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 economies of colleges. The National Association of College and University Business Officers (NACUBO) has collected information from 235 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 those campuses are concerned about financial aid budgets and the continuing rise in tuition. For example, the NACUBO data show an increase from 68.8 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 [Abelow, 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 colleges and universities which is consistent with the standard approach in the college-pricing literature (Hoeckerts, 1971; Ehrenberg and Sherman, 1984; Denziger, 1990; and Breneman, 1994). 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. Formally, it can be written as

$$N = (n_1, n_2, ..., n_i) = \text{vector of enrollments of different types of students},$$

$$Q = (q_1, q_2, ..., q_i) = \text{vector of l measures of student quality (e.g., SAT, ACT),}$$

$$D = (d_1, d_2, ..., d_i) = \text{vector of u measures of student diversity},$$

$$R = (r_1, r_2, ..., r_i) = \text{vector of v measures of research output}. $$

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:

$$T + E + L + G + O_p + O_g + I_2 = \text{costs} = \text{revenues} = \text{N(Q,D,R)} + F + A. $$

where:

$$T = \text{tuition and fees},$$

$$O_p = \text{"outside" government aid},$$

$$F = \text{fixed costs},$$

$$A = \text{price discounts ("Institutional Aid"),}$$

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

Our model is a special case of the more general model which allows us to focus on the market behavior of private undergraduate colleges. 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, we 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.

PRICE DISCRIMINATION BY COLLEGES

Our experience as college educators suggests that desired enrollment levels in an important aspect of each college'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 assured 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. 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 exploited 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 these assumptions is to reduce CN(Q,D,R) to a monotonically increasing $\Pi(q) = q$.

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 ($O_p$) as well as endowment and gift income ($G$) lump-sum and can be subtracted from fixed costs ($F$). Consequently, we interpret $F$ as net of these amounts.

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 know this function with certainty. This demand curve includes only students that the college has already accepted. 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 $n$ 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. Under the above assumptions, $A$, $F$, $G$, and $Q$ are replaced by the revenue function:

$$\text{TR}(q) = f_s^b (r - mx)dx = ry - (m/2)y^2.$$  

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 $I$, 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:

$$\text{Max } q, \text{ s.t. } ry - (m/2)y^2 = aq + F.$$  

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

$$q_1, q_2 = (r - a) \pm \sqrt{-(a - r)^2 - 2mF}/m.$$  

These solutions will be real-valued when $(a - r)^2 > 2mF$. 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, $q_2$.

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. The largest output at which the college can break even is $q_2$. The firm's total revenue is the area under the demand curve up to $q_2$; its total cost is rectangle OGDH. 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 OARE. The amount of financial aid needed to support an output of $q_2$ is then shown by triangle ABC.

Demographics and steadily increasing costs are two factors which have been cited as exerting pressure on colleges. 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. 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-THE 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 $s < r$. The quantity demanded at the sticker price then becomes $q(s) = (r - s)/m$ and total revenue is $\int_s^b (r - mx)dx = (r - s)ry/2m$. Break-even enrollment can be calculated as above to yield.
FIGURE 2
Setting Tuition Less than Maximum Willingness to Pay

\[ q_1, q_2 = \frac{(r - a) s - (a - r)^2 - (r - a)^2 - 2mF}{m}. \]

These expressions differ from (1) by \(- (r - a)^2\), 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 \( q(s) \) and \( q(r) \) respectively. The dark-shaded areas 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 prices 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 \( s \) to \( s^* \). Enrollment rises from \( q(s) \) to \( q(s^*) \) 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. 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.

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:

\[ NR = a_0 + a_1 \text{STICKER} + a_2 \text{ENDOW} + a_3 \text{FULLPAY} + a_4 \text{GRANTPER} + \epsilon, \]

and

\[ Q = b_0 + b_1 \text{STICKER} + b_2 \text{ENDOW} + b_3 \text{FULLPAY} + b_4 \text{GRANTPER} + \epsilon. \]
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 $q$. 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 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 I, II, III, 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 2,14 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.15 In general, the inverse-demand shifts (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

![Inverse Demand Curves Diagram]

TABLE 2
Regression Results (1995-1996 academic year)

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>NR: IB colleges</th>
<th>Dependent Variable</th>
<th>NR: all colleges</th>
<th>Enrollment: IB colleges</th>
<th>Enrollment: all colleges</th>
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</thead>
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<tr>
<td>CONSTANT</td>
<td>-2,381,669</td>
<td>4,062,090</td>
<td>103.0</td>
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<tr>
<td>(1.38)</td>
<td>(-1.31)</td>
<td>(-2.77)</td>
<td>(2.67)</td>
<td>(2.64)</td>
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<tr>
<td>GRANTPER</td>
<td>-812,105</td>
<td>-679,304</td>
<td>-27.54</td>
<td>-39.74</td>
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<tr>
<td>($1,000)</td>
<td>(3.87)</td>
<td>(-4.67)</td>
<td>(-2.92)</td>
<td>(-3.90)</td>
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<tr>
<td>PULLPAY</td>
<td>36,340</td>
<td>66,640</td>
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<td>(1%)</td>
<td>(4.46)</td>
<td>(4.95)</td>
<td>(1.23)</td>
<td>(2.59)</td>
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<tr>
<td>ENROLL</td>
<td>6,196</td>
<td>3,142</td>
<td>53</td>
<td>15</td>
<td></td>
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<tr>
<td>($1,000,000)</td>
<td>3.37</td>
<td>2.57</td>
<td>1.56</td>
<td>1.56</td>
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<td>STICKER</td>
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<td>756,530</td>
<td>28.3</td>
<td>35.26</td>
<td></td>
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<tr>
<td>($1,000)</td>
<td>7.98</td>
<td>6.98</td>
<td>(4.99)</td>
<td>(3.65)</td>
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<tr>
<td>DUMMY1</td>
<td>9,831,404</td>
<td>7,867,757</td>
<td>796.5</td>
<td>260.2</td>
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<tr>
<td>(9.60)</td>
<td>(8.44)</td>
<td>(8.44)</td>
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<td></td>
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<tr>
<td>DUMMY2</td>
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<td>280.2</td>
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<tr>
<td>(2.46)</td>
<td>(4.45)</td>
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<td></td>
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<tr>
<td>r squared</td>
<td>0.73</td>
<td>0.50</td>
<td>0.31</td>
<td>0.40</td>
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<tr>
<td>N</td>
<td>161</td>
<td>233</td>
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CONCLUSIONS

As the 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 Brennan'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].
7. This interpretation technically allows for a subsidy from endowment income so large as to make \$F < 0. However, given the high level of fixed costs in higher education, it is hard to imagine a subsidy of this magnitude, hence we are 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 would be an interesting extension of our model, but is beyond our current task.
8. Survey [1980] 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 formulating the problem. Below, we gain some useful insights by looking at sticker prices that are less than \$F.
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 readily 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 level.
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.
REFERENCES


OTHER THINGS EQUAL

Quarreling with Ken

Deirdre McCloskey
University of Iowa
and
Erasmus University of Rotterdam

I've praised Kenneth Arrow here from time to time. But during the January 1998 meetings of the American Economic Association in Chicago, at which Ken spoke on theory and Ed Leamer spoke on econometrics, and Barbara Bergmann in the chair, discussed my new book The Vices of Economists: The Virtues of the Bourgeoisie [University of Michigan and University of Amsterdam Presses, 1997], I did not.

Regular readers of this column will have heard the gist (which is a poor excuse for not buying the book, dear); I need money and you need the amusement of seeing your colleagues go red when you use arguments out of context. It is Economics in serious trouble because of the three "vices" of statistical significance, blackboard economics, and social engineering. A bourgeois and anti-ascetic virtue, the virtues of bench-and-field scientists like Rosalind Franklin (Soyre, 1975) and Edward Wilson (1988) or theorists with a serious interest in the world like Richard Feynman (1965), can bring economics back to its scientific sense.

At the Chicago meetings, I focused on the first two vices—statistical significance and blackboard economics. Since Ed Leamer has been a leader against mindless use of statistical significance (1978, 1983), and Ken declared decades ago that its common use is indefensible (1959), and Barbara has long and consistently advocated simulation as the scientific alternative (1980), I did not get any disagreement on Point One: Statistical significance is bankrupt; all the "findings" of the Age of Statistical Significance are erroneous and need to be redone; economists have thrown away gigabytes of scientific time spent on finding out how big is big—observing and estimating and arguing rather than pseudo-testing by Student's t. That's news: leaders of the economics profession think that the main empirical rhetoric in economics is nonsense.

Point Two, the futility of blackboard theory, evoked a lot more quarreling, predictably between Ken and me. Kenneth Arrow, with his sister's husband's brother Paul Samuelson, was the pioneer of blackboard economics, and by 1950 had set the standard for chalk talk in the field. I was an eager student in the 1960s of such mysteries, but eventually decided that they were not science. At Chicago in a big Hyatt ballroom filled with economists this January we quarreled.

"Quarreling" is not necessarily a bad thing. C. S. Lewis pointed out once that quarreling—as against mere angry abuse—means trying to show that the other man (or woman, if you please) is in the wrong. And there would be no sense in trying to do...