholastic Aptitude Test (SAT) (or ACT equivalent), and total score on the Graduate Record Exam (GRE). SAT/ACT scores were measured in quartiles ranging from 0 ("did not take SAT/ACT") to 4 ("highest quartile"). Similarly, GRE scores were measured in quartiles ranging from 1 ("Top 25% on all 3 exams") to 4 ("middle 50% on all 3"); a fifth category ("did not take GRE/other") was used to omit those who did not take a particular test from the statistical analyses. Prior research has shown that the academic department or field of study is critically important when studying graduate student outcomes (Bowen & Rudenstein, 1992; Nerad & Miller, 1996); therefore, the study included a single item measuring whether respondents were enrolled in science, technology, engineering, or math-related (STEM) graduate fields of study (0 = no; 1 = yes). STEM was defined in accordance with guidelines provided by the National Science Foundation, which includes all related fields (e.g., physical sciences, biological sciences, engineering, math, computer science) but excludes health, medicine, and social sciences.

Finally, several financial variables were included in the estimated statistical model. Variables included total aid borrowed for graduate school, total aid borrowed for undergraduate, and total educational *loans* borrowed (including both undergraduate and graduate degrees); response options were coded from 0 ("none") to 4 ("40,000 or more"). While the latter is related to the first two items, tests indicate that collinearity was not a problem for this investigation. Analyses were run with and without the total loans measure to see if its inclusion altered statistical results; similar results were found in both cases. Two items measured the *type* of aid received for graduate school. One item asked respondents, *did you receive loans to pay for graduate school?* Responses were coded dichotomously: 0 ("no, did not receive") to 1 ("received").

Four items measured respondent's educational debt situation based on information that student loan debt has nearly doubled in recent years (Kim & Eyerhmann, 2006). One item determined the amount of undergraduate educational debt owed (by 2003); responses were coded from 0 (none) to 4 (\$12,600 or more). A separate item measured the amount of total education debt, including undergraduate and graduate loans, with the highest category (4) indicating "\$40,000 or more" in total educational debt. Two dichotomous variables measured whether respondents had ever deferred or defaulted on their educational loans.

Finally, given the various types of financial support available to graduate students, the study included three dichotomous variables indicating whether respondents received a research assistantship, teaching assistantship, or tuition reduction for graduate study. The appendix presents the model's specification and coding scheme.

Data Analysis

Data analysis proceeded in three stages. First, data were prepared for analysis using data reduction techniques, data cleaning strategies (Meyers, Gamst, & Guarino, 2006), and recoding of the original variables. Next, a combination of frequencies and descriptive statistics were calculated using the weighted B&B:1993/2003 sample to answer the first two research questions.

Third, in response to the third research question, advanced regression procedures and specialized data analysis software (*AM* beta version 0.06.03; American Institutes of Research, 2002) for complex sample designs were used to estimate the relationship between financial variables and the criterion. Given the nature of the dependent variable and the study's goal of controlling for differences in background and academic characteristics, the study employed hierarchical binomial logistic regression procedures to analyze data instead of ordinary least squares (OLS) regression which assumes equality of variance in the dependent variable (Keith, 2006). Hierarchical regression analysis is "a method of regression analysis in which independent variables are entered into the regression equation in a sequence specified by the research in advance. The hierarchy (order of the variables) is determined by the researcher's theoretical understanding of the relationships among the variables" (Vogt, 1999, p. 129). This design allowed assessment of the "net effect" of financial variables on graduate student persistence. And, using logistic regression is a widely accepted method for examining binary outcomes (Aldrich & Nelson, 1984; Kerlinger & Pedhazur, 1973). In fact, logistic regression is deemed "the more popular method [for analyzing binary outcomes] at the current time" (Keith, 2006, p. 206).

To evaluate the overall strength of statistical relationships, the author calculated and interpreted several statistics — including calculated predicted probabilities, predicted odds, and adjusted odds ratios (Keith, 2006; Pampel, 2000) where necessary. Probabilities relate to the probability of persisting in graduate school relative to the independent variable(s), controlling for all others. Predicted odds, on the other hand, measure the odds of persisting in graduate school relative to the influence of an independent variable, controlling for all others. Odds ratios are "a ratio of the odds for each group" (Meyers, Gamst, & Guarino, 2006, p. 230); that is, they represent the effect of a unit change in the independent variable on the odds of being retained relative to dropping out. These statistics were derived using the following formulas:

$$\text{Predicted probabilities} = p' = \frac{1}{1 + e^{-(B_0 + B_1X_1 + \dots + B_iX_i)}}$$

$$\text{Predicted odds} = \text{odds}' = (\text{constant Exp}(\beta)) (\text{Exp}(\beta)IV)^{IV(\text{value})}$$

$$P_i / P_j = e^{B_{i0} + B_{i1}X_1 + \dots + B_{ip}X_p} = e^{B_{i0}} e^{B_{i1}X_1} \dots e^{B_{ip}X_p} \quad \text{or}$$

$$\text{odds ratio} = \frac{\text{odds}'_1}{\text{odds}'_2}$$

Finally, the author interpreted several tests to assess the validity of the model including the likelihood ratio test, omnibus test of model coefficients, and several modified R^2 values (referred to a pseudo- R^2) which measure the overall strength of association between independent and dependent variables (Pampel, 2000).

Due to the complex sampling technique employed in the B&B:1993/2003, appropriate sampling weights must be applied to the data before analysis. The B&B:1993/2003 panel weight was appropriate for approximating the population of 1992-1993 bachelor's degree recipients in the longitudinal study. To minimize the influence of large sample sizes on standard errors while also correcting for oversampling of some groups (e.g., those in teaching fields), each case was weighted by the B&B panel weight divided by the average weight of the sample (Thomas & Heck, 2001) using the following equation:

$$\text{Relative weight} = w_i / \bar{w}$$

$$\text{where } w_i = \text{original panel weight and } \bar{w} = \sum w_i / n.$$

Limitations

Before presenting the results of the present study, several limitations should be discussed. First, some variables in this study are limited by the magnitude of missing data. Variables with the largest share of missing data were those pertaining to financial matters such as loan debt, though no variables were missing from more than 10% of cases. In some cases, listwise deletion would reduce the analytic sample significantly and possibly result in a non-representative sample. Thus, to avoid the substantial reduction in sample size, the author took several steps to address missing cases. In some instances, mean scores were imputed for missing values on continuous independent variables. This procedure may result in an underestimation of standard errors by 10-20% and increase the chances of making a type-1 error (Thomas & Heck, 2001), so a more rigorous threshold of statistical significance was adopted when interpreting test results.

When data were missing on non-continuous (e.g., scale, etc.) variables, the study used trend equations to impute values for missing cases (except in cases where missing values were no more than 1% of cases). Trend equations predict missing values using information provided on valid cases in the sample. And, consistent with advice from others (Galloway, 2004), missing cases for the dependent variable were excluded from the analysis.

Perhaps another limitation relates to secondary data analysis. Despite widespread use in education, secondary data analysts are limited by the factors that can be defined, operationalized, and measured in a single study. That is, this study was limited to only those factors that can be measured, at least in part, by the *Baccalaureate & Beyond Longitudinal Study* (B&B). It is possible that the B&B did not measure all of the variables needed to explain the variance in graduate student persistence. Similarly, items from the B&B may be marginally related with the

constructs (e.g., prior achievement, graduate experiences, financial factors) that they purport to measure (Pascarella & Terenzini, 2005). To the extent that this is true, the study's findings may be limited.

While important, these limitations do not diminish the study's potential to contribute to understanding of the role that financial factors play in predicting graduate student persistence. The next section presents the results of this study followed by a discussion of their relevance to previous research.

Results

Descriptive statistics reveal that, by 2003, a majority (52%) of 1992-1993 bachelor's degree recipients had never enrolled in graduate school. That is, only 36 percent of BA degree recipients had enrolled in a masters or doctoral program by 2003.

The second research question focused on the proportion of 1992-1993 graduates who persisted in graduate school by 2003. Results indicate that approximately 74 percent of all those who enrolled in graduate school had persisted. Approximately 20 percent of BA recipients earned a masters degree, 2 percent earned a doctoral degree, and the balance remained enrolled in graduate school by 2003. On the other hand, 26 percent of all individuals who had enrolled in graduate school by 2003 left without earning a graduate degree (i.e., non-persisters).

In response to the third research question, hierarchical binomial logistic regression results were significant. The final model (including all control variables and predictors) is considered a "well-fitting" model based on several model fit indices including the change in scaled deviance ($\Delta - 2 \log$ likelihood = 251.74); the model's chi-square results ($X^2(430) = 251.73, p < 0.01$); and the Hosmer-Lemeshow test results ($X^2(8) = 14.85, n.s.$). Additionally, Cox & Snell pseudo- R^2 was 0.08, Nagelkerke pseudo- R^2 was 0.12, and McFadden pseudo- R^2 (Cabrera, 1994) was 0.13 in the last and final model, indicating that a significant portion of the variance or change in probability of graduate student persistence is accounted for by the factors in the statistical model. Approximately 75 percent of all cases could be correctly classified using the final regression model that included financial variables along with the statistical controls. Taken together, these indices indicate an acceptable match between predicted and observed probabilities.

Several independent variables emerged as significant predictors of graduate student persistence, in the last and final model (at the $p < 0.01$ level): race, estimated family contribution, undergraduate GPA, receipt of graduate loan(s), total education loan, graduate loan amount, deferment status, research assistantship, and tuition reduction. A number of important relationships will be explicated further in the discussion section below. Table 3 presents the results of all three regression models.

Table 3: Logistic Regression Results

Factor	Model 1 (β)	Model 2 (β)	Model 3 (β)
Parent's education			
High school or less	-0.179	-0.149	-0.206
Some postsecondary education	-0.013	0.030	0.022
Bachelor's	-0.016	-0.003	-0.105
Advanced degree (reference)	—	—	—
Age at receipt of bachelor's degree			
Below 24 years	0.116	0.153	-0.158
25-29 years	-0.222	-0.176	-0.346*
30 and above (reference)	—	—	—
Gender			
Female	—	—	0.136
Male (reference)	—	—	—
Race/Ethnicity			
American Indian/Alaska Native	0.681	0.681	0.899
Asian	-0.158	-0.171	-0.092
Black	0.423	0.526	0.482*
Hispanic	0.063	0.109	0.185
White (reference)	—	—	—
EFC			
No support	-0.776	-0.759	-1.151*
Less than \$2,999	-0.570	-0.541	-0.652**
\$3000-5,999	-0.049	-0.011	-0.018
\$6,000-8,999	-0.413	-0.406	-0.320
\$9,000 or more (reference)	—	—	—
Undergraduate GPA			
2.49 and below	—	-0.420	-0.634**
2.5 to 2.99	—	-0.168	-0.153
3.0 to 3.49	—	-0.085	-0.119
3.5 and above (reference)	—	—	—
SAT/ACT Scores			
Did not take SAT/ACT	—	-0.145	-0.029
Lowest quartile	—	-0.337	-0.139
Second quartile	—	-0.164	0.083
Third quartile	—	-0.172	-0.013
Highest quartile (reference)	—	—	—
Major			
STEM	—	-0.372**	-0.286**
Non-STEM (reference)	—	—	—

Table 3: Logistic Regression Results (continued)

Factor	Model 1 (B)	Model 2 (B)	Model 3 (B)
Graduate loan			
None	—	—	1.505*
Less than \$9,999	—	—	1.060
\$10,000-24,999	—	—	1.577**
\$25,000 to 39,999	—	—	1.204*
\$40,000 or more (reference)	—	—	—
Total educational loan (Undergraduate/Graduate)			
None	—	—	-2.175**
Less than \$9,999	—	—	-2.073**
\$10,000-24,999	—	—	-1.532*
\$25,000 to 39,999	—	—	-1.566**
\$40,000 or more (reference)	—	—	—
Graduate Loan			
Yes	—	—	0.504**
No (reference)	—	—	—
Tuition Reduction			
Reduction	—	—	0.451*
No reduction (reference)	—	—	—
Research Assistantship			
Yes	—	—	0.665**
No (reference)	—	—	—
Teaching Assistantship			
Yes	—	—	0.337
No (reference)	—	—	—
Default			
Yes	—	—	-0.532
No (reference)	—	—	—
Defer			
Yes	—	—	0.456*
No (reference)	—	—	—
Undergraduate debt owed			
None	—	—	0.875
Less than \$9,999	—	—	0.629
\$10,000-24,999	—	—	0.754
\$25,000 to 39,999	—	—	-0.022
\$40,000 or more (reference)	—	—	—

* $p < 0.05$. ** $p < 0.01$.

Finally, the author conducted follow-up tests to check for multicollinearity. Multicollinearity exists when two or more independent variables are highly correlated or when “one independent variable is a near linear combination of other independent variables” (Keith, 2006, p. 199). This makes it difficult if not impossible to determine direct effects on the outcome variable. Results suggest that collinearity is not a problem for this investigation as all statistics approach “1,” indicating near complete independence (Cohen, Cohen, West, & Aiken, 2003).

Discussion

The purpose of this study was to examine the influence of financial aid and other related variables on graduate student persistence. Using data from the National Center for Education Statistics' *Baccalaureate and Beyond Longitudinal Study* (B&B:1993/2003) database, three research questions were explored using descriptive and multivariate statistical techniques. Findings suggest a number of important conclusions that have implications for future policy, practice, and research in the area of student financial aid.

First, several background characteristics were related to the probability of persisting in graduate school. Race/ethnicity was significantly associated with persistence in graduate school, controlling for all other differences. African Americans were significantly more likely than their non-Black peers to persist in graduate school, holding all other variables constant. Specifically, Black students were 1.36 times more likely than Hispanics and 1.62 times more likely than Whites to persist according to this analysis. In addition, parent's level of education was expected to have a significant influence on graduate student persistence. Surprisingly, results were not consistent with the expected relationship, although the positive direction of this association was supported. That is, while the odds of persisting in graduate school were lower for students whose parents had no more than a high school education compared to their counterparts whose parents had more education, this relationship failed to meet the threshold for statistical significance. Finally, age was significantly associated with the graduate student persistence indicating that, consistent with prior research (Vaquera, 2007-2008), older students were more likely to persist than their younger counterparts.

Another important finding of this study was that expected family contribution (EFC) was found to be significantly related to persistence. Those with a zero EFC represent the smallest proportion of persisters. That is, having a zero EFC decreased one's probability of persisting in graduate school by 16 percentage points. Students whose expected family contribution was \$10K or more (i.e., students from higher income families) were 3.20 more likely to persist than those with EFC equal to zero.

Only two academic variables were found to have a statistically significant relationship with persistence in graduate school: undergraduate grade point average (GPA) and graduate major. Predicted probabilities reveal that the lowest achievers in college (i.e., undergraduate GPA = less than 2.5) and those who major in STEM in graduate school represent the smallest proportion of persisters. Those with an undergraduate GPA's above 3.5 are nearly two times more likely to persist in graduate school than their lowest performing peers. And, STEM majors are 0.75 times less likely than non-STEM majors to persist in graduate school.

The central purpose of this study was to measure the influence of financial variables on graduate student persistence. Results suggest that borrowing a loan for graduate study exerted a significant and positive effect on the probability of persisting; those who borrowed were 1.66 times more likely to persist than those who did not borrow graduate loans. Since most students are eligible for loans, the difference may be that those who are willing or able to borrow are more likely to persist than those who are less willing or able due to extenuating circumstances such as poor credit history, defaulted educational loans, or worries about repayment (Long & Riley, 2008).

Related, graduate loan *amounts* were significantly related to the probability of persisting. Results suggest that the highest proportion of persisters was found among those who borrowed less than \$25K. And, in fact, those who borrowed less were nearly five times more likely to persist than those who borrowed over \$40,000. So while borrowing a loan for graduate school was associated with persistence, there is clear evidence of a sort of “tipping point” to the amount borrowed beyond which one is less likely to persist in graduate study.

In light of findings that undergraduate debt has nearly doubled in recent years (Kim & Eyermaun, 2006), total educational debt was included in this analysis. Results were mixed with respect to undergraduate loans and total educational debt. Consistent with previous research (Choy & Li, 2006; Heller, 2001; Millett, 2003), this study found that undergraduate borrowing has little to no influence on graduate student outcomes such as persistence. However, total educational debt (including undergraduate and graduate loans) was significantly and positively related to persistence. This finding should be interpreted with a degree of caution as “borrowers” who remain enrolled in graduate school for a longer period of time or those who earn a graduate degree are more likely to accumulate larger loan debt than those who leave before earning their degree. This finding may indicate an intuitive relationship between “duration of enrollment” and “amount borrowed” much more than a true “advantage” that borrowing confers on graduate students.

Deferring repayment of one’s educational loans increased the probability of persisting in graduate school. Deferrers are 1.6 times more likely to persist than those who do not defer. Defaulting on one’s loans, however, was inversely related to persistence although this estimate only approached statistical significance ($p = 0.052$). Interpretation of the regression coefficient suggests that those who do not default on their loans are 1.72 times more likely than defaulters to persist in graduate school. And since students do not default on their loans while attending school, this finding likely relates to those who defaulted on educational loans prior to enrolling in graduate school. Defaulting on one’s loans may put students under pressure to leave graduate school, start work, and begin (or resume) paying off loans. An alternative explanation exists as well. It may be that defaulting on undergraduate loans prior to entering graduate school makes it difficult for students to receive the financial support necessary for staying in graduate school. Without such support, students drop out before completing their degree (Sanford & Adelson, 1962; Tinto, 1993).

Two other forms of aid were related to graduate student persistence. Having a research assistantship (RA) and a tuition reduction were significant predictors of retention. Graduate students with RAs are nearly 2 times more likely to persist than those who do not have an RA, consistent with previous findings (Lovitts, 2001). This difference may be attributed to RAs’ socialization and meaningful engagement with faculty and staff members. Students with a

tuition reduction are 1.6 times more likely to persist than those who do not receive such aid. Interestingly, having a teaching assistantship (TA) was not related to persistence. Prior research suggests that TAs may deter a student from pursuing a profession (Austin, 2002; Meyers & Prieto, 2000) or entail heavy teaching loads and teaching-related activities, which in turn, may either extend one's time-to-degree or compromise one's academic success resulting in attrition. Indeed, additional research is warranted especially in fields where TAs are widely used such as humanities, social sciences, and business.

That approximately 40 percent of those who enrolled in graduate school after completing their BA degree had dropped out of school by 2003 is a cause for alarm. Generally speaking, these results support startling graduate student retention rates found in other studies (Berelson, 1960; Bowen & Rudenstein, 1992). Still, consistent results are no consolation for the enormous loss of talent associated with such high attrition rates—what Lovitts (2001) calls the “invisible problem” (p. 2). Referring to this phenomenon, Knox (1970) noted the enormous “loss of time, effort, and resources to students and faculty when students leave graduate school.” The results of the present study are cause for action to identify and develop new ways of ensuring the success of graduate students.

Implications

This study may be significant for several campus constituencies. One group that might benefit particularly from the results of this study includes financial aid administrators. Findings provide financial aid administrators with data about the importance of various types of aid to graduate student persistence. Financial aid professionals should consider these findings when planning aid packages that meet the “unmet” needs of graduate students. For instance, packages that include a combination of scholarships, research assistantships rather than a teaching assistantships, tuition reductions through fee waivers, and a modest loan may provide optimal levels of financial support without placing graduate students at risk of leaving before earning their degree. Moreover, financial aid administrators might use the results of this study to determine which source(s) of aid are most likely to help a student persist in graduate school on their campus.

These findings may also be helpful to graduate deans and coordinators of graduate degree programs. This study provides information about the influence of various types of financial aid on graduate student success. Coordinators and deans might consider these results when creating new programs that offer financial assistance to students. For instance, based on these findings, research assistantships should be offered where possible and use of loans to graduate students should be limited. One way to limit the amount of graduate students' loans is to diversify their aid package with other sources of support such as RAs, TAs, tuition reduction, and, to the extent possible, scholarships funded through private gifts and contributions.

Another group that might benefit from the results of this study consists of graduate faculty members. Findings suggest that having a research assistantship positively affects graduate student persistence while having a teaching assistantship has little to no effect on graduate retention. Thus, faculty members might consider this information when securing external grants to employ students. RAs may be more effective ways of assisting students. There are other benefits as well. RAs have been lauded as vehicles for socialization to a profession and means for becoming academically and socially integrated into a

department or institution (Tinto, 1993). Additional research is warranted to study the nature of RAs and benefits that accrue to students from such experiences. Socialization or social exchange theory may be appropriate perspectives for investigating this issue.

There are a number of other areas for future research that may clarify and extend the results of the present study. For instance, the study found that EFC is related to graduate student persistence with higher EFC's predicting higher odds for retention. To the extent that EFC is an appropriate proxy for socioeconomic status, these findings may provide reason for concerns about low-income graduate students whose experiences are virtually absent in the existing literature. Thus, additional research is needed to study this subgroup closely.

Consistent with previous studies (Bowen & Rudenstein, 1992; Geiger, 1997; Tinto, 1993), this study found that graduate major, serving as a proxy for department life and the nature of research in a given field, is related to the odds of persisting in school. In this analysis, science, technology, engineering, and mathematics (STEM) majors are significantly less likely to persist than their non-STEM counterparts. And in light of national imperatives to increase the number of individuals earning STEM degrees (Heller & Martin, 1994), more information is needed to understand this apparent "brain drain" from the STEM pipeline. Future researchers should design studies focusing exclusively on STEM graduate students or comparative studies that juxtapose them and their peers in other graduate fields.

Much remains to be learned about the role that finances play in predicting graduate student persistence. This study provides an initial foray into factors associated with graduate student persistence using a nationally representative sample. Further research is needed, though it is clear from the present study that money matters.

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Appendix: Model Specification: Factors, Variables, and Codes for the Integrated Model

Factors	Variables	Code
Dependent	Persistence	0 = non-persister
		1 = persister
Financial	Total aid borrowed for graduate school	0 = none
		1 = less than \$9,999
		2 = \$10,000-24,999
		3 = \$25,000-39,999
	Total aid borrowed for undergraduate	4 = \$40,000 or more
		0 = none
		1 = less than \$9,999
		2 = \$10,000-24,999
	Total aid borrowed for undergraduate / graduate	3 = \$25,000-39,999
		4 = \$40,000 or more
		0 = none
		1 = less than \$9,999
<i>Aid Type</i>	Graduate loans	2 = \$10,000-24,999
		3 = \$25,000-39,999
	Aid Package	4 = \$40,000 or more
		0 = did not receive
		1 = received
<i>Debt</i>	Undergraduate (amount owed)	1 = loans, no grants
		2 = grants, no loans
		3 = grants and loans
		4 = other
	Total debt (Undergraduate / graduate)	5 = no aid
		0 = none
		1 = less than \$4,000
		2 = \$4,000-7,999
		3 = \$8,000-12,599
		4 = \$12,600 or more
Default status	0 = none	
	1 = less than \$9,999	
	2 = \$10,000-24,999	
	3 = \$25,000-39,999	
Deferment status	4 = \$40,000 or more	
	0 = defaulted on neither	
<i>Institutional aid</i>	Assistantship	1 = defaulted
		0 = no deferment
	Tuition reduction	1 = deferment
		0 = no
		1 = yes
		0 = no
		1 = yes

**Appendix: Model Specification: Factors, Variables, and Codes for the Integrated Model
(Continued)**

Factors		Variables	Code	
Academic	<i>Grades</i>	Undergraduate GPA	0 = 2.49 and under 1 = 2.5 to 2.99 2 = 3.0 to 3.49 3 = 3.5 and above	
		SAT/ACT Quartile score	0 = did not take SAT/ACT 1 = lowest quartile 2 = second quartile 3 = third quartile 4 = highest quartile	
		GRE Sum score	1 = Top 25% on all 3 2 = Top 25% on 2 of 3 3 = Top 25% on 1 of 3 4 = Middle 50% on all 3	
		Major STEM	0 = non STEM 1 = STEM	
		Background	Parent's level of education	0 = high school or less 1 = some postsecondary, associate's degree 2 = bachelor's 3 = advanced degree
		Gender	0 = male 1 = female	
	Age at receipt of bachelor's degree	0 = 24 years or younger 1 = 25-29 years 2 = 30 or older		
	Expectations	1 = bachelor's or less 2 = masters 3 = PhD 4 = First professional		
	Race	1 = American Indian/Alaska Native 2 = Asian 3 = Black 4 = Hispanic 5 = Caucasian		
	<i>Socioeconomic Status</i>	Expected Family Contribution	0 = no support 1 = less than \$2,999 2 = \$3,000-5,999 3 = \$6,000-8,999 4 = \$9,000 or more	

The Relationship of Institutional Tuition Discounts with Enrollment at Private, Not-for-Profit Institutions

By Nathan E. Lassila

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Empirical studies exploring the impact of student aid on postsecondary enrollment often stop short of the specific examination of institutional tuition discounting. This research uses separate empirical ordinary least squares (OLS) regression models to examine three questions using public choice theory, positing that enrollment decisions may be affected by many variables but will be driven primarily by discounted cost. These questions are: Does a relationship exist between institutional tuition discount and enrollment? Does institutional tuition discount have a measurably different effect on enrollment of different racial or ethnic groups? What is the relationship between institutional tuition discount and enrollment over time? Results provide evidence of a positive relationship between increasing institutional tuition discount and enrollment, and suggest tuition discounting may be effective specifically in increasing minority enrollment.

Colleges compete for students. Many have specific institutional goals, such as increasing enrollments of low-income or other underrepresented students, raising enrollments of students with high academic achievements or other talents, or increasing net revenue from tuition and fees (Redd, 2000). College administrators use institutional tuition discounting (ITD) as a tool to help attract these students to their institution by lowering the price. While there is voluminous research regarding effects of tuition cost and financial aid on undergraduate enrollment, empirical research beyond descriptive analyses specifically addressing the effects of ITD (whether based on need or merit) on the institutional enrollment in college systems is less abundant (Davis, 2003).

Some colleges may have an idea of how ITD affects their enrollment; others lack good data or resources to assess the effectiveness of their actions (Davis, 2003). The intent of this research is to identify relationships between ITD and first-time, first-year enrollment at private, not-for-profit institutions.

Background

Institutional tuition discounting is the art and science of establishing a net price of attendance for postsecondary students at amounts that will maximize tuition revenue while achieving enrollment goals (Davis, 2003). Institutional tuition discounting has grown tremendously in recent years and as greater resources are dedicated to this type of aid (rather than to new facilities or improving instruction); greater scrutiny is needed to assess its effectiveness in attaining enrollment goals. About a quarter of the students enrolled in public colleges and universities and about 60 percent of those in private institutions receive institutional grant aid (The College Board, 2004). Institutional aid to students increased 130% from 1996-97 to 2006-07 (The College Board, 2007). The importance of this form of aid to assist affordability corresponds with the weakening purchasing power of other forms of aid. One example, the Federal Pell Grant, continues to lose purchasing power as occasional increases do not keep pace with increased cost to attend college (St. John, 2005). For example, in

1986-87, the maximum Pell Grant covered 52 percent of average tuition, fees, room, and board at public four-year institutions and 21 percent at private institutions. These figures had declined to 35 percent and 13 percent respectively by 1996-97 and 32 percent and 13 percent in 2007-08. (The College Board, 2007 and 2008).

This research does not attempt to separate need and merit ITD due to difficulty in identifying pure need-based and pure merit-based aid for the many students receiving both. Some grant aid is based only on financial need and some based only on merit, and some are based on a combination of these criteria. When students receive both types of aid under the umbrella of ITD and there is no simple way to draw a line between what is considered need-based and non-need based aid. Ambiguity is even greater for institutional grant aid, particularly at the most selective private colleges and universities that award aid only on the basis of financial need (The College Board, 2007).

National organizations, including the National Association of College and University Business Officers (NACUBO, 2008), the American Association of State Colleges and Universities (2007) and, the National Association of Student Financial Aid Administrators (Redd, 2002) have been or are exploring effects of ITD. Scholarly papers have also been written on this topic (Winston and Zimmerman, 2000; Redd, 2000; and Davis, 2003). Further, research suggests ITD may not fully achieve desired goals and may potentially incur negative externalities. For example, ITD may actually decrease enrollment, fail to result in increased net revenue, deteriorate quality of student profiles at institutions, and decrease resources available for low income students (Redd, 2000; Davis, 2003). If ITD has a limited effect on enrollment, and the possibility of negative impacts exist (especially for students in financial need), possibly its use can be modified while other alternatives are created or emphasized avoiding the negative impacts. Thus, different forms of aid mechanisms, including ITD, should be explored to provide options for federal, state, and institution policymakers to consider when attempting to increase enrollment (St. John and Starkey, 1995).

Public choice theory predicts market conditions drive individuals' choices when competing alternatives are presented (Ostrom and Ostrom, 1971). Using a public choice conceptual framework, it is assumed that as total cost of college increases, all else being equal, students and their families will choose the college or university offering the lowest cost (Winston and Zimmerman, 2000). There are several examples in education literature that discuss education phenomena using market theory (Hoxby, 1997; Winston and Zimmerman, 2000; Coulson, 1996).

The sample in this research is deliberately limited to private, not-for-profit institutions for two reasons. First, ITD has a longer history of use at private institutions and it may be assumed that this history has allowed for a more mature process that has endured trial and error in an effort to most effectively employ ITD strategies (The College Board, 2006). Second, because these institutions are private, they more closely resemble a free market, unlike public schools that are heavily subsidized by tax dollars that artificially lower published tuition costs and may decrease the effectiveness ITD has in attracting students. While the United States does not have significant competition to resemble a true free market for public education, the private education role in this limited choice framework is an appropriate approximation for effects of market theory (Coulson, 1996 and Witte, 2000). Additionally, limiting the

research to one sector differs from previous research and tightens the focus to institutions funded similarly and facing similar choice, competition, and challenges (Shin and Milton, 2006)¹. However, if evidence of a relationship is found, it may assist enrollment managers not only at private institutions, but also at public institutions as their use of ITD becomes more prevalent.

Following the framework that a rational decision will be based on cost ceteris paribus, in higher education tuition price is one element that is weighed as prospective students consider their college option.

Following the framework that a rational decision will be based on cost *ceteris paribus*, in higher education tuition price is one element that is weighed as prospective students consider their college options. Literature suggests that cost does matter in the student enrollment decision. Changes in price of tuition have been found to effect individual enrollment decisions (Leslie and Brinkman, 1987; Hossler, Braxton, and Coopersmith, 1989; Savoca, 1990; St. John, 1990; Kane, 1995; Heller, 1997; and Paulsen, 2002). Leslie and Brinkman's (1987) meta-analysis of 25 quantitative studies found evidence that increases in tuition resulted in declines in the college participation rate of approximately three-fourths of a percent per \$100 tuition increase. Similarly, St. John (1990) found that a \$1,000 increase in tuition is related to a 2.8% decrease in enrollment. Heller (1997) attempted to address relationships between tuition and enrollment by extensively reviewing literature produced since the 1987 Leslie and Brinkman work. Heller's extension of this previous research took advantage of the large number of student demand studies that gained popularity over the 10-year period. Generally, Heller's findings indicate that as price of college increases, likelihood of enrollment decreases. This simple statement is built upon various methodological approaches and model specifications investigating enrollment of poor students, wealthy students, White students, or minority students.

Other factors may impact enrollment decisions, including geographic location, socioeconomic conditions, reputation, or program offerings (Akerhielm, Berger, Hooker, and Wise, 1998; Rouse, 1994; Manski and Wise, 1983; Pamusch, 1991; Betts and McFarland, 1995; Hsing and Chang, 1996; Heller, 1999; Perna 2000; Beattle, 2002; Kane, 2003; Shin and Milton, 2006; and Titus, 2006). For instance, research suggests that after controlling for unemployment rates, tuition increases have been found to relate to decreases in public enrollments (Kane, 1995). However, although other factors may affect enrollment decisions, tuition price comparatively is more directly under the control of private, not-for-profit college enrollment administrators and their Board of Trustees and can be more easily manipulated to assist the attainment of enrollment goals.

Tuition remediation strategies through various forms of financial aid (merit and/or need-based state and federal grants or loans) have been found to be predictors of individual enrollment decisions (Leslie and Brinkman, 1987; St. John, 1990; Moore, Studenmund, and Slobko, 1991; McPhearson and Schapiro, 1994; Reyes, 1994; Kane, 1995; Heller, 1997; Avery and Hoxby, 2000; and Perna and Titus, 2002). Avery and Hoxby (2000) provide evidence that student decisions are rational in deciding whether to attend college based on financial aid. St. John (1990) modeled the change in probability of enrollment given effects of tuition change, grants, and loans, and found that all variables had a role in effecting enrollment while Moore, Studenmund, and Slobko (1991) found only grant aid was most effective indicating \$1,000 in grant aid increases

¹ It should be noted that while the research lumps all private institutions together for the purpose of analysis, it is conceded that all private not-for-profits are not in fact similar. They can differ in their selectivity, wealth, prestige, reaction to economic fluctuations, class size, and many other variables. The more important factor in focusing on private not-for-profits in this research is their similarity when compared to their public counterparts in terms of historical use of tuition discounting and pricing strategies.

the probability of student enrollment by nearly 8 percent. Heller (1997) also indicates that as aid decreases, so does enrollment of students in college. Specifically, enrollment was sensitive toward type of aid as grant awards, compared to loans, had greater relationship with increased enrollment.

While much of the research on aid and enrollment views aid generally or examines federal or state aid only, specific focus on ITD decisions is less represented (Davis, 2003). Of recent research focusing on tuition discounting and private institutions, findings indicate that freshmen at institutions with low growth in tuition discount rates increased by 11 percent, while high discounting institutions suffered enrollment decreases by 5 percent from 1990-91 to 1997-98 (Redd, 2000). Further, ITD may actually fail to increase net revenue for colleges, deteriorate quality of institutions (as it does not always lead to students with improved SAT scores), and hurt access for financially needy students (Davis, 2003).

Financial need is not always a condition for ITD, and when coupled with competition for the strongest students, low-income students may suffer (Davis, 2003). Thus, ITD may be used as incentive for students to enroll even if they and their parents could pay the full cost of tuition and fees (Redd, 2000). This suggests deleterious effects of ITD (Winston and Zimmerman, 2000). For instance, recent research suggests that increases in tuition discounting have resulted in lost net revenue of \$300 to \$800 per full-time student (Redd, 2000).

In sum, empirical research has found negative relationships between increasing tuition and enrollment. Also, increased financial aid is positively related to enrollment, specifically aid in the form of grants. While empirical evidence is less developed regarding ITD effects on enrollment, initial findings suggest failure to achieve intended goals, and may result in negative externalities when the tool is employed. Additionally, current research does not specifically address a difference in enrollment based on varying levels of ITD while controlling for other factors.

Method

This research investigates three questions: Does a relationship exist between institutional tuition discount and enrollment? Does institutional tuition discount have a measurably different effect on enrollment of different racial or ethnic groups? What is the relationship between institutional tuition discount and enrollment over time? Separate empirical ordinary least squares (OLS) regression models examine these questions.

Institutions used for the analysis include U.S. four-year private, not-for-profit, degree-granting colleges and universities. Using fall 2004-05 data from the Integrated Postsecondary Education Data System (IPEDS), OLS regression is used to present estimated relationships between average ITD and first-time, first-year college enrollment. Additional data for control variables are obtained from the American Communities Survey and the Bureau of Labor Statistics. These data serve to control for environmental factors that may impact institution enrollment rates.

For the aggregate enrollment analysis, models measure variance in first-time, first-year enrollment given variance in three discount variables (institution, state, and federal tuition discount) and demographic and reputational controls. To address enrollment by race, five separate regression models are estimated using enrollment for each race/ethnicity category as a separate dependent variable. The final question consists of the same 2004-05 variables, but will be

calculated as their change from 1999-00. Thus, six models will examine change in enrollment from 1999-00 to 2004-05 controlling for change in the other independent variables over the same time period.²

The initial sample drawn from IPEDS included 1,262 institutions. Cases without published tuition were removed from the analysis. Upon calculating ITD for the remaining institutions, those with institutional, federal, or state discounts greater than 100% were removed. Lastly, institutions with no reported composite ACT scores were removed to avoid methodological issues due to missing data. The resulting dataset used for the aggregate and five race/ethnicity models is 630 institutions. This same process of elimination was used for the final six models estimating change from 1999-00 to 2004-05. Cases with missing data were removed from the 1999-00 data year. As a result, data used for the final model measuring change over time consists of 427 cases.

Average ITD is calculated as described by Baum and Lapovsky (The College Board, 2006) and NACUBO (2008). The models presented use three discount rates (institutional, federal, and state) separately to measure the relationship of each with enrollment. Rates for state and federal grant aid (referred to as state and federal discount) are calculated in the same manner.

$$\text{Institution Average Discount Rate} = \frac{\text{Average Institutional Aid Per Student}}{\text{Published Tuition and Required Fee Rate}}$$

Control variables are similar to those used in prior research on student enrollment decisions and constitute other factors that may affect student decisions beyond cost. Individual factors such as family income and high school achievement levels have predicted likelihood of a student's applying to college (Akerhielm, Berger, Hooker, and Wise, 1998; Rouse, 1994). Institutional traits have previously been controlled for in models regarding effects on enrollment and include tuition levels, financial aid availability, "quality of school" (as measured by the average combined SAT score of incoming freshmen), and endowment value (Manski and Wise, 1983; Pamusch, 1991; Rouse, 1994; Betts and McFarland, 1995; Hsing and Chang, 1996; Heller, 1999; Perna 2000; Beattle, 2002; Kane, 2003; Shin and Milton, 2006; and Titus, 2006). The inclusion of unemployment rate, median household income, composite ACT, endowment value, tuition cost, state population, and institutions four year graduation rate is also derived from use in this previous research.

As mentioned above, a limitation of the research is the inability to distinguish need-based versus merit-based ITD. A second limitation of the research is use of private, not-for-profit enrollment as a dependent variable. The limitation is due to the potential ceiling effect these institutions may provide with self-mandated freshmen class enrollment maximums. While many schools work hard for the enrollments they obtain and are attempting to grow, some institutions, often of a very selective ilk, cap enrollment and thus limit overall growth. If this phenomenon were rampant among institutions in the sample, variance in the dependent variable would be constrained and the relationship between increasing ITD and enrollment would not be fully justified or explained.

² Endowment change was not used in these models because data were not available for 2000. Also, total completions are substituted for graduation rate due to rates not being available for 2000. ACT data were from 2001 as the data were not available in 2000.

Findings *Discount Relationship with Aggregate Enrollment*

To address the first two research questions posed, OLS regression models presented in Table 1 examine ITD's relationship with enrollment. As shown in Table 1, a positive relationship exists between ITD and aggregate enrollment as well as for enrollment of Black and Hispanic students. The model, including state environmental factors and college reputational control variables has an adjusted R^2 (.687) and an unstandardized beta of $\beta = .285$ for ITD. Federal tuition discount is negative for aggregate enrollment as well as for White, Hispanic, and Asian students, but positive for American Indian students. Standardized coefficients in the aggregate model indicate the relative strength for ITD ($b=.093$) which, while small, is among the stronger variables exceeded by graduation rate, federal discount, and average enrollment standardized coefficients.

Table 1: OLS Regression Results for Aggregate Enrollment and Enrollment by Race/Ethnicity

	Coefficients (Standardized in Parentheses)					
	Aggregate Enrollment	White	Black	Hispanic	Asian	American Indian
Institutional Discount (ITD, 2005)	.285 ** (.093)	-.024 (-.007)	.807*** (.184)	.380* (.080)	-.122 (-.022)	-.120 (-.039)
Federal Aid Discount (2005)	-.664 *** (-.140)	-1.830*** (-.296)	.199 (.029)	-.852 * (-.099)	-.799* (-.071)	.781* (.125)
State Aid Discount (2005)	.180 (.049)	.091 (.020)	-.320 (-.062)	.601** (.106)	-.383 (-.057)	.388* (.108)
Population (in millions, 2005)	.001 (.021)	-.002 (-.041)	.004 (.054)	.020** (.281)	.005** (.068)	.003 (.078)
State Median Income estimate (in thousands, 2005)	-.002 (-.037)	-.004 (-.055)	.000 (-.005)	.009*** (.097)	.014*** (.136)	-.006* (-.110)
State Unemployment Rate estimate. (2005)	.001 (.002)	.001 (.001)	.092*** (.146)	-.045 (-.066)	.022 (.029)	-.047* (-.115)
Average. First-Time, First-Year Enrollment (1995-2004)	.001 *** (.711)	.001 *** (.495)	.001 *** (.625)	.001 *** (.481)	.001 *** (.454)	.000 *** (.444)
Endowment (in millions, 2005)	-.002 ** (-.073)	-.003** (-.100)	.002 (.062)	.000 (.004)	.001 (.031)	.003** (.139)
Graduation Rate - Bachelor Degree within 4 Years, Total (2004)	.002** (.095)	.003** (.124)	-.003 (-.100)	-.004** (-.152)	-.002* (-.078)	-.001 (-.064)
ACT Composite 75th Percentile Score (2005)	-.004 (-.036)	.026*** (.182)	-.057*** (-.358)	.010 (.061)	.027*** (.137)	.013 (.122)
Published Tuition (in thousands, 2005)	.006 (.094)	.002 (.032)	.002 (.020)	.014** (.148)	.046*** (.421)	.004 (.067)
Adjusted R^2	.687	.551	.390	.507	.682	.291
	$n = 574$	$n = 556$	$n = 550$	$n = 535$	$n = 503$	$n = 394$

* $p < 0.05$. ** $p < 0.01$. *** $p < 0.001$

Discount Relationship with Enrollment by Race/Ethnicity

Results indicate that ITD is positively related to Black ($\beta = .807$, adj. $R^2 = .390$) and Hispanic ($\beta = .380$, adj. $R^2 = .507$) first-time, first-year enrollment, while controlling for state environmental and institution reputational variables. Models for Hispanic and Asian provide the most information in attempting to explain factors effecting enrollment as they have a high adjusted R^2 and several statistically significant variables.

Few variables are consistent across race/ethnicity either in direction of relationship or statistical significance. One exception is average enrollment from fall 1995 to 2004. This variable is statistically significant ($p < .001$) and positive, albeit weak ($\beta = .001$), for all five race/ethnicity models and has the highest standardized coefficient of variables included in the analyses (b range = .444 to .625). This suggests that average enrollment over the past several years is a consistent predictor of current and future enrollment which is not entirely unexpected due to factors such as the ceiling effect private not-for-profits may impose to limit entering classes.

Federal discount is statistically significant for all variables except Black, and while negative for the remaining race/ethnicity variables changes from negative to positive for American Indians. A similar distinction is found for composite ACT score as it is significant for all models except Hispanic and American Indian, and has a positive relationship with the exception of Blacks.

Four of five institutional variables are statistically significant for White and Asian and three of five are significant for Hispanic. Other variables show limited impact on their respective models with two of five institutional variables being significant in each. A similar pattern is found for state environmental variables: None of the variables are significant for White, Black has one, and Hispanic, American Indian and Asian have two— none being consistent across models.

Comparing the two analyses (aggregate enrollment model and five race/ethnicity models) provides little consistency. The exception may be federal discount's negative association with enrollment across all models (except for its relationship with American Indian enrollment). Also, average enrollment is positive and statistically significant in all models.

Discount and Enrollment: Relationship Over Time

The final research question examines change in enrollment over time. Figure 1 depicts raw data for enrollment and the three discount variables over time. While average full-time, first-time enrollment has increased, discount rates have generally decreased since 1999-00. Given these descriptive data, one may hypothesize a negative relationship between ITD and enrollment.

Figure 1: Enrollment Has Increased While Tuition Discounting Has Decreased Since 1999

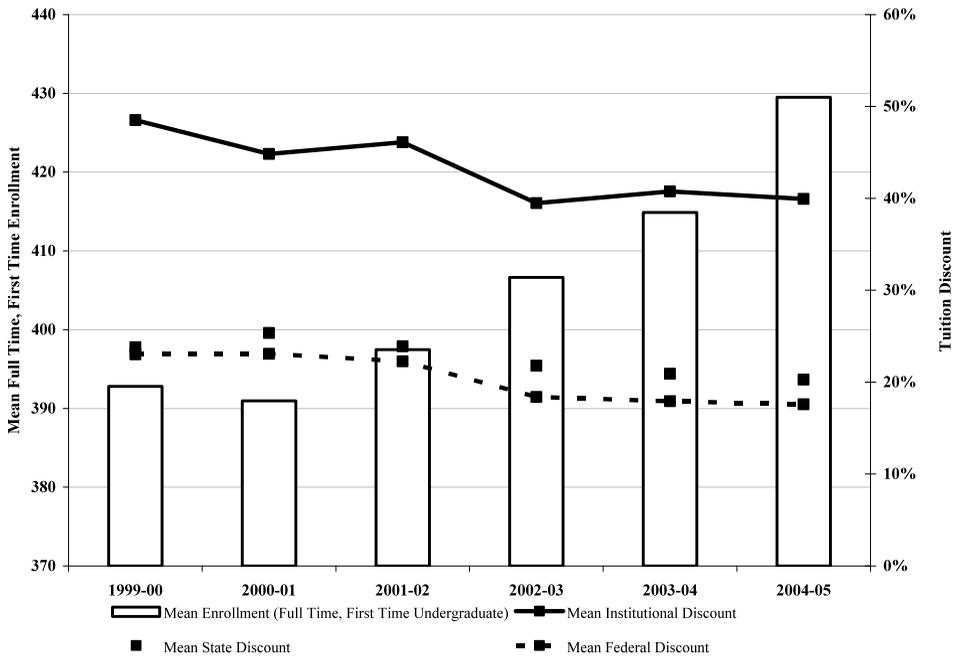


Table 2 presents the final models in this research. As shown, change in ITD has no statistically significant relationships with changes in either aggregate enrollment or enrollment disaggregated by race/ethnicity.³ Only two financial aid-related relationships appear in the regression models. The two exceptions are the positive relationship between federal discount and Black ($\beta = 64.288$) and state discount with American Indian ($\beta = 5.733$) first-time, first-year enrollments.

Table 2: OLS Regression Results for Enrollment Change from 1999-00 to 2004-05

	Coefficients (Standardized in Parentheses)					
	Aggregate Enrollment	White	Black	Hispanic	Asian	American Indian
Institutional Discount (ITD) -Change	-72.164 (.124)	-31.282 (.075)	-13.687 (.090)	-2.117 (.025)	-4.242 (.060)	-1.023 (.088)
Federal Discount - Change	117.032 (.098)	8.844 (.010)	64.288 ** (.205)	-1.915 (.011)	6.509 (.045)	-2.765 (.116)
State Discount - Change	-2.140 (.002)	-2.851 (.004)	-26.037 (.088)	10.338 (.064)	2.818 (.020)	5.773 ** (.258)
Population - Change	-.006 (.023)	-.011 (.061)	.003 (.050)	.008 *** (.215)	-.001 (.039)	.001 ** (.157)
Median Family Income - Change	2.199 (.070)	1.255 (.055)	.159 (.019)	.438 (.096)	.277 (.072)	.104 ** (.165)
Unemployment - Change	-4.798 (.031)	-4.006 (.035)	.884 (.021)	-.091 (.004)	.120 (.006)	-.109 (.035)
Total Completions - Change	.339*** (.409)	.233 *** (.389)	.013 (.060)	.020 ** (.170)	.012 * (.119)	.001 (.056)
ACT - Change	4.492 (.060)	4.644 (.086)	-.267 (.014)	.662 (.061)	.481 (.052)	.004 (.003)
Tuition Price - Change	.005 (.079)	.000 (.008)	.000 (.017)	.001 * (.112)	.001 ** (.162)	.000 * (.111)
Adjusted R ²	.171	.147	.001	.091	.029	.075

n = 352.

*p < 0.05. **p < 0.01. ***p < 0.001

Discussion

This research investigates three questions regarding ITD and its relationship with undergraduate enrollment. Understanding the relationship between ITD and enrollment is important for institutions because of potential positive and/or negative effects of employing the tool.

A few conclusions can be drawn from the findings of the research. The research suggests there is a positive relationship between ITD and enrollment when examining effects on aggregate enrollment at private not-for-profit institutions. However, when disaggregating enrollment by race/ethnicity, the relationship only remains statistically significant for Black and Hispanic students. This may suggest that ITD is more effective in increasing targeted subgroup enrollment or has been employed more for these populations as institutions make efforts to increase diversity of enrollment and attract this growing population to their college.

While previous research suggests concerns that ITD may be limiting the enrollment of financially needy students or not effective at attracting high

quality students, this research's findings suggest institutions may be successfully using discounting to enroll students of color—a different subgroup (Davis, 2003).⁴ A positive relationship between discount and a specific subgroup's enrollment (in this research race/ethnicity) lends some support to previous research suggesting the effect of ITDs on enrollment of low-income students (identified as Pell Grant recipients) at institutions (Redd, 2000). The support of these findings for the effect of discount on enrollment, suggests that future research estimate effects on a range of dependent variables representing student characteristics to see how the student body may be changing or diversifying rather than merely growing.

Models analyzing change over time provide no statistically significant support for ITD. However, this may be due to the limitation discussed previously regarding enrollment ceilings at many institutions. Failure to produce statistical significance may only mean that ITD does not greatly influence continual, cumulative growth of enrollments over time at private, not-for-profit institutions. It may however mean that what ITD is doing is changing is the profile of the students enrolled.

Comparing the aggregate cross-sectional and longitudinal models shows a differing direction of relationship for statistically significant discount variables. In the 2004-05 cross-section, federal discount is negative in all models (with the exception of the positive relationship with American Indian enrollment). However, in the model looking at change over time, the relationship is positive for Black enrollment. ITD is positive for statistically significant variables in the cross-section, but is no longer significant in the longitudinal model. State discount is negatively associated with all enrollments, positive in two models looking at relationship with enrollment by race, and positive for American Indian enrollment in the longitudinal model.

The inconsistent statistical relationship of discount variables may be a product of the decreasing value these forms of aid have maintained over time. While these discount variables have remained flat or decreased over time, institutions tuition and fees have increased. Thus, the value of even a flat discount rate is diminishing as the costs not covered are increasing in real dollars.

This research provides useful information to private not-for-profit institutions and public institutions as their use of ITD grows. For public institutions, the variance in enrollment may be greater as they may be less prevalent to strictly cap enrollment of incoming freshmen. Thus, to provide greater detail regarding the specific impact ITD has for public institutions, they should be included or examined separately in future research.

While ITD may be an effective tool for private not-for-profit enrollment managers to employ in an effort to increase enrollment or attract specific subgroups, the impact of negative externalities must be reconciled. Essentially, this research provides evidence for one side of the cost benefit equation, i.e., that ITD is positively related to aggregate enrollment. Armed with this information, enrollment managers must weigh potential negative externalities in a cost benefit analysis to determine if discounting should be used at all, and if so, to what degree should discounts be awarded.

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Optimization Techniques for College Financial Aid Managers

By Donald I. Bosshardt, Larry Lichtenstein, George Palumbo, and Mark P. Zaporowski

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In the context of a theoretical model of expected profit maximization, this paper shows how historic institutional data can be used to assist enrollment managers in determining the level of financial aid for students with varying demographic and quality characteristics. Optimal tuition pricing in conjunction with empirical estimation of matriculation probability functions illustrates how financial aid can be used to maximize net tuition revenue given institutionally determined objectives. The model provides insight to the level of price sensitivity of prospective matriculants at a medium-sized comprehensive private college.

The recent economic decline and financial market collapse have negatively impacted family, state government, and college budgets. Shrinking endowments and uncertain enrollments have prompted institutions of higher education to focus on revenue enhancement and cost containment. In this environment, the decisions made by financial aid administrators have become more important in achieving financial stability given other institutional objectives such as student quality and diversity. This paper uses rules of optimal tuition pricing developed in a theoretical model, in conjunction with empirical estimation of matriculation probability functions, to illustrate how financial aid can be used to maximize net tuition revenue given institutionally determined quality objectives. The results may be particularly useful to colleges and universities that find themselves more heavily dependent on tuition revenue as a result of shrinking endowments and the current economic recession.

Following Somers and St. John (1997), we focus on institution-specific data from a comprehensive, predominantly undergraduate private college. First, this paper develops a theoretical model of optimal tuition pricing that specifies the optimal level of financial aid for each applicant, based on individual demographic and academic quality characteristics. Second we use historic data from this institution to estimate matriculation probability functions associated with applicants that possess varied demographic backgrounds. Finally, using these estimated probability functions, we simulate how the institution should allocate financial aid among various applicants in order to attain institutional objectives.

Studies of Enrollment and Student Aid

Early matriculation probability models, including Cabrera (1994), Dembowski (1980), Fuller, Manski and Wise (1982), Tierney (1980, 1982) and Weiler (1987), focused on student enrollment probabilities using historical data based on tuition and the demographic characteristics of the applicants. These papers forecast the matriculation probability of an individual applicant, but generally do not identify a net tuition level (stated tuition less financial aid) designed to promote specific institutional objectives.

Ehrenberg and Sherman (1984) present a model of optimal tuition pricing for highly selective institutions where the objective is to maximize utility, which is a function of prestige, student quality, diversity of the student body, and other attributes. While utility maximization models may be appropriate for the most prestigious institutions, where there are long waiting lists of acceptable students and large endowments that act as a cushion in turbulent times, the same cannot be said for the majority of colleges and universities in the United States. According to Peterson's (2009), approximately 6 percent of all colleges accept 30 percent or less of their applicant pool and only 11 percent accept less than 60%. This group of highly selective institutions includes public universities, many of which have deep applicant pools due to taxpayer subsidized tuition rates.

Epple, Romano, and Sieg (2006) have recently presented a price discrimination model for higher education that gives rise to a continuum of institutions of varying quality. They conclude that while top-tier institutions face minimum competition from alternatives that are perceived to be of higher quality, institutions outside of the top tier have many close substitutes and thus limited market power. At these institutions, the relationship between incremental costs and revenues guide admissions policies. Without large endowments, they operate in an environment where tuition-paying students must produce revenue large enough to cover the costs of operation. Private institutions that are not in the highly selective top tier generally operate without long waiting lists. For these institutions, a net tuition revenue maximization strategy may be the key to the maintenance of financial stability. This has become increasingly important to enrollment managers at public institutions as well, since the impact of the recent economic downturn has had negative effects on state expenditures for postsecondary education.

Spaulding (2003) and Spaulding and Olswang (2005) provide the framework for the analysis of financial aid on enrollment yield at a specific public institutions. The focus of these studies is on maximizing yield to meet institutional enrollment goals. Our analysis reorients these objectives to the use of financial aid to generate sufficient tuition revenue to ensure financial stability. While of growing importance to public institutions, this objective has been at the heart of most private colleges and universities in America for a number of years.

The Theoretical Model

Bosshardt, Lichtenstein, and Zaporowski (2008, 2009) present optimal tuition pricing models for academic institutions with enough market power to use price-discriminating techniques that tailor financial aid to each applicant. Rules of optimal tuition pricing are developed where the enrollment decisions of applicants are stochastic in nature and the probability of matriculation is a function of both the demographic characteristics of the applicant and the effective tuition that the applicant must pay. Following Bosshardt, Lichtenstein, and Zaporowski, this paper presents a theoretical model of optimal tuition pricing that specifies the optimal level of financial aid for each applicant, based on individual demographic and academic quality characteristics.

Consider an institution that is composed of both commuter and resident students. The physical plant is sufficiently large such that there is no binding capacity constraint. Over the relevant range of tuition pricing, the institution can accommodate more students than will actually matriculate. The cost of delivering education to the student body has a fixed cost component, f , which

reflects expenses such as interest cost on debt, insurance, utilities, and the wage bill for tenured faculty. The marginal cost of delivering education to an additional student is denoted as v . Marginal cost is assumed to be greater than or equal to zero indicating that some institutional costs such as cleaning expenses, laboratory supplies, and the cost of hiring adjunct faculty may be related to the size of the student body.

The institution makes an offer in the form of an effective tuition, t , where t is defined as stipulated tuition less scholarships and grants. The applicant accepts this offer with probability p , which is assumed to be a decreasing function of effective tuition. The probability function is allowed to vary by the demographic and quality characteristics of the applicant. The probability function is expressed as

$$(1) \quad p = p(t, \beta), \quad \frac{\partial p}{\partial t} < 0,$$

where β is a vector of demographic and quality characteristics of the applicant. The partial derivative of t with respect to β can be either positive or negative. For expositional ease, we assume that this function is linear.

Assuming that there are N applicants, where N_c is the number of applicants who will not live in the institution's residential housing and N_r is the number of applicants who will live in on-campus housing, then $N = N_c + N_r$. The decision of each applicant to matriculate is expressed as a Bernoulli random variable x_i , which takes on the value one if the applicant enrolls with probability p and takes on a value of zero with probability $(1-p)$ if the applicant does not enroll.

N_c and N_r are partitioned into k mutually exclusive sub-groups such that $N_{1,c} + N_{2,c} + \dots + N_{k,c} = N_c$ and $N_{1,r} + N_{2,r} + \dots + N_{k,r} = N_r$. There are $2k$ distinct student quality-demographic profiles for the combined commuter and resident populations. For example, one demographic profile could be applicants from high-income families who planned to major in accounting, had high school averages above 90, and standardized test (SAT) scores above 1200. Since the institution acts as a price discriminator, there can be a different effective tuition charged to each of the $2k$ quality-demographic sub-groups. $t_{j,c}$ is defined as the effective tuition charged to commuter applicants in sub-group j as j varies from 1 to k . Similarly, $t_{j,r}$ denotes effective tuition charged to resident applicants in sub-group j .

For commuter students, the profit function can be expressed as

$$(2) \quad \pi = \sum_{i=1}^{N_{1,c}} (t_{1,c} - v)x_i + \sum_{i=1}^{N_{2,c}} (t_{2,c} - v)x_i + \dots + \sum_{i=1}^{N_{k,c}} (t_{k,c} - v)x_i - f.$$

For each commuter student's quality-demographic profile, the probability of matriculating is:

$$(3) \quad p_{i,c} = a_{i,c} - b_{i,c} t_{i,c} \quad \text{where } i = 1, 2, \dots, k.$$

The intercept term ($a_{i,c}$) represents the probability that the student will matriculate at an effective tuition of zero. The slope coefficient ($b_{i,c}$) reflects the change in the probability of matriculating per dollar increase in effective tuition. From (2) and (3), expected profit can be expressed as

$$(4) \quad E(\pi) = N_{1,c} (a_{1,c} - b_{1,c} t_{1,c})(t_{1,c} - v) + \dots + N_{k,c} (a_{k,c} - b_{k,c} t_{k,c})(t_{k,c} - v) - f.$$

Maximizing expected profit yields the following optimal effective tuition for commuter students

$$(5) \quad t_{i,c}^* = \frac{a_{i,c}}{2b_{i,c}} + \frac{v}{2} \quad \text{where } i = 1, 2, \dots k.$$

For residential students, the above analysis is altered since room and board fees, d , are an additional source of revenue if the student matriculates. The profit function for residential students is

$$(6) \quad \pi = \sum_{i=1}^{N_{1,r}} (t_{1,r} + d - v)x_i + \sum_{i=1}^{N_{2,r}} (t_{2,r} + d - v)x_i + \dots + \sum_{i=1}^{N_{k,r}} (t_{k,r} + d - v)x_i - f.$$

For each resident student quality-demographic profile, the probability of matriculating is

$$(7) \quad p_{i,r} = a_{i,r} - b_{i,r} t_{i,r} \quad \text{where } i = 1, 2, \dots k.$$

Expected profit can be expressed as

$$(8) \quad E(\pi) = N_{1,r} (a_{1,r} - b_{1,r} t_{1,r})(t_{1,r} + d - v) + \dots + N_{k,r} (a_{k,r} - b_{k,r} t_{k,r})(t_{k,r} + d - v) - f.$$

Maximizing expected profit yields the following optimal effective tuition for resident students

$$(9) \quad t_{i,r}^* = \frac{a_{i,r}}{2b_{i,r}} + \frac{v-d}{2} \quad \text{where } i = 1, 2, \dots k.$$

Thus, tuition guidelines for the maximization of expected profit can be applied once the probability function for each student quality-demographic profile is estimated.

The Data

The data are composed of a pooled cross-sectional time series covering freshman class applicants from the 1993-94 through 1995-96 academic years at a medium-sized comprehensive college enrolling approximately 4,500 students, approximately 3,000 of which are undergraduates. The college had major programs in arts and sciences, business, and education. The data contained approximately 5,000 observations and averaged 1,666 applicants over the three-year period.

The academic quality of the applicant, QINDEX, takes on a value of 1 through 5 and depends upon the applicant's high school average and SAT score. QINDEX is defined by the following minimum thresholds:

QINDEX = 1 if the applicant's high school average > 90 and SAT score > 1000

QINDEX = 2 if the applicant's high school average > 85 and SAT score > 900

QINDEX = 3 if the applicant's high school average > 80 and SAT score > 800

QINDEX = 4 if the applicant's high school average > 77 and SAT score > 800

QINDEX = 5 if the applicant's high school average > 74 and SAT score > 750

Two premium majors offered by the college are accounting and biology. Students from these two majors have historically enjoyed a high placement rate in graduate and professional schools and, for those not seeking a graduate education, have commanded a high entry level salary in the job market upon graduation. To capture the influence of planned major upon matriculation probability, we define the following dummy variables: BIO equals one for students listing either biology or bio-chemistry as their intended major and zero for all others. ACC equals one for students listing accounting as their intended major and zero for all others. RES equals one for prospective students wishing to live in college housing and zero for all others.

The variable INCOM is defined as the family income of the applicant measured in thousands of dollars. TUIT is defined as the per semester effective tuition offered to prospective students measured in thousands of dollars. This variable is the difference between stipulated tuition and the amount of financial aid offered.

An Econometric Model of Matriculation Probability

The matriculation probability of student i is assumed to be a linear function of the independent variables described above. For expositional clarity, separate regression equations were estimated for each of the ten possible residential-status, quality-index profiles. Each has the following form.

$$(10) p_i = \beta_0 + \beta_1 \text{TUIT}_i + \beta_2 \text{ACC}_i + \beta_3 \text{BIO}_i + \beta_4 \text{INCOM}_i + \varepsilon_i$$

The β 's are parameters to be estimated and ε_i is an independently and identically distributed error term. The estimated β 's can be interpreted as the change in matriculation probability that will occur with respect to a change in the specific independent variable of interest, holding all other independent variables constant. One does not actually observe matriculation probabilities, but only the realization of whether the student decides to matriculate or not. Consequently, we code the dependent variable as MATRIC, which takes on a value of one if the student matriculated and is equal to zero otherwise. An estimable version of equation (10) is as follows

$$(11) \text{MATRIC}_i = \beta_0 + \beta_1 \text{TUIT}_i + \beta_2 \text{ACC}_i + \beta_3 \text{BIO}_i + \beta_4 \text{INCOM}_i + \varepsilon_i$$

When one estimates the β parameters in the above model, the predicted value of MATRIC for a student with a specific set of demographic characteristics will yield the matriculation probability for this student. A variety of statistical techniques can be used to estimate the parameters of (11), including ordinary least squares regression (OLS), Probit and Logit analysis. Since it provides a reasonably intuitive representation of the change in matriculation probability resulting from a change in each of the independent variables, only the results of the OLS regressions are reported in Tables A1 and A2.

As suggested by economic theory, the sign of the coefficient on TUIT is negative and statistically significant at the 1 percent level in all ten cases. The absolute value of the estimated coefficients on TUIT ranges in value from .065 to .159. This implies that, *ceteris paribus*, (other things being equal) a \$1,000 increase in effective tuition results in a decrease in matriculation probability in the range of 6.5 to 15.9 percent. This is higher than reported for a similar time period by Kane (1999) since it represents the probability of enrolling at a specific institution, rather than the probability of entering any two or four year institution. The absolute value of the coefficients on TUIT, controlling for QINDEX, are always larger for commuters than for resident students. This suggests that more price sensitive commuter students may be minimizing expenses by residing at home instead of more expensive on-campus housing.

The coefficient on the ACC dummy variable is always positive. The probability of matriculation for applicants planning to major in accounting is from .044 to .202 higher than the matriculation probability for other majors, holding the other explanatory variables constant. The coefficients on BIO are less consistent in that they are positive in only six of ten cases. The coefficient on INCOM is always positive and varies in the range from .0001 to .003. *Ceteris paribus*, a \$10,000 increase in household income results in an increase in matriculation probability from .1 to 3 percent, consistent with Spaulding (2003)

Using the Forecasted Matriculation Probabilities to Optimize Financial Aid

Enrollment managers can use the results of the probability model to optimize their financial aid offers to students with varying demographic characteristics. In our model, there are two categories of residential status, three categories for student major and five categories for academic quality. Ignoring household income, there are thirty student profiles in total ($2 \times 3 \times 5$). The continuous nature of the INCOM variable in the model makes each applicant a unique case for the purposes of forecasting. Since we wish to illustrate how an enrollment management administrator can use the theoretical model in conjunction with the estimated probability functions to determine the optimal tuition for each student profile, we treat the INCOM variable as discrete. For our purposes, INCOM takes on only two values, high (\$80,000) and low (\$40,000). These values of high and low income were selected since the mean value of INCOM in our sample was approximately \$60,000 with a standard deviation of approximately \$20,000. Given the relatively small coefficient on the INCOM variable, little error is introduced into the analysis as a result of this simplification. Consequently, there are sixty student profiles that will be considered for purposes of forecasting.

The historic period over which the data was collected generated an annual average number of applicants amounting to 1,666. We use this number of applicants in our simulation. The breakdown of applicants by student profile is based on the historic proportions of applicants from each of these groups. Table B3 shows the number of applicants for each student profile.

Using the rules of optimization shown in equations (5) and (9), the probability functions shown in Tables B1 and B2, and the applicant pool shown in Table B3, we solve for the optimal tuition for each student profile type in Tables B4, B5, B6 and B7. The model allows the cost of delivering education to have a variable component (v). In the simulations, we have considered the limiting case where variable cost is zero ($v=0$), indicating that the marginal cost of providing education to an additional student is equal to zero. In this scenario, the school has sufficient faculty and classroom space such that admitting an additional student does not require additional resources. Projections using this assumption appear in Tables B4 and B5. This contrasts with the projections in Tables B6 and B7 where the marginal cost of providing education is assumed to be \$1,000 per semester per student. The tuition discount that appears in these tables is simply the difference between the published full semester tuition rate of \$5,375 and the optimal tuition for that profile. The matriculation probability at the optimal tuition is solved for by inserting the optimal tuition into the appropriate probability function. The expected number of matriculants is found by multiplying the number of applicants in the appropriate pool by the matriculation probability. Expected net tuition revenue is the product of the expected number of matriculants and the optimal tuition.

Table B8 summarizes the data presented in Tables B4-B7. The following conclusions can be drawn. Residential students receive a deeper tuition discount than do commuter students. For example, when variable costs are zero, the average tuition discount for residential students is 56.6% compared to a 35.8% discount for commuter students. This result is intuitive since residential students bring an additional source of revenue in the form of housing payments to the institution. Of course, this result is dependent upon the assumption that the college has excess capacity in its dormitories. Similar results are obtained for the case where variable costs are positive. A second result is that as the magnitude of variable cost rises, the tuition discount diminishes. For example, for commuter students, as variable costs increase from \$0 to \$1,000 per student, the average tuition discount falls from \$1,924 to

\$1,416. These results are consistent with the behavior of a price discriminating producer, since *ceteris paribus*, as marginal costs increase, the optimal price increases.

In Table B9, we summarize how the tuition discount varies by academic quality. Generally, the size of the discount increases as academic quality improves. This occurs since many institutions compete for high-quality students resulting in a greater number of options for the applicant and a lower probability of matriculating.

The influence of the student's choice of academic major upon the optimal tuition discount is shown in Table B10. *Ceteris paribus*, students who plan on majoring in one of the premium subjects have a higher probability of matriculating and consequently require smaller tuition discounts. For example, in the case of commuter students where the institution faces zero variable costs, the average tuition discount for accounting majors is \$1,654 and for biology majors is \$1,890. The average tuition discount for all other majors aggregated is \$2,168.

Conclusion

In the context of a theoretical model of expected profit maximization, this paper has shown how historic data can be used to assist enrollment administrators in determining the level of financial aid for students with varying demographic characteristics. The data needed to estimate the probability functions is readily available as long as the decision makers keep track of historic applicant characteristics, the financial aid offered to applicants and each applicant's matriculation decision. For the institution analyzed in this paper, the variables that had a significant effect on matriculation probability were: the choice of academic major, the academic quality of the student, the applicant's family income, and whether or not the applicant wished to live in on-campus housing. These variables by no means comprise an exhaustive set of the factors influencing a student's matriculation probability, but were important variables for the institution that we analyzed.

Our approach allows consideration of a cost structure comprised of both fixed and variable costs. In our simulation, we present a limiting case where the variable cost is zero, as well as a scenario where the marginal cost of delivering education at \$1,000 per student. We have shown that greater variable costs lead to higher optimal effective tuition and therefore less financial aid. Since residential students provide an additional source of revenue to the institution, it is not surprising to find that they receive more financial aid than their commuting counterparts. It is interesting to observe that even though our model did not consider an academic quality constraint whereby the institution actively recruits high quality students to improve its reputation; higher quality students nonetheless generally received more financial aid than their academically inferior peers. Students pursuing marquis majors tend to receive less financial aid *ceteris paribus* when estimates of matriculation probability play a role in determining the size of the financial aid offer.

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Appendix A

Table A1: Ordinary Least Squares Estimates of Equation 11 for Commuter Students

QINDEX	VARIABLE	COEFFICIENT	t-Ratio	R ²	N
1	CONSTANT	.7096*	14.28	.223	448
	TUIT	-.1354	9.47		
	ACC	.2015*	3.10		
	BIO	.0881	1.58		
	INCOM	.0011	1.32		
2	CONSTANT	.8562*	15.73	.184	469
	TUIT	-.1586*	9.01		
	ACC	.1058	1.63		
	BIO	.0635	1.04		
	INCOM	.0029	.003		
3	CONSTANT	.8307*	16.47	.173	524
	TUIT	-.1410*	8.52		
	ACC	.1234*	2.23		
	BIO	.1318*	1.65		
	INCOM	.0028*	2.76		
4	CONSTANT	.8187*	6.59	.178	101
	TUIT	-.1183*	2.65		
	ACC	.1012	0.71		
	BIO	-.1560	0.83		
	INCOM	.0004	0.16		
5	CONSTANT	.8526*	14.01	.204	279
	TUIT	-.1341*	6.53		
	ACC	.1845*	2.41		
	BIO	.0619	0.58		
	INCOM	.0030*	2.40		

* indicates significance at the 5% level for a one tail test.

N indicates sample size

R² is the coefficient of determination

t-ratio is the absolute value of the estimated regression coefficient divided by its standard error.

Table A2: Ordinary Least Squares Estimates of Equation 11 for Resident Students

QINDEX	VARIABLE	COEFFICIENT	t-Ratio	R ²	N
1	CONSTANT	.3059*	14.28	.132	573
	TUIT	-.0871*	7.75		
	ACC	.0778	1.27		
	BIO	.0830*	1.99		
	INCOM	.0014*	2.57		
2	CONSTANT	.3881*	13.60	.147	763
	TUIT	-.0751*	8.73		
	ACC	.0442	0.85		
	BIO	-.0040	0.10		
	INCOM	.0006	1.42		
3	CONSTANT	.5167*	18.11	.176	996
	TUIT	-.0860*	9.83		
	ACC	.0953*	1.92		
	BIO	.0129	0.26		
	INCOM	.0001	0.30		
4	CONSTANT	.4068*	7.55	.131	331
	TUIT	-.0653*	4.13		
	ACC	.1163	1.18		
	BIO	-.0775	0.79		
	INCOM	.0011	1.15		
5	CONSTANT	.5067*	12.26	.125	518
	TUIT	-.0901*	7.40		
	ACC	.1256	1.62		
	BIO	-.0082	0.09		
	INCOM	.0015*	2.20		

* indicates significance at the 5% level for a one tail test.

N indicates sample size

R² is the coefficient of determination

t-ratio is the absolute value of the estimated regression coefficient divided by its standard error.

Appendix B

Table B1: Matriculation Probability Functions for Commuter Students by Income, Intended Major, and Student Quality

Income	Major	QINDEX	Probability Function
Low	Accounting	1	$p = .9551 - .1354 \text{ TUIT}$
Low	Biology	1	$p = .8417 - .1354 \text{ TUIT}$
Low	Other	1	$p = .7536 - .1354 \text{ TUIT}$
High	Accounting	1	$p = .9991 - .1354 \text{ TUIT}$
High	Biology	1	$p = .8857 - .1354 \text{ TUIT}$
High	Other	1	$p = .7976 - .1354 \text{ TUIT}$
Low	Accounting	2	$p = 1.0780 - .1586 \text{ TUIT}$
Low	Biology	2	$p = 1.0357 - .1586 \text{ TUIT}$
Low	Other	2	$p = .9722 - .1586 \text{ TUIT}$
High	Accounting	2	$p = 1.1940 - .1586 \text{ TUIT}$
High	Biology	2	$p = 1.1517 - .1586 \text{ TUIT}$
High	Other	2	$p = 1.0082 - .1586 \text{ TUIT}$
Low	Accounting	3	$p = 1.0661 - .1410 \text{ TUIT}$
Low	Biology	3	$p = 1.0745 - .1410 \text{ TUIT}$
Low	Other	3	$p = .9427 - .1410 \text{ TUIT}$
High	Accounting	3	$p = 1.1781 - .1410 \text{ TUIT}$
High	Biology	3	$p = 1.1865 - .1410 \text{ TUIT}$
High	Other	3	$p = 1.0547 - .1410 \text{ TUIT}$
Low	Accounting	4	$p = .9359 - .1183 \text{ TUIT}$
Low	Biology	4	$p = .6787 - .1183 \text{ TUIT}$
Low	Other	4	$p = .8347 - .1183 \text{ TUIT}$
High	Accounting	4	$p = .9519 - .1183 \text{ TUIT}$
High	Biology	4	$p = .6947 - .1183 \text{ TUIT}$
High	Other	4	$p = .8507 - .1183 \text{ TUIT}$
Low	Accounting	5	$p = 1.1571 - .1341 \text{ TUIT}$
Low	Biology	5	$p = 1.0345 - .1341 \text{ TUIT}$
Low	Other	5	$p = .9726 - .1341 \text{ TUIT}$
High	Accounting	5	$p = 1.2771 - .1341 \text{ TUIT}$
High	Biology	5	$p = 1.1545 - .1341 \text{ TUIT}$
High	Other	5	$p = 1.0926 - .1341 \text{ TUIT}$

Note: Low income variable = \$40,000; High income variable = \$80,000

Table B2: Matriculation Probability Functions for Resident Students by Income, Intended Major, and Student Quality

Income	Major	QINDEX	Probability Function
Low	Accounting	1	$p = .4397 - .0871 \text{ TUIT}$
Low	Biology	1	$p = .4449 - .0871 \text{ TUIT}$
Low	Other	1	$p = .3619 - .0871 \text{ TUIT}$
High	Accounting	1	$p = .4957 - .0871 \text{ TUIT}$
High	Biology	1	$p = .5009 - .0871 \text{ TUIT}$
High	Other	1	$p = .4179 - .0871 \text{ TUIT}$
Low	Accounting	2	$p = .4563 - .0751 \text{ TUIT}$
Low	Biology	2	$p = .4081 - .0751 \text{ TUIT}$
Low	Other	2	$p = .4121 - .0751 \text{ TUIT}$
High	Accounting	2	$p = .4803 - .0751 \text{ TUIT}$
High	Biology	2	$p = .4321 - .0751 \text{ TUIT}$
High	Other	2	$p = .4361 - .0751 \text{ TUIT}$
Low	Accounting	3	$p = .6160 - .0860 \text{ TUIT}$
Low	Biology	3	$p = .5336 - .0860 \text{ TUIT}$
Low	Other	3	$p = .5207 - .0860 \text{ TUIT}$
High	Accounting	3	$p = .6200 - .0860 \text{ TUIT}$
High	Biology	3	$p = .5076 - .0860 \text{ TUIT}$
High	Other	3	$p = .5247 - .0860 \text{ TUIT}$
Low	Accounting	4	$p = .5671 - .0653 \text{ TUIT}$
Low	Biology	4	$p = .3733 - .0653 \text{ TUIT}$
Low	Other	4	$p = .4508 - .0653 \text{ TUIT}$
High	Accounting	4	$p = .6111 - .0653 \text{ TUIT}$
High	Biology	4	$p = .4173 - .0653 \text{ TUIT}$
High	Other	4	$p = .4948 - .0653 \text{ TUIT}$
Low	Accounting	5	$p = .6923 - .0901 \text{ TUIT}$
Low	Biology	5	$p = .5749 - .0901 \text{ TUIT}$
Low	Other	5	$p = .5667 - .0901 \text{ TUIT}$
High	Accounting	5	$p = .7523 - .0901 \text{ TUIT}$
High	Biology	5	$p = .6349 - .0901 \text{ TUIT}$
High	Other	5	$p = .6267 - .0901 \text{ TUIT}$

Note: Low income variable = \$40,000; High income variable = \$80,000

Table B3: Number of Student Applying for Admission by Income, Intended Major, Student Quality, and Residential Status

Income	Major	QINDEX	Number of Commuter Students	Number of Resident Students
Low	Accounting	1	4	5
Low	Biology	1	9	12
Low	Other	1	62	79
High	Accounting	1	4	5
High	Biology	1	9	12
High	Other	1	62	79
Low	Accounting	2	4	7
Low	Biology	2	10	16
Low	Other	2	64	105
High	Accounting	2	4	7
High	Biology	2	10	16
High	Other	2	64	105
Low	Accounting	3	4	9
Low	Biology	3	11	21
Low	Other	3	72	137
High	Accounting	3	4	9
High	Biology	3	11	21
High	Other	3	72	137
Low	Accounting	4	1	3
Low	Biology	4	2	7
Low	Other	4	14	45
High	Accounting	4	1	3
High	Biology	4	2	7
High	Other	4	14	45
Low	Accounting	5	2	4
Low	Biology	5	6	11
Low	Other	5	38	71
High	Accounting	5	2	4
High	Biology	5	6	11
High	Other	5	38	71

Note: Low income variable = \$40,000; High income variable = \$80,000

Table B4: Optimal Tuition, Expected Number of Matriculants and Net Tuition Revenue for Commuter Student Profiles (Variable Costs = 0)

Income	Major	Qindex	Optimal Tuition	Tuition Discount	Matriculation Probability at Optimal Tuition	Expected Number of Matriculants	Expected Net Tuition Revenue
Low	Accounting	1	\$3,527	\$1,848	0.478	2	\$6,462
Low	Biology	1	\$3,108	\$2,267	0.421	4	\$12,155
Low	Other	1	\$2,783	\$2,592	0.377	23	\$64,496
High	Accounting	1	\$3,689	\$1,686	0.500	2	\$7,071
High	Biology	1	\$3,271	\$2,104	0.443	4	\$13,459
High	Other	1	\$2,945	\$2,430	0.399	25	\$72,248
Low	Accounting	2	\$3,398	\$1,977	0.539	2	\$7,357
Low	Biology	2	\$3,265	\$2,110	0.518	5	\$16,448
Low	Other	2	\$3,065	\$2,310	0.486	31	\$95,935
High	Accounting	2	\$3,764	\$1,611	0.597	2	\$9,025
High	Biology	2	\$3,631	\$1,744	0.576	6	\$20,339
High	Other	2	\$3,431	\$1,944	0.544	35	\$120,194
Low	Accounting	3	\$3,780	\$1,595	0.533	2	\$9,034
Low	Biology	3	\$3,810	\$1,565	0.537	6	\$22,228
Low	Other	3	\$3,343	\$2,032	0.471	34	\$113,250
High	Accounting	3	\$4,178	\$1,197	0.589	3	\$11,032
High	Biology	3	\$4,207	\$1,168	0.593	6	\$27,103
High	Other	3	\$3,740	\$1,635	0.527	38	\$141,759
Low	Accounting	4	\$3,956	\$1,419	0.468	0	\$1,601
Low	Biology	4	\$2,869	\$2,506	0.339	1	\$2,039
Low	Other	4	\$3,528	\$1,847	0.417	6	\$20,417
High	Accounting	4	\$4,023	\$1,352	0.476	0	\$1,656
High	Biology	4	\$2,936	\$2,439	0.347	1	\$2,137
High	Other	4	\$3,596	\$1,779	0.425	6	\$21,207
Low	Accounting	5	\$4,314	\$1,061	0.579	1	\$5,963
Low	Biology	5	\$3,857	\$1,518	0.517	3	\$11,546
Low	Other	5	\$3,626	\$1,749	0.486	19	\$67,552
High	Accounting	5	\$4,762	\$613	0.639	2	\$7,264
High	Biology	5	\$4,305	\$1,070	0.577	3	\$14,380
High	Other	5	\$4,074	\$1,301	0.546	21	\$85,250

Note: Low income variable = \$40,000; High income variable = \$80,000

Table B5: Optimal Tuition, Expected Number of Matriculants and Net Tuition Revenue for Resident Student Profiles (Variable Costs = 0)

Income	Major	Qindex	Optimal Tuition	Tuition Discount	Matriculation Probability at Optimal Tuition	Expected Number of Matriculants	Expected Net Tuition Revenue
Low	Accounting	1	\$1,837	\$3,538	0.280	1	\$2,521
Low	Biology	1	\$1,866	\$3,509	0.282	3	\$6,263
Low	Other	1	\$1,390	\$3,985	0.241	19	\$26,335
High	Accounting	1	\$2,158	\$3,217	0.308	2	\$3,259
High	Biology	1	\$2,188	\$3,187	0.310	4	\$8,070
High	Other	1	\$1,711	\$3,664	0.269	21	\$36,196
Low	Accounting	2	\$2,350	\$3,025	0.280	2	\$4,294
Low	Biology	2	\$2,030	\$3,345	0.256	4	\$8,207
Low	Other	2	\$2,056	\$3,319	0.258	27	\$55,467
High	Accounting	2	\$2,510	\$2,865	0.292	2	\$4,782
High	Biology	2	\$2,189	\$3,186	0.268	4	\$9,269
High	Other	2	\$2,216	\$3,159	0.270	28	\$62,562
Low	Accounting	3	\$2,894	\$2,481	0.367	3	\$9,057
Low	Biology	3	\$2,415	\$2,960	0.326	7	\$16,251
Low	Other	3	\$2,340	\$3,035	0.319	44	\$102,168
High	Accounting	3	\$2,917	\$2,458	0.369	3	\$9,179
High	Biology	3	\$2,438	\$2,937	0.328	7	\$16,509
High	Other	3	\$2,363	\$3,012	0.321	44	\$103,830
Low	Accounting	4	\$3,655	\$1,720	0.328	1	\$3,397
Low	Biology	4	\$2,171	\$3,204	0.232	2	\$3,446
Low	Other	4	\$2,764	\$2,611	0.270	12	\$33,903
High	Accounting	4	\$3,992	\$1,383	0.350	1	\$3,959
High	Biology	4	\$2,508	\$2,867	0.254	2	\$4,359
High	Other	4	\$3,101	\$2,274	0.292	13	\$41,131
Low	Accounting	5	\$3,154	\$2,221	0.408	2	\$5,710
Low	Biology	5	\$2,503	\$2,872	0.349	4	\$9,396
Low	Other	5	\$2,457	\$2,918	0.345	25	\$60,345
High	Accounting	5	\$3,487	\$1,888	0.438	2	\$6,777
High	Biology	5	\$2,836	\$2,539	0.379	4	\$11,560
High	Other	5	\$2,790	\$2,585	0.375	27	\$74,474

Note: Low income variable = \$40,000; High income variable = \$80,000

Table B6: Optimal Tuition, Expected Number of Matriculants and Net Tuition Revenue for Commuter Student Profiles (Variable Costs > 0)

Income	Major	Qindex	Optimal Tuition	Tuition Discount	Matriculation Probability at Optimal Tuition	Expected Number of Matriculants	Expected Net Tuition Revenue
Low	Accounting	1	\$4,027	\$1,348	0.410	2	\$6,332
Low	Biology	1	\$3,608	\$1,767	0.353	3	\$11,841
Low	Other	1	\$3,283	\$2,092	0.309	19	\$62,414
High	Accounting	1	\$4,189	\$1,186	0.432	2	\$6,941
High	Biology	1	\$3,771	\$1,604	0.375	3	\$13,145
High	Other	1	\$3,445	\$1,930	0.331	20	\$70,166
Low	Accounting	2	\$3,898	\$1,477	0.460	2	\$7,197
Low	Biology	2	\$3,765	\$1,610	0.439	4	\$16,063
Low	Other	2	\$3,565	\$1,810	0.407	26	\$93,382
High	Accounting	2	\$4,264	\$1,111	0.518	2	\$8,866
High	Biology	2	\$4,131	\$1,244	0.497	5	\$19,953
High	Other	2	\$3,931	\$1,444	0.465	30	\$117,641
Low	Accounting	3	\$4,280	\$1,095	0.463	2	\$8,876
Low	Biology	3	\$4,310	\$1,065	0.467	5	\$21,845
Low	Other	3	\$3,843	\$1,532	0.401	29	\$110,717
High	Accounting	3	\$4,678	\$697	0.519	2	\$10,874
High	Biology	3	\$4,707	\$668	0.523	6	\$26,720
High	Other	3	\$4,240	\$1,135	0.457	33	\$139,225
Low	Accounting	4	\$4,456	\$919	0.409	0	\$1,575
Low	Biology	4	\$3,369	\$2,006	0.280	1	\$1,977
Low	Other	4	\$4,028	\$1,347	0.358	5	\$20,007
High	Accounting	4	\$4,523	\$852	0.417	0	\$1,631
High	Biology	4	\$3,436	\$1,939	0.288	1	\$2,075
High	Other	4	\$4,096	\$1,279	0.366	5	\$20,797
Low	Accounting	5	\$4,814	\$561	0.512	1	\$5,883
Low	Biology	5	\$4,357	\$1,018	0.450	3	\$11,352
Low	Other	5	\$4,126	\$1,249	0.419	16	\$66,268
High	Accounting	5	\$5,262	\$113	0.572	1	\$7,184
High	Biology	5	\$4,805	\$570	0.510	3	\$14,186
High	Other	5	\$4,574	\$801	0.479	18	\$83,965

Note: Low income variable = \$40,000; High income variable = \$80,000

Table B7: Optimal Tuition, Expected Number of Matriculants and Net Tuition Revenue for Resident Student Profiles (Variable Costs > 0)

Income	Major	Qindex	Optimal Tuition	Tuition Discount	Matriculation Probability at Optimal Tuition	Expected Number of Matriculants	Expected Net Tuition Revenue
Low	Accounting	1	\$2,337	\$3,038	0.236	1	\$2,708
Low	Biology	1	\$2,366	\$3,009	0.239	3	\$6,716
Low	Other	1	\$1,890	\$3,485	0.197	16	\$29,333
High	Accounting	1	\$2,658	\$2,717	0.264	1	\$3,446
High	Biology	1	\$2,688	\$2,687	0.267	3	\$8,523
High	Other	1	\$2,211	\$3,164	0.225	18	\$39,194
Low	Accounting	2	\$2,850	\$2,525	0.242	2	\$4,508
Low	Biology	2	\$2,530	\$2,845	0.218	3	\$8,727
Low	Other	2	\$2,556	\$2,819	0.220	23	\$58,907
High	Accounting	2	\$3,010	\$2,365	0.254	2	\$4,997
High	Biology	2	\$2,689	\$2,686	0.230	4	\$9,788
High	Other	2	\$2,716	\$2,659	0.232	24	\$66,001
Low	Accounting	3	\$3,394	\$1,981	0.324	3	\$9,378
Low	Biology	3	\$2,915	\$2,460	0.283	6	\$17,028
Low	Other	3	\$2,840	\$2,535	0.276	38	\$107,311
High	Accounting	3	\$3,417	\$1,958	0.326	3	\$9,500
High	Biology	3	\$2,938	\$2,437	0.285	6	\$17,285
High	Other	3	\$2,863	\$2,512	0.278	38	\$108,972
Low	Accounting	4	\$4,155	\$1,220	0.296	1	\$3,478
Low	Biology	4	\$2,671	\$2,704	0.199	1	\$3,642
Low	Other	4	\$3,264	\$2,111	0.238	11	\$35,200
High	Accounting	4	\$4,492	\$883	0.318	1	\$4,040
High	Biology	4	\$3,008	\$2,367	0.221	2	\$4,555
High	Other	4	\$3,601	\$1,774	0.260	12	\$42,428
Low	Accounting	5	\$3,654	\$1,721	0.363	2	\$5,885
Low	Biology	5	\$3,003	\$2,372	0.304	3	\$9,819
Low	Other	5	\$2,957	\$2,418	0.300	21	\$63,148
High	Accounting	5	\$3,987	\$1,388	0.393	2	\$6,952
High	Biology	5	\$3,336	\$2,039	0.334	4	\$11,983
High	Other	5	\$3,290	\$2,085	0.330	23	\$77,278

Note: Low income variable = \$40,000; High income variable = \$80,000

Table B8: Summary of Expected Number of Students, Tuition Revenue, and Tuition Discount for Commuter and Resident Students (Variable Costs > 0)

	Expected Number of Students	Expected Net Tuition Revenue	Expected Housing Revenue	Total Revenue	Average Tuition Discount	Discount as a percent of Stated Tuition
Variable Cost = 0						
Commuter Students	293	\$1,010,606	\$0	\$1,010,606	\$1,924	35.8%
Resident Students	318	\$742,674	\$437,560	\$1,180,234	\$3,041	56.6%
Variable Cost > 0						
Commuter Students	250	\$989,097	\$0	\$989,097	\$1,416	26.3%
Resident Students	275	\$780,727	\$377,762	\$1,158,489	\$2,533	47.1%

Table B9: Average Tuition Discount by Academic Quality Profiles, Residential Status, and Variable Cost Assumptions

	QINDEX	Average Tuition Discount	Discount as a Percent of Stated Tuition
Variable Cost = 0			
Commuter Students	1	\$2,418	45.0%
	2	\$2,072	38.6%
	3	\$1,734	32.3%
	4	\$1,856	34.5%
	5	\$1,441	26.8%
Resident Students	1	\$3,723	69.3%
	2	\$3,224	60.0%
	3	\$2,982	55.5%
	4	\$2,444	45.5%
	5	\$2,697	50.2%
Variable Cost > 0			
Commuter Students	1	\$1,915	35.6%
	2	\$1,570	29.2%
	3	\$1,230	22.9%
	4	\$1,353	25.2%
	5	\$938	17.5%
Resident Students	1	\$3,219	59.9%
	2	\$2,724	50.7%
	3	\$2,481	46.2%
	4	\$1,941	36.1%
	5	\$2,195	40.8%

Table B10: Average Tuition Discount by Academic Major, Residential Status, and Variable Cost Assumptions

	Major	Average Tuition Discount	Discount as a Percent of Stated Tuition
Variable Cost = 0			
Commuter Students	Accounting	\$1,654	30.8%
	Biology	\$1,890	35.2%
	Other	\$2,168	40.3%
Resident Students	Accounting	\$2,621	48.8%
	Biology	\$3,138	58.4%
	Other	\$3,174	59.1%
Variable Cost > 0			
Commuter Students	Accounting	\$1,150	21.4%
	Biology	\$1,385	25.8%
	Other	\$1,663	30.9%
Resident Students	Accounting	\$2,110	39.3%
	Biology	\$2,635	49.0%
	Other	\$2,666	49.6%

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