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Cost, quality and enrollment demand at liberal arts colleges

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Abstract

This paper examines the effects of cost, quality and macroeconomic factors on the demand for higher education (represented by the share of admitted freshmen choosing to enroll) at a group of selective liberal arts colleges over the period from 1988 to 1998. Students are segregated by their financial-aid status with different demand equations estimated for each. Students who have no financial need or did not apply for aid are found to have a tuition elasticity close to unity, implying that a 1% increase in tuition will lead to about a 1% decrease in enrollment yield. The analysis of aid recipients suggests that both relative tuition and financial-aid levels play a significant role in determining the enrollment yield of a college. Tuition and room and board levels negatively affect the enrollment yield of this group of students, while grants and loans increase the likelihood of enrollment of admitted students. The evidence on the effects of school quality variables and macroeconomic factors is weak. There is some evidence that a higher ranking in the US News and World Report college guide increases yield, but specific quality measures such as SAT scores have little statistical significance.

JEL classification: I20; I21

Keywords: Demand for schooling; Educational economics

1. Introduction

This study examines the influence of cost, quality and macroeconomic variables on the decisions of students who have been admitted to a selective liberal-arts college. It presents the results of an econometric analysis of enrollment yield—the fraction of admitted applicants who actually enroll—at 102 schools using the Higher Education Data Sharing (HEDS) database over the 11-year period from 1988 to 1998. The schools we examine are those formerly classified by the Carnegie Commission as 'Liberal-Arts Colleges I' and those now classified as 'Baccalaureate Colleges I'.[1] These institutions are all private, mainly undergraduate colleges with selective admissions policies. We address three sets of questions for these colleges. First, what effect does the cost of education have on the yield of potential students? Second, how do quality characteristics of an individual college affect the share of an admitted pool of applicants

[1] A college was considered a Liberal Arts College I by the Carnegie Commission if 40% or more of bachelor's degrees were awarded in liberal-arts fields, and if admission was 'restrictive', i.e. not inevitable, but 'selectively indicated by achievement profile of entering students (high school class rank, and standardized test scores)' (from Carnegie Commission classifications). More information on the selection of sample schools can be found in Buss (2000).

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that chooses to enroll? Third, what effect do macroeconomic factors have in the enrollment yield of selective liberal arts colleges?

Cost factors include tuition, mandatory fees and room and board charges, as well as the size and composition of financial-aid packages. To measure quality we consider both measures of perceived quality, such as the US News and World Report rankings of colleges, and directly observable school characteristics, such as size, average SAT scores, and urban/rural location. The macroeconomic indicators include stock market levels, the level of disposable income and the rate of unemployment.

We find that college costs are strongly and negatively associated with enrollment yield over our sample. Our measures of college quality have less influence, although the effects of improvements in perceived quality are statistically significant. Our sample is not able to identify any significant effects from macroeconomic variables.

2. Background

Economists have taken several approaches to modeling enrollment demand at private universities. Some have emphasized how a given population of prospective students decides whether or not to attend college, while others have attempted to analyze the choice of which school to attend. Some have used student-level data, often from only one school, which facilitates the identification of the effects of determinants that vary across students. Other school-level studies have relied on data sets observed across a number of institutions, allowing the researcher to examine the importance of school-level characteristics more readily. Recognizing that both student-specific factors and school characteristics are likely important in determining enrollment yield, the ideal study would incorporate microeconomic data from a large number of schools. However, data of this sort have not been available.

This section summarizes the results of a few studies closely related to ours. For a broader review of the literature on college demand, see Buss (2000). Two student-level, single-school studies of particular interest are Ehrenberg and Sherman (1984) for Cornell University and Moore, Studenmund and Slobko (1991) for Occidental College. They analyze the likelihood of an individual admitted applicant attending the target school. Both include loans, work-study, and grants offered as well as the relative cost of the school that they chose to attend.

Ehrenberg and Sherman's study examines financial-aid applicants admitted to Cornell in 1981. They find a significant negative effect of net relative cost on enrollment. In their study, higher grants increase the probability of enrollment for applicants significantly, but loans and work-study do not. Moore, Studenmund and Slobko (MSS) find broadly similar results for the entering class of 1989 at Occidental College, though their tuition effect is smaller. MSS also look at non-financial-aid applicants, and find that cost considerations are less significant.

The present study extends Parker and Summers' (1993) study of selective liberal arts colleges, using data from the Higher Education Data Sharing (HEDS) Consortium. Working with the data at the level of the individual college, they estimated the effects on enrollment yield (the ratio of enrollments to admitted applicants) of school-specific costs and quality variables for 87 private liberal arts colleges from 1988 to 1990. They find that higher tuition significantly reduces enrollment yields for non-financial-aid students. For financial-aid applicants, they find no effect of the aid package on enrollment yields, while tuition has a significant and negative effect that is slightly stronger than for non-aid students. Significant school quality effects include non-tuition revenue sources and US News and World Report rankings. The latter result is supported by a recent study by Monks and Ehrenberg (1999).

3. An economic model of enrollment demand

The decision to attend college can be viewed as a three-part process: (1) application (selecting a set of colleges to which to apply); (2) acceptance (each college admits a subset of its applicants); and (3) enrollment (each student chooses which school to attend, or not to attend college). Each of these processes is important in determining how many students attend a particular school in a given year, so a full examination of enrollment demand would involve separate analyses of each of these stages. We examine only the third stage of this process, estimating the effects of cost and quality factors on the matriculation rate of admitted applicants. (See Bezmen and Depken (1998) for a study of the application decision.) Our demand function is developed with respect to a group of selective liberal-arts colleges, which are assumed to be competing for a common, or at least similar, pool of students. Three main categories of factors are considered in our model of this decision: cost, quality and macroeconomic conditions.

3.1. Cost variables

Our primary cost measures are real (inflation-adjusted) tuition (plus required fees) and room and board charges. These two variables proved to have statistically similar effects, so they were summed as a total cost measure. For many students, financial-aid awards discount the cost of attendance. Aid packages usually include some combination of loans, work-study jobs, and both need-based and merit-based grants. The amount of aid that a school

awards to any particular applicant depends on his or her financial need, the strength of the application in relation to other applicants, and the school's financial-aid policies. However, our aggregate data do not allow us to determine a directly comparable measure of the level of financial aid that schools would provide to a hypothetical applicant with a certain level of need and given academic and demographic characteristics. We must therefore use as a proxy the average level of aid provided to students receiving aid. This average award variable for each component of the aid package should capture at least a portion of the differences among schools and over years. However, to the extent that schools' applicant pools differ, any particular student might expect a more generous offer from a school with a weaker pool, where he or she is a relatively stronger applicant, than from a school where his or her application ranks lower. If this is the case, then school quality measures might be negatively correlated with the (unmeasured) individual aid awards. Both school quality and aid award should positively affect yield, so omission of the latter is likely to bias the estimated coefficients of the quality variables toward zero in the regressions for financial-aid recipients.

3.2. Cost of substitutes

The prices and qualitative characteristics of close substitutes are likely to be among the main determinants of the demand for education at a particular school. We study students who have applied to selective liberal arts colleges. We assume that there are two main substitutes for a liberal arts college: other liberal arts colleges and public or private universities. The former are direct competitors, closest in both price and general characteristics, while the latter represent an alternative educational investment that (in the case of public universities) is far less expensive.

The question of exactly which other colleges and universities are the most relevant substitutes is a difficult one. The variables used to measure the price of substitute schools are (1) the average real price of all selective liberal-arts colleges in the HEDS database; and (2) the average real price of public universities located in the college's region.[2]

3.3. Quality variables

Quality variables are measurable academic and other attributes of a college that affect its attractiveness. We consider two kinds of quality measures: direct measures of college attributes and summary rankings or ratings published by external institutions.

We included as direct measures several academic factors: the student/faculty ratio, the average SAT score of enrolling students, and average per-student expenditures on instruction. Non-academic factors we examined include urban/rural location, college size, ethnic diversity, presence of athletic programs, and non-instructional expenditures. Revenue (per student) from endowment or other non-tuition sources may also affect student enrollment decisions, because each dollar of such revenue provides services to the student without increasing his or her cost.

In addition to these direct measures, there are many indirect measures of 'college quality'. Most of these measures are based loosely on variables similar to those discussed above. The best known, longest running, and most controversial is the annual series of rankings published by US News and World Report (USNWR). We use dummy variables for the 'tier' ranking in the national liberal-arts college category of USNWR (Top 25, second tier, third tier, fourth tier) to represent the effects of such ratings on students' choices.[3] We use USNWR over other publications both because it is the best known and also because it is the only ranking that covers our entire sample period.

The degree to which these rankings measure true academic quality is the subject of considerable debate.[4] However, the recent proliferation of similar rankings among competing publishers suggests that prospective students and their parents pay attention to them. Thus, even if they do not provide a very accurate measure of quality, the rankings may be a good indicator of perceived quality, either by measuring public attitudes about schools or by influencing them.

As one might expect, the direct and indirect quality measures are substantially correlated. In our econometrics results, discussed below, we are unable to identify the effects of most of our direct measures with precision. Our preferred specifications rely strongly on our

[2] We use a regional breakdown for the public school cost because students are most likely to enroll at public universities located in their home states in order to take advantage of in-state tuition rates. Since the majority of liberal-arts colleges schools in our sample draw a disproportionately large share of their applicants from their home region, the most likely public-school substitutes are those located nearby. Because there is no in-state discount at private schools, the competition among liberal-arts colleges is generally less regionally focused.

[3] The 'omitted category' in the set of dummy variables includes schools that are either considered as regional colleges by USNWR or are not ranked at all. Since the end of the sample period, USNWR has changed the categories into which schools are ranked. The top 25 plus tiers was in effect during our sample period.

[4] For a sample of the extensive criticism of the USNWR rankings, see Heinz (1989), Webster (1992), Pulka (1995), and Steklow (1995).

indirect quality measure to summarize the effects of 'college quality'.

3.4. Time series macroeconomic variables

In making college decisions, students and parents must decide how much they can pay for college and whether spending money on college has a high expected return relative to opportunity cost. Ability to pay, expected return, and opportunity cost all depend on economic conditions. The following macroeconomic variables were examined as potential indicators: (1) real per-capita personal income in previous year (positive income effect); (2) prime interest rate (negative effect through opportunity cost of investment); (3) unemployment rate (negative effect through parental employment status or positive through lower opportunity cost of school for student); and (4) stock prices (positive wealth effect). In addition a time trend was included to capture variation over time that was not picked up in other variables.[5]

3.5. Dependent variables

We follow Parker and Summers (1993) and model the behavior of aid and non-aid students separately.[6] In each case, our dependent variable is the log of the freshman enrollment yield—number enrolling divided by number of admitted applicants—of that group of students.[7]

4. Data and analysis

4.1. Econometrics

We run ordinary least-squares (OLS) regressions of enrollment yield on the cost, quality, and macroeconomic factors discussed above. We use two specifications: one in which both the dependent and cost variables are measured in natural logs and one in which the cost variables enter linearly. We chose a log specification in part based on the results of Bezmen and Depken (1998), who found the log model to be preferred, and in part because it bounds the predicted values of the dependent variable to be positive and allows the coefficients to be interpreted directly as constant elasticities. We estimate the alternative model with the cost variables in linear form in order to test hypotheses about the effects of equal-dollar changes in tuition and in financial-aid measures. Although not reported here, the results are qualitatively similar when the model is estimated with a fully linear functional form.[8]

In addition to OLS estimation, we estimated both models using a fixed-effects estimator with dummy variables for year and/or school. This estimator provides a stern test for the model because strictly cross-school and/or cross-time variation is eliminated prior to estimating the coefficients. Results based on these estimators can be found in Buss (2000). The fixed-effects model with only time dummies yields similar results to OLS; including school dummies causes little change in the aid-students results but increases the (negative) tuition effect for non-aid students.

A few of the quality variables that the HEDS database provides are very sparsely populated, containing missing values for many schools and years. Including these variables in the regression reduces the total number of observations significantly. Therefore, we perform the regressions both with and without these variables. The additional sample observations gained by removing this variable seem to outweigh the loss of the potential explanatory power of these quality measures. Given that there is substantial correlation among quality factors, the removal of these factors subtracts little from the explanatory power of the regression.

4.2. Results for non-aid students

Students who are in this category are those who are determined by the college not to have a need for financial aid, or who have not applied for aid and have therefore self-selected to pay full tuition. Given that these students are, by the definition of calculated need, able to afford the school of their choice, we might expect that these students come from relatively wealthy families and therefore may worry less about differences in the relative costs of education for the schools among which they choose. If that is true, then students within this category could have lower tuition elasticities than those in the other categories. Our results for non-aid students are summarized in Table 1. Column 1 of Table 1 shows OLS results including all quality measures and two macroeconomic variables. Because of incomplete data for many schools, this regression is based on only 138 observations. Column 2 reports an OLS regression that includes only the US News quality measures and an urban-location dummy. Deleting the other quality variables more than doubles the sample size. Column 3

[5] Only the first two variables are included in the regressions reported here. See Buss (2000) for results including all four macroeconomic variables.

[6] A third category, those who applied and qualified for aid but were denied aid, proved to have too few non-empty observations to include.

[7] Although the enrollment rate is theoretically restricted to the [0, 1] interval, all observations in our sample are comfortably within the (0,1) interval, so actual truncation does not arise.

[8] For a comparison of linear and log-linear estimates, see Buss (2000).

Table 1
Enrollment yield regressions

Group:		Non-aid applicants						Aid applicants					
Specification:		Log-log (1)		Log-log (2)		Semi-log (3)		Log-log (4)		Log-log (5)		Semi-log (6)	
Cost variables	Real tuition, fees, and room and board	−0.600*	(0.361)	−0.761***	(0.157)	−0.600*	(0.361)	−1.270***	(0.228)	−1.180***	(0.127)	−0.069***	(0.0082)
	Mean real cost of other liberal arts colleges	0.563	(4.08)			0.563	(4.08)	−1.175	(1.95)				
	Mean real cost of regional state schools	−0.261	(0.190)			−0.261	(0.190)	−0.023	(0.087)				
Aid	Real grants							0.255***	(0.090)	0.305***	(0.060)	0.0395***	(0.0092)
	Real loans and work study							0.012	(0.039)	0.118***	(0.036)	0.0371***	(0.0085)
Quality measures	USNWR Top 25	−0.228	(0.245)	0.377***	(0.079)	−0.228	(0.245)	−0.138	(0.112)	0.070	(0.051)	0.063	(0.053)
	USNWR Tier 2	−0.083	(0.246)	0.223**	(0.097)	−0.083	(0.246)	0.033	(0.115)	0.069	(0.064)	0.064	(0.065)
	USNWR Tier 3	−0.300∗	(0.176)	0.080	(0.076)	−0.300*	(0.176)	−0.202**	(0.091)	−0.010	(0.050)	−0.019	(0.051)
	USNWR Tier 4	−0.344**	(0.165)	0.068	(0.077)	−0.344**	(0.165)	−0.193**	(0.088)	0.016	(0.047)	0.014	(0.048)
	Enrollment (1000s)	−0.016	(0.071)			−0.016	(0.071)	−0.052	(0.032)				
	Five-year graduation rate	0.936	(0.566)			0.936	(0.566)	0.177	(0.249)				
	Student/faculty ratio	0.0128	(0.0252)			0.0128	(0.0252)	−0.0078	(0.012)	−0.029***	(0.007)	−0.031***	(0.007)
	Percent of students non-White	−0.108	(0.376)			−0.108	(0.376)	−0.170	(0.190)				
	Urban location	0.131**	(0.063)	0.125***	(0.037)	0.131**	(0.063)	0.011	(0.031)	0.024	(0.022)	0.020	(0.022)
	Average SAT score (1000s)	0.367	(0.571)			0.367	(0.571)	−0.009	(0.280)				
	Share of revenue from non-tuition	0.442	(0.393)			0.442	(0.393)	0.131	(0.192)				
	Share of expend. for non-instruction	−0.152	(0.564)			−0.152	(0.564)	0.117	(0.283)				
Macro	Real median family income	1.21	(4.77)					−1.51	(2.57)				
	Prime interest rate	−0.0891	(0.242)					−0.032	(0.127)				
	Time trend	−0.0525	(0.253)	0.0081	(0.0071)	−0.0525	(0.253)	0.067	(0.124)	−0.0044	(0.0047)	−0.0049	(0.0049)
	Constant	−11.5	(79.7)	5.71***	(1.51)	−11.5	(79.7)	36.7	(41.3)	7.27***	(0.93)	0.245	(0.135)
	Adjusted R^2	0.160		0.166		0.160		0.403		0.332		0.314	
	Standard error of estimate	0.332		0.328		0.332		0.178		0.194		0.197	
	Number of observations	138		333		138		168		356		356	

Standard errors shown in parentheses below coefficients. *(**, ***) Statistically different from zero at 0.10 (0.05, 0.01) level of significance.

shows the semi-log specification in which the cost variables enter as levels rather than as logs.

Table 1 shows that non-aid students have an estimated tuition elasticity that is negative and less than one (in absolute value). In all cases, we are able to reject the null hypothesis of zero elasticity at conventional significance levels. The regression results are unclear regarding the role of the cost of substitute liberal-arts colleges. Neither the coefficient of the other liberal-arts colleges' cost nor that of the state-college cost measure is statistically significant. These measures of alternative-school costs may be too broad to pick up school-specific effects, or they may simply not vary sufficiently to yield a significant coefficient.

The results of most quality variables show relatively weak measured influences. However, although few quality variables are independently significant, a joint F test of whether the quality variables are insignificant as a group is generally rejected. The insignificance of individual quality measures may occur because of collinearity among quality indicators. For instance, the US News and World Report ranking may proxy for many of the individual quality measures in students involved in students' enrollment decisions making it difficult to identify the significance of individual factors.

While most of the quality variables are not significant consistently, the results for the US News and World Report ranking in the first tier indicate that inclusion in the top 25 listing does increase the enrollment yield of a school. The results suggest that inclusion in the top 25 increases enrollment yield by about $e^{0.38}-1 = 46\%$ relative to being in the omitted category. Given that the mean enrollment yield for non-aid students is 0.254, this translates to an enrollment yield that is about 12 percentage points higher when a school is included in the top 25 relative to unlisted schools. Being in the second tier has a significant effect of about 25%, or 6 percentage points relative to the bottom tier. The estimated coefficients for the third tier and fourth tier indicate that there is essentially no difference between the third and fourth tiers in yield for non-aid students.

The macroeconomic indicators are not found to have statistically significant effects on enrollment yield. As the non-aid group is, by definition, able to pay for college, and is therefore likely to be in a relatively high income bracket, it may be that changes that occur on a macroeconomic scale do not reach this group of potential students and their families. Note also that our sample period does not include any major periods of recession or inflation. Perhaps future data will provide more useful variation in income and interest rates.

Our preferred specification is shown in column 2. This specification includes a limited set of quality variables and excludes the alternative-school cost and macroeconomic variables. It is worth noting that the time trend is not statistically significant in any of our regressions. This suggests that the cost, quality and macroeconomic variables that we have included in the regression have been successful in explaining the general (downward) trend in enrollment yields that have occurred over the sample period.

Column 3 of Table 1 shows that the results are qualitatively similar when the cost variables are entered as levels rather than logs. The fit of this equation is not quite as good as the double-log specification. It is included in the table both to demonstrate the robustness of the results and for comparison with the regressions for aid students, for which the semi-log specification is required in order to test two important hypotheses.

4.3. Aid students

Our category of 'aid students' includes those students who are shown to have a demonstrated need and who are offered aid. The Parker and Summers results using a similar methodology did not establish a significant effect of aid on these students' enrollment decisions. They propose that this occurred because 'the average aid award to matriculants is a poor measure of a school's financial-aid posture. Differences in offers between matriculants and non-matriculating admittees may be significant.' (Parker and Summers, 1993: 318).

These limitations are present in this study as well, but estimation with our extended sample implies strong effects of financial aid on enrollment yield. Regression results are presented in columns 4, 5 and 6 of Table 1. The results indicate a tuition elasticity of about -1.2, considerably larger that that found for non-aid students. As this population of students is, by the standard definition of need, not fully able to pay the cost of tuition, greater cost sensitivity is expected. The point estimates are again significantly higher than the results found by Parker and Summers (1993) and Moore et al. (1991). They are, however, similar to those of Ehrenberg and Sherman (1984), who found the applicants entering Cornell in 1981 to have an elasticity of -1.09.[9]

Turning to the financial-aid measures, the demand equations show that the average financial-aid offer has a positive and statistically significant effect on enrollment yield. Both grants and loans have significant effects, however we cannot infer which is larger from the dou-

[9] One must be careful in comparing the results of these studies with ours. They used a sample of admitted students for a single year at a single institution. Their cost and aid measures were the difference between the value at the single school and those reported by the student at the most relevant competing school. Thus, all variation in their cost measure was in the competing school's cost. Despite these differences, both methods lead to estimates that can be interpreted as the elasticity of percentage (or probability) of enrollment with respect to relative college cost.

ble-log specification. The larger coefficient on the grants variable implies that a 1% increase in grants affects enrollment roughly twice as much as a 1% increase in loans. But because the average level of grants is larger than the average level of loans, these 1% changes do not correspond to similar dollar amounts. To test whether grants have a greater dollar-for-dollar effect on enrollment than loans, we must examine the results of the semi-log specification in the final column of Table 1, which we discuss below. The substitute-cost results are generally quite similar to those found for non-aid students except that the cost of substitute liberal-arts colleges generally has an anomalously large, although statistically insignificant, point estimate when using the full-quality specification.

As with non-aid students, the quality variables are not individually found to be statistically significant, although *F* tests of the coefficients being simultaneously zero are rejected at the 1% significance level. Column 5 of Table 1 reports the estimated model with only the US News dummies, the urban-location dummy (retained for symmetry with the non-aid model) and the student-faculty ratio. Financial-aid students appear to respond favorably, other things held equal, to schools with few students per faculty member.

The results reported in column 5 for the US News variables are consistent with economic theory and similar to, though smaller than, those found for non-aid students. The point estimate suggests that inclusion in the top 25 increases the likelihood of enrollment by about 8% relative to the omitted category, or about 2 percentage points at the average yield rate of 0.411 for aid students. The macroeconomic indicators again have no significant effects.

Column 6 presents the estimates of the semi-log model. Because the cost and financial-aid variables are measured in real dollar levels in this specification, we can use it to test two hypotheses that are important to college financial-aid policies. First, we can examine whether the grant-vs.-loan composition of the financial-aid package matters to enrollment yield. Second, we can test the hypothesis that only 'net cost'—the difference between total college cost and the average financial-aid package—matters to aid students.

The coefficients on average grants and average loans in the final column of Table 1 are strikingly similar. This suggests that the composition of the aid package does not matter for aid-student yield. A *t* test for equality between the coefficients yields a test statistic of 0.23, which is insignificant at any meaningful significance level. This result contrasts with that of Moore et al. (1991) and seems inconsistent with economic theory. Because loans must be repaid, a dollar of loan should be valued less by a prospective student than a dollar of grant. We can think of two possible explanations for this apparent inconsistency. One is that prospective students may apply a very high discount rate to the distant future, i.e. they may be short-sighted. Because repayment is to occur several years in the future, it may just not be very important to students. (Many parents of teenagers would probably find short-sightedness a plausible characterization of their children's behavior.) Moreover, in this case, the parents may also have personal incentive to support this behavior because loans may shift the financial burden of college costs from their own current expenditures to their children's future spending.

A second possible explanation of our finding, which has some support in the macroeconomic literature on consumption behavior, is that financial-aid students may be liquidity constrained. According to this explanation, expenditures are constrained not so much by a lack of lifetime income as by a lack of current income and liquid assets. Although an additional dollar of loan leads to a smaller increase in the present value of lifetime income (through the subsidized interest rate and deferral of interest accrual) than a dollar of grant, they are equally effective in mitigating liquidity constraints. The existence of federal subsidies for student loans is justified by the presumption of binding liquidity constraints for students with financial need.

With respect to the net-cost hypothesis, the coefficients on the grant and loan variables are considerably smaller in absolute value than that on the college cost variable. To test whether only net college cost matters, we perform a joint test that all three coefficients are of equal absolute value with the sign of the cost variable opposite the sign of the aid variables This hypothesis is rejected decisively with an *F* statistic of 12.4 (the 1% critical value is about 4.7), implying that changes in gross cost levels matter to financial-aid students, even they are compensated by equal dollar changes in the aid package.

5. Implications

In order to explore the implications of our results, we consider how changes in several key right-hand variables would affect enrollment yield. For these experiments, we consider a hypothetical Benchmark College that charges $17 500 for tuition, fees, and room and board, is ranked in the second tier by US News, and admits 625 aid students, of which 40% (250) enroll, and 1000 non-aid students, of which 25% (250) enroll. The average financial aid award is $7500 in grants and $3000 in loans.[10] We use the coefficients from the semi-log specification including only our preferred explanatory variables and no time or school dummy variables—columns 3 and 6 of Table 1.[11]

[10] These figures were chosen arbitrarily as 'round numbers.' They are, however, representative of the sample.

[11] Although the double-log specification gives a slightly better fit, the simulations using the semi-log model are more intuitively natural, especially for the financial-aid model. Using the benchmark values above, the simulations for the double-log model yield very similar results.

Table 2
Effects of changes in tuition and perceived quality

		Effects of $1000 increase in total cost		Effect of moving from tier 2 to top 25 in USNWR	
		Change in enrollment (from 250)	Additional admits to hit 250 target	Change in enrollment (from 250)	Additional admits to hit 250 target
Non-aid students	Point estimate	−10	43	42	−143
	95% confidence interval	(−15, −6)	(24, 62)	(1, 89)	(−263, −4)
Aid students	Point estimate	−17	45	−0.1	0.4
	95% confidence interval	(−21 −13)	(34, 56)	(−24, 24)	(−69, 66)

First suppose that Benchmark increases its tuition by $1000. Using the coefficient estimate of −0.042 for non-aid students, the increase in cost would change enrollment yield of non-aid students by a factor of $e^{-0.042} = 0.959$, resulting in a new yield of 25% × 0.959 = 24.0%. If Benchmark continued to admit 1000 non-aid students, matriculation would decrease from 250 to 240. Performing the same calculation using the estimated coefficient of –0.069 for aid students gives a new yield of 37.3% rather than 40%, or 233 of the 625 students admitted, assuming that there is no increase in financial aid or in the number admitted to compensate for the tuition increase. The left-hand column of Table 2 summarizes these effects and gives 95% confidence intervals.

Another way of thinking of these effects is to consider how many additional applicants Benchmark would have to admit in order to achieve its matriculation target of 250 aid and 250 non-aid students. These estimates and their confidence intervals are given in the second column of Table 2. To get 250 non-aid students, Benchmark would have to admit 250/0.240≈1043, admitting 43 students it would previously have rejected. To hit its target of 250 aid students, about 45 additional students would have to be admitted. Thus, Benchmark would have to offer admission to 88 more students overall (an increase of 5.4% in its acceptance rate) to maintain its enrollment following a $1000 tuition hike.

It may be more realistic to assume that Benchmark would increase financial-aid awards along with the increase in tuition. We consider four possible increases in the average financial-aid award. The first two are increases, respectively, in grants or loans by $1000 to fully offset the increase in costs. The latter two are proportional increases (of 5.7%) in the grant or loan amount. Table 3 shows that a full-dollar offset of the rise in tuition mitigates the enrollment decline (from 17 students to seven if grants increase or to eight if loans increase), but does not eliminate it. Smaller, proportional increases in grants or loans have correspondingly smaller effects. Even increasing both grants and loans by the same 5.7% that tuition increased requires 29 additional aid students to be admitted in order to meet the 250-student target.

Next consider the implications of an increase in the perceived quality of Benchmark College that led to its inclusion in the US News and World Report top 25. Since Benchmark began in the second tier, this would change its enrollment yield for non-aid students by a factor of $e^{(0.374 - 0.219)} = 1.167$, which implies an increase from 25 to 29.2%. Thus, an additional 42 of the original 1000 non-aid admittees would enroll. For aid students, the coefficients for the top 25 and the second tier are almost identical, so the effect is much smaller—the point estimates show a negative effect of less than one student. The third column of Table 2 shows point estimates and confidence intervals.

In terms of how Benchmark could change its admission rate to maintain its target of 250 aid and 250 non-aid matriculants, it could lower the number of non-aid students offered admission from 1000 to 857, but would still have to admit 625 aid applicants. Thus, achieving a higher perception of quality would allow Benchmark to become significantly more selective—a virtuous circle—by screening out 143 students (all non-aid students) who would have been admitted previously. The right-hand column of Table 2 shows that these results must be interpreted with caution, however, because the standard errors are large enough that even the apparently strong effect on non-aid students is barely statistically significant at a 5% level.

6. Conclusions

The negative association between tuition and enrollment yield is a consistent and striking feature of our results. Liberal-arts colleges seem to face downward-sloping demand curves with elasticities closer to one than to zero for non-aid students and slightly above one for aid students. Moreover, increases in financial aid

Table 3
Effects of $1000 (5.7%) increase in tuition with change in financial-aid awards

		$1000 dollar increase		5.7% increase	
		Change in enrollment (from 250)	Additional admits to hit 250 target	Change in enrollment (from 250)	Additional admits to hit 250 target
Grants	Point estimate	−7	19	−13	34
	95% confidence interval	(−10, −4)	(11, 27)	(−15, −10)	(26, 41)
Loans	Point estimate	−8	20	−15	41
	95% confidence interval	(−13, −3)	(7, 34)	(−19, −12)	(30, 51)
Both	Point estimate			−11	29
	95% confidence interval			(−14, −8)	(22, 37)

have a large positive effect on yield for aid students. However, increasing both tuition and average grant levels by one dollar leads to a reduction in enrollment yield. Students appear to look beyond a 'net cost' number and consider tuition and aid separately. Perhaps this reflects uncertainty about continuation of aid in future years, whereas 'tuition is forever'.

Attempts to identify the quality variables that are important for college choice have been less successful than the efforts to identify the cost effects. Urban location and student–faculty ratio are significant for selected groups of students. The only variable that appears to have a statistically significant effect across a number of different model specifications is the US News and World Report dummies for students with no need. The parameter estimates for the top 25 variable and this group of prospective students are consistently significant at the 10% level. The macroeconomic factors that were included in the regression had small and insignificant effects. We attribute this in part to our sample period, which includes eleven years with no serious macroeconomic recession or credit-market disturbance.

In the conclusion of an earlier study, Parker and Summers (1993) suggested that the extension of their model to additional sample years might sharpen the results. We find that to be true. Perhaps a more complete data set—either through additional years of observations or through elimination of some of the missing data for quality variables from individual schools—would allow quality effects to be identified more precisely. Moreover, recent updates of the HEDS data structure incorporate more detailed income and racial demographics, which may allow more precise estimation of tuition and financial-aid effects by racial group and income stratum.

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