NÚMERO 183

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ON THE DYNAMICS OF QUALITY STUDENT ENROLMENT AT INSTITUTIONS OF HIGHER EDUCATION

Resumen

Las instituciones académicas atraen buenos estudiantes a través de su reputación. ¿Cuál es su nivel académico óptimo? Supongamos que la enseñanza tiene como objetivo maximizar la suma de los logros agregados descontados de sus estudiantes, mientras que la reputación deduce de esto el riesgo de fracaso de los mismos. La política óptima intertemporal (a) escoge el nivel académico que maximiza los logros de los estudiantes *actuales*; (b) optimiza estos logros utilizando tantos instrumentos como sea posible (enseñanza individual, tutorías, enseñanza por niveles, etc.) (c) minimiza el costo de estas políticas para los estudiantes. En un estudio empírico encontramos que los niveles académicos de los estudiantes atraidos por instituciones de enseñanza supeerior en los Estados Unidos (medidos por los exámenes SAT) siguen un proceso convergente en que los recursos destinados al aprendizaje, su nivel, y la tasa esperada de éxito se combinan para atraer mejores futuros estudiantes.

Abstract

Academic institutions attract good students through reputation. What is their optimal academic level policy? Suppose teaching maximizes aggregate discounted student achievement, while reputation deducts from this the risk of student failure. The inter-temporal optimal policy (a) sets academic level to maximize *current* student achievement; (b) optimize achievement using as many instruments as possible, (individual teaching, tutorials, teaching according to skill, etc.) (c) minimizes the costs of these policies for students. We find empirically that attracted students' SAT levels follow a convergent process in which resources for achievement, its level, and the expected success rate combine to attract better future students.

Introduction

Higher education institutions compete in the market for quality students on the basis of the reputation of the services they offer. What is the optimal academic level to pursue? This question requires a practical answer on the part of decision-makers, professors and deans. Yet opinions tend to be based on personal educational (and emotional) experiences rather than on objective criteria optimizing institutional performance.

The level of learning that a group of students can achieve depends heavily on their learning potential when they join the institution. In turn, the potential that an institution can attract depends on its reputation, which is ultimately based on the achievements of its students. When institutions compete for their students on the basis of their reputation, what academic level should they set? If this level is set too high or too low, current achievement may decrease, and this will reduce future reputation. Also, higher failure rates represent a cost for students that may hamper the institution's reputation, if the reputation that students assign to an institution takes into account their expected achievement. This question is especially relevant for young institutions whose reputation cannot yet attract the level of students they may desire.

The ideas in this paper arose during actual meetings at a young institution committed to the long-term goal of academic excellence. The decision in hand was whether to impose a higher academic standard, at the cost of a higher rate of student failure, or whether to accept for the present a somewhat lower level closer to the current students' ability. Some of the participants held a *conservative* academic opinion inclined to impose strict teaching standards and to fail as many students as necessary. This point of view insists that raising academic levels is the only available instrument for the institution to achieve excellence and reputation in the long run, and models itself on the perceived practices of the best academic institutions. Also present was a more *liberal* point of view, more inclined to adapt academic levels to students' capacity, and to minimize the costs that failure may impose. Finally, a more *radical* attitude that education should benefit as many people wishing to study as possible, independently of their present academic attainment, also had something to say.

Which decision best serves the long-term goal? Can the application of some analytical methodology throw light on this discussion? Are there objective reasons why the stage of development of an institution should be a relevant consideration when setting its academic standards?

In a previous working paper (Mayer, 1998), we answer these questions by developing an inter-temporal optimization model linking academic achievement, reputation, and the pool of student quality available to an institution. In the model, the choice of academic level acts in effect as a policy variable controlling the pool of student ability available in the future through the institution's reputation. The main result is that institutions should set their academic level so as to maximize the achievement of their

current students, and that in the process it should minimize the costs that failure may impose upon its students. This means that institutions with a lower reputation will find it optimal to set a lower academic level then those at the higher end of the spectrum. As time passes, institutions that produce higher student achievement will earn a higher reputation that will permit them to raise their academic level. This means that the conservative position mentioned above is optimal for institutions with a higher reputation while the liberal position is better adapted to younger institutions. The radical position has more to do with the resources allocated to education, which are usually not decided by the schools themselves. From this point of view, the main reason why students should be separated from a program is that the presence of less able students reduces the achievement of their more able counterparts. According to our model the optimal cut-off line defining which students to exclude results from maximizing the aggregate achievement of the current pool of students. Such exclusion should minimize students' costs by occurring sooner rather than later (better still before initiating the program) and, if possible, by offering low cost alternatives to exit a program, such as obtaining a lower-level degree.

In this paper we give some empirical backing for the theoretical findings of the previous one (Mayer, 1998). We study the dynamic process followed by the acquisition of student quality by higher education institutions in the U.S. We study some of the variables that have an inter-temporal impact on this process. Specifically, we study the SAT levels of students attracted by the best national universities and national liberal arts colleges, as reflected by the well-known survey which U.S. News and World Report has carried out for a number of years to produce its college rankings. The survey includes information on the conditions faced by students such as institutional expenditure rates, the level of student achievement, reputation, graduation rates and other variables reflecting the resources available for learning and the probability of student success. We analyze the impact of these variables on future attracted student ability. We find that SAT levels follow a convergent process in which several variables have an impact. Higher graduation rates, which reflect a lower risk of failure, attract better future students. So do expenditure rates and academic reputation as measured by that survey.

The remainder of the paper is organized as follows. In the next section we describe our empirical study and how it supports the model. Then we make some final remarks.

Empirical study of student quality dynamics

The study of student ability, institutional quality and reputation are well-established in the research literature on education (e.g. Hanushek, 1986; Bacdayan, 1994; Dolan and Schmidt, 1994; Bonesrønning. and Rattsø, 1994; Murphy and Trandell, 1994, Heath, 1995). Here what we seek is to study the medium to long-term *intertemporal dynamics* of the reputation of academic institutions and of the quality of the pool of students entering them. To do this we use a well-known survey carried out by the U.S. News and World Report for a number of years to publish its college rankings. This survey ranks U.S. national

universities and national liberal arts colleges, and serves as a resource for students choosing their educational institutions. It collects a series of variables on several hundred academic institutions, and uses these to construct a reputation index. However, during the time it has existed it has changed format and introduced more variables. Thus the 1995 survey is the earliest one which is reasonably complete and can be compared with the 2000 survey. Taken together these give a five-year period that is adequate for our purposes.[1]

Table I

Partial correlation of several 1995 variables with the rate of improvement of SAT levels for students enrolling in higher education between 1995 and 2000 (Obtained in independent regressions)

	National Universities **(115 to 118 observations)**		***National Liberal Arts Colleges*** **(94 to 97 observations)**	
	25th percentile SAT	**75th percentile SAT**	**25th percentile SAT**	**75th percentile SAT**
Academic Reputation	**0.005** **(0)**	**0.004** (0)	0.002 (0.191)	**0.004** **(0)**
Expenditure	**0.01** **(0)**	**0.009** **(0)**	0.003 (0.512)	**0.007** **(0.047)**
Freshmen Retention Rate	**0.044** **(0.001)**	**0.033** **(0.002)**	**0.035** **(0.003)**	**0.029** **(0.008)**
Graduation Rate	**0.016** **(0.005)**	**0.019** **(0)**	**0.01** **(0.014)**	**0.013** **(0)**
Acceptance Rate	**-0.006** **(0.088)**	**-0.005** **(0.033)**	-0.001 (0.81)	**-0.01** **(0.004)**
Alumni Giving Rate	0.002 (0.333)	0.002 (0.255)	0.003 (0.176)	**0.005** **(0.041)**
Student to Faculty Ratio	-0.003 (0.437)	**-0.005** **(0.078)**	-0.004 (0.436)	-0.004 (0.391)
Yield	-0.004 (0.211)	-0.002 (0.291)	-0.004 (0.21)	0 (0.902)

Probabilities stated in parenthesis. Results in bold are significant at the 10% level.

[1] The 1995 survey was reported in the September 18th, 1995 edition of the U.S. News and World Report, while the 2000 survey was downloaded from the web at http://www.usnews.com/usnews/edu/college/corank.htm. Detailed information on the survey's method, classification schemes and variables is available at the site.

The reputation index constructed by the survey is a weighted average of several variables. These include the SAT levels of entering student's at the 25th and 75th percentiles, expenditure on undergraduate programs, freshmen retention rate, graduation rate, acceptance rate, alumni giving rate (percentage giving to their school), student to faculty ratio, yield (ratio of students who enroll to those admitted), and proportion of students who were in the top ten percent in their high school class. It is a somewhat arbitrary variable, since it does not measure reputation directly as a student perception, although in fact it plays a role in forming the kind of consensus that is involved in the concept of reputation.

However, the 25th and 75th percentile SAT level variables are carefully constructed variables giving what should be a reliable measure the quality of students entering an institution. Thus we choose to ground our study on the dynamics of this variable.

We refer now to our theoretical model, using the notation in (Mayer, 1998). According to our hypotheses, if an institution follows the optimal academic policy optimal policy $Q^*(R)$, reputation follows the differential equation $R' = P(Q^*(R), R) - \delta R$. The right hand side is a concave function $f(R)$ which is diminishing in R near the steady state R^*. If instead institutions follow a policy $Q = Q^*(R) + \Delta Q$ the differential equation for R will be approximately

$$R' = f(R) + P_Q(Q^*(R), R)\Delta Q - C_Q(Q^*(R), R)\Delta Q. \tag{7}$$

Since $P_Q(Q^*(R), R) > 0$ (see equation [14] in the appendix) and $C_Q > 0$, along paths close to the optimal path policies will raise reputation in so far as they raise aggregate achievement and will diminish it in so far as they raise costs. These signs coincide with those expected naively, that is, when it is not supposed that institutions operate near an optimal policy.

Let us suppose as in the model that the average potential q of student's entering a given institution is an increasing function $q(R)$ of its reputation. Then we may also write $R = R(q)$. Thus, by studying q we can indirectly study the unobserved R. Equation (7) therefore has an analogue in terms of q as follows:

$$q' = h(q) + \Sigma_i \beta_i \Delta Q^i \tag{8}$$

where h is must be diminishing in q and we have now introduced several policy changes ΔQ^i. For the econometric estimation, we study the linear approximation

$$\Delta q_k = \gamma + \alpha q_k + \Sigma_i \beta_i X^i_k + u_k \tag{9}$$

where Δq_k is the rate of change of student potential, X^i are variables reflecting academic policies and resources influencing student achievement and costs, and u_k is the error term. We expect α to be negative, while β_i should be positive if X^i has mainly effects on achievement and negative if its effects mainly increase the costs $C(Q,R)$ faced by students.

The U.S. News and World Report survey constructs a reputation index separately for national universities and national liberal arts colleges. Thus we study these samples

separately. For the variables Δq_k we use the rates of change of either the 25th or the 75th percentile SAT levels between 1995 and 2000 for each of these samples.[2]

The explanatory variables used and the expected signs for their coefficients are the following. All of the variables were entered as logarithms.

Table II

Regression results for the rate of improvement of SAT levels for students enrolling in higher education between 1995 and 2000
(Single regression with most significant variables)

	National Universities **(115 observations)**		***National Liberal Arts Colleges*** **(95 and 94 observations)**	
	25th percentile SAT	**75th percentile SAT**	**25th percentile SAT**	**75th percentile SAT**
Constant	**0.6**	**0.8**	*0.2*	**0.7**
	[0, 0]	**[0, 0]**	*[0.086, 0.381]*	**[0, 0.002]**
Initial SAT	**-0.098**	**-0.112**	**-0.054**	**-0.107**
	[0, 0]	**[0, 0]**	**[0.001, 0.032]**	**[0, 0.003]**
Academic Reputation	**0.003**	**0.003**	0.001	0.002
	[0.002, 0.008]	**[0.002, 0.023]**	[0.682, 0.744]	[0.105, 0.293]
Expenditure	**0.007**	**0.006**	0.003	0.002
	[0, 0.004]	**[0, 0.003]**	[0.512, 0.574]	[0.623, 0.679]
Freshmen Retention Rate	-0.008	*-0.024*	*0.033*	0.01
	[0.617, 0.675]	*[0.057, 0.137]*	*[0.027, 0.115]*	[0.448, 0.532]
Graduation Rate	**0.02**	**0.02**	0	0.01
	[0.009, 0.044]	**[0, 0.028]**	[0.456, 0.625]	[0.155, 0.195]
Acceptance Rate	0	0.001	0	0
	[0.56, 0.613]	[0.716, 0.798]	[0.506, 0.604]	[0.305, 0.371]
R-squared	0.498	0.488	0.221	0.367
Log likelihood.	396.9	420.2	326.4	331.4

The square brackets represent ranges of p values or of R-squared statistics resulting from the application of OLS, White and Newey West regression methods. Results in bold are consistently significant while results in italics are significant in at least one regression at the 3% level.

[2] In fact, student quality is measured by achievement tests instead of aptitude tests for parts of the survey. The corresponding observations had to be excluded since they were not strictly comparable.

1) Initial SAT level. We expect a negative sign, due to the convergence effect explained before.
2) Reputation. This variable summarizes a perception of learning opportunity, achievement, resources and excellence. Therefore we expect it to obtain a positive sign.[3]
3) Expenditure. This variable is a direct index of the resources available for student achievement, so we expect it to obtain a positive sign.
4) Freshmen retention rate. A high rate of retention minimizes costs while a low rate signals excellence in achievement. Therefore the expected sign is ambiguous.
5) Graduation rate. A high rate of graduation minimizes costs and reflects a high probability of success, unless of course academic standards are reduced to obtain it. Since this is not expected to be a very strong factor we expect the sign to be positive.
6) Acceptance rate. This variable may signal a low standard of achievement. On the other hand, it may represent smaller costs faced by students during the selection process, which nevertheless are low compared to those implied by not graduating. Thus the expected sign is ambiguous.
7) Alumni giving rate. This variable may be correlated with student achievement, reputation and resources so we expect a positive sign.
8) Student to faculty ratio. A high ratio represents less opportunity for achievement so a negative sign is expected.

We did not use the proportion of students in the top ten percent in their high school class, because it is a fuzzier variable than the SAT variables yet may present problems of colinearity due to the possible correlation.

We ran three sets of regressions. Each of these has the rates of change of the 25^{th} and 75^{th} percentile SAT levels as dependent variables for each sample. In the first set, the independent variables were the initial SAT level and one of the variables 2 to 8. In the second set, we included together as independent variables those obtaining the most significant coefficients in the first set, namely initial level of SAT, academic reputation, expenditure, freshmen retention, graduation and acceptance rates. In the third we included all of the variables as independent variables. The sample sizes were about 114 in the case of universities and 95 in the case of liberal arts colleges. Thus in the latter case we are somewhat concerned with loosing degrees of freedom and therefore expect somewhat less significant results.

Each set of regressions was run using OLS as well as the White and Newey West corrections for heteroskedasticity. We report the coefficients as well as the range of the confidence levels (probabilities) obtained by the three methods. Tables I to III show the results for the three sets of regressions.

The confidence levels obtained by the variables in the different sets of regressions do not vary too much, lending robustness to our results. Comparison of the results shows that the third set of regressions, which uses all of the available variables as independent variables, did not suffer too much from the loss of degrees of freedom. Overall, the results

[3] We took the negative of the survey variable, so that a higher number represents a higher reputation.

for the sample of universities are more significant and consistent then those for the liberal arts colleges. This seems to be only partially explained by the larger sample of the former. Once all of the variables are included, however, both the signs of the coefficients and the pattern of significance obtained for the two samples are quite consistent.

We first analyze the results for the sample of universities. The variables governing the attraction of students with higher SAT levels that were consistently significant were the following. Initial SAT level, academic reputation, expenditure and graduation rate. The acceptance rate, originally significantly negative (indicating the prominence of its role as a signal of low achievement), lost its significance when combined with the remaining variables. This is consistent with the fact that acceptance rate is neither a good indicator of final student achievement nor a large component of cost, as compared to the graduation rate. The student to faculty ratio was originally negative and sometimes significant, but also lost some significance when combined with other variables.

Each of the consistently significant variables obtained the expected sign. Only the sign for graduation rate could be expected to be ambiguous, in the unlikely case that these rates would reflect a reduced student achievement. In the presence of the other indicators we think that graduation rate signals lower failure costs and a higher probability of success, independently of the academic level at which it is attained. Together, the results confirm that the acquisition of quality by educational institutions is a dynamic process with a convergence effect in which the resources available for achievement, its level, and the expected rate of success combine to attract higher quality students. Less important are variables such as yield (ratio of students who enroll to those admitted), which only reflects a low-level cost to students. The student to faculty ratio obtained the expected negative sign when considered on its own but was only significant for the 75^{th} percentile SAT level at national universities. When combined with other variables it was only somewhat significant in the case of the 25^{th} percentile level at national liberal arts colleges. Perhaps this ratio does not obtain very significant coefficients since it is only an incomplete measure of the opportunities for student learning.

The results for liberal arts colleges are similar except that the freshmen retention rate is more significant while academic reputation is less so. The first of these indicates that in this case the aspects of cost reduction captured by the variable are important. That these results differ with those for universities may reflect differences in the preferences of students choosing these colleges, differently constructed variables, or simply an effect of the different sample sizes. As to the second, perhaps the fact that liberal arts colleges are not as prominent in graduate study and research makes their academic reputation a less well-formed and accurately transmitted perception, both at the public and at the individual levels.

Table III

Improvement of SAT Levels for Students Entering Higher Education. Regressions with all independent variables (Single regression with all variables)

	National Universities **(114 observations)**		***National Liberal Arts Colleges*** **(95 and 94 observations)**	
	25th percentile SAT	**75th percentile SAT**	**25th percentile SAT**	**75th percentile SAT**
Constant	***0.62***	***0.809***	*0.273*	***0.703***
	[0, 0]	**[0, 0]**	*[0.042, 0.169]*	**[0, 0.002]**
Initial SAT	**-0.103**	**-0.115**	**-0.055**	**-0.107**
	[0, 0]	**[0, 0]**	**[0.001, 0.021]**	**[0, 0.003]**
Academic Reputation	**0.003**	**0.004**	0.001	*0.002*
	[0.011, 0.024]	**[0.002, 0.017]**	[0.506, 0.58]	*[0.079, 0.233]*
Expenditure	**0.008**	*0.004*	-0.003	0
	[0.002, 0.012]	*[0.017, 0.11]*	[0.64, 0.676]	[0.94, 0.944]
Freshmen Retention Rate	-0.01	-0.021	**0.034**	0.011
	[0.55, 0.592]	[0.146, 0.21]	**[0.022, 0.099]**	[0.377, 0.468]
Graduation Rate	**0.016**	**0.022**	0.005	**0.009**
	[0.022, 0.087]	**[0, 0.068]**	[0.365, 0.512]	**[0.066, 0.094]**
Acceptance Rate	0.001	0.001	0.003	-0.002
	[0.7, 0.748]	[0.836, 0.881]	[0.497, 0.573]	[0.543, 0.593]
Alumni Giving Rate	0.003	0.001	-0.001	-0.002
	[0.159, 0.221]	[0.575, 0.688]	[0.722, 0.731]	[0.573, 0.6]
Student to Faculty Ratio	0.003	-0.002	*-0.011*	-0.004
	[0.345, 0.493]	[0.434, 0.557]	*[0.1, 0.123]*	[0.477, 0.516]
Yield	0	-0.002	-0.001	0.003
	[0.993, 0.995]	[0.38, 0.442]	[0.823, 0.84]	[0.261, 0.407]
R-squared	0.507	0.493	0.243	0.376
Log likelihood.	394.2	416.7	327.8	332.1

The square brackets represent ranges of p values or of R-squared statistics resulting from the application of OLS, White and Newey West regression methods. Results in bold are consistently significant while results in italics are significant in at least one regression at the 10% level.

Conclusion

Our model that supports the view that academic institutions seeking excellence must recognize that their mission is to maximize the aggregate achievement of their *current students*. Attempts to prematurely raise the academic level before a pool of high quality students is attracted to the institution are likely to be futile. As an institution succeeds in student achievement, it will be rewarded with an increased reputation that will in turn attract better students. In maximizing current achievement, institutions should use all instruments at their disposal, such as tutorials, individual attention and instruction by levels of skill. They should also take care to minimize the costs incurred by students failing the institution, by designing effective selection mechanisms that reduce problems of information and uncertainty, by providing mid-course alternatives which reduce the cost of failing, or by other means. Improvements in extracurricular benefits will also attract better students.

We have also shown empirically that the quality of the students attracted by institutions of higher education follows a dynamic process. Although there is a tendency for student quality to converge amongst institutions, the resources dedicated to student achievement, the academic level, and the expected success rate, all combine to attract better future students.

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