Tuition Discounting for Revenue Management

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Paper presented at the Association for the Study of Higher Education's 35th Annual Meeting, November 17-21, 2010. Indianapolis, IN.

Abstract

Over the past decade, institutionally-funded financial aid (or "tuition discounts") have been the fastest-growing item within most public four-year college and university operating budgets. One explanation for this trend is due to the changing structure of public colleges' revenue streams, as tuition and fees have replaced state appropriations as a viable and predictable source of funding. This analysis explores the extent to which expenditures on institutionally-funded financial aid generates additional revenue for public four-year colleges and universities. Using institutional data (n=174) from 2002 to 2008, the analysis implements a generalized method of moments (GMM) technique and concludes that aid indeed can be leveraged for revenue generation. However, this relationship is only sustainable to a certain point. When unfunded tuition discount rates exceed approximately 13 percent, institutions may experience diminishing revenue returns to this financial aid investment.

Keywords: institutional aid, net tuition revenue, generalized method of moments

Tuition Discounting for Revenue Management

Public colleges and universities have traditionally relied upon state appropriations as a primary revenue source for financing institutional operating budgets. Over the past two decades, however, this source of support has been strained due to a variety of changes in the nation's economic, political, and demographic landscape (Archibald & Feldman, 2008; Heller, 2006). As these changes persist, public colleges and universities are seeking out alternative sources of revenue to replace funds that were once publicly available. Tuition and fees[1] have emerged as one of the most viable "alternative" revenue sources for many public four-year institutions, as this source accounts for 30 percent of their total operating revenues (Derochers, Lenihan, & Wellman, 2010). To the extent that students are now viewed as a source of revenue, colleges and universities are experimenting with enrollment and revenue management strategies, such as "tuition discounting," to capitalize on these resources (Hossler, 2004; 2006).

Tuition discounting is the practice of awarding institutionally-funded financial aid in the form of non-repayable grants and scholarships to students. Similar to state and federal grant programs, colleges provide aid to reduce the "sticker price" students pay for college. In 2008, students attending public four-year institutions received over $14 billion in grant and scholarship aid from federal, state, and institutional providers; campus-based aid programs accounted for approximately 33 percent of this total amount (U.S. Department of Education, 2009). If federal and state government offer financial aid, then why do colleges also aid students? This question has been asked by several scholars (Martin, 2005; McPherson & Schapiro, 1998; Weisbrod, Ballou, & Asch, 2010) and a common conclusion is that aid is used as an enrollment management tool to fulfill such objectives as enticing students to choose their college over a

[1] Hereafter, "tuition and fees" is referred to as "tuition."

competitor, recruiting academically or athletically talented students, reducing price barriers for lower-income students, or to simply increase enrollment capacity (Curs & Singell, 2010; DesJardins & McCall, 2010; Reed & Shireman, 2008). By offering tuition discounts, colleges can "craft a class" of desirable students that helps colleges reach various objectives (Duffy & Goldberg, 1998).

However, colleges also offer tuition discounts for revenue management purposes (Breneman, Doti, & Lapovsky, 2001; Cheslock, 2006). This is particularly true given the tight financial environment in which public institutions operate. Many institutions are becoming strategic in their use of tuition discounts so that aided students not only enhance institutional prestige but they can also enhance institutional revenue goals. Institutions may desire to achieve a variety of enrollment management objectives through the strategic use of tuition discounts, but these efforts are ultimately conditioned by the financial benefits and costs associated with aiding students. It is from this perspective that the following study is framed because, from the budgetary standpoint, the most important reason colleges engage in discounting is to generate or enhance net tuition revenue (Lasher & Sullivan, 2005).

According to economic theory, the process of aiding students can yield financial benefits for colleges. By enticing students *and their associated tuition dollars* to enroll, colleges can strategically leverage aid to maximize (or at least enhance) the amount of net tuition revenue generated per aided student. However, overly-aggressive or inefficient discounting strategies can sometimes reduce, rather than enhance, revenue streams (Davis, 2003; Massa & Parker, 2007; Redd, 2000). In today's tight fiscal environment it is not in an institution's best financial interest to offer tuition discounts that erode tuition revenue generation. If public institutions choose to engage in discounting to achieve revenue generation objectives, then it behooves

administrators and college leaders to understand the impact this strategy has on the financial wellbeing of the institution. To that end, this paper addresses the following research questions. *To what extent does the provision of financial aid yield financial benefits to public colleges and universities? Secondarily, is there a point at which the provision of institutional aid no longer yields financial benefits to the institution?*

This study uses a dynamic panel dataset of public four-year colleges (n=174) between 2002 and 2008 to empirically examine the relationship between tuition discounting and tuition revenue generation. The panel dataset is robust with 1,218 total observations. Framed within microeconomic theory of firm behavior, this study finds that tuition discounting can indeed be a tool for enhancing net tuition revenue, but only to a limited extent. After controlling for various economic and institutional indicators, it appears that colleges offering unfunded tuition discount rates[2] beyond 13 percent begin to yield smaller amounts of net tuition revenue. This finding implies that many public institutions are diminishing their net tuition revenues by aiding students; institutions operating beyond this threshold may find it in their financial best interests to design a more economically efficient method of distributing financial aid. All institutions will design aid strategies that align with their organizational culture, resource capacity, and academic mission, but findings from this analysis urge them to take fiscal caution when engaging in discounting practices. Results from this analysis have implications on the financial risks and rewards of current discounting trends, and they also draw attention to the tradeoffs that exist when aiding students from unfunded sources.

[2] Tuition discount rates are calculated by dividing total institutional aid expenditures by gross tuition revenue, as advocated by Baum & Lapovsky (2006).

The economic pressure to discount

The expansion of institutional aid has steadily grown in recent years. This expansion can be viewed in relation to state higher education spending and trends in rising tuition rates. Nationally, states are scaling back appropriations for higher education which has resulted in students carrying a greater cost-sharing burden for their education (Johnstone & Marcucci, 2010; Johnstone, 2004). Due to this shift in cost-sharing, tuition and fees have risen inversely with state appropriations and institutions are now relying on students as a primary revenue source. This can be seen in the table below, where institutions received nearly $5,000 in net tuition revenue per student in 2002 but by 2008 this value had increased to $6,649. Alternatively, state appropriations per student declined by nearly $1,000 during the same period. The financial structure of public institutions has slowly shifted towards tuition reliance over the past several decades, but in recent years this trend has been accentuated (McPherson & Schapiro, 2006).

Table 1: Primary revenue sources per FTE (2008 dollars)

	Gross tuition	Net tuition	State appropriations
2002	$5,972	$4,956	$8,381
2003	$6,373	$5,356	$7,774
2004	$6,889	$5,789	$7,220
2005	$7,264	$6,119	$7,049
2006	$7,560	$6,337	$7,056
2007	$7,762	$6,458	$7,304
2008	$8,003	$6,649	$7,563

There is a wide degree of variation across the country with regard to state subsidization of public institutions. Some institutions receive relatively low levels of state financial support, resulting in greater pressure to generate revenue from students through tuition and fees. These institutions may face greater pressure to discount tuition by providing aid from their own operation budgets. Alternatively, institutions may generate high levels of state subsidization which allow them to keep tuition levels low for all students. When tuition is low, institutions

may face little pressure to engage in discounting. The extent to which an institution relies on students as a revenue stream is a function of state subsidies, and discounting strategies will invariably be designed to account for these trends.

Since public institutions charge resident and non-resident students two separate prices, there may be an economic incentive to recruit non-resident students in order to generate tuition revenue. Some public institutions seek to maximize non-resident enrollment levels in order to capitalize on the substantially higher price these students pay compared to their in-state peers (Zhang, 2007). Colleges that seek to enroll non-resident students may have financial gains, but they may also face greater economic pressure to provide non-residents with financial aid. So, the extent to which an institution enrolls students from out-of-state may not only impact net tuition revenue but it may also shape tuition discounting strategies. In the private sector of higher education, these economic issues are not relevant since institutions charge a unitary price to all students and endowments, rather than state appropriations, serve as a primary source of subsidization.

Recent discounting trends

In 2008, public four-year institutions awarded more than $5.4 billion of institutional aid to approximately 22 percent of their undergraduate students (U.S. Department of Education, 2009). To put this value into context of the national student financial aid landscape, institutions provide approximately 33 percent of total grant aid to undergraduate students. That same year, federal and state grant programs awarded $4.7 and $4.3 billion, respectively, to undergraduate students enrolled in public four-year institutions. Despite being a primary source of financial aid for a significant proportion of undergraduate students, little empirical research has been

conducted on expenditure patterns of institutional aid. Researchers tend to examine financial aid expenditures patterns at the federal and state levels, but less often at the campus level. Recently, this trend has begun to shift as more scholars are examining public sector tuition discounting patterns (Curs, 2008; Curs & Dar, 2010; Doyle, Delaney, & Naughton, 2009; Doyle, 2010; Hillman, 2010).

When studies have looked at tuition discounting at the campus level, researchers tend to focus on private rather than public institutions. This is understandable, as private institutions have a long history of aiding students and many of these colleges are tuition-dependent which means they rely on aid to generate tuition revenue (Thelin, 2004; Wilkinson, 2005). However, the trend towards tuition discounting is not isolated to the private sector, and researchers have called for further inquiry into the role aid plays within public college and university budgets (Baum & Lapovsky, 2006; Hossler, 2006). Not until the late 1970's and early 1980's did public institutions began to experiment with leveraging aid in similar ways as their private sector counterparts (Potter & Sidar, 1978; Wilkinson, 2005). Due to a low tuition model, combined with a relatively high degree of governmental subsidization, many public institutions did not have much necessity to offer aid out of their own operating budgets. But in today's financial climate, new challenges exist for financial planners who are charged with projecting net tuition revenues and for the strategic use of financial aid (Brinkman & Morgan, 2010). The provision of institutional aid is now a standard business practice in the public sector of higher education. To be sure, expenditures on institutional aid have been the fastest-growing item in most public four-year college budgets during the past decade (Derochers et al., 2010).

When public colleges offer grants and scholarships, the funds are generally available from one of two sources. The most common source is institutional operating budgets, while the

less common source is restricted endowment revenues. The former source of aid is often classified as "unfunded" because the funds can be used for any variety of alternative institutional objectives such as teaching, research, or service. The latter sources of aid are considered "funded" when endowed funds are dedicated to supporting a specific financial aid program; these funds cannot be used for other institutional objectives. Unlike funded aid, unfunded aid is subject to the competing opportunity costs associated with various institutional priorities and are thus subject to the law of diminishing returns (Martin, 2004; 2005). The difference between funded and unfunded aid has significant policy implications for campus officials, particularly among private colleges that operate large endowments (Allan & Lapovsky, 2005). Most public colleges do not have large endowment payouts, so the way in which *unfunded* aid is leveraged bears significant financial implications for many of these institutions (Lapovsky, 2007).

The average discount rate for public four-year institutions in this study is approximately 16 percent, which means that these institutions retain $0.84 for every tuition dollar they charge. Funded and unfunded discount rates are approximately 4 and 12 percent, respectively. Other analyses have found similar discount rates ranging between 14 and 20 percent in recent years (Baum & Lapovsky, 2006; Baum, Lapovsky, & Ma, 2010; Derochers et al., 2010).

Table 2: Average spending on institutional aid (2008 dollars)

	Average award per FTE			Discount rate		
	Funded	Unfunded	*Total*	Funded	Unfunded	*Total*
2002	$326	$691	*$1,017*	5.3%	11.5%	*16.8%*
2003	$310	$708	*$1,018*	4.7%	10.9%	*15.6%*
2004	$302	$798	*$1,100*	4.2%	11.2%	*15.4%*
2005	$311	$835	*$1,146*	4.0%	11.1%	*15.1%*
2006	$326	$897	*$1,223*	4.0%	11.6%	*15.6%*
2007	$310	$994	*$1,304*	3.8%	12.4%	*16.2%*
2008	$338	$1,016	*$1,354*	4.0%	12.3%	*16.3%*

Review of the literature

Public colleges have invested a significant amount of resources into financial aid to meet a variety of enrollment management and revenue management objectives. Literature on tuition discounting tends to focus on the former objective, while there is a significant amount of work to be done in understanding the latter. The purpose of this study is to examine the revenue management objectives of aiding students, yet the enrollment management purposes can not be ignored. Colleges design aid programs to achieve a range of such enrollment outcomes as encouraging academically talented students to enroll in college (Curs, 2008; Ehrenberg, Zhang, & Levin, 2006), reducing price barriers for students demonstrating financial need (Perna, Lundy-Wagner, Yee, Brill, & Tadal, 2010), encouraging students to persist (Chen & DesJardins, 2010; Hossler, Ziskin, Gross, Kim, & Cekic, 2009; Perna, 2010), and even simply meeting the institution's enrollment capacity (Curs & Singell, 2010; DesJardins & McCall, 2010). Several researchers have examined how aid influences these enrollment outcomes, revealing a nontrivial relationship between aid and student participation or persistence behaviors. When one turns attention towards the revenue management purposes of tuition discounting, however, the literature becomes less comprehensive.

McPherson and Schapiro (1998) provide a starting point from which one can frame the revenue management objectives of tuition discounting. Reflecting upon their experiences with campus leadership teams and their observations of national trends, the authors explain that financial aid is a necessary revenue management tool that has developed from the "intense competition among colleges and universities for dollars and students." To them, student financial aid is a "strategic variable" for ensuring the financial wellbeing of an institution. In

order to achieve desired financial outcomes, McPherson & Schapiro (1998) explain that colleges can intentionally exploit students' willingness to pay in order to extract their consumer surplus. Engaging in this revenue management tactic will, in theory, maximize tuition revenue for the institution. In practice, however, institutions offer aid without a thorough interpretation of each student's willingness to pay. As a result, some students end up paying a significantly lower price than what they would actually be willing to pay and the provision of aid can be viewed as an economically inefficient allocation of resources if an institution is awarding "too much" aid to students.

Martin (2005) offers an economic model to further describe the relationship between aid and revenue generation. To ensure that an institution is maximizing its tuition revenue, he explains that the revenue associated with enrolling an additional student should always exceed the average cost of institutional aid. If an institution spends more money on a student compared to the amount it generates from that student's tuition payment, then the college will operate an inefficient aid program that diminishes overall net tuition revenue. A degree of inefficiency is expected within the higher education production function; however, aid expenditures are one of only a few variable cost items within operating budgets. More uniquely, aid expenditures are one of very few budgetary items that can also generate short-term revenue gains.

An example of strategic alignment of discounts for revenue generation can be seen in Massa and Parker's (2007) analysis of a private liberal arts college. In the late 1990's, Dickinson College had been discounting their tuition by more than 50 percent to incoming freshmen. The institution was only generating $0.48 cents for every dollar charged in tuition. At this pace, the institution would approach long-run fiscal insolvency or at least fiscal strain. To avoid this "net tuition revenue dilemma," the institution reduced its discount rate to approximately 30 percent by

2007 and actually generated greater amounts of tuition revenue in the process. Their solution included a strategic effort to target aid to a smaller portion of the student body while simultaneously analyzing students' willingness to pay. Between the late 1990's and mid 2000's, students continued to express high demand for a Dickinson College degree, so they continued to enroll even if they did not benefit from as deep of discounts earlier cohorts received. The authors concluded that "discounting gone wild can handcuff a college...where it doesn't have sufficient revenue to cover expenditures or it reduces expenditures and threatens the quality of educational experience" (Massa & Parker, 2007). Many public institutions do not have as inelastic demand curves as Dickinson College or other elite private institutions, yet the fundamental economic lessons from the private sector experience remain relevant to public institutions.

An additional empirical example of aid's relationship to net tuition revenue is found in Summers (2004). Here, the author utilizes institution-level data from 1997 to 2000 to uncover a statistical relationship between institutional aid awards and net tuition revenue among private colleges and universities. After implementing an econometric model, net tuition revenue was found to increase when expenditures on institutional aid increase. This linear and positive relationship led the author to conclude that aid is being "distributed in a manner that boosts enrollment and earns a net revenue return from these expenditures." However, such a conclusion is counter-intuitive to the economic theory and to that which was found in Massa and Parker's (2007) analysis. Aid is expected to increase tuition revenue, but after a certain point there is a high likelihood that aid actually diminishes this source of revenue. In other words, the cost of aiding students is expected to eventually outweigh the (financial) benefits of enrolling students. Summers' model does not account for this possibility.

Considering the limited empirical findings that have tested this economic model, in addition to the conflicting results that have surfaced, questions remain regarding aid's relationship to net tuition revenue. Do similar patterns found in Massa and Parker (2007) hold when multiple institutions are analyzed? Also, to address Summers' work (2004), is it possible that the relationship between aid and revenue is hill-shaped rather than linear, where aid can generate additional revenues only to a certain threshold at which time revenues begin to decline when "too much" aid is awarded?

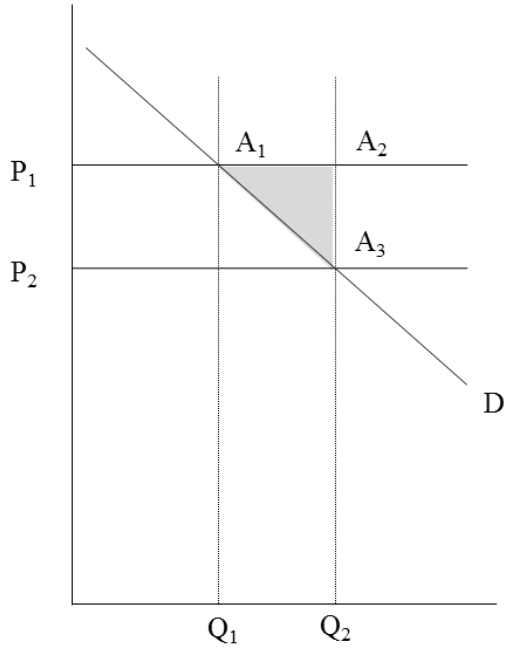
Conceptual framework

Microeconomic theory of non-profit firm behavior provides the conceptual framework for this analysis. Economists have offered conceptual models demonstrating that net tuition revenue is a function of the following budgetary constraints: price, enrollment, price elasticity, and financial aid expenditures. This conceptual model provided in Figure 1 and is briefly explained below, for additional information on this conceptual model, see Breneman et al. (2001) and Cheslock (2006).

An institution charging tuition, designated by point P_1 in Figure 1, will enroll students up to the point Q_1, where the downward-sloping line (D) represents the students' aggregate elasticity of demand. If the institution discounts its price to P_2, then enrollment will increase to the point of demand, or Q_2. The area within points P_1, A_1, Q_1, represents the institution's gross tuition revenue from non-aided students, and the area under A_1, A_3, Q_2, Q_1, represents the gross tuition revenue of aided students. The area within A_1, A_2, A_3 represents the amount of institutional aid necessary to entice students to enroll to the point Q_2, so this amount is subtracted from gross tuition revenue to calculate net tuition revenue. Net tuition revenue is expressed in

this figure as the non-shaded region below P_1, A_1, A_3, Q_2, and the origin. Due to the two-tiered pricing structure of public institutions, resident and non-resident students face two distinctly different tuition levels and consequently, two different demand elasticities. The economic model designed for this analysis includes two prices and price elasticities; one each for resident and non-resident students.

Figure 1.
The economic relationship between enrollment, tuition, and aid



The nature of this relationship is subject to the economic phenomenon of diminishing returns. For instance, if an institution offered a 100 percent discount rate to all students, then it would reduce the price they pay to zero and enrollment could be maximized to the point of capacity. As a result of fully discounting tuition for all students, however, this institution would no longer yield any net tuition revenue. The shaded area of A_1, A_2, and A_3 would be greater than the gross tuition revenue associated with enrolling students; the financial returns of aiding students would diminish to zero. Because of this tradeoff, it would be inefficient and

unsustainable for tuition-dependent institutions to offer full discounts to all students. Microeconomic theory suggests that institutions can only provide discounts up to a certain point and any additional movement beyond this point will begin to diminish net revenues. It is tempting for colleges to spend additional money on aid simply to maximize their net tuition revenue because of the potential financial benefits; however, the risk of diminishing tuition revenues is profound.

Empirical techniques

Data sources. Public four-year colleges and universities in the U.S. are the primary unit of analysis for this study. Because of the unique financial environment and microeconomic frameworks in which state-funded institutions operate, this analysis excludes all private institutions. The Delta Cost Project provided institution-level data from the U.S. Department of Education IPEDS database. Delta Cost Project data disaggregates financial aid data between "funded" and "unfunded" sources, which is unavailable through IPEDS.

In 2002, a broad range of accounting standards changed the way some institutions report financial aid records. Accordingly, this analysis includes those institutions charging tuition and offering financial aid for each year between 2002 and 2008 (the most recent year available) creating a panel dataset of 174 institutions over seven years (n=1218). Institutions voluntarily reported interstate migration data for odd-numbered years, thus reducing the sample size to include only those reporting data in all years between 2002 and 2008. All financial data are inflation-adjusted using the 2008 Consumer Price Index.

Outcome variable. Variables are selected based on the conceptual theory outlined above. The outcome of interest is net tuition revenue per full-time equivalent student (*NTR*) which is

calculated by the gross tuition revenue less tuition discounts excluding tuition waivers. Under this definition, net tuition revenue is the final amount of funds brought into institutional budgets from student tuition payments.

Predictor variables. Net tuition revenue is expected to be a function of the following economic factors described in the conceptual framework: resident and non-resident sticker price, enrollment, and demand elasticity. Resident and non-resident sticker price is the published amount charged to students during the fall semester and does not include other charges such as room, board, books, supplies, or transportation. Enrollment levels by student residency status are reported for first-time, full-time incoming freshmen students. The percent of in-state and out-of-state freshmen is multiplied by the institution's undergraduate FTE to estimate total institutional enrollment levels based on residency status. Demand elasticity is calculated by implementing a price-point formula (annual percent change in enrollment divided by annual percent change in price). Demand for in-state students is relatively inelastic while non-resident enrollment is elastic. Finally, funded and unfunded tuition discount rates are the key predictor variables of interest and are introduced into the model both linearly and quadratically to account for the potential diminishing returns described in the conceptual framework.

The purely economic model does not control for unique institutional characteristics that are expected to influence net tuition revenues. To that end, additional variables described in the literature review are introduced in a second model. This model includes the economic predictors in addition to such predictors as: percent of undergraduate students who are ethnic/racial (i.e. non-white) minorities, the median SAT score for the incoming freshman cohort, institutional selectivity, and the degree of state subsidization. For SAT, only the 25^{th} and 75^{th} percentile verbal and math scores are available in the dataset, so the average of these two data points are

added together as an estimated median SAT score. In the event that ACT is the dominant standardized test for an institution, then these scores are converted to SAT scores based on the College Board concordance tables (College Board, 2010). Institutional selectivity is calculated by dividing the number of admitted freshmen by the number of applicants, and state subsidization is the total amount of current-year state appropriations by FTE. Each of these variables is continuous in scale and is described in Table 2 below.

Table 3: Descriptive statistics

Variable	Mean	Std. Dev.
Net tuition revenue per FTE	$5,952	2,428.99
Percent minority	0.267	0.1869
Median SAT	1,062	108.038
Selectivity (% admitted)	0.733	0.157
Percent poor	0.100	0.0498
State revenue per FTE	$7,478	3599.16
Elastic (in)	0.499	38.72
Elastic (out)	-3.960	335.14
Enrollment (in)	9,847	7,735.70
Enrollment (out)	2,329	3,247.12
Tuition (in)	$5,352	1,810.07
Tuition (out)	$13,999	4,780.11
Funded discount rate	4.28%	4.87
Unfunded discount rate	11.57%	9.08

Several of these predictor variables are introduced into the model endogenously: enrollment, SAT, selectivity, percent minority, and percent low-income. While this analysis is framed around the assumption that the outcome institutions seek to maximize (or at least enhance) is net tuition revenue, there are several alternatively compelling outcomes related to tuition discounting practices. The pursuit for high-achieving students as measured by SAT score and selectivity, the priority of ensuring greater student diversity along the lines of race and ethnicity, and assisting low-income students are but three motivations driving colleges to engage

in discounting. It is unclear whether gains in net tuition revenue are leveraged to "craft a class" of desirable students, or whether the opposite may occur; these variables both *influence* and are *influenced by* net tuition revenue. Additionally, the key variable of interests (the unfunded tuition discount rate) is endogenous to the model because aid is utilized to generate revenue but institutions generating greater revenue are able to provide additional aid to students. As a result of the endogeneity these enrollment and aid variables introduce into the model, this model runs the risk of violating several assumptions of ordinary least squares regression. Accordingly, a generalized method of moments model is designed which utilizes instrumental variable techniques to purge endogeneity from the equation. Unit root tests concluded that no endogenous predictors were stationary, thus warranting the use of this technique.

Analytical techniques. This analysis implements an Arellano-Bond generalized method of moments (GMM) technique designed for dynamic panel data estimation (Blundell, Bond, & Windmeijer, 2000; Bond, 2002; Roodman, 2006). Arellano-Bond models are particularly appropriate for panel datasets with large number of cross-sectional units and relatively short periods of time. The GMM technique allows for estimating regression models in which some predictor variables are not exogenous to the model. In this case, enrollment profiles and tuition discount rates are endogenous to net tuition revenue and will decrease the model efficiency if not treated endogenously. In addition to being robust to model endogeneity, GMM also accounts for autocorrelation that is often present in panel data. This allows researchers to include a lagged value of the dependent variable as a predictor in the model, which is particularly appealing since current-year revenue streams are best predicted by the previous years' budget. Based on the results from the Wooldridge test for autocorrelation, the model indeed suffers from autocorrelation and if gone uncorrected will yield biased parameter estimates (Drukker, 2003).

The Arellano-Bond model is implemented in two stages. It first takes the first-difference of the regression equation in order to eliminate the unobserved institutional-specific effects. Next, it utilizes the lagged values of endogenous predictors as instruments in subsequent first-differences. The second step demonstrates the unique advantage GMM has over two-stage least squares (2SLS) estimates; unlike 2SLS, GMM produces its own instruments by lagging the endogenous variables from within the dataset. The "system" GMM technique implemented in this study takes advantage of both levels and differences of the data, for more details see Blundell & Bond (1998) and Roodman (2006).

The model is expressed through the following equation:

$$y_{it} = \alpha_{it} + \beta_1 y_{it-1} + \gamma_2(W_{it} - W_{it-1}) + \gamma_3(Z_{it} - Z_{it-1}) + (e_{it} - e_{it})$$

where *y* is the inflation-adjusted net tuition revenue per FTE, α is the intercept, W is the vector of endogenous variables and Z is the vector of exogenous variables for each institution (i) in each period of time (t). The error term, e, is robust to small sample sizes (Windmeijer, 2005).

The successful implementation of GMM requires that the instruments meet two conditions. First, instruments must provide a source of variation for the model and secondly the lags must provide an exogenous source of variation for the model (Roodman, 2006). To meet the first condition, instruments must be strong and this strength can be identified through the first-stage two-stage least square F-value. If the F-value is greater than 10, then the instruments are generally considered to be strong although this is only a "rule of thumb" that econometricians have yet to agree upon (Bound, Jaeger, & Baker, 1995; Stock & Yogo, 2002). To meet the second condition, instruments must be valid; the Hansen-J test with a chi-square distribution is implemented to address instrument validity. If the Hansen-J test is significant, then the instruments are systematically correlated with the error term, rendering them invalid. Table 4

provides information on the strength and validity of the instruments, concluding that all instruments are valid and three are unambiguously strong.

Table 4: F-statistics for first-stage 2SLS fixed effect estimate of instrument strength

	F-statistic
Percent minority	406.45***
Selectivity (% admitted)	9.52***
Median SAT	99.28***
Enrollment (in)	97.07***
Enrollment (out)	27.98***
Percent poor	12.67***
Funded discount rate	16.59***
Unfunded discount rate	19.20***

*Note: * p<.01, ** p<.005, *** p<.001*

After implementing the GMM model, autocorrelation has successfully been addressed and eliminated from the model as evidenced by the rejection of the null AR(2) Arellano-Bond hypothesis (Arellano & Bond, 1991). One additional caveat when implementing GMM techniques rests with the total number of instruments utilized in the model. It is possible for researchers to include too many instruments, which yields an artificial correction for endogeneity (Roodman, 2009). One rule of thumb is that the number of instruments does not exceed the number of groups. When this occurs, the model is over-identified and estimates are biased. This analysis utilizes 66 and 69 instruments for Models 1 and 2, respectively, and a total of 174 groups.

Models with quadratic predictors. The funded and unfunded discount rates are introduced into the model as linear predictors of net tuition revenue. Their quadratic values are also introduced to account for the potential diminishing returns that are expected to exist with the outcome variable. Under the diminishing return principle, the linear relationship should yield positive coefficient estimates representing an upward-sloping relationship between discount rates

and net tuition revenue. The quadratic value is expected to be negatively-sloping which would indicate that at some point the linear value begins to diminish downwards toward zero. By calculating the vertex of these coefficients, one is able to estimate the point at which discount rates begin to diminish net tuition revenues.

Limitations. This study is limited in various ways. First, the data source does not enable us to examine all public four-year institutions for all years between 2002 and 2008. Only those submitting state residency data and those providing institutional aid were included in this study, which limited the total number of observations to account for approximately one-third of the total public four-year population. While there is no way to address this data limitation, caution should be taken when interpreting and generalizing these results. Second, the GMM technique cannot be implemented for separate Carnegie Groups because the number of instruments would invariably be larger than the number of within-group observations. It is possible that variations among Carnegie groups exist, but the GMM technique used in this paper would be inappropriate for such an analysis. Finally, the GMM model is designed to offer a parsimonious solution to the challenges associated with instrumental variables. While all instruments are jointly *valid* in this study, some are only moderately *strong* (SAT and percent poor) demonstrating that GMM models are not necessarily immune to the challenges associated with instrumental variable techniques. Difference GMM techniques significantly suffer from weak instrument bias, so system GMM is employed in this paper to address this limitation.

Key findings

The average discount rate for institutions in this sample is 15.9 percent; disaggregated by aid source, the unfunded discount rate is 11.6 percent and the funded rate is 4.3 percent (Table

3). These rates have remained relatively stable between the years 2002 and 2008. However, total expenditures on institutional aid have increased 54 percent during the years studied, increasing from $2.4 in 2002 to $3.7 billion in 2008 as have net tuition revenues. This paper has explored the nature of this relationship, asking to what extent tuition discounting may be a mediating factor in tuition revenue generation. Is there a systematic relationship between aid and net tuition revenue after controlling for other factors such as tuition, enrollment, and other institutional characteristics?

Results from this study identify a non-trivial and systematic pattern between tuition discounts and net tuition revenue. More specifically, unfunded discounts generate gains in net tuition revenue, *ceteris paribus,* but these gains will eventually begin to diminish after a certain threshold. The economic model (Model 1) offers a conservative estimate of this threshold, as this model does not control for such important contextual factors as enrollment profile, external subsidies, and selectivity; the full model (Model 2) accounts for these factors and offers a less conservative estimate for this threshold.

Results from Model 1 conform well to the economic theory described above. Holding all else equal, tuition rates for in-state students express a positive relationship with net tuition revenue. Institutions charging higher tuition prices yield greater net tuition revenue, which would be expected according to the economic model. Similarly, institutions enrolling a greater quantity of students (from both in- and out-of-state) also generate greater quantities of net tuition revenue, holding all else equal. Tuition and enrollment are expected to have positive relationships with net tuition revenue, as expressed in Model 1.

The Model 1 coefficient estimates for funded and unfunded tuition discounts also behave in ways that conform to economic theory. One-unit increases in both funded and unfunded

Table 5: Regression models explaining net tuition revenue per FTE, 2002-2008

	Model 1		Model 2	
Lagged net tuition revenue	0.811154	***	0.7960124	***
	(.019)		(.021)	
Elasticity (in)	-0.34737		-0.142111	
	(.464)		(.2672)	
Elasticity (out)	0.528312		0.0046026	
	(.455)		(.0428)	
Enrollment (in)	0.015507	***	0.0115511	***
	(.004)		(.0033)	
Enrollment (out)	0.05553	***	0.0608698	***
	(.01)		(.0064)	
Tuition (in)	0.187269	***	0.1536294	***
	(.019)		(.0154)	
Tuition (out)	0.000607		0.0094432	
	(.005)		(.0061)	
Funded discount rate	83.42265	***	58.79905	
	(13.569)		(9.2134)	
Funded discount rate (sq.)	-2.15761	***	-2.232381	***
	(.313)		(.317)	
Unfunded discount rate	13.20955	*	14.39962	***
	(8.041)		(7.1122)	
Unfunded discount rate (sq.)	-0.69509	***	-0.565899	***
	(.186)		(.1438)	
Selectivity (% admitted)	-		-230.4595	
			(180.7787)	
Percent minority	-		-246.942	***
			(159.2685)	
Median SAT	-		1.075266	***
			(.3953)	
Percent poor (AGI<$30,000)	-		1579.868	**
			(431.971)	
State appropriations	-		-0.043463	***
			(.007)	
Constant	-210.515	***	-703.8609	
	(74.021)		(444.9405)	
Num. of groups	174		143	
Num. of instruments	73		99	
Post-hoc tests				
Arellano-Bond test for AR(1)	*0.000*	***	*0.000*	***
Arellano-Bond test for AR(2)	*0.829*		*0.376*	
Hansen J test statistic	*0.002*	*	*0.426*	
Difference-in Hansen	*0.236*		*0.397*	

Note: *Small sample standard errors (Windmeijer, 2004) presented in parenthesis*

Note: ** p<.01, ** p<.005, *** p<.001*

discount rates yield positive gains to net tuition revenue, *ceteris paribus*. However, the squared value of these discount rates is negative, indicating a hill-shaped relationship between discounts and net tuition revenue. Financial gains from discounting are experienced, but only to a certain point. The point at which gains begin to level off and diminish towards zero differs for both funded and unfunded aid. A one-unit increase in the funded discount rate is associated with an $83.42 per FTE increase in net tuition revenue. When the funded discount rate reaches approximately 19 percent, however, these marginal benefits begin to diminish. Similarly, unfunded discounts yield $13.21 per FTE gains in net tuition revenue but this financial benefit begins to diminish when unfunded discounts reach 9 percent.

Using the purely economic model, one can empirically support the theoretical relationships described in Cheslock (2006), Martin (2005) and Breneman et al. (2001). However, the relationship between aid and net tuition revenue is expected to vary depending on institutional characteristics. Such factors as state appropriations, minority and low-income student enrollment, selectivity, and SAT scores are expected to be mediating factors that shape the extent to which aid can be leveraged for net tuition revenue gains. Model 2 builds upon the purely economic model by controlling for these additional variables, which results in a less conservative tipping-point estimate between discounts and net tuition revenue gains. After adding these controls, Model 2 finds similar patterns with all the economic variables except for funded discount rates which are no longer found to be statistically significant.

In Model 2, the economic variables continue to conform to the expectations of economic theory where tuition and enrollment remain positively associated with net tuition revenue. Unfunded tuition discounts express a positive relationship with net tuition revenue where a one-unit increase in the discount rate yields a $14.40 increase in net tuition revenue per FTE. The

point at which the marginal financial benefit of unfunded discounts begins to level off and diminish towards zero is estimated at 12.7 percent. So, an institution that offers unfunded tuition discounts will be expected to generate net tuition gains up to approximately 13 percent, but beyond this point the net tuition revenue per FTE is estimated to decline.

Findings from Models 1 and 2 empirically support what has been theoretically described in the tuition discounting literature. That is, tuition discounts from unfunded sources can yield financial benefits to public colleges and universities. Public sector institutional leaders may be inclined to follow their private sector counterparts by leveraging aid to generate tuition revenues; however, results from this study indicate that discounting practices run the risk of fiscal insolvency. Institutions may desire to aid all students for various reasons, but the financial reality is that there are significant financial risks associated with aiding students from unfunded revenue streams. After implementing an econometric technique that accounts for autocorrelation and endogeneity, while simultaneously controlling for relevant institutional characteristics, findings suggest that unfunded tuition discounts can be used for revenue management but they begin to erode revenues when the rate exceeds 13 percent. Funded discount rates do not have a systematic pattern across the two models, so the following section will synthesize the implications associated with unfunded tuition discounts and will offer suggestions for further research. Results from the two models are provided in Table 5 below.

Conclusions and further research

The primary purpose of this study was to identify whether or to what extent tuition discounting yields net financial benefits to public four-year college and university budgets. Much of the literature on tuition discounting focuses on the enrollment management function of

aiding students, leaving a gap in what is known concerning discounting's role in revenue management. Given the austere fiscal environment in the public sector, colleges and universities are looking for ways to maximize revenue from all sources -- particularly student tuition revenue.

This study utilized panel data analysis with GMM techniques to control for autocorrelation and endogeneity and concluded that public institutions are able to leverage unfunded discounts to generate net tuition revenue, but after the rate exceeds approximately 13 percent these benefits begin to diminish. The average unfunded discount for the sample is 11.6 percent indicating that a significant amount of institutions may be running discounts near or beyond a point of economic efficiency. Of the 174 institutions included in this study, 89 offered unfunded discounts in excess of 13 percent between the years 2002 and 2008. These institutions may be at the greatest risk of diminishing their net tuition revenues due to their discounting practices.

Three key implications are associated with these findings. First, the practice of aiding students from unfunded sources has significant opportunity costs that may potentially interfere with other institutional objectives. Since unfunded discounts are made available through operating budgets, resources that support aid programs may be competing with other institutional priorities. While the scope of this analysis did not examine the tradeoffs associated with spending money on financial aid, the nature of aiding students from unfunded sources will inevitably impact other institutional objectives.

Institutional aid expenditures are the fastest-growing item in most public colleges' budgets. This practice accounts for billions of dollars each year and in tight financial times every dollar spent is viewed with scrutiny. This is especially true with regard to expenditures

that are not central to the teaching, research, and service missions of public institutions. If a college is aiding students through unfunded sources, then internal stakeholders such as faculty, trustees, and non-aided students may begin to scrutinize the collective benefits (particularly those associated with net tuition revenue) that are generated by engaging in this practice. The ability to anticipate and identify these opportunity costs may become increasingly relevant to those institutions seeking to increase their unfunded tuition discount rate. Further research could examine whether and to what extent changes in institutional aid expenditures are associated with systematic changes in "mission-critical" or other institutional expenditures items.

Second, an institution's desire to achieve enrollment management objectives and their capacity to generate tuition revenue are two competing but reconcilable goals. Tuition discounting programs are often viewed as enrollment management tools for crafting a class of desirable students, but they also serve revenue management functions. By strategically targeting aid, it is possible for institutions to maximize (or at least enhance) net tuition revenues. Therefore, it is not unreasonable to posit that institutions can jointly strive for crafting a class of desirable students while simultaneously enhancing their revenue profiles. Further research should continue to explore how institutional aid programs are impacting the enrollment profile of students *and* revenue outcomes for institutions. Some colleges have initiated "no-loan" programs where funded discounts are targeted to students who qualify for need and non-need-based criteria. Research could examine the extent to which the initiation of these programs has simultaneously enhanced enrollment goals (e.g. student diversity) *and* revenue goals.

And third, aggressive price discounting from unfunded sources has non-trivial impacts on the financial wellbeing of public institutions. University administrators may be inclined to offer discounts to craft a class, but these efforts can only be sustained to a certain threshold.

Eventually, institutions that aid students from unfunded sources will approach economic inefficiencies that are neither politically nor financially sustainable. In today's financial climate where institutions are challenged to "do more with less," campus leaders will face greater accountability demands from trustees, budget officials, and academic leadership to operate discounting programs that enhance tuition revenues. Institutions that operate "deep" discounts will likely need to revisit their strategies and find new ways to achieve enrollment objectives without accentuating financial risks. To inform practice in this area, further research could examine the characteristics associated with those institutions falling beyond the 13 percent threshold found to diminish net tuition revenues; perhaps these institutions enroll many lower-income students that have unmet financial need, or perhaps they are positioned low in college ranking guides and are using aid to recruit students with high SAT scores. These questions are beyond the scope of this paper, but further research could examine how these institutions allocate aid based on need and non-need criteria.

In conclusion, colleges offering no tuition discounts are bound to set themselves at a competitive disadvantage in today's academic marketplace. Today's environment makes aiding students from campus operating budgets a common business practice in the public sector of higher education. Institutions may desire to offer aid to all students, but they are economically constrained from doing so; as a result, they offer aid to a select group of students in ways that are not always economically efficient. Ultimately, every institution must design its discounting strategy that fits its own unique circumstances, but this study raises awareness of the financial risks associated with tuition discounting.

Appendix A: Correlation matrix

	NTR per FTE	Selectivity	Pct. Minority	Median SAT	Pct. Poor	State rev.	Elasticity (in)	Elasticity (out)	Enroll. (in)	Enroll. (out)	Tuition (in)	Tuition (out)	Fund. Disc.	Unfund. Disc.
NTR per FTE	1													
Selectivity	-0.2756	1												
Pct. Minority	-0.033	-0.2342	1											
Median SAT	0.5076	-0.4455	-0.1362	1										
Percent poor	-0.3792	-0.0032	0.5909	-0.3616	1									
State rev per FTE	0.0603	-0.221	0.3314	0.3849	0.1361	1								
Elasticity (in)	-0.0218	0.0023	0.0541	0.0358	0.0497	0.0564	1							
Elasticity (out)	-0.0142	0.0205	0.0229	0.0253	0.0268	0.0381	-0.0052	1						
Enrollment (in)	0.2919	-0.2696	0.1892	0.5325	-0.0656	0.4822	0.0336	-0.0005	1					
Enrollment (out)	0.5263	-0.0596	-0.0506	0.4286	-0.2612	0.2162	0.0201	0.0187	0.4612	1				
Tuition (in)	0.7566	-0.2467	-0.0719	0.4405	-0.357	0.0069	-0.0403	-0.0257	0.1055	0.2422	1			
Tuition (out)	0.6845	-0.4094	0.1674	0.6588	-0.211	0.2688	-0.0051	-0.0049	0.5064	0.3593	0.6418	1		
Funded discount	-0.0114	-0.1946	-0.0222	0.1864	0.0304	0.2629	0.0105	0.0171	0.0029	0.098	0.1211	0.1774	1	
Unfund. discount	-0.1211	-0.1402	0.2034	0.1127	0.2619	0.2164	0.051	0.0477	0.1827	0.061	0.0101	0.0263	-0.0137	1

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