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Dynamic Adjustment in the U.S. Higher Education Industry, 1955–1997

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Abstract. We analyze how the number of higher education institutions responds to demand growth by applying a dynamic model to U.S. data over the period 1955–1997. We derive our dynamic, partial adjustment model from first principles under various assumptions about firm behavior, ranging from profit-maximization by Cournot firms to output-maximization by non-profit firms. Empirical estimates from this dynamic model suggest that the higher education industry does indeed respond to demand growth, but only moderately in the short run and little more in the long run. Certain segments within the overall industry exhibit much stronger responsiveness in the short and long run, in particular, public and 2-year schools.

Keywords: Dynamic model, entry, higher education, partial adjustment

JEL Classification: L11, I21, D21, C22.

I. Introduction

Markets adjust to demand shocks through a combination of price and output effects. Output effects, in turn, may take the form of increases in the size of existing firms or increases in the number of producers as the result of entry. Where the costs of expansion are substantial but entry is easy, the number of suppliers can be expected to increase. Alternatively, where entry is subject to significant impediments but size is more readily adjusted, incumbent firm expansion will dominate. If both expansion and entry are difficult and costly, price will rise to choke off a significant part of increased demand.

We therefore expect each industry to respond to demand shifts with a mix of entry and expansion specific to its underlying cost and behavioral characteristics.[1] This paper models these adjustment dynamics explicitly and

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[1] For analyses of the entry process, see, for example, Hall (1987), Dunne *et al.* (1988), Kessides (1990), and Troske (1996). Summaries of the literature can be found in Siegfried and Evans (1994) and Geroski (1995).

tests the applicability of the models in the context of the higher education "industry." We build our dynamic, partial adjustment model used in the empirical analysis from first principles. We begin by analyzing the comparative statics of firm numbers under a variety of assumptions about the behavior of institutions of higher education, ranging from profit-maximization by Cournot firms to output-maximization by non-profit firms. The different behavioral assumptions turn out to produce similar comparative statics effects of demand shifts and cost differences on firm numbers. Next, we relax the assumption of instantaneous adjustment and incorporate an alternative partial adjustment mechanism to represent the time path of firm numbers. Thus, the response to a demand shock is distributed over current and future periods in a manner that depends upon the ease and speed of entry. An industry (or segments thereof) with slower adjustment processes will have a smaller current-period impact and take longer to achieve any given degree of proximity to long-run equilibrium. The resulting dynamic model forms the basis for the empirical estimation on the higher education industry.

As considered here, this industry consists of all institutions that grant educational degrees – associates, bachelors, masters, doctoral, and professional – beyond the high school diploma. Over the past 40 years, demand for higher education in the United States has grown dramatically. Between 1955 and 1997 total enrollments grew more than fivefold, from 2.7 to 14.3 million, an enormous increase and one requiring considerable adjustment by this industry. But this industry is also very diverse, consisting of public and private, non-profit and for-profit, 4-year and 2-year institutions. Each of these segments has experienced somewhat different enrollment growth over this period, and more importantly, each is characterized by a different constellation of entry and expansion possibilities. The latter predictably result in different patterns of increased numbers, size, and price.

Our initial question concerns the degree to which this increased demand has been met by greater total number of institutions as opposed to increases in their size. Using data spanning the period 1955–1997, we estimate this partial adjustment model for the higher education industry as a whole as well as for several of its segments. Overall the model fits the data quite well, indicating that this is a fruitful approach to represent the dynamics of this and perhaps other industries. Substantively, we find that the higher education industry does indeed respond to demand growth, but only moderately in the short run and little more in the long run. Certain segments within the overall industry, however, exhibit much stronger responsiveness. In particular, public colleges and universities and 2-year schools expand their numbers to a much greater degree both initially and in long-run equilibrium. We go on to examine the responsiveness of these institutions in terms of growth of their size, finding a roughly similar pattern of effects.

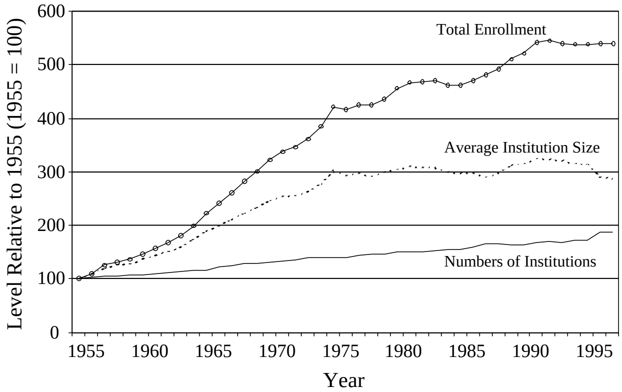

Figure 1. Trends in the U.S. Higher Education Industry.

II. The U.S. Higher Education Industry, 1955–1997

The higher education industry in the United States has undergone an enormous transformation over the past 40 years. As noted in Section I, enrolments, an indicator of demand, increased more than fivefold between 1955 and 1997. The number of colleges, universities, and technical institutes increased as well, but only by about 70%. The remainder of demand growth was accommodated by a tripling of the average size of existing institutions during this period. Figure 1 portrays these trends, and Table I summarizes the underlying data by 10-year increments.

It should be noted that the IPEDS database which forms the cornerstone of this study does not contain a consistent series on institution numbers for the entire period.[2] Early on, the number of institutions is reported excluding branch campuses; later a second series including branch campuses was also provided, and this became the only series reported. We exploit the 12-year overlap between the two series to obtain a consistent series for number of institutions including branch campuses. We regress N_i, the series including branch campuses, on N_x, the series which excludes branches, plus time-related variables. We the use this estimated relationship to predict N_i for the years 1955–1975, thereby completing the series for the entire period. Details on the imputation procedure are provided in Appendix A.

Figure 1 and Table I highlight several facts of particular interest for this study. Enrollment demand grew throughout the 1955–1997 period, although far more rapidly in the first 20 years than in the last. Rising population of the

[2] The Integrated Post-Secondary Education Data System (IPEDS) comprises data since 1987. Its predecessor is the Higher Education General Information Survey (HEGIS). Data from both are usefully compiled in a National Center for Education Statistics publication (Snyder and Hoffman, 2001). We shall refer to these data collectively as IPEDS.

Table I. Descriptive statistics for all U.S. higher education institutions

Years	Total enrollment (thousands)	Number of institutions	Average institution size
Levels for selected years			
1955	2,653	2,156	1,230
1965	5,921	2,529	2,341
1975	11,185	3,026	3,696
1985	12,247	3,340	3,667
1995	14,262	3,706	3,848
Percent change over various periods			
1955–1995	437.6	71.9	212.8
1955–1975	321.6	40.4	200.5
1975–1995	27.5	22.5	4.1

college-age cohort, the G.I. Bill, and rapid increases in female enrollment rates propelled these changes.[3] In response, number of institutions increased as well, but much more slowly and uniformly over time. By contrast, the average size of institutions grew quickly and in tandem with the large enrollment increases of 1955–1975. Both size and enrollment growth eased after 1975, even as institution numbers continued their steady increase. It would appear, not surprisingly, that size bears the brunt of the initial adjustment to demand shocks, while numbers respond more slowly and, indeed, continue to adjust well after the triggering demand shift has occurred.

As previously noted, the higher education industry consists of segments with quite different characteristics. Table II provides descriptive statistics for the public/private split of the sample. The table suggests that public and private institutions have undergone rather different adjustment processes. In response to the huge demand shift in 1955–1975, public institutions moderately increased their numbers, but nearly quadrupled their average size. As a result, collectively state colleges and universities accommodated a more than sixfold increase in total enrollments. By contrast, private schools increased their average size only by about a half between 1955 and 1975 and their numbers by even less. Under no corresponding public obligation and perhaps more protective of their franchise, private colleges and universities merely doubled their total enrollment. The period after 1975 has been characterized by much slower growth of enrollments, with private institutions accounting for relatively more of that growth – and more of the increase in institution numbers – than public schools.

[3] For studies of demand determinants, see, for example, Becker (1990) and Clotfelter *et al.* (1991).

Table II. Descriptive statistics for public versus private institutions

Years	Total enrollment (thousands)		Number of institutions		Average institution size	
	Public	Private	Public	Private	Public	Private
Levels for selected years						
1955	1,476	1,177	927	1,238	1,592	950
1965	3,970	1,951	1,088	1,446	3,647	1,349
1975	8,835	2,350	1,442	1,584	6,127	1,484
1985	9,479	2,728	1,498	1,842	6,328	1,503
1995	11,092	3,169	1,655	2,051	6,702	1,545
Percent change over various periods						
1955–1995	651.5	169.2	78.5	65.7	321.1	62.6
1955–1975	498.6	99.7	55.6	27.9	284.9	56.2
1975–1995	25.5	34.9	14.8	29.5	9.4	4.1

Table III. Descriptive statistics for 2- versus 4-year institutions

Years	Total enrollment (thousands)		Number of institutions		Average institution size	
	4-Year	2-Year	4-Year	2-Year	4-Year	2-Year
Levels for selected years						
1965	4,748	1,173	1,669	839	2,845	1,198
1975	7,215	3,970	1,898	1,128	3,801	3,520
1985	7,716	4,531	2,029	1,311	3,803	3,456
1995	8,769	5,493	2,244	1,462	3,908	3,757
Percent change over various periods						
1965–1995	84.7	368.3	34.5	74.3	37.4	213.6
1965–1975	52.0	238.4	13.7	34.4	33.6	193.8
1975–1995	21.5	38.4	18.2	29.6	2.8	6.7

Table III reports similar data for the 4-year/2-year split of the sample. Since IPEDS contains enrollment data for these segments only as far back as 1965 (and since data on institution numbers prior to 1975 are estimated anyway), we begin our comparisons in 1965. These data reveal that 2-year schools have increased their numbers, average size, and total enrollments several-fold as much as have 4-year schools. A considerable part of the overall change in the structure of the higher education industry over the past 30 or 40 years is clearly the result of increased demand for technical and specialized education beyond high school. While the traditional 4-year segment has also grown during this period, expansion by those institutions is considerably more modest.

III. Modeling the Adjustment Process

The discussion of trends in the previous section is useful in characterizing the transformation of the higher education industry over the past 40 years, but it does not cast light on the actual adjustment behavior of such institutions. That is, by themselves these data do not measure the speed of adjustment over time or across the various segments. In order to test for such behavior and behavioral differences, we employ a model of partial adjustment to demand shifts. We will show that this model is consistent with a variety of different assumptions about the behavior of higher education institutions, ranging from profit-maximizing firms engaging in Cournot competition to non-profit firms maximizing enrollments subject to a budget constraint.

Consider first a model of Cournot competition among profit-maximizing institutions. Let N be the number of symmetric firms; q, the output of a representative institution; Q, the aggregate output of other institutions in the same market; X, a demand shifter; K, fixed cost; $C(q)$, variable cost; $AC(q,K) = [C(q)+K]/q$, average cost; and $P(q+Q,X)$, inverse demand, with $P_Q < 0$ and $P_X > 0$. The profit of a representative institution thus can be written $\pi(q,Q,X,K) = P(q+Q,X)q\text{-}C(q)\text{-}K$. Let $N^*(X,K)$ be the number of institutions in the symmetric Cournot equilibrium under free entry. The following proposition follows from Corchón and Fradera (2002).

PROPOSITION *1*. In the model of Cournot competition among profit-maximizing institutions, assuming, $\pi_{qq} < \pi_{qQ} < 0$ then $N^*(X,K)$ is weakly decreasing in K. Further assuming $\pi_{qX} \geq 0$ and $\pi_{qX}/\pi_X \leq \pi_{qQ}/\pi_Q$, then $N^*(X,K)$ is weakly increasing in X.

The first statement of the proposition follows from Theorem 2 of Corchón and Fradera (2002) and the second statement from Theorem 3 of Corchón and Fradera (2002).

The first statement of the proposition is that, under the conditions proposed by Hahn (1962) to ensure stability of equilibrium, which have since been standard assumptions in analyses of Cournot competition, comparative statics with respect to fixed costs work in the intuitive way: an increase in fixed costs leads to a decrease in the long-run equilibrium number of institutions. The second statement of the proposition is that, under a further assumption on the effect of the demand shifter on the slope of demand relative to its effect on the level of demand, comparative statics with respect to demand shifts work in the intuitive way: a shift up in demand leads to an increase in the long-run equilibrium number of institutions. The conditions involved in both statements of the proposition are satisfied, for example, if demand is linear, cost is quadratic, and the demand is shifted up through an increase in the intercept (Corchón and Fradera, 2002).

We next show that similar comparative statics emerge from a model with symmetric non-profit institutions maximizing output subject to a budget constraint.[4] Assume institutions maximize utility $u(q)$ subject to the budget constraint $P(q+Q,X)q - C(q) - K \geq 0$, modeled for simplicity as a zero-profit constraint (but which could more generally depend on the institution's endowment). Assume further that institutions' average cost function is U-shaped. Two conditions characterize long-run (free entry) equilibrium:

$$q^*(X,K) = \max\{q|P(N^*(X,K)q,K) = AC(q,K)\} \quad (1)$$

$$N^*(X,K) = \max\{N|P_Q(Nq^*(X,K),X) = AC_q(q^*(X,K),K)\} \quad (2)$$

where $q^*(X,K)$ denotes institution output (enrollment) in long-run equilibrium. Condition (1) follows from optimizing behavior by institutions, which entails the zero-profit constraint binds in equilibrium. Condition (2) follows from free entry: ignoring integer problems and treating the number of institutions as a continuous variable (as we shall do for convenience from now on), the largest number of institutions in a free-entry equilibrium results in the highest tangency between an institution's residual demand curve and its average cost curve. If the residual demand curve intersects the average cost curve in more than one place, there would be space for more institutions to enter. An analysis of conditions (1) and (2) turns out to yield intuitive comparative statics results with respect to the long-run equilibrium number of institutions, as the next proposition, proved in the Appendix, states.

PROPOSITION 2. In the model of non-profit institutions maximizing output subject to a break-even constraint, $N^*(X,K)$ is increasing in X and decreasing in K.

Putting Propositions 1 and 2 together, we see that there is a range of models providing the intuitive comparative statics results – namely, that shifts up in demand increase the number of institutions and shifts up in fixed costs decrease the long-run equilibrium number of institutions – under general conditions. Linearizing this relationship for estimation purposes, we obtain

$$N^*(X,K) = \alpha + \beta X + \gamma K \quad (3)$$

where from the preceding theory, $\beta > 0$ and $\gamma < 0$.

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[4] While we do not claim that constrained output maximization is necessarily the objective of universities, much less of non-profits in general, output above the profit-maximizing level captures an essential feature of many proposed objectives. See, for example, James (1983), Hansmann (1986), and Weisbrod (1988).

To move from comparative statics results to a dynamic model, we will assume that institution numbers do not fully equilibrate in one period. Rather, numbers change by some proportion $\lambda(K_t)$ of the gap between last period's number N_{t-1} and the equilibrium value $N^*(X_t,K_t)$. Note that this specification allows the speed of adjustment to depend on the fixed cost of setting up the institution; presumably higher fixed costs require a longer adjustment process. Formally,

$$N_t - N_{t-1} = [1 - \lambda(K_t)][N^*(X_t, K_t) - N_{t-1}] + \epsilon_t \tag{4}$$

where ϵ_t is an error term. Substituting Equation (3) into Equation (4) and rearranging yields the familiar autoregressive form

$$N_t = \alpha[1 - \lambda(K_t)] + \lambda(K_t)N_{t-1} + \beta[1 - \lambda(K_t)]X_t + \gamma[1 - \lambda(K_t)]K_t + \epsilon_t. \tag{5}$$

Equivalently, Equation (5) can be derived by applying a Koyck transformation to a process involving a geometric lag in the causal factors X and K (Greene, 1993). We do not have data on fixed costs K_t, but assuming they vary across classes of institutions (i.e., 2- versus 4-year, public versus private, etc.) indexed by c but are relatively constant over time and across institutions within the classes, we can express Equation (5) as

$$N_t = \alpha_c + \lambda_c N_{t-1} + \beta(1 - \lambda_c)X_t + \epsilon_t \tag{6}$$

where $\lambda_c = \lambda(K_c)$, $\alpha_c = \alpha\ (1-\lambda_c)\ +\ \gamma\ (1-\lambda_c)K_c$, and K_c denotes the fixed cost for institutions within class c. The form of Equation (6) motivates our estimating the autoregressive form of the partial adjustment model separately for each class c of institutions.

The partial adjustment model embodied in Equations (4)–(6) has been presented as a reduced form, but it can be built up from several alternative structural models. In the context of a single institution, Griliches (1967) showed that if adjustment costs of being out of equilibrium are quadratic, the partial adjustment model follows from cost minimization. Other explanations are possible in our market setting with many institutions. First, convex adjustment costs may arise at the market-wide level if the supply of inputs required to set up institutions, or the supply of financing, is upward-sloping. Second, institutions may differ in their private information concerning, and forecasts of, future random variables, and the partial adjustment process may reflect idiosyncratic updating of private information. Third, firms may enter sequentially as a coordinating device ensuring that the mixed strategy entry equilibrium does not result in too little entry. Regarding this last point, we provide an example in the Appendix of an infinitely repeated entry game, in which potential entrants can enter in future periods based on their observation of the current number of active firms, in which the number of firms follows an adjustment process identical with Equation (4).

In the next section, we will estimate Equation (6) and obtain estimates of the short-run and the long-run multipliers. The short-run or impact multiplier is given by the coefficient $\beta(1-\lambda_c)$ on the contemporaneous independent variable X_t, while the long-run or equilibrium multiplier β can be recovered by dividing the impact multiplier by one minus the estimated coefficient on lagged numbers $N_{t\text{-}1}$. It is reasonable to hypothesize the following effects on numbers of institutions:

(a) The impact and equilibrium multipliers are different, implying an adjustment process of several periods for the number of institutions of higher education to return to equilibrium. This is likely to be the case, since mobilizing the resources to create a new college, university, or institute is a clearly non-trivial undertaking.[5]
(b) The impact or short-run multiplier of public institutions is larger than for private institutions. The private sector appears to be slower to create new institutions than is the public sector. This may be due to lesser access to capital by the private sector or to a greater aversion to experimenting with new institutions.
(c) The short-run multipliers for 2-year institutions are larger than for their 4-year counterparts. Given their status and structure, we expect 2-year institutions to be better able to respond quickly to changing market opportunities, relative to full 4-year schools.

We test all these propositions about entry and number of institutions, and then go on to examine how demand shifts cause expansion in the sizes of existing institutions. Like entry, expansion is likely to be a process that is not completed in the same period as the initial shock. For this reason, we estimate a partial adjustment model to changes in the average sizes of institutions, both overall and by segment, analogous to that for institution numbers. We seek to compare the speed of adjustment of size relative to numbers, both overall and by segment. The next section begins with the analysis of the dynamics of institution numbers.

IV. Estimation and Results

The data employed in this study for total number of institutions and for public versus private institutions cover the period 1955–1997. For the 4-year versus 2-year segments, the study period is 1965–1997, due to data limitations previously discussed. The model to be tested is essentially that derived in Equation (6) above, subject to certain data transformations. Any attempt to

[5] The number of new start-up institutions in any year is non-trivial, but entry is concentrated in technical and 2-year schools.

estimate Equation (6) as written will encounter a number of econometric issues. First, the disturbance term is likely to exhibit serial correlation. Second, the combination of serial correlation and the presence of a lagged dependent variable on the right-hand side will induce a violation of the exogeneity assumption necessary for ordinary least squares to be consistent, requiring the use of instrumental variables. Third and perhaps most fundamentally, the N_t and X_t series are not stationary, as is apparent from Figure 1. Collectively, these problems will result in inefficient and inconsistent estimates of the relevant parameters.

Our basic approach is to transform the data into rates of growth by taking differences of the logs of all continuous variables. Growth rates are unlikely to be non-stationary, and in this case tests confirm that stationarity is no longer an issue. Differencing turns out to eliminate serial correlation in the errors, implying that the lagged dependent variable on the right-hand side need not be instrumented for and thus that ordinary least squares (without any correction for serial correlation) is efficient.

We do, however, wish to preserve one property exhibited by Equation (6), specifically, that it allows for a short-run ("impact") effect that may differ from the long-run (or "equilibrium") effect. This is accomplished by including the lag of the dependent variable, in the present case the growth rate of N_t, in the model to be estimated. This allows the time path of growth in numbers to affect the current rate of change.

From an expository point of view, the growth rate transformation results in estimated coefficients that are elasticities, specifically, the elasticity of institution numbers with respect to enrollments. Then, as with the equation in levels, the impact multiplier is given by $\beta(1 - \lambda_c)$ – the estimated coefficient on current enrollment – while the equilibrium multiplier can be recovered from this impact multiplier together with the estimated coefficient on the lagged growth rate.

The results of this estimation are reported in Table IV. Column (a) presents results for all institutions, while columns (b) and (c) do so for public and private institutions, respectively, and columns (d) and (e) do so for 4-year and 2-year schools. All regression models include dummy variables for 1987, 1988, and 1989 controlling for a reporting change that affected the number of institutions in those years, in addition to a dummy for 1996 as a result of a later change in reporting definitions.[6] In addition, it should be noted that the enrollment numbers used in all models are total enrollments, not those

[6] The IPEDS data source notes that as a result of "revised survey procedures (in 1987, and once again involving branch campuses), data are not entirely compatible with figures for earlier years." Statistical analysis reveals that the anomaly affects these 3 years only. Starting in 1996, the number of institutions jumps as a result of inclusion of schools accredited by an additional agency.

Table IV. Ordinary least squares regressions for growth rate of number of institutions

Variable	All institutions (a)	Public institutions (b)	Private institutions (c)	4-year institutions (d)	2-year institutions (e)
Constant	0.009 **	0.004	0.010 **	0.010 **	0.012
	(0.002)	(0.003)	(0.003)	(0.002)	(0.006)
Enrollment growth	0.110 **	0.125 *	0.044	0.086 **	0.199 *
	(0.032)	(0.054)	(0.047)	(0.022)	(0.093)
Lagged growth of numbers	0.001	0.420 **	0.031	−0.245	−0.052
	(0.087)	(0.137)	(0.088)	(0.150)	(0.104)
R^2	0.80	0.54	0.78	0.58	0.68
Summary of elasticities of number of institutions with respect to enrollments					
Impact	0.110 **	0.125 *	0.044	0.086 **	0.199 *
	(0.032)	(0.054)	(0.047)	(0.022)	(0.093)
Equilibrium	0.110 *	0.215 *	0.046	0.069 **	0.189 *
	(0.032)	(0.085)	(0.049)	(0.017)	(0.089)

Notes: Regressions include dummies for the years 1987, 1988, 1989, and 1996 to account for data reporting changes as described in the text; coefficients not reported here for brevity. All regressions involve 41 observations. Standard errors reported in parentheses below coefficient estimates. Significantly different from zero in a two-tailed test at the *5% level; **1% level. The impact elasticity can be read directly from the coefficient on enrollment growth. The equilibrium, or long-run, elasticity is computed by dividing the coefficient on enrollment growth by one minus the coefficient on lagged growth of numbers. Standard error on the long-run equilibrium elasticity, a non-linear function of the coefficients, computed using the delta method.

specific to each category of institution. The rationale for this is that total demand (enrollments) is what guides the entry decision, rather than enrollments into each specific segment. Indeed, the segmentation of enrollments would seem more the result of entry decisions than their cause.[7]

The growth rate of enrollments is a significant influence on growth of institution numbers for all types of institutions except for private colleges and universities. The magnitude of the effect is strongest for 2-year institutions. The coefficient on current enrollment implies a short-run elasticity of numbers with respect to enrollment of about 20%. That is, the first-year rate of growth of 2-year institution numbers is 20% as large as the enrollment increase they experience. Four-year institutions, by contrast, respond more slowly. Their impact elasticity of only 8.6% implies that a 10% enrollment increase causes a less than 1% increase in their numbers. This difference is consistent with the view that impediments to entry into the ranks of 4-year institutions are greater than for 2-year schools.

The growth rate of public school numbers is quite responsive to enrollment increases as well, with an estimated impact multiplier of 12.5%. This, too, is statistically significant, whereas the estimate for private institutions is both much smaller and insignificant. Once again, consistent with other evidence, public institutions demonstrate a high degree of response to demand increases during the postwar period, whereas private schools are considerably slower to adjust. Indeed, a literal reading of this significance level of this estimate would call into question any immediate response whatsoever on the part of private colleges and universities.

A smaller immediate response does not, however, necessarily imply a smaller equilibrium response to a demand shock. As noted previously, the long-run equilibrium multiplier is obtained by dividing the impact multiplier by one minus the coefficient on the lagged growth rate of numbers. In the case of all institutions in column (a), the equilibrium multiplier (elasticity) is obtained by dividing 0.110 by $(1 - 0.001)$. The small size of the latter factor implies little difference between the impact and equilibrium values: in practical terms, most of the response by these institutions is observed in the immediate period.

Since the impact multiplier in regression (c) for private institutions is statistically insignificant to begin with, and the long-run equilibrium multiplier is essentially no different, we conclude that the creation of private institutions appears to be unrelated to external demand shocks.

Contrast that with the nature of responses by public colleges and universities. Despite an impact multiplier that is only modestly greater than that

[7] The possibility that enrollments of any type are at least in part the result of entry, rather than their cause, will be considered below.

for all institutions (0.125 versus 0.110), the equilibrium elasticity for public institutions is 0.215, nearly twice that for all schools. The large and significant coefficient on the lagged growth rate of numbers reflects the importance of adjustment dynamics by public institutions: past growth rates affect current rates, and current shocks will continue to have effects in future periods. When all those have been accounted for, the growth elasticity of public numbers is 0.215, nearly twice its immediate value. Public institutions respond quickly and substantially, and then continue to respond until their full adjustment rivals that of the most responsive segment, namely, 2-year schools.

The equilibrium values of adjustment elasticities for other segments of this industry do not generally differ much from their first-period, impact values. The estimated coefficients on lagged growth rates of numbers for private and for 2-year institutions are very small – indeed, in one case negative – and statistically insignificant.[8] For these schools their equilibrium elasticity is given by their first-period elasticity, with no further effects in future periods. In the case of 4-year schools, the lagged growth rate appears with a negative sign and borders on statistical significance, suggesting "overshooting" of expansion in the initial period followed by a reversal. All of these calculated elasticities are summarized at the bottom of Table IV.

V. Extensions

We have uncovered significant differences in responsiveness to rising demand for higher education between types of institutions and between the short and long runs. These differences are both economically meaningful and by no means apparent from mere inspection of the data. We may therefore conclude that this modeling and estimation technique can make a real contribution to our understanding of adjustment behavior in this and perhaps other industries. Here we wish to extend this analysis in three directions: first by considering the possibility of endogeneity, second by studying the interaction of macroeconomic variables with the adjustment process of numbers, and third by analyzing adjustment in size of institutions.

1. Potential Endogeneity of Enrollments

Endogeneity may be a potential problem because enrollment, which we have taken to be an exogenous demand shock to be placed on the right-hand side

[8] The previously discussed coefficient on the lagged growth rate for all institutions is also insignificant, with a *t*-value of 0.01. We nonetheless used its value to illustrate the computation of equilibrium effects and to draw distinctions between impact and equilibrium values.

of Equation (6), may itself be the result of supply-side adjustments as well as demand shifts. That is, a larger number of institutions may lead to more students actually enrolled, through any of several mechanisms. For example, if existing institutions are capacity-constrained, then increasing the number of institutions will result in more enrollment. Another possibility is that competition among more numerous institutions ends up attracting more students than otherwise might in total enroll.

If enrollments are, for whatever reason, caused in part by the number of institutions, that direction of causality must be reflected in the econometric technique employed to measure response elasticities. Our approach here is to use instrumental variables regression techniques, instrumenting for enrollments by their determinants in equations otherwise identical to those in Table IV. We employ three instrumental variables: the number of high school graduates (the population from which demand for higher education arises),[9] disposable personal income of the median household,[10] and percent females in institutions of higher education (capturing the large secular increase in female college participation in the postwar period).[11] Because enrollment appears in this model as a growth rate, these instruments for enrollment are expressed as rates of growth as well.

The resulting instrumental variables regressions are reported in Table V. Qualitatively these results tell much the same story as do those in Table IV. All impact elasticities are statistically significant except for that on private institutions. The largest elasticity is for 2-year schools, followed by that on public colleges and universities. The factor used to convert this impact elasticity into an equilibrium elasticity is small and insignificant for all but public and 4-year institutions. For public schools, it implies a long-run elasticity of numbers growth with respect to enrollment growth of 0.261, compared to the first-period elasticity of 0.162. For 4-year schools, the negative sign mirrors that found in the ordinary least squares version.

It is noteworthy, however, that all the coefficients on the current growth rates of enrollments in all these regressions are considerably larger than in Table IV. The fact that the coefficients change would seem to support the view that enrollment data are subject to endogeneity in this model. However, the direction of change is somewhat surprising; namely, the corrected coefficients are larger than their ordinary least squares counterparts which

[9] We also experimented with alternatives such as the population of 17-year olds and total population for this instrument.

[10] Alternative instruments, including measures of income at the upper tail of the distribution, often found a significant factor in other studies, are not available back to 1955. Cost measures such as tuition also do not extend that far back.

[11] Female enrollment data have missing values for 1958, 1960, and 1962. Interpolated values were used for these 3 years.

Table V. Instrumental variables regressions for growth rate of numbers

Variable	All institutions (a)	Public institutions (b)	Private institutions (c)	4-year institutions (d)	2-year institutions (e)
Constant	0.007*	0.003	0.010	0.008 **	0.009
	(0.003)	(0.004)	(0.005)	(0.003)	(0.009)
Enrollment growth	0.177 *	0.162	0.057	0.209 *	0.261
	(0.076)	(0.139)	(0.099)	(0.078)	(0.209)
Lagged growth of numbers	−0.022	0.380	0.034	−0.496	−0.058
	(0.095)	(0.194)	(0.090)	(0.253)	(0.107)
Summary of elasticities of number of institutions with respect to enrollments					
Impact	0.177 *	0.162	0.057	0.209 *	0.261
	(0.076)	(0.139)	(0.099)	(0.078)	(0.209)
Equilibrium	0.173 *	0.261	0.059	0.140 **	0.247
	(0.072)	(0.168)	(0.103)	(0.042)	(0.219)

Notes: Regressions include dummies for the years 1987, 1988, 1989, and 1996 to account for data reporting changes as described in the text; coefficients not reported here for brevity. All regressions involve 41 observations. Standard errors reported in parentheses below coefficient estimates. Significantly different from zero in a two-tailed test at the *5% level; **1% level. The impact elasticity can be read directly from the coefficient on enrollment growth. The equilibrium, or long-run, elasticity is computed by dividing the coefficient on enrollment growth by one minus the coefficient on lagged growth of numbers. Standard error on the long-run equilibrium elasticity, a non-linear function of the coefficients, computed using the delta method. Instrumental variables include number of high school graduates, disposable personal income of the median household, and percent females in higher education institutions.

presumably incorporated both demand-side effects (which we are interested in measuring) as well as supply-side effects. At present it is unclear what is responsible for this particular result.

2. Effect of Macroeconomic Variables on Adjustment

In the second extension, we analyze the possibility that the elasticity of number of institutions with respect to demand growth might be influenced by macroeconomic variables. The regressions in Table V allowed for the possibility that macroeconomic variables may influence number of institutions, namely through the effect of these macroeconomic variables on demand, proxied by enrollments, which in turn affects number of institutions. Macroeconomic variables may affect the elasticity of numbers with respect to enrollment growth as well. Tuition is an important source of revenue, but other sources of revenue are also used to fund entry and growth. The availability of these other sources of revenue likely depends on macroeconomic conditions, thereby affecting the ability of institutions to respond to demand growth. In a boom, there may be more entry of private institutions in response to demand growth because there are more potential donors to endow them. In a boom, state governments might find spending easier and therefore might respond to demand increases by expanding enrollments and campuses (rather than increasing price or rationing spaces as they might do during a recession).

Stated in formal terms, the effect of demand shifter X on long-run equilibrium number of institutions N^*, rather than being a constant β as it is in Equation (3), may be a function of macroeconomic variables Z, say $\beta(Z) = \beta_0 + Z\,\beta_1$. Working through the rest of the model, this modification would add an extra vector of variables to our basic regression, a vector containing the interaction of macroeconomic variables Z_t with enrollment growth.

In the interest of parsimony, we will use a single macroeconomic variable for Z_t, namely the deviation of the natural log of U.S. gross domestic product (GDP) from trend, referred to as our "business cycle" variable. Table VI presents the regression results. For simplicity the results are from ordinary least squares regressions which ignore possible endogeneity already addressed in the previous subsection. The coefficients that are common across Tables IV and VI are qualitatively similar. The new interaction term between enrollment growth and business cycle is positive and statistically significant for all institutions in regression (a), for public institutions in (b), and 2-year institutions in (e). These results suggest that public and 2-year institutions' response to a demand increase is stronger in booms rather than recessions, perhaps because sufficient funding is available then. Private and 4-year institutions responses are not sensitive to macroeconomic conditions. Of

Table VI. Ordinary least squares regressions for growth rate of numbers with business cycle interaction

Variable	All institutions(a)	Public institutions (b)	Private institutions (c)	4-year institutions (d)	2-year institutions (e)
Constant	0.009**	0.005	0.010**	0.010**	0.012*
	(0.002)	(0.003)	(0.003)	(0.002)	(0.005)
Enrollment growth	0.111**	0.157**	0.044	0.086**	0.202*
	(0.030)	(0.053)	(0.048)	(0.023)	(0.087)
Enrollment growth × business cycle	1.037*	2.078*	−0.308	0.013	3.590*
	(0.493)	(0.890)	(0.779)	(0.350)	(1.429)
Lagged growth of numbers	−0.026	0.223	0.028	−0.246	−0.099
	(0.084)	(0.153)	(0.090)	(0.152)	(0.099)
R^2	0.82	0.61	0.78	0.58	0.73

Notes: The business cycle variable is the deviation from trend in the natural log of U.S. GDP. Regressions include dummies for the years 1987, 1988, 1989, and 1996 to account for data reporting changes as described in the text; coefficients not reported here for brevity. All regressions involve 41 observations. Standard errors reported in parentheses below coefficient estimates. Significantly different from zero in a two-tailed test at the *5% level; **1% level. Impact and long-run equilibrium elasticities not reported since they are a function of the business cycle variable; see table for average values.

course it should be recognized that our business cycle measure is only a crude proxy for general macroeconomic conditions, and cruder still for regional economic conditions.

To give some idea of the economic importance of the coefficients on the interaction terms, consider regression (a), in which the coefficient is 1.037. A one-standard-deviation increase in the business cycle variable from its mean would cause the impact elasticity of enrollment growth to increase from 0.111 to 0.151. Thus, the interaction terms are economically important in the three cases they are statistically significant, i.e., regressions (a), (b), and (e).

3. Dynamics of Institution Size

The third extension concerns the dynamics of institution size. When subject to a shock increasing demand, colleges and universities in general may be expected to increase in size as well as in numbers. Size changes may be expected to be quicker and larger than numbers changes, a proposition that we can test. There is one respect, however, in which this adjustment process may be more complicated than that explaining numbers. When demand shifts out, one might expect a steady increase in the number of firms until long-run equilibrium is re-established. One might expect size also to increase in the short run, but as entry occurs, price declines, and the size of existing institutions may fall. Whether institutions revert to their previous long-run equilibrium sizes or remain permanently larger depends on the shape of their cost functions.[12] Therefore, we might expect the long-run elasticity to be closer to zero than the impact elasticities in regressions involving the growth of average institution size.

It is thus instructive to consider the dynamics of size as a companion phenomenon to adjustment in numbers and to compare the parameters of the two processes. Accordingly, we estimate the very same model on growth rates of institution size as was previously employed for growth rates of institution numbers. The results are reported in Table VII. As would be expected the impact elasticity of demand on size is far larger than it was for numbers. That for all institutions, in column (a), is 0.899, implying that the growth rate of size is about 90% of that for enrollments. For public institutions, the estimated elasticity of 1.110 means that the initial size adjustment actually

[12] If cost functions are U-shaped and are not affected in the long run by entry, institutions might be expected to revert back to their previous long-run equilibrium sizes before the demand shift. If cost functions have a flat bottom, implying the institution has a range of efficient scales, it may not revert all the way back to its size prior to the demand shift. Another reason it may not return to its previous size is that its cost function may shift downward in response to entry, say because the long-run market supply curve for inputs is downward-sloping.

Table VII. Ordinary least squares regressions for growth rate of size of institutions

Variable	All institutions (a)	Public institutions (b)	Private institutions (c)	4-year institutions (d)	2-year institutions (e)
Constant	−0.009**	−0.010**	−0.004	−0.007**	−0.013*
	(0.002)	(0.003)	(0.004)	(0.002)	(0.005)
Enrollment growth	0.899**	1.110**	0.344**	0.541**	1.654**
	(0.041)	(0.066)	(0.078)	(0.057)	(0.147)
Lagged size growth	−0.014	−0.036	0.091	0.074	0.030
	(0.040)	(0.056)	(0.103)	(0.088)	(0.067)
R^2	0.97	0.94	0.76	0.88	0.92
Summary of elasticities of size of institutions with respect to enrollments					
Impact	0.899**	1.110**	0.344**	0.541**	1.654**
	(0.041)	(0.066)	(0.078)	(0.057)	(0.147)
Equilibrium	0.886**	1.071**	0.379**	0.584**	1.705**
	(0.032)	(0.053)	(0.077)	(0.052)	(0.141)

Notes: Regressions include dummies for the years 1987, 1988, 1989, and 1996 to account for data reporting changes as described in the text; coefficients not reported here for brevity. Regressions (a)–(c) involve 41 observations, and (d) and (e) involve 31 observations. Standard errors reported in parentheses below coefficient estimates. Significantly different from zero in a two-tailed test at the *5% level; **1% level. The impact elasticity can be read directly from the coefficient on enrollment growth. The equilibrium, or long-run, elasticity is computed by dividing the coefficient on enrollment growth by one minus the coefficient on lagged growth of numbers. Standard error on the long-run equilibrium elasticity, a non-linear function of the coefficients, computed using the delta method.

exceeds the growth in enrollments, whereas for private colleges and universities the elasticity is far less. The responsiveness of 2-year institutions' growth rates also exceeds 100%, in contrast to the much slower growth response by 4-year institutions. All of these impact elasticities confirm what Figure 1 suggested: that size adjustments represent the initial mechanism by which the higher education industry responds to demand shocks, but once again with major differences among its segments.

Further insight can be gained by examining the coefficient on the lagged growth rate of size, and by implication, the equilibrium growth elasticity of size. All of these elasticities are summarized at the bottom of Table VII. While none of the coefficients on the lagged growth rate of size approaches statistical significance, there is some evidence supporting the expectation that initial size increase is followed by a reduction in the long run. For example, lagged size elasticities in columns (a) and (b) appear with negative signs, indicating that for these institutions the long-run elasticity is less than the short run. For all colleges and universities the equilibrium elasticity is 0.886, less than the short run impact but only trivially so. The difference is also slight for public institutions, but for private schools the long-run equilibrium effect differs more substantially from the short run, but in an unexpected direction. In no case is the equilibrium elasticity zero, implying that institutions do not eventually return all the way back to their pre-shift sizes in response to a demand shift: demand shocks have a permanent effect on institution size.[13] Further modeling of the size adjustment process will be required in order to better understand the process.

VI. Conclusions

Over the past 50 years higher education has had one of the largest demand increases faced by any industry. This study has modeled its response to that demand increase first by representing the comparative statics and then by incorporating a partial adjustment mechanism for the actual process. Substantively, we have determined that the industry's response to demand growth in terms of increasing the number of institutions is modest at best and concentrated in the initial period of demand growth. But notable differences emerge among segments of the industry, with public and 2-year institutions respond more strongly both in the short and long runs. It appears that these responses depend on macroeconomic conditions, with greater responses in booms when institutions are perhaps better able to access external funds. In

[13] Returning to the discussion in the previous footnote, this result suggests something about institutions' cost functions: either that they have flat bottoms or perhaps shift down in response to entry.

addition, institution sizes also grow as a result of the demand shifts. As expected, size responds more strongly than do numbers, but once again there are significant differences among segments of this industry.

Our study focused on two ways institutions adjust to demand shocks: number of institutions and their size. As noted in Section I, a third way institutions could respond is through price, i.e., tuition in the case of higher education. We did not explore price responses because of data availability. In future work, it would be useful to continue the search for a sufficiently long time series on tuition, estimate a partial adjustment model using this time series, and compare the results to those of the present paper on the other avenues of adjustment.

From a methodological standpoint, this study confirms the applicability of partial adjustment models to industry dynamics. This is noteworthy since these models permit actual measurement of the response of industries to exogenous shocks, including comparisons over time, between industries, among segments of the same industry, between different responses, and between short-run and long-run effects. This would seem to be a very fruitful approach to better understand the process of industry adjustment generally.

Appendix

Imputation of number of institutions

As discussed in the text, IPEDS does not contain a consistent series on institution numbers for the entire period. Until 1985 the number of institutions is reported excluding branch campuses, but starting in 1975 a second series including branch campuses is provided (and after 1985, this is the only series). Simple inspection reveals that the inclusion of branch campuses increases the count by a relatively uniform amount, and otherwise the two series move in a similar fashion. In order to obtain a consistent series throughout, we exploit the 12-year overlap of the two IPEDS series by regressing N_i, the series including branch campuses, on N_x (which excludes branches) plus time-related variables. We the use this estimated relationship to predict N_i for the years 1955–1975, thereby completing the series for the entire period. The statistical relationship is as follows:

$$N_i = \underset{(2.10)}{-11,829} + \underset{(8.23)}{0.812}\,N_x + \underset{(2.14)}{6.38}\,\mathrm{YEAR} - \underset{(5.19)}{69.0}\,\mathrm{POST77}$$

where YEAR is a simple trend variable and POST77 is a fixed effects term for years after 1977, and where t-statistics are presented in parentheses below coefficient estimates. Data for 1978 and thereafter indicate a clear anomaly, possibly due to one or more large institutions altering their reporting of branch campuses (this explanation was offered by IPEDS personnel). All coefficients in the preceding regression are statistically significant, and the R^2 for this regression equation is 0.998.

We estimate N_i for the years 1955–1975, rather than N_x for the period 1986–1997, for two reasons. First, given the need to correct data after 1977, there are virtually the same number of years with estimated data using either approach. Second, current IPEDS definitions include branch campuses, making it more useful to extend that series backwards rather than to project data based on now-abandoned definitions to the present. The same technique is employed to complete the series for public, private, 2-year and 4-year institutions.

Note also that the IPEDS series on enrollments has missing values for 1958, 1960, and 1962. These are estimated using an interpolation algorithm in Stata.

Proof of proposition 2.
Consider first an increase in K. This causes the average cost curve to shift up. If, in addition, N weakly increases, the residual demand curve shifts down weakly. Since the original equilibrium involved the highest N for which residual demand was tangent to average cost, after the curves shift, they no longer intersect. Thus the set in Equation (1) is empty, and so this new configuration cannot be an equilibrium. Therefore, $N^*(X,K)$ must decrease.

Consider next an increase in X. If, in addition, N weakly decreases, the residual demand curve shifts up strictly. Since average cost is U-shaped, the residual demand curve must intersect the average cost curve in two points. Thus, the new configuration cannot be a long-run equilibrium since it cannot satisfy condition (2). Therefore, $N^*(X,K)$ must increase. □

Proof that partial adjustment model follows from coordination in repeated entry game

In this part of the Appendix, we provide an example of an infinitely repeated entry game in which the expected number of firms follows a process identical to the partial adjustment model in Equation (4). For simplicity, we will assume there are two symmetric firms. Time is indexed by periods $t = 1, 2, \ldots$. Let $\delta \in (0,1)$ be the discount factor. Firms earn zero each period they are not in the market. If one firm enters the market, it earns profit $\pi_1 > 0$ each period. If two firms enter the market, they each earn $\pi_2 < 0$. Once a firm decides to enter, it cannot exit the market, but a firm that has not yet entered has the option each period of entering. We will look for a symmetric equilibrium in mixed strategies. Let p_t be the probability a firm enters in period t conditional on no firm having entered up to that point. It is obvious that the symmetric equilibrium will involve zero expected profits for the firms since each is indifferent between entering in period t and never entering. Thus p_t is the implicit solution to

$$0 = (1 - p_t)\left(\frac{\pi_1}{1-\delta}\right) + p_t\left(\frac{\pi_2}{1-\delta}\right)$$

implying

$$p_t^* = \frac{\pi_1}{\pi_1 - \pi_2} = p^*$$

The strategies in other contingencies are straightforward: if one firm has entered, the rival never enters in subsequent periods; if two firms have entered, firms no longer have a strategic entry decision to make (they are assumed to persist in the market).

Letting $E(N_t)$ be the expected number of firms that have entered the market by the end of period t, it can be shown that $E(N_1) = 2p^*$ and

$$\begin{aligned} E(N_t) &= E(N_1) + (1-p^*)^2 E(N_1) + \cdots + (1-p^*)^{2(t-1)} E(N_1) \\ &= E(N_1)\left[\frac{1-(1-p^*)^{2(t-1)}}{1-(1-p^*)^2}\right] \end{aligned} \tag{A.1}$$

implying the expected long-run equilibrium number of entrants is

$$E(N^*) = \lim_{t\to\infty} E(N_t) = \frac{2}{2-p^*}. \tag{A.2}$$

We can find a value of λ_t such that the following process links the expectation of the number of firms across periods:

$$E(N_t) = \lambda_t E(N_{t-1}) + (1-\lambda_t)E(N^*) \tag{A.3}$$

To justify the partial adjustment model in Equation (4), we need to show that the value of λ_t that is the implicit solution to equation (A.3) is independent of t. Brute force calculations, substituting for $E(N_t)$ and $E(N_{t\text{-}1})$ from Equation (A.1) and for $E(N^*)$ from Equation (A.2), imply $\lambda_t = (1\text{-}p^*)^2$, indeed independent of t. □

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