THE COMPETITIVE USE OF PRICE DISCRIMINATION BY COLLEGES

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INTRODUCTION

Statistical evidence from the last few years presents an interesting picture of the economics of colleges. The National Association of College and University Business Officers (NACUBO) has collected information from 233 mostly small private colleges for the period 1991-95. The survey indicates a pattern of increasing enrollment and net revenue, despite the fact that many administrators on these campuses are concerned about financial aid budgets and the continuing rise in tuition. For example, the NACUBO data show an increase from 59.8 percent to 68.8 percent in the proportion of the freshman class receiving institutional grants and an increase of 55.6 percent in the average institutional grant budget for freshmen. The data also show an increase of 28.1 percent in average tuition, a 26.1 percent increase in net revenue (total revenue minus institutional grants) from the average freshman class, and an 18.7 percent increase in average net revenue per freshman, all exceeding inflation of 14.96 percent. In addition, freshman enrollment increased 5.8 percent during the period. We contend that this pattern of increasing tuition ("sticker price"), institutional financial aid, net revenue and enrollment, is the result of colleges using price discrimination to a greater degree and better effect than in the past.

In this paper we develop a simple model of private, undergraduate colleges as monopolistically competitive output-maximizing firms which produce the single service of undergraduate education and use first-degree price discrimination. We focus on such schools in order to isolate price discrimination from other factors affecting more complex institutions and because they form an interesting market in their own right. Based on simple econometric tests, we conclude that the 1991-95 period of increasing enrollment and net revenue is consistent with our model.

THE MODEL

There have been a host of studies of demand for higher education [for surveys Leslie and Brinkman, 1987; and Becker, 1990] as well as work on the market as a whole, including the supply side [Abowd, 1984]. Breneman [1994] has attempted a model which directly incorporates price discrimination. Price discrimination has also been referred to indirectly in work on the effectiveness of cross-subsidization by colleges [Rose and Sorensen, 1992].

To place our particular model in perspective, we begin with a general model of the economic behavior of non-profit[1] colleges and universities which is consistent with the standard approach in the college-pricing literature [Hoenack, 1971; Ehrenberg and Sherman, 1984; Danziger, 1990; and Breneman, 1994].[2] The general model assumes that schools maximize an objective function which includes the numbers of different types of students (e.g., undergraduate, graduate and professional), measures of the quality and diversity of students, and measures of research productivity.[3] Formally, it can be written as U (**N**,**Q**,**D**,**R**), where:

$\mathbf{N} = (n_1, n_2,..., n_s)$ = vector of enrollments of s different types of students,
$\mathbf{Q} = (q_1, q_2,..., q_t)$ = vector of t measures of student quality (e.g., SAT, ACT),
$\mathbf{D} = (d_1, d_2,..., d_u)$ = vector of u measures of student diversity,
$\mathbf{R} = (r_1, r_2,..., r_v)$ = vector of v measures of research output

The school is subject to the constraint that its revenues from all sources must be greater than or equal to its costs, which can be written as:

$$T + E + L + G + O_P + O_G + I_G \geq \mathrm{C}(\mathbf{N},\mathbf{Q},\mathbf{D},\mathbf{R}) + \mathrm{F} + A,$$

where:

T = tuition and fees,	O_G = "outside" government aid,
E = endowment and gift income,	I_G = "inside" government aid,
L = legislative appropriations,	C (·) = variable cost function,
G = research grants and contracts,	F = fixed costs,
O_P = "outside" private aid,	A = price discounts ("Institutional Aid").

"Outside" and "inside" refer respectively to aid that students bring with them to the school and aid distributed to students by the school.[4]

Our model is a special case of the more general model which allows us to focus on the market behavior of private undergraduate colleges.[5] We narrow the school's utility function to the point that the school simply maximizes its enrollment subject to the constraint developed below. The explanation proceeds in several steps. To begin, our focus on private undergraduate colleges which emphasize teaching allows us to eliminate **R** and reduce **N** to a single element, n, representing the number of full-time undergraduate students. In addition, because there are many such schools, each providing an undergraduate education differentiated in such areas as curriculum, campus appearance, and location, we assume a monopolistically competitive market structure.

Our experience as college educators suggests that desired enrollment level is an important aspect of each school's differentiated product. This observation is supported by Breneman [1994, 37] who notes that in "the site visits conducted for [his] book, ...every college has a desired enrollment which it seeks to maintain, usually within some fairly narrow range." Following Breneman, we assume that every college chooses a desirable long-run enrollment or "capacity" and builds an optimal physical plant and tenured faculty for that capacity. Although a few private colleges are able to attain capacity enrollment without price discounting, the high level of attention it has received in the last few years suggests that most are not.[6] We assume that all colleges in our model must use price discrimination in order to come as close as possible to their desired enrollment while breaking even.

While others have explored the trade-offs involved in a school's obtaining a student body with an optimal distribution of quality and diversity characteristics [Ehrenberg and Sherman, 1984; and Danziger, 1990], little has been said about the *market* behavior of colleges. In order to concentrate on market pricing behavior, we assume that each college faces a demand curve for its differentiated education composed of "standard enrollment units." We interpret such a unit as a student with a weighted average of the college's desired quality and diversity characteristics and denote the number of such units enrolled in the school as q. These units, which we will henceforth call "students", differ only in their willingness to pay. The final result of our assumptions is to reduce U(**N**,**Q**,**D**,**R**) to a monotonically increasing $V(q) = q$.

The constraint in our model is also a special case of the general model. Given the assumptions above, the variable cost function is now simply $c(q)$. Similarly, the schools we have described do not receive legislative appropriations (L) or research grants (G). In addition, we assume that "inside" government aid (I_G) as well as endowment and gift income (E) are lump-sum and can be subtracted from fixed costs (F). Consequently, we interpret F as net of these amounts.[7]

The essential aspect of the school's constraint in our model, however, is that it practices first-degree price discrimination by awarding "institutional aid" (A). This assumption is consistent with our observation of the financial aid practices of private undergraduate colleges. Before making most financial aid awards, these schools carefully investigate the financial status of a student and his or her family, using the detailed information provided on the Financial Aid Form. Based on this information and whatever other indicators of willingness to pay it may use, the college offers a tuition discount in the form of an "institutional grant" which it hopes will be enough to induce the student to attend. Therefore, the college's published tuition is equivalent to a sticker price from which the final price may be discounted. From the college's perspective, all outside aid reduces the size of the discount necessary to induce a student to attend. It effectively increases the student's willingness to pay.

For the purposes of our model, we assume that each college faces linear inverse demand $p(q) = r - mq$, $m > 0$, and knows this function with certainty. This demand curve includes only students that the college has already accepted.[8] Each (weighted average) student demands one unit of undergraduate education if the price is less than or equal to the student's reservation price and zero units otherwise. Each college sets its tuition equal to r and offers individualized price discounts in the form of financial aid. With its tuition set equal to r, a college will have only one "full-pay" student.[9] Under the above assumptions, A, T, O_P, and O_G are replaced by the revenue function:

$$(1) \qquad TR(q) = \int_0^q (r - mx)dx = rq - (m/2)q^2.$$

In the short run, we assume colleges have relatively large fixed costs. This assumption is consistent with the observation that a very large proportion of a college's short-run costs consists of physical facilities, such as dorms, classrooms, and office space, along with tenured faculty, who are essentially a fixed factor. Thus, even though F is interpreted as net of E and I_G, we assume $F > 0$. As noted above, we also assume that in the long run a college builds a plant that is optimal for its desired capacity. Therefore, its short-run marginal and average variable costs are relatively small and constant. These assumptions are captured in a linear total cost function, $TC(q) = aq + F$.

The end result of our assumptions is that the general optimization problem for each college in our model reduces to:

$$(2) \qquad \text{Max } q, \text{ s.t. } rq - (m/2)q^2 = aq + F.$$ [10]

Assuming such a quantity exists, it can be found by setting total revenue equal to total cost and applying the quadratic formula to obtain:

$$(3) \qquad q_1, q_2 = ((r - a) +/- [(a - r)^2 - 2mF]^{1/2})/m.$$

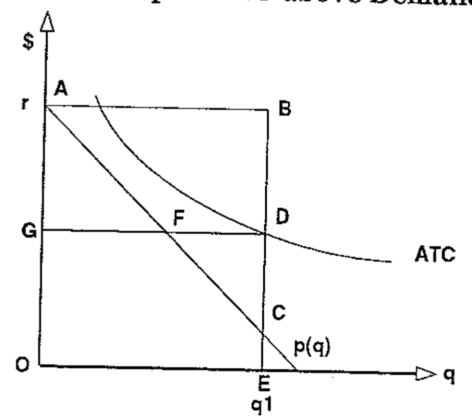
These solutions will be real-valued when $(a - r)^2 \geqslant 2mF$. This condition, which amounts to a restriction on the relationship between inverse demand and cost, can be interpreted as saying that the firm will not be able to break even for any output if fixed costs are sufficiently high. As an output maximizer, the firm will choose the larger output, q_1.[11]

It is possible that there will be no level of enrollment for which a given college can break even. One condition which would guarantee this result would be for marginal cost to exceed the highest reservation price. In what follows, we will always assume that $r > a$.

Figure 1 is a graphical representation of the college's choice of output. It depicts a case in which the ATC curve is everywhere above the demand curve. Unlike a firm which charges a single price, a price-discriminating firm can break even or make a profit in such a circumstance.[12] The largest output at which the college can break even is q_1. The firm's total revenue is the area under the demand curve up to q_1; its total cost is rectangle OGDE. The firm will break even if triangles AFG and FCD have equal area.

Although the relevant price for a college is what it charges each student net of any financial aid it offers, the college may think of itself as charging the price r to every student and then awarding financial aid from a financial aid "budget." From this perspective, total revenue becomes rectangle OABE. The amount of financial aid needed to support an output of q_1 is then shown by triangle ABC.

FIGURE 1
Choice of Output: ATC above Demand



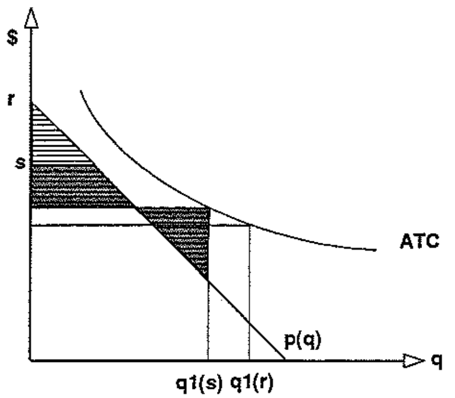
Demographics and steadily increasing costs are two factors which have been cited as exerting pressure on colleges.[13] The model can be used to analyze both of these factors. With a linear inverse demand curve, a change in demand can be characterized by a *ceteris paribus* change in either the highest reservation price, r, or the slope, m. A change in r will result in a parallel shift of the inverse demand curve, while a change in the slope of the inverse demand curve would cause it to pivot around its vertical intercept. As one would expect, these results show that a decrease in the demand for a college's services (or, equivalently, the willingness to pay for each unit of its services) would, *ceteris paribus*, lower its enrollment.[14] Increases in either fixed or variable cost can be represented as an upward shift of the ATC curve, which results in a decline in break-even enrollment. Since we interpret F as net of endowment revenue, this result also indicates that an increase in endowment income should increase enrollment.

LESS-THAN-PERFECT PRICE DISCRIMINATION

In order to test our hypothesis about the behavior of private colleges over the last few years, it is necessary to examine a feature of real-world private college behavior which is not an equilibrium outcome of the model developed above. Previously, the college practiced first-degree price discrimination, setting its tuition sufficiently high that only one student paid full price (shown in Figure 1). To set a lower sticker price would be to give away consumer surplus to "full-pay" students which could be used instead for expanding enrollment through price discounts to low willingness-to-pay students.

The implications of less than first-degree price discrimination can be illustrated by denoting the sticker price as s and allowing the firm to set $s \leqslant r$. The quantity demanded at the sticker price then becomes $q(s) = (r - s)/m$ and total revenue is $\int_0^q (r - mx)dx - (r - s)^2/2m$. Break-even enrollment can be calculated as above to yield:

FIGURE 2
Setting Tuition Less than Maximum Willingess to Pay



(4) $$q_1, q_2 = ((r - a) +/- [(a - r)^2 - (r - s)^2 - 2mF]^{1/2})/m.$$

These expressions differ from (1) by $-(r - s)^2$, which approaches zero as the sticker price approaches the maximum willingness to pay.

Figure 2 shows the effect of setting tuition less than the maximum willingness to pay. Break-even enrollment for tuition levels s and r are denoted q_1(s) and q_1(r) respectively. The dark-shaded shapes are of equal area and the lost consumer surplus is indicated by the light shading. Clearly, the greater the distance between s and r, the lower will be enrollment.

Although we know of no colleges which actually set tuition high enough that they have only one "full-pay" student, we conjecture that many colleges have moved closer to first-degree price discrimination by raising sticker price while simultaneously increasing the size and number of institutional financial aid awards. While the experiences of individual colleges have varied, the result has been rising average freshman enrollments and revenue, as we will discuss in the next section. Figure 3 illustrates the consequences of raising the sticker price from s_1 to s_2. Enrollment rises from $q_1(s_1)$ to $q_1(s_2)$ and net revenue increases by the amount of the two lightly-shaded areas. The school's "financial aid" budget increases by the darkly shaded area.

EMPIRICAL RESULTS

Our empirical analysis is based on data obtained by the National Association of College and University Business Officers (NACUBO). These data have been collected as a part of a continuing effort by NACUBO to study the effects of rising discount rates at colleges.[15] The data set includes information obtained from a survey sent to business officers on tuition, financial aid, enrollment counts, SAT scores, enrollment yields and endowment. For our study, we used 233 colleges that provided information on the variables discussed below, and separated the sample into three groups using the American Association of University Professors (AAUP) classification system. We divided the sample into larger research institutions (I), an intermediate category of schools offering some graduate degrees (IIA) and small liberal arts colleges granting no graduate degrees (IIB). The largest category, by far, was IIB.

FIGURE 3
Raising the Sticker Price

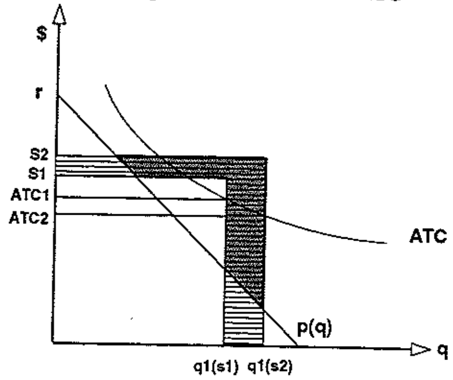


Table 1 presents summary statistics for our sample of 233 colleges. With the exception of the sticker price, all of the data refer to freshman classes. It is important to remember when interpreting these statistics that some colleges experienced better net revenue and enrollment results than others. It is the general pattern with which we are concerned.

As noted in the introduction, the average sticker price rose faster than inflation for the 1991-95 period. This rise was associated with a substantial increase in the use of institutional financial aid (price discounts) as shown by increases in the average number and size of grants, the proportion of the average class receiving grants, the average institutional grant budget, and the discount rate. At the same time, as predicted by our model, average institutional net revenue for the freshman class and per freshman student also grew, as did average freshman enrollment.

Our model, along with the descriptive statistics presented above, suggests several specific hypotheses about the effect of college characteristics and policy decisions on two dependent variables, net revenue (*NR* = tuition revenue − institutional financial aid grants) and enrollment (*Q*). These hypotheses are captured in the following regression equations:

(5) $$NR = a0 + a1\,STICKER + a2\,ENDOW + a3\,FULLPAY + a4\,GRANTPER + e,$$

and

(6) $$Q = b0 + b1\,STICKER + b2\,ENDOW + b3\,FULLPAY + b4\,GRANTPER + e.$$

TABLE 1
Descriptive Statistics, 1991 - 1995

CATEGORY	1991	1995	% CHANGE
Avg. institutional NR from freshman class	$4.04 million	$5.05 million	26.1
Avg. NR per freshman	$7,453	$8,384	18.7
Avg. enrollment, new freshmen	478	506	5.8
% freshmen receiving grants	59.8%	68.8%	
Avg. grants per freshmen class	286	348	21.7
Avg. institutional freshmen grant budget	$1.52 million	$2.36 million	55.6
Avg. discount rate	28.7%	34.3%	
Avg. grant per freshman	$3,178	$4,669	46.9
Avg. sticker price	$10,579	$13,548	28.1
CPI			14.96

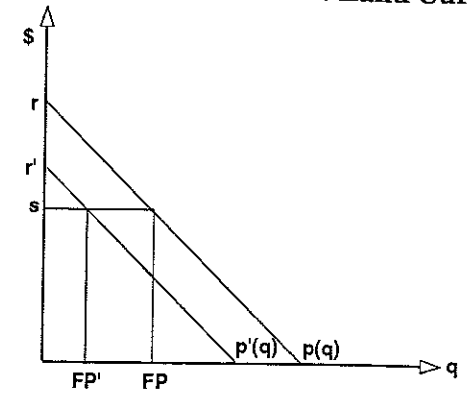
As illustrated in Figure 3 above, an increase in the sticker price (*STICKER*) should increase both net revenue and enrollment by allowing a college to tap more consumer surplus. This additional consumer surplus causes enrollment to expand because colleges in our model are output maximizers which will use the surplus to enroll lower-willingness-to-pay students. Revenue will increase because of both the higher price paid by full-pay students (the upper, lightly shaded trapezoid of Figure 3) and the revenue brought in by the additional students enrolled (the lower, lightly shaded trapezoid of Figure 3).

The size of a school's endowment (*ENDOW*) can also affect both revenue and enrollment. Schools with larger endowments have a greater capacity to transfer endowment earnings to the operating budget. *Ceteris paribus*, this additional revenue would be used by an output-maximizing college to increase enrollment. As noted above, we model transfers of endowment income by interpreting fixed costs as net of such transfers. Therefore, because our model predicts that a decrease in fixed costs will increase enrollment, endowment size should have a positive effect on enrollment.

As demonstrated in Section II, the position of the inverse demand curve has an effect on enrollment. We have two variables which indirectly indicate the position of this curve. The first is the number of full-pay students (*FULLPAY*). Figure 4 shows two inverse demand curves, with p'(q) depicting a lower willingness to pay for each q than p(q). For a given sticker price s, the number of full-pay students, FP, will be larger with p(q) than with p'(q).

The second variable which indirectly indicates the position of inverse demand is an institution's average freshman grant among those receiving grants (*GRANTPER*). Figure 5 is drawn so that the average freshman grant can be compared for two institutions with different inverse demand curves at a given sticker price s and enrollment q_1. For any $q >$ FP, p'(q) depicts a lower willingness to pay than p(q). The average grant associated with inverse demand p(q) is line segment AB, while line

FIGURE 4
Position of the Inverse Demand Curve



segment AC denotes the average grant associated with p'(q). Thus, larger average freshman grants are associated *ceteris paribus* with lower willingness to pay, and therefore lower demand for a college's services.

Section II showed a positive relationship between inverse demand and enrollment. Consequently, we propose the hypotheses that *FULLPAY* is positively related to enrollment (Q) and *GRANTPER* is negatively related to Q. Since, for a given s, higher enrollment implies greater net revenue, we also propose that *FULLPAY* is positively related to *NR* and that *GRANTPER* is negatively related to it.

We tested our hypotheses by applying Ordinary Least Squares to the NACUBO data. In order to test for differences in the behavior of the larger and smaller schools in the sample, AAUP IIB, IIA, and I subgroups were created. This separation necessitated the use of two dummy variables. *DUMMY1* is set equal to 1 if an institution is in the AAUP I category and *DUMMY2* is set equal to 1 if the college is in the IIA category.

The regression results, shown in Table 2,[16] suggest that a $1,000 increase in *STICKER* leads to a statistically significant increase in both net revenue and an increase in enrollment for both the larger sample and for IIB colleges alone.[17] In general, the inverse-demand shifters (*GRANTPER* and *FULLPAY*) have the expected signs and are statistically significant. Larger endowments do appear to raise enrollment and net revenue but the magnitude of the effect is very small. As expected, the control variable *DUMMY1* confirms that AAUP I colleges experience both higher net revenue and enrollment, but *DUMMY2* suggests that IIA and IIB colleges are not different. While we recognize that pricing strategies are dynamic and that strategic behavior is an element of the pricing environment in which colleges operate, these results suggest that colleges have used price discrimination to increase both enrollments and net revenues.

FIGURE 5
Average Grant with
Different Inverse Demand Curves

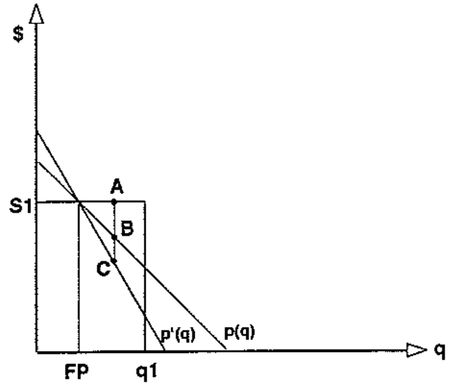


TABLE 2
Regression Results (1995-1996 academic year)

(t - statistics) independent variables	Dependent Variable NR: IIB colleges	NR: all colleges	Enrollment: IIB colleges	Enrollment: all colleges
CONSTANT	-2,381,689	-4,062,080	103.0	69.58
	(-1.38)	(-1.17)	(.557)	(.216)
GRANTPER	-352,105	-678,384	-27.54	-39.74
($1,000)	(-3.87)	(-4.57)	(-2.82)	(-2.90)
FULLPAY	36,340	66,640	1.06	2.85
(1%)	(4.45)	(4.95)	(1.21)	(2.29)
ENDOW	6,196	3,142	.53	.18
($1,000,000)	(3.37)	(2.57)	(2.68)	(1.58)
STICKER	509,648	758,528	28.3	35.26
($1,000)	(7.90)	(6.86)	(4.09)	(3.45)
DUMMY1		9,831,604		796.5
		(9.63)		(8.44)
DUMMY2		1,967,757		260.2
		(3.46)		(4.95)
r squared	.573	.650	.211	.480
N	161	233	161	233

CONCLUSIONS

As the public policy debate on college pricing and financial aid progresses, a clear understanding of the economic behavior of colleges is required. In this paper we have presented a model of colleges as single-product, price-discriminating, output-maximizing firms. Hypotheses implied by our model are supported by data for a large number of colleges. Our overall conjecture has been that colleges in recent years have made more and better use of price-discrimination, in the form of institutional financial aid grants, as a response to increasing competitive pressure. Increased use of price discrimination can be seen in the increase in average sticker price from 1991-95. Our model predicts that such an increase will lead to increases in both net revenue and enrollment and our statistical analysis validates these predictions.

NOTES

The authors wish to thank three anonymous referees for helpful comments which improved this paper. Nevertheless, any remaining shortcomings are the sole responsibility of the authors.

1. We define non-profit organizations as those which cannot distribute any operating surplus to shareholders.
2. Our specific model parallels Breneman's in several aspects.
3. In our general model, research and teaching are seen as separable inputs. However, at small private colleges, they are typically seen in a symbiotic relationship.
4. We consider loans, from whatever source, as providing students access to capital markets. They do not provide revenue to the school.
5. This can also be said of the papers cited above, particularly Danziger [1990].
6. Breneman [1994, 39] notes that his book is a response to the growing use of price discounting.
7. This interpretation technically allows for a subsidy from endowment income so large as to make $F \leq 0$. However, given the high level of fixed costs in higher education, it is hard to imagine a subsidy of this magnitude, hence our simplifying assumption of $F > 0$. This type of subsidy has redistributive aspects . Subsidies may be shifted to lower income or higher ability students. This analysis could be an interesting extension of our model, but is beyond our current task.
8. Savoca [1990] has estimated the price elasticity of the college application decision. Note also that even though students who have been accepted are likely to realize that published tuition is only the sticker price, some students may not have applied in the first place due to "sticker shock."
9. This assumption is only a first step in formalizing the problem. Below, we gain some useful insights by looking at sticker prices that are less than r.
10. Due to our assumption that schools in our model have to use price discrimination to reach their desired enrollment, we consider the break-even constraint to be binding.
11. Scholarships given to football players at major universities suggest that the price paid by a student may be negative. These athletes have a negative willingness to pay if they know that their services are in great demand by universities. However, the vast majority of students admitted to smaller private colleges do pay non-negative prices. Consequently, we only consider such prices, although the model could easily be extended to accommodate negative prices for some students.
12. An analogous picture can be drawn for the case in which the ATC falls below the demand for some output levels.
13. Although predicted in the late 1980s, enrollment declines never materialized because of higher enrollment rates in higher education. As our paper shows, it is possible for a decline in demand, accompanied by a more effective use of price discrimination, to result in higher enrollment levels. While falling demand does not characterize the 1991-95 situation, it is a comparative static result worth examining.

14. The first derivatives of equation (1) with respect to r, m, F and a confirm these results. Note that our firm is maximizing *output* subject to the break-even constraint. An increase in fixed cost leading to a decrease in output would not be consistent with the behavior of a *profit*-maximizing firm.
15. The "discount rate," in the language of college business offers, is simply the ratio of institutional financial aid to gross tuition revenues.
16. We report results for the 1995 academic year only. The results for the other academic years fit very closely the pattern established for 1995.
17. For example, a $1,000 increase in sticker price for IIB institutions leads to a $509,648 increase in net revenue and an enrollment increase of 28.3 students.

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