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An Analysis of Tuition and Enrollment in Higher Education: Measuring Price Elasticity of Student Quality

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Abstract

The hierarchical nature of higher education, in which schools compete in small enclaves for the best students, and competition for higher rankings among private, non-profit liberal arts colleges has prompted some schools to drastically increase their tuition in order to correspond with the price changes of rival institutions. Since top liberal arts schools operate with sizable excess demand for enrollment spots, significant tuition alterations generally do not affect the quantity of enrolled students at these schools. However, the extent to which increases in tuition affect the quality of enrolled students has not been thoroughly examined. This study directly analyzes the sensitivity of student quality to a change in tuition. This analysis includes the development of a theoretical model that relates student quality to price by maximizing the educational reputation of a non-profit, liberal arts college subject to its tuition revenue minus its cost of operation. This model is used to derive an equation for the price elasticity of student quality and then is tested empirically by measuring the effect of tuition changes on student quality. The results show a more significant negative relationship between full tuition and student quality for lower ranked schools.

I. Introduction

In 2004, the University of Richmond, a private, non-profit liberal arts college, decided to raise the total cost of attendance for its 2005-06 first-year students by 27 percent. As an institution that is primarily concerned with maximizing its reputation, it is safe to assume that one of the objectives of this price modification was to enhance the quality of the university and its incoming students. While it is easy to see how additional revenue could be used to enhance the academic quality of a school's faculty and physical resources, it is more difficult to discern how an increase in net tuition affects the enrollment decisions of students. Some studies speculate that enrollment may be positively related to tuition. Rapidly rising prices at private institutions in the 1980's, characterized by a nominal growth of 106 percent between 1981 and 1989, were met with increased enrollment applications at many selective schools. Some have hypothesized that this was due, in part, to full tuition amounts acting as a signal of quality. Not wanting to lower their actual or perceived quality, private college presidents had little reason to keep their prices down; the worst thing a president could do during this time was to lower tuition relative to that of a less prestigious university (Breneman (1994), p.32-33).

More recently, in an article relating college tuition and enrollment figures, Jonathan Glater and Alan Finder (2004) discuss the growing trend of colleges to sharply increase their tuition in order to stay competitive with schools of comparable quality. Many schools use a "follow the price leader" model when making tuition decisions in which colleges competing in the same market for student quality tend to make pricing decisions based on the school that has the highest tuition within their market enclave.

Ultimately, the authors of the article contend that higher tuition accompanied by more applicants at universities may be the result of families associating price with quality or consumers being generally attracted to an education that is subsidized by aid in the form of scholarships and grants.[1] However, the authors do not discuss the wider implications of increasing prices, namely the effects it has on student quality.

While some universities may find pricing policies aimed at increasing their applicant base to be effective, economists are generally split over whether changes in tuition lead to significant changes in enrollment figures. Studies by Epple, Romano and Sieg (2006) and Leslie and Brinkman (1987) conclude that because the market for higher education is so competitive, even small changes in tuition lead to relatively large changes in enrollment. Contrarily, O'Connell and Perkins (2003) and Clotfelter (1991) infer that because liberal arts colleges operate with so much excess demand, any reasonable increase in tuition would not be accompanied by a decrease in applicants or enrollment. These studies comment on how the quantity of student enrollment is affected by price, but say nothing about how price affects the quality of these students.

The objective of this study will be to directly examine the sensitivity of student quality in higher education to a change in tuition. This analysis includes the development of a theoretical model that estimates the effect of price on student quality by maximizing the educational reputation of a non-profit, liberal arts college subject to its tuition revenue minus its cost of operation. The price elasticity of student quality of an institution is then measured empirically by using average SAT scores and the percent of incoming students who graduated in the top ten percent of their high school class as measures of student

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[1] "In Tuition Game, Popularity Rises With Price." New York Times 12 Dec. 2006. <http://www.nytimes.com/2006/12/12/education/12tuition.html>.

quality at different non-profit, liberal arts colleges across the hierarchical educational industry.

II. Literature Review

Numerous scholarly papers have presented theoretical models and conducted empirical studies in order to describe tuition pricing and enrollment decisions within higher education. However, it is more difficult to find studies that directly examine the effect of a change in tuition price on the quality of enrolling students. Hoenack and Weiler (1975) explore tuition policy and whether price elasticity of student quality is significant. Choosing to sample one liberal arts Ph.D. program and one professional program (programs they observe having sizable excess demand), they hypothesize that tuition could be allowed to increase without significantly sacrificing student quality. Using data from the University of Minnesota in 1971-1972, they estimate the effect of a 50 percent tuition increase and find that student quality is mostly unresponsive to a change in price, but they do not rule out the possible substantial effect of tuition changes on demand by students of comparable quality.

Dolan, Schmidt, and Jung (1985) use a three-equation simultaneous model to examine the institutional production of higher education in order to identify the implications of institutional resource allocation. In their empirical model, student quality is treated endogenously and is measured as the median composite SAT score of the 1981 freshmen class at 174 private undergraduate institutions. They find a significant, negative effect of scholarships (aid) on student quality and a positive relationship between student quality and tuition. The seemingly perverse nature of these findings suggests, as explicated by the authors, that less prestigious universities are relatively unsuccessful at attracting quality students through aid and that tuition may be perceived as an index of institutional quality.

Nicholson (1995) expands upon the ideas of Newhouse (1970), who examines the nature of the non-profit hospital by jointly maximizing its quantity and quality of service subject to its costs, and provides a basic theoretical framework for constrained utility maximization of a non-profit organization. Nicholson assumes that non-profit firms make decisions which afford maximum utility to their managers and administration. He maximizes a two-variable utility function, in which both variables are assumed to have positive but diminishing marginal utility, subject to a zero-profit budget constraint. The Lagrangian maximization yields an equation that sets the ratio of the marginal utility of the first variable to the marginal utility of the second variable equal to the ratio of the net marginal cost of each variable. Since the marginal utilities of both variables are assumed to be positive, the marginal cost of each variable is greater than its respective marginal revenue. Nicholson concludes that non-profit organizations expand production beyond profit-maximizing levels, diminishing their own profits, in order to maximize utility.

White and Rothschild (1995) focus on developing a theoretical model that concentrates on educational technology of various inputs and outputs in order to examine tuition pricing. They note that students in higher education are inputs into the educational process as well as recipients of educational services known as human capital output. Assuming that students only care about the amount of human capital they receive and the amount of tuition they pay, White and Rothschild's model maximizes the amount of human capital output allocated to each student subject to the amount of general resources available at a given non-profit university. Thus, tuition is equal to the human capital increment per student. Breneman (1994) uses a similar model that maximizes education inputs, accounting for a school's size and prestige, subject to various revenue sources and costs. Wetzel (1998), on the contrary, concludes that the nature of the competition in higher education is too complex to model holistically. He insists that enrollment demand models must be specific to each institution of higher education to obtain meaningful insight.

The preponderance of papers concerning the market for higher education mention the effect of price elasticity of student demand in determining tuition. An early and influential study of estimating student responsiveness to price was conducted by Schultz (1963). Schultz's study, which was essential to the development of educational economics, was one of the first to examine the returns to investments in human capital to estimate the demand for higher education. Epple, Romano, and Sieg (2006) use enrollment and tuition data from 768 private universities and colleges in the United States for the academic year 1995-1996 to test the effect of tuition on attendance. They conclude that even small changes in tuition lead to relatively large changes in enrollment. Along these same lines, Leslie and Brinkman (1987), Becker (1990), and McPherson and Schapiro (1991) find that there exists an inverse relationship between attendance and cost of enrollment in institutions of higher education. Allen and Shen (1999) agree, concluding that there is a negative association between tuition price and student demand.

Other studies have found that a change in tuition price does not significantly affect enrollment. O'Connell and Perkins (2003) study 138 designated liberal arts colleges to see how price, cost, and reputation affect enrollment decisions. They conclude that because liberal arts colleges operate with so much excess demand, any reasonable increase in tuition would not be accompanied by a decrease in applicants or enrollment. Similarly, Clotfelter (1991) looked at a sample of 24 highly selective institutions of higher education from 1981-1988 and reached the same conclusion.

Epple, Figlio, and Romano (2004) and Hoxby (1997) show that the changing competitive market structure has led American schools to raise their tuition and attract students of greater ability. Both studies generally only note this correlation and do not mention any kind of causation between tuition and student quality. In another analysis of the market for higher education, Winston (1999) contends that universities operate in a very hierarchical industry based on selectivity. Thus, universities compete only within small market sectors for enrollment.

Following this idea, Monks and Ehrenberg (1999) show that universities with different reputations are affected differently by various exogenous variables. In a study of the impact of *U.S. News and World Report* college rankings on enrollment and pricing policies, Monks and Ehrenberg find the effect of an increase in rank on admittance rates and yields is a decrease in the average SAT score of the school's incoming freshmen class. Notably, he finds that this effect is larger for higher ranking schools and less pronounced for lower ranking schools. This "effect discrepancy" among universities implies that the top ranked schools compete in separate market enclaves, as determined by rank, for student quality. While there are many studies and theoretical models that aim to determine price elasticity of demand of students in higher education, this study is unique in that it will theoretically predict and empirically examine the sensitivity of student quality to a change in tuition for different market enclaves in the higher education industry.

III. Theoretical Model

In modeling the market for higher education from the perspective of a non-profit liberal arts college, it is important to specify what exactly the university is attempting to maximize. For the purpose of this study, a university will attempt to maximize its educational reputation, which will be considered a function of enrolled student quality and faculty quality. In particular, this study will be examining the effect of a change in net tuition price on student quality by deriving the price elasticity of student quality. This will be accomplished by modeling the reputation of a university, which will exclude any quality attributed to the institution from sports, social life, quality of life or any other potential factor that may contribute to a university's reputation.[2] It is important to note that students are inputs into the reputation function but only affect educational reputation as enrolled students (in many cases reputation takes into account production externalities and human capital output of students). Thus, the reputation of a school can be enhanced by a student only if that student raises the academic prestige of the university. Ignoring any non-tuition revenue, the budget constraint to a non-profit university's reputation maximization will be the revenue raised from tuition after costs of operation have been subtracted. It will also be assumed that a university will attempt to increase its reputation until its profits are equal to zero. Therefore, the maximization equation for a college takes the form:

[2] While it may be argued that the reputation of a university is a function of more than just student and faculty quality, the solution derived for the two-variable case also holds true for the *n*-variable case.

$$
\text{(i)} \quad \begin{aligned} &\max R = R(S, F) \\ &\text{subject to} \\ &T(S) * q = P_S(S) * q + P_F * F \end{aligned}
$$

where R is the reputation function, S is average student quality and F is average faculty quality. The budget equation follows the zero-profit constraint of non-profit liberal arts colleges by equating total revenue and total cost. Total revenue is the full tuition price per student, T, multiplied by the quantity of incoming students, q. Total cost is a function of quantity of incoming students and faculty quality multiplied by their average prices which are P_S and P_F respectively. For the purpose of this model, the quantity of incoming students is assumed to be fixed as most liberal arts colleges have enough excess demand to fill enrollment openings. Lewis and Winston (1997) note that nearly all students receive some amount of subsidy for their education in the form of aid. Given that the presence of high quality students is particularly beneficial to a university's reputation, it is assumed that these students may be entitled to tuition discounts in the form of merit aid. Conceptually, the price of a student can be thought of as the average amount of merit and financial aid awarded. Each student's tuition is therefore equal to the full amount of tuition (or sticker price) as determined by the university, minus any aid he or she receives.

It is assumed that the variables of the reputation function, S and F, tend to increase a university's reputation. Furthermore, the interaction of the two inputs, represented by the mixed partial derivative of the reputation function with respect to student and faculty quality, increases reputation. This can be written as:

$$
\text{(ii)} \quad R_S = \frac{\partial R}{\partial S} > 0, \quad R_F = \frac{\partial R}{\partial F} > 0, \quad R_{SF} = \frac{\partial^2 R}{\partial S \partial F} > 0
$$

in which R_S represents the marginal reputation of student quality and R_F is the marginal reputation of faculty quality.[3] The positive value of R_{SF} reflects the complementary nature of student and faculty quality in the production of reputation.[4] However, it is also assumed that the variables S and F increase the reputation function at a decreasing rate. This can be described as:

$$\text{(iii)} \qquad R_{SS} = \frac{\partial^2 R}{\partial S^2} < 0, \quad R_{FF} = \frac{\partial^2 R}{\partial F^2} < 0$$

The Lagrangian function of a university can be represented by:

$$\text{(iv)} \qquad L(\lambda) = R(S, F) + \lambda\,(T(S) * q - P_S(S) * q - P_F * F)$$

and the Kuhn-Tucker conditions are:

$$\text{(v)} \qquad \begin{aligned} &\frac{\partial L}{\partial S} = R_S + \lambda\,(MR_S - MC_S) \leq 0 && S \geq 0 \quad \text{and} \quad S * \frac{\partial L}{\partial S} = 0 \\ &\frac{\partial L}{\partial F} = R_F + \lambda\,(-P_F) \leq 0 && F \geq 0 \quad \text{and} \quad F * \frac{\partial L}{\partial F} = 0 \\ &\frac{\partial L}{\partial \lambda} = T * q - Ps * q - P_F * F \geq 0 && \lambda \geq 0 \quad \text{and} \quad \lambda * \frac{\partial L}{\partial \lambda} = 0 \end{aligned}$$

where MC is marginal cost and MR is marginal revenue, both in terms of student quality. Assuming that the maximization problem does not yield a corner solution, a university's reputation maximization will involve some amount of both student quality and faculty quality. Also, given the presence of a binding constraint (total revenue must equal total cost for non-profit liberal arts colleges), the Lagrange multiplier (λ) must take on a positive, fixed value and can be interpreted as the marginal reputation of revenue.

[3] By Clairaut's Theorem, $R_{FS} > 0$.

[4] That is to say an increase in faculty quality increases the marginal reputation of student quality. For example, better faculty can utilize student quality more efficiently to increase reputation.

Solving for the marginal revenue and marginal cost of student quality from the total revenue and total cost equations results in:

(vi) $$MRs = q * \frac{\partial T}{\partial S} \neq 0$$

(vii) $$MCs = q * \frac{\partial Ps}{\partial S} \neq 0$$

where $\partial T / \partial S$ and $\partial Ps / \partial S$ are non-zero because it is assumed that a university can exhibit some price control and that the supply curve of student quality is not infinitely elastic. Rearranging the Lagrangian equation so that total revenue is equal to quantity of students multiplied by net tuition (full tuition minus the average price paid to students) and differentiating with respect to student quality gives the first order Langrangian condition:

(viii) $$Rs = -\lambda * q * \frac{\partial (T - Ps)}{\partial S}$$

Solving equation (viii) in accordance with the Implicit Function Theorem[5] for how student quality changes with a change in net tuition and substituting R_F / P_F for λ (solved from the first order Langrangian condition with respect to faculty quality) gives:

(ix) $$\frac{\partial S}{\partial (T - Ps)} = -\frac{R_F * q}{P_F * Rs}$$

Then, in order to get an elasticity equation, equation (ix) is multiplied by (T - Ps)/S to yield:

(x) $$\frac{\partial S}{\partial (T - Ps)} * \frac{(T - Ps)}{S} = -\frac{R_F * q}{P_F * Rs} * \frac{(T - Ps)}{S}$$

5 The Inverse Function Theorem implies that if $\frac{\partial (T - Ps)}{\partial S} = -\frac{Rs}{\lambda * q}$, then $\frac{\partial S}{\partial (T - Ps)} = -\frac{\lambda * q}{Rs}$.

Equation (x) measures the net tuition elasticity of student quality and has a few important implications regarding the nature of elasticity at schools with different amounts of student quality and net price. Since q and P_F are fixed in the short run, the magnitude of a school's price elasticity of student quality varies directly with net tuition and inversely with amount of student quality. All variables in this equation are positive, therefore, student quality is negatively affected by an increase in net tuition. Furthermore, schools that charge relatively large net tuition prices experience greater price elasticity than cheaper schools. Also, a school that enjoys a relatively large amount of student quality is predicted to have student quality amounts that are less price elastic (responsive), that is to say an increase in net tuition would lead to a relatively small decrease in student quality. Similarly, student quality at schools that have relatively low amounts of student quality is expected to be more price elastic. The marginal reputation ratio of faculty to student quality (R_F / R_S) is different across schools but its value should not affect the price elasticity of student quality as schools with different levels of student quality may very well have similar marginal reputation ratios.

Based on the hypothesized inverse relationship between price and quality, this theory is meant to represent the basic enrollment and pricing choices of students and private, non-profit liberal arts colleges, respectively. Although a key assumption of equation (x) is that student quality responds to net tuition levels, a similar outcome is produced when the full tuition elasticity of student quality is derived.[6] This study attempts to establish the elasticity of student quality with respect to price, and to determine if, in fact, the student quality response is the same with respect to full tuition

[6] Assuming that $\frac{\partial S}{\partial P_S} = -\frac{\partial S}{\partial T}$, $\frac{\partial S}{\partial T} * \frac{T}{S} = -\frac{2 * R_F * q}{P_F * R_S} * \frac{T}{S}$

and net tuition at schools of different quality. The extent to which student quality is observed to be influenced by price will determine the nature and magnitude of student quality control that schools can exhibit.

IV. Data

The cohort of schools analyzed in this study is the top 50 private, non-profit liberal arts colleges as ranked by *U.S. News and World Report* (*USNWR*) in 2008.[7] Annual data were extracted from the Integrated Postsecondary Education Data System (IPEDS), *The Chronicle of Higher Education* (*TCHE*), and *USNWR* for the academic years 1996/1997 through 2006/2007. The academic year 1999/2000 was excluded as IPEDS does not provide any institutional data during this period. Descriptive statistics of all variables included in the analysis can be found on Table 1. A liberal arts college, as defined by the 2006 Basic version of Carnegie Classifications, is an institution that emphasizes undergraduate education and awards at least half of its degrees in liberal arts disciplines.[8] These institutions are observed as having sizable excess demand for enrollment and thus are able to meet incoming student quotas (in terms of quantity) regardless of tuition alterations.

Data measuring student quality and relative overall quality of a university were taken from the annual "America's Best Colleges" issue of *USNWR*. The percentage of incoming freshmen that were in the top ten percent of their high school class (Top 10) was taken directly from *USNWR* whereas an institution's average SAT score of the

[7] The U.S. Naval Academy and U.S. Military Academy were excluded because they are public schools.
[8] Before 2000, a liberal arts college was defined as one that awarded 40 percent of its degrees in liberal arts subjects.

incoming freshman class is the average of its 25th and 75th percentile scores.[9] Average SAT scores ranged from 1150 to 1485 and Top 10 data ranged from 22 percent to 94 percent. The rankings provided by *USNWR* were adjusted to account for the reclassification of liberal arts colleges and variability of an institution's rank over the years. If the *USNWR* rank of a school was greater than 40 or not included in the liberal arts category, then it was assigned a rank of 41. The top 40 schools each year were assigned their rank (RANK) and those with a rank of 41 were assigned a rank of zero. The average rank of these schools was approximately 15. Then, a dichotomous variable (RANKNOT) was introduced and set equal to one for schools ranked outside the top 40 and zero for those within the top 40 in a given year. This dummy variable was included in order to measure the effect on student quality of dropping out the top 40 schools. The descriptive statistics show that schools in the sample were not ranked within the top 40 roughly 23 percent of the time. The lagged (previous year's) *USNWR* rank was inserted for each academic year in the data set because students are usually required to accept admission in April in order to matriculate in the fall (and thus make enrollment decisions based on rank information from the year before they enter school). All else being equal, students attempt to maximize the quality of school they attend. Therefore, both RANK and RANKNOT are predicted to inversely affect student quality as a higher rank number (worse ranking) would attract less quality students the next academic year.

All tuition and student aid data were found online using IPEDS. The variable for annual full price of attendance was created using tuition, fee, room and board amounts of full-time, in-state undergraduate students living on campus (TFRB). The TFRB of each school ranged from $23,907 to $44,632 over the ten years. Two different variables were

[9] All ACT scores were converted to SAT scores.

used to represent average net tuition, which is defined as the difference between full tuition and the average amount of student aid given by a school. Student aid information was only available from IPEDS for the academic years 2000/2001 though 2004/2005 and is comprised of institutional, federal and state and local grant aid. Average student aid was calculated by multiplying the percent of full-time, first-time undergraduate students who received aid by the average amount of aid received. The amount of student aid received varied from $3,938.08 to $16,288.65. Student-loan aid was also included in the average student aid calculation for one of the two net tuition variables and was assumed to provide a subsidy of half the face value of the loan.[10] The average subsidy provided by student loans was equal to $806.07. The predicted sign for all three tuition variables is negative as it is assumed, for now, that the top 50 liberal arts schools are similar enough to be considered substitutes in student consumption and thus, ceteris paribus, a relatively high tuition should discourage quality students from enrolling.[11]

Endowment per student (ENDPS) was calculated by dividing a university's endowment, which was accessed online from *TCHE,* as of the beginning of each academic year by the corresponding full-time equivalent undergraduate enrollment of the university as reported by IPEDS.[12] ENDPS reflects the ability of a school to enhance its reputation and draw quality students and varied largely across schools (from $46,497.41 to $962, 291.11). ENDPS was lagged one year and its predicted sign is positive. Year dichotomous variables are incorporated to account for student quality changes that are

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[10] Bosworth et al. (1987) and Hauptman (1985) find the subsidy value of a student-loan to be worth approximately 50 percent of the original value of the loan.
[11] Dolan et al. (1985) note that tuition may positively affect student quality if different tuitions are an indication of "real or perceived quality differences" that are not reflected in other variables.
[12] For the 2002/2003 academic year, full-time equivalent undergraduate enrollment was not reported and was estimated by averaging the data from 2001/2002 and 2003/2004.

consistent across highly ranked liberal arts schools. Institutional dichotomous variables are used to capture the effect of each school's fixed reputation.[13] The aforementioned endowment and tuition variables were converted to real terms based on the year 2006 using the annual CPI for all major expenditure class items.

V. Regression

The estimation method chosen to model student quality was a least squares regression with institution level fixed effects. This technique was utilized in order to look at the change in student quality within schools over time while accounting for fixed institution and year effects. Two different measures of student quality, the percentage of incoming freshmen who were in the top ten percent of their high school class (Top 10) and the average institutional SAT scores, are employed as dependent variables in the regression analyses. The objective of this model is to calculate price elasticity of student quality. This elasticity measures a percent change in student quality for a percent change in price, which can be written as:

$$E_{SQ} = \frac{\%\Delta \mathrm{SQ}}{\%\Delta \mathrm{P}}$$

where SQ is student quality and P is price. The value of the elasticity describes the degree of responsiveness of student quality with respect to price. A greater value of the elasticity signifies that student quality is more elastic (responsive) to price. An elasticity that is less than one and greater than zero means that student quality is price inelastic (relatively unresponsive) whereas a value greater than one means that it is price elastic.

[13] This amount of reputation can be thought of as the inherent amount of prestige a school has that does not change with time.

The student quality, tuition and endowment per student variables were changed to logarithmic form in order observe elasticities in the regression outputs.

The independent variables used to model student quality in the final regressions were chosen based upon theoretical justification, adjusted R^2 in the model, statistical significance, plausibility of positive or negative affect on student quality, and magnitude.[14] Included in the models, henceforth referred to as the SAT model and the Top 10 model, are the variables of full tuition (TFRB), RANK, RANKNOT, and ENDPS. The double-log models of student quality are given below:

$$\ln(SAT_{it}) = \beta_0 + \beta_1(\ln(TFRB_{it})) + \beta_2(RANK_{it-1}) + \beta_3(RANKNOT_{it-1}) + \beta_4(\ln(ENDPS_{it-1})) + \delta_i + \upsilon_t + \varepsilon_{it}$$

$$\ln(TOP10_{it}) = \beta_0 + \beta_1(\ln(TFRB_{it})) + \beta_2(RANK_{it-1}) + \beta_3(RANKNOT_{it-1}) + \beta_4(\ln(ENDPS_{it-1})) + \delta_i + \upsilon_t + \varepsilon_{it}$$

in which *i* denotes institution, *t* is year, δ_i represents institutional fixed effects, and υ_t is year effects.

In order to measure elasticities across different markets based on rank, the cohort of schools under examination will first be assumed to compete in the same market and then will be divided into two equal groups based on average rank over the ten years under examination. An investigation of the empirical output including all schools shows that both models contain independent variables with high explanatory power of student quality. Table 2 and Table 3 give the regression output for the SAT and Top 10 models, respectively. The SAT model yields an adjusted R^2 value of 0.93 and one significant variable. When included in the SAT model, the coefficient on endowment per student is not only statistically insignificant but also has the opposite sign of what had been

[14] LIMDEP 8.0 was used to perform the regression analysis.

predicted. Therefore, analyzing the results of the SAT model without endowment per student seems most appropriate. Most notably in the SAT model, the coefficient of the full tuition variable is -0.045 and significant at the 10 percent level. As this data was transformed by the natural log function, it now measures a percentage change in average SAT score for a given percentage change in full tuition. Thus, a one percent increase in full tuition corresponds to a -0.045 percent decrease in average SAT score. The negative correlation between full tuition level and SAT implies that some quality students are deterred from enrolling at schools with high tuition although, on the whole, SAT scores are shown to be very price inelastic.

A surprising aspect of the SAT model is the apparent insignificance of the rank coefficients on the average SAT score of incoming students. Monks and Ehrenberg (1999) find that an increase in rank number (worse ranking) leads to a decline in an institution's average SAT score on the order of 2.8 points for every one place moved. The inconsequentiality of rank on SAT average in this study may suggest that inherent (non-time variant) institutional reputation is more important to prospective students then year to year measures of school quality. It also may be, though, that the insignificance of rank in this regression is due to missing variables in the data set or the fact that the selection of the school sample was based on 2008 rankings.

Much like the SAT model, the Top 10 model yields a high adjusted R^2 value (0.83) and theoretically expected results. As anticipated, the sign of the coefficient on the full tuition variable is negative but the coefficient itself is not found to be significant at the 10 percent level, implying the effect of full tuition on Top 10 is trivial (Top 10 is very price inelastic). The dummy variable of being ranked outside of the top 40 is both significant at the 5 percent level and negatively correlated with the student quality. The coefficient suggests that dropping out of the top 40 schools would lead to an 8.7 percent decrease in Top 10.[15] It is interesting to note the more profound effect on Top 10 of moving from a ranking of 40 to 41 than from moving from 39 to 40, implying that competition for student quality varies across different rank-based groupings.

Endowment per student also appears to have a statistically significant (at the 10 percent level) effect on student quality. Since the endowment per student data was transformed by the natural log function, its coefficient of 0.065 means that a one percent increase in endowment per student has the effect of increasing Top 10 by 0.065 percent. Although statistically significant, the relatively small magnitude of this coefficient suggests that increasing endowment per student does not necessarily correspond to significant increases in institutional student quality levels.

Since the year 1996 was omitted in both of the models, the positive and increasing values of the coefficients on the year variables show that the average SAT scores and Top 10 values of these 50 liberal arts schools are trending upward with time.[16] While this may be a result of better students attending the cohort of schools under examination, the upward trend likely also reflects the inherent bias of the data. Data from schools that are ranked within the top 50 in 2008 that are not ranked within the top 50 in previous years, perhaps due in part to a poor freshman class in terms of average SAT score or high school class rank, are not included for the years they are outside of the top 50. Thus, the

[15] As Top 10 is measured in terms of percent, this is a percent decrease, not a percentage point decrease.
[16] Note: Values of Top 10 and average SAT are generally increasing. Average SAT scores at these schools are increasing from 1996 though 2005 but then decline slightly in 2006. Top 10 increases from 1996 to 1997, decreases in 1998, and then increases from 2000 through 2006.

measures of student quality are biased upward because only data from the years when schools are ranked within the top 50 are included.

When all of the 50 schools are included in the regression, student quality is shown to be very price inelastic. This suggests that even relatively large increases in full tuition will not be accompanied by significant decreases in student quality. Pooling all 50 schools, however, assumes that the responsiveness of student quality with respect to price is the same among these schools. As it is unreasonable to assume that a top ranked liberal arts college competes directly with a school near the bottom of the rankings, more accurate elasticity calculations could be derived if the cohort is broken down into market spheres where competition for student quality is more equal among schools. Therefore, schools are divided into two enclaves based on average rank.[17] The top 25 schools have an average rank ranging from 1.4 to 27.1 and the rank of the bottom 25 schools varies from 28.2 to 41. The top 25 schools have an average SAT score of 1348.90 and average TOP 10 of 69.24 percent. The bottom 25 schools have an average SAT score of 1265.94 and average Top 10 of 55.33 percent.

The regression output for the SAT and Top 10 models of the top 25 schools is shown in Table 4 and 5, respectively. It is interesting to note that the coefficient on full tuition in the SAT model is relatively more inelastic compared to the SAT model which included all 50 schools. The SAT model shows that the effect of tuition, fee, room and board is not statistically different from zero at the 10 percent level. This signifies that average SAT scores at the top 25 schools are very price inelastic. This result is not terribly surprising; the theoretical model suggests that as student quality (and presumably

[17] Data limitations and convenience were the main factors in determining the division of the market enclaves. Schools in the top 25 are assumed to have relatively better student quality than lower ranked schools.

a school's reputation as determined by its rank) increases, its price elasticity should decrease. A simple explanation for this result stems from the fact that top quality schools have very few substitutes in student consumption, and thus the demand for high quality schools is relatively inelastic. It is difficult to compare the Top 10 model's full tuition coefficient for the top 25 schools and all 50 schools because neither is statistically significant.

The regression results of both models for the bottom 25 colleges, in Table 6 and 7, further substantiate the theoretical predictions, which state that as student quality decreases it should become more price elastic. The coefficient of full tuition in the SAT model is -0.154 and is significant at the 1 percent level. Thus, a one percent increase in sticker price, for example, is predicted to lower average SAT scores by 0.154 percent (compared to a decline of -0.045 percent in the 50 school regression). The Top 10 model yields a full tuition coefficient of -0.659 and is significant at the 10 percent level. A one percent increase in full tuition corresponds to a 0.659 percent decrease in Top 10 (compared to a statistically insignificant coefficient of -0.083 in the 50 school regression). As anticipated, the student quality of the bottom 25 schools is much more price elastic. As a corollary of prior reasoning, this outcome likely reflects the relative abundance of less quality schools, the demand for which is more elastic when compared to the demand of better schools. Along these same lines, it may hold that these schools are generally regarded as close substitutes. Therefore, a relatively high tuition would be a deterrent to prospective quality students.

The net tuition variables (either with or without loans) were substituted as measures of price for both the SAT and Top 10 models containing all schools, but were found to be insufficient for two main reasons. Firstly, the short panel of financial aid data available meant that most of the variability found in the regressions that included net tuition was attributable to year effects. Secondly, there was not strong justification for the presence of net tuition in the models as the output, found in Tables 8 and 9, showed that student quality was not significantly affected by net tuition in eight separate regressions. In the SAT model, the positive coefficients for net tuition with loans and without are theoretically implausible and statistically insignificant. In addition, the coefficients on rank, not being ranked, and endowment per student in the regressions of this model were found to be of the opposite predicted sign and have no statistically significant impact on average SAT score. These results, taken into consideration with the statistically significant inverse relationship between full tuition level and SAT score, may reflect the possibility that quality students (as measured by SAT score) respond more to the sticker price of an institution than the amount of financial aid they receive.

When net tuition was used in the Top 10 model, the coefficients did have the anticipated signs, but a change in net tuition, rank, not being ranked, or endowment per student had no significant effect on the percent of students who graduated in the top 10 percent of their high school class. Although the SAT and Top 10 models containing net tuition did have higher adjusted R^2 values than those produced when using full tuition, the statistical significance of only the year variables in the net tuition models meant that nearly all of the variability in student quality was due to fixed effects. For these reasons, net tuition may not be the best measure of price in these models.

VI. Conclusion

The aim of this study is to examine the sensitivity of student quality at private, non-profit liberal arts colleges to a change in tuition by calculating the price elasticity of student quality. The analyses presented suggest that not only is there a negative and statistically significant relationship between price and student quality, but also that student quality may very well respond more to changes in full tuition than net tuition. Also, the theory that the price elasticity is inversely related to amount of student quality is largely corroborated by the regression output. This means that relatively large tuition increases negatively affect lower ranked schools more than higher ranked schools. When comparing the SAT model with data from all 50 schools to the SAT model with just the top 25 schools, the price elasticity of student quality becomes more inelastic. A similar comparison of both models containing all 50 schools to the models of just the bottom 25 schools shows that student quality becomes more price elastic. In the bottom 25 school regressions, the SAT model shows that the full tuition variable becomes about 1 percentage point more elastic whereas in the Top 10 model the coefficient of full tuition becomes roughly 6.6 percentage points more elastic. These effect discrepancies reinforce the presence of market enclaves, where different schools can expect different price elasticities of student quality based on rank.

Although the SAT models provide the most theoretically plausible results, there may be more justification for using the percent of students who graduated in the top 10 percent of their high school class as a measure of student quality. Monks and Ehrenberg (1999) speculate that the growing popularity and influence of *USNWR* ranks may give schools reason to adjust their self-reported data in order to increase rank. While both

SAT scores and Top 10 levels are self-reported, it may be easier to manipulate the parameters that determine which SAT score are reported. For instance, a school may or may not choose to include SAT scores from exchange students or part-time students, depending on their affect on the school's SAT average.

Based on the findings of this study, there are certain implications for some schools employing the "follow the price leader" model, where schools raise tuitions to match those of their competitors. Universities choose the schools in which they believe they are in competition with in order to set prices to vie for student quality in market enclaves. However, problems arise when trying to specify which schools directly compete with one another. In this study, market spheres for liberal arts colleges were broken down based on average rank into the top 25 and those ranked 26 through 50. If the original data set analyzed in this study, which included all 50 schools, were considered by the schools under examination to be a reasonable market enclave, the subsequent regressions would show that price elasticity varies for different schools within the same market sphere, meaning similar pricing changes made by schools within the same enclave would have different implications for student quality. In essence, if price affects student quality differently for different schools within same market, then the "follow the price leader" theory does not hold (in that is does not maximize student quality and thus reputation) because schools making similar pricing decisions would see significantly different changes in student quality.

This prompts the question: what determines an enclave? If enclaves are defined as markets in which schools compete equally for student quality, this is a difficult question to answer. It is not unreasonable to believe that market enclaves are established based on rank. Data limitations and convenience determined the market spheres analyzed in this study. More accurate market enclaves could possibly be derived by giving ranks of different years certain weight, rather than just taking the average of all past ranks.[18] However, the year-to-year variability of ranks and extent to which they actually reflect the competition for student quality may prove them unreliable for grouping schools. Future studies may choose to concentrate on enclaves that factor in other similarities between schools that may create competition such as location, quantity of students or degree offerings. It may very well be that accurate measures of price elasticity of student quality can only be done on a per school basis.

Finally, the nature of the double-log model in the regressions may not produce the most accurate price elasticities. The double-log model assumes that the elasticity coefficient between student quality and price remains constant regardless of the absolute price level, while the theoretical model predicts that the magnitude of the price elasticity is directly related to absolute price level. This discrepancy, though, would only have implications for schools within the same enclave that had significantly different levels of tuition.

[18] For instance, ranks from more recent years could be given greater weight than older ranks in order to reflect current market competition.

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Table 1: Descriptive Statistics and Predicted Sign of Variables within the Model

Variable (X)	$\frac{\partial S}{\partial X}$	Mean and Std. Dev.	Max Min
Dependent Variables			
Average SAT (S)		1308.12 69.65	1485 1150
Percent of students who graduated in top 10% of high school class (S)		62.47 14.02	94 22
Independent Variables			
Tuition, fee, room and board ($) [a]	–	36,847.51 4,464.26	44,632.00 23,907.46
Net tuition with loans ($) [a]	–	25,507.33 4,105.19	34,240.06 11,511.92
Net tuition without loans ($) [a]	–	26,328.86 4,006.46	34,835.03 12,946.30
Ranked among top 40 liberal arts colleges by U.S. News	–	14.99 12.95	1 40
Not ranked among top 40 liberal arts colleges dummy variable	–	0.23 0.43	
Endowment per student ($) [a]	+	261,172.73 185,134.25	962,291.11 46,497.41

[a] Real monetary value with base year 2006

Table 2: SAT Model with Full Tuition – All Schools

Variable	ln(SAT score – 50th percentile)	
ln(Tuition, fee, room and board)	-0.042* (0.031)	-0.045* (0.030)
Lagged U.S. News rank of top 40 liberal arts colleges	-0.0001 (0.0003)	-0.0002 (0.0003)
Dummy of lagged U.S. News rank > 40	-0.005 (0.009)	-0.008 (0.009)
ln(Endowment per student)	-0.003 (0.006)	
Fixed Effects		
1997	0.004 (0.003)	0.003 (0.003)
1998	0.008** (0.004)	0.007** (0.003)
2000	0.016*** (0.005)	0.015*** (0.004)
2001	0.020*** (0.005)	0.019*** (0.004)
2002	0.030*** (0.005)	0.029*** (0.005)
2003	0.035*** (0.006)	0.035*** (0.006)
2004	0.043*** (0.007)	0.042*** (0.006)
2005	0.049*** (0.008)	0.049*** (0.007)
2006	0.046*** (0.009)	0.046*** (0.008)
Institutional fixed effects	Yes	Yes
R^2	0.94	0.94
Adjusted R^2	0.93	0.93
Number of observations	424	432
LM test statistic (end p-value)	919.39 (<0.001)	876.74 (<0.001)

Notes:
Standard errors are in parentheses.
*, **, *** Denotes significance at the 10%, 5% and 1% level, respectively.

Table 3: Top 10 Model with Full Tuition – All Schools

Variable	ln(Percent of students who graduated in the top 10% of their high school class)	
ln(Tuition, fee, room and board)	-0.083 (0.236)	-0.160 (0.228)
Lagged U.S. News rank of top 40 liberal arts colleges	-0.002 (0.002)	-0.002 (0.002)
Dummy of lagged U.S. News rank > 40	-0.087* (0.066)	-0.080** (0.065)
ln(Endowment per student)	0.065* (0.040)	
Fixed Effects		
1997	0.031 (0.025)	0.039* (0.023)
1998	0.017 (0.028)	0.036 (0.024)
2000	0.049 (0.034)	0.078*** (0.028)
2001	0.075* (0.035)	0.100*** (0.031)
2002	0.080* (0.039)	0.102*** (0.036)
2003	0.123*** (0.045)	0.0145*** (0.042)
2004	0.129** (0.051)	0.0158*** (0.047)
2005	0.141** (0.059)	0.178*** (0.053)
2006	0.155** (0.066)	0.198*** (0.058)
Institutional fixed effects	Yes	Yes
R^2	0.86	0.86
Adjusted R^2	0.83	0.83
Number of observations	427	436
LM test (end p-value)	665.32 (<0.001)	712.42 (<0.001)

Notes:
Standard errors are in parentheses.
*, **, *** Denotes significance at the 10%, 5% and 1% level, respectively.

Table 4: SAT Model with Full Tuition – Top 25 Schools

Variable	ln(SAT score – 50th percentile)	
ln(Tuition, fee, room and board)	0.048 (0.039)	0.036 (0.036)
Lagged U.S. News rank of top 40 liberal arts colleges	-0.0004 (0.0004)	-0.0004 (0.0004)
Dummy of lagged U.S. News rank > 40	-0.020* (0.013)	-0.020* (0.012)
ln(Endowment per student)	0.005 (0.006)	
Fixed Effects		
1997	-0.001 (0.004)	-0.0002 (0.004)
1998	-0.002 (0.005)	0.0004 (0.004)
2000	0.003 (0.006)	0.006 (0.004)
2001	0.006 (0.006)	0.009* (0.005)
2002	0.010 (0.007)	0.013** (0.006)
2003	0.010 (0.007)	0.014** (0.006)
2004	0.017* (0.009)	0.021*** (0.007)
2005	0.023** (0.010)	0.028*** (0.008)
2006	0.017 (0.011)	0.022** (0.009)
Institutional fixed effects	Yes	Yes
R^2	0.93	0.93
Adjusted R^2	0.92	0.92
Number of observations	211	213
LM test statistic (end p-value)	466.79 (<0.001)	457.32 (<0.001)

Notes:
Standard errors are in parentheses.
*, **, *** Denotes significance at the 10%, 5% and 1% level, respectively.

Table 5: Top 10 Model with Full Tuition – Top 25 Schools

Variable	ln(Percent of students who graduated in the top 10% of their high school class)	
ln(Tuition, fee, room and board)	0.197 (0.231)	0.055 (0.215)
Lagged U.S. News rank of top 40 liberal arts colleges	0.003 (0.002)	0.003 (0.002)
Dummy of lagged U.S. News rank > 40	-0.031 (0.072)	-0.036 (0.072)
ln(Endowment per student)	0.061* (0.037)	
Fixed Effects		
1997	0.012 (0.023)	0.023 (0.022)
1998	0.009 (0.027)	0.032 (0.023)
2000	0.020 (0.033)	0.054** (0.026)
2001	0.027 (0.034)	0.059** (0.028)
2002	0.019 (0.039)	0.052 (0.034)
2003	0.037 (0.044)	0.072* (0.038)
2004	0.052 (0.050)	0.096** (0.043)
2005	0.059 (0.057)	0.112** (0.047)
2006	0.060 (0.064)	0.121** (0.052)
Institutional fixed effects	Yes	Yes
R^2	0.89	0.89
Adjusted R^2	0.87	0.87
Number of observations	214	216
LM test statistic (end p-value)	222.34 (<0.001)	233.83 (<0.001)

Notes:
Standard errors are in parentheses.
*, **, *** Denotes significance at the 10%, 5% and 1% level, respectively.

Table 6: SAT Model with Full Tuition – Bottom 25 Schools

Variable	ln(SAT score – 50th percentile)	
ln(Tuition, fee, room and board)	-0.141*** (0.049)	-0.154*** (0.049)
Lagged U.S. News rank of top 40 liberal arts colleges	0.0002 (0.0004)	0.0001 (0.0004)
Dummy of lagged U.S. News rank > 40	0.009 (0.013)	0.006 (0.013)
ln(Endowment per student)	0.003 (0.010)	
Fixed Effects		
1997	0.010* (0.006)	0.009 (0.005)
1998	0.015** (0.006)	0.016*** (0.006)
2000	0.027*** (0.007)	0.029*** (0.006)
2001	0.033*** (0.007)	0.034*** (0.007)
2002	0.050*** (0.008)	0.051*** (0.008)
2003	0.062*** (0.009)	0.064*** (0.010)
2004	0.070*** (0.011)	0.073*** (0.011)
2005	0.077*** (0.012)	0.081*** (0.012)
2006	0.076*** (0.014)	0.081*** (0.014)
Institutional fixed effects	Yes	Yes
R^2	0.91	0.91
Adjusted R^2	0.89	0.89
Number of observations	213	219
LM test statistic (end p-value)	393.57 (<0.001)	380.49 (<0.001)

Notes:
Standard errors are in parentheses.
*, **, *** Denotes significance at the 10%, 5% and 1% level, respectively.

Table 7: Top 10 Model with Full Tuition – Bottom 25 Schools

Variable	ln(Percent of students who graduated in the top 10% of their high school class)	
ln(Tuition, fee, room and board)	-0.659* (0.437)	-0.579* (0.430)
Lagged U.S. News rank of top 40 liberal arts colleges	-0.004* (0.003)	-0.004 (0.003)
Dummy of lagged U.S. News rank > 40	-0.131 (0.107)	-0.109 (0.104)
ln(Endowment per student)	0.155** (0.079)	
Fixed Effects		
1997	0.052 (0.046)	0.059 (0.043)
1998	0.016 (0.049)	0.049 (0.045)
2000	0.083 (0.059)	0.123** (0.053)
2001	0.139** (0.062)	0.165*** (0.059)
2002	0.177** (0.071)	0.182*** (0.070)
2003	0.259*** (0.084)	0.256*** (0.082)
2004	0.253*** (0.093)	0.259*** (0.091)
2005	0.282** (0.109)	0.296*** (0.105)
2006	0.307** (0.121)	0.333*** (0.116)
Institutional fixed effects	Yes	Yes
R^2	0.78	0.78
Adjusted R^2	0.74	0.73
Number of observations	213	220
LM test statistic (end p-value)	310.32 (<0.001)	313.17 (<0.001)

Notes:
Standard errors are in parentheses.
*, **, *** Denotes significance at the 10%, 5% and 1% level, respectively.

Table 8: SAT Model with Net Tuition – All Schools

Variable	ln(SAT score – 50th percentile)			
ln(Net tuition with loans)	0.002 (0.016)	0.002 (0.016)		
ln(Net tuition without loans)			0.002 (0.017)	0.002 (0.017)
Ranked among top 40 liberal arts colleges by U.S. News	0.0003 (0.0003)	0.0003 (0.0003)	0.0003 (0.0003)	0.0003 (0.0003)
Not ranked among top 40 liberal arts colleges by U.S. News	0.013 (0.012)	0.013 (0.012)	0.013 (0.012)	0.013 (0.012)
ln(Endowment per student)		-0.005 (0.010)		-0.005 (0.010)
Fixed Effects				
2000	-0.022*** (0.003)	-0.021*** (0.003)	-0.022*** (0.003)	-0.021*** (0.003)
2001	-0.019*** (0.002)	-0.019*** (0.003)	-0.019*** (0.003)	-0.019*** (0.003)
2002	-0.011*** (0.002)	-0.011*** (0.002)	-0.011*** (0.002)	-0.011*** (0.003)
2003	-0.006*** (0.002)	-0.007*** (0.002)	-0.006*** (0.002)	-0.006*** (0.002)
Institutional fixed effects	Yes	Yes	Yes	Yes
R^2	0.97	0.97	0.97	0.97
Adjusted R^2	0.96	0.96	0.96	0.96
Number of observations	217	216	217	216
LM test (end p-value)	314.43 (<0.001)	320.28 (<0.001)	314.61 (<0.001)	320.89 (<0.001)

Notes:
Standard errors are in parentheses.
*, **, *** Denotes significance at the 10%, 5% and 1% level, respectively.

Table 9: Top 10 Model with Net Tuition – All Schools

Variable	ln(Percent of students who graduated in the top 10% of their high school class)			
ln(Net tuition with loans)	-0.092 (0.119)	-0.094 (0.122)		
ln(Net tuition without loans)			-0.071 (0.133)	-0.072 (0.136)
Ranked among top 40 liberal arts colleges by U.S. News	-0.002 (0.003)	-0.002 (0.003)	-0.002 (0.003)	-0.002 (0.0003)
Not ranked among top 40 liberal arts colleges by U.S. News	-0.072 (0.094)	-0.070 (0.095)	-0.072 (0.095)	-0.070 (0.096)
ln(Endowment per student)		0.025 (0.074)		0.026 (0.074)
Fixed Effects				
2000	-0.075*** (0.022)	-0.078*** (0.024)	-0.072*** (0.023)	-0.076*** (0.025)
2001	-0.050** (0.019)	-0.051** (0.020)	-0.050** (0.020)	-0.050** (0.021)
2002	-0.053*** (0.019)	-0.052*** (0.019)	-0.052*** (0.019)	-0.051** (0.020)
2003	-0.010 (0.018)	-0.008 (0.019)	-0.009 (0.018)	-0.007 (0.019)
Institutional fixed effects	Yes	Yes	Yes	Yes
R^2	0.91	0.91	0.91	0.91
Adjusted R^2	0.88	0.88	0.88	0.88
Number of observations	221	219	221	219
LM test (end p-value)	255.37 (<0.001)	255.54 (<0.001)	255.31 (<0.001)	255.87 (<0.001)

Notes:
Standard errors are in parentheses.
*, **, *** Denotes significance at the 10%, 5% and 1% level, respectively.