DYNAMIC ADJUSTMENT IN THE HIGHER EDUCATION INDUSTRY, 1955-1997

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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 numbers 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 tests the applicability of the models in the context of the "higher education industry." The modeling first considers the comparative statics of firm numbers in the context of Cournot competition, and then in the context of nonprofit institutions that maximize output subject to a budget constraint. These analytics have similar implications for the 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

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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)

long-run equilibrium. This 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 forty years demand for higher education has grown dramatically. Between 1955 and 1997 total enrollments grew fully fivefold, from 2,653,000 to 14,345,000--an enormous increase and one requiring considerable adjustment by this industry. But this industry is also very diverse, consisting of public and private, nonprofit and for-profit, four-year and two-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 numbers of institutions as opposed to increases in their size. Using data spanning the period 1955 through 1997, we estimate this partial adjustment model for the higher education industry overall as well as for several of its segments. Overall the model fits the data quite well, indicating that this is a fruitful approach to representing 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, evidence much stronger responsiveness. Public colleges and universities and two-year schools in particular expand their numbers to a much greater degree both initially and in equilibrium. We also examine these responsiveness of these institutions in terms of growth of their size, finding a roughly similar pattern of effects.

II. The Higher Education Industry, 1955-97

The higher education industry in the United States has undergone an enormous transformation over the past forty years. As previously noted, enrollments–an indicator of demand–increased more than five-fold between 1955 and 1997. The number of colleges, universities, and technical institutes increased as well, but only by about 70 percent. 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 1 summarizes the underlying data by five-year increments.[2]

It should be noted that the IPEDS/HEGIS data base which forms the cornerstone of this study does not contain a consistent series on institution numbers for the entirety of this period.[3] 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 twelve-year overlap of the two IPEDS series by regressing N_i, the series including branch campuses, on N_x (which excludes branches) plus

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[2] In an earlier paper, we provide more descriptive statistics (Kwoka and Snyder, 1999)

[3] 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 the *Digest of Education Statistics* (NCES, 2000). We shall refer to these data as IPEDS.

time-related variables. We the use this estimated relationship to predict N_i for the years 1955-75, thereby completing the series for the entire period.[4]

The graph and the data breakdown highlight several facts of particular interest for this study. Enrollment demand grew throughout the 1955-97 period, although far more rapidly in the first twenty years than in the last. Rising population of the college-age cohort, the GI Bill, and rapid increases in female enrollment rates propelled these changes.[5] In response, numbers 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 1955-75. 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.

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[4] The statistical relationship is as follows:

$$N_i = - 11829\ (2.10) + .812\ (8.23)\ N_x + 6.38\ (2.14)\ \text{YEAR} - 69.0\ (5.19)\ \text{POST77}$$

where YEAR is a simple trend variable and POST77 is a fixed effects term for years after 1977. 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 are statistically significant (t-statistics are given in parentheses) and the R^2 for this regression equation is .998.

We estimate N_i for the years 1955-75, rather than N_x for the period 1986-97, 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. And 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-years institutions.

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

[5] For studies of demand determinants, see, for example, Becker (1990) and Clotfelter (1991).

As previously noted, the higher education industry consists of segments with quite different characteristics. Table 2 reports summary data on public and private institutions, while Table 3 contains analogous information on four-year and two-year institutions. For ease of exposition, somewhat less detail is provided in these tables than in Table 1, although the relevant distinctions are quite clear.

Table 2 suggests that public and private institutions have undergone rather different adjustment processes. In response to the huge demand shift in 1955-75, public institutions moderately increased their numbers, but nearly quadrupled their average size. As a result, collectively state colleges and universties 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.

Finally, Table 3 reports similar data for four-year and two-year institutions. 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 two-year schools have increased their numbers, average size, and total enrollments several-fold as much as have four-year schools. A considerable part of the overall change in the structure of the higher education industry over the past thirty or forty years is clearly the result of increased demand for technical and specialized education beyond high school. While the traditional four-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 $\pi(q,Q,X,K) = P(q+Q,X)q - C(q) - K$. Let $N^*(X,K)$ be the number of institutions in the symmetric Cournot equilibrium under free entry.   We have the following proposition:

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.

Proof: The first statement follows from Corchón and Fradera (2002), Theorem 2. The second statement follows from Corchón and Fradera (2002), Theorem 3.

Q.E.D.

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 leading 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 demand, comparative statics with respect to demand shifts work in the intuitive way: a shift up in demand leading 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. 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:

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

$$N^*(X,K) = \max\{\, N \mid P_Q(N\, q^*(X,K),X) = AC_q(q^*(X,K),K)\} \qquad (2)$$

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 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.

Proof: See the appendix. *Q.E.D.*

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

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

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

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 may require a longer adjustment process. Formally,

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

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

$$N_t = \alpha\,[1-\lambda(K_t)] + \lambda(K_t)\,N_{t-1} + \beta\,[1-\lambda(K_t)]\,X_t + \gamma\,[1-\lambda(K_t)]\,K_t + \varepsilon_t \quad (5)$$

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 (Green 1993). We do not have data on fixed costs K_t, but assuming they vary across classes of institutions (i.e., two versus four 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

$$N_t = \alpha_c + \lambda_c\,N_{t-1} + \beta\,(1-\lambda_c)\,X_t + \varepsilon_t \quad (6)$$

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) through (6) can be justified on several grounds. 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:

•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.

•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.

•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-1}. It is reasonable to hypothesize the following effects on numbers of institutions:

(1) 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 nontrivial undertaking.[6]

[6] The number of new start-up institutions in any year is nontrivial, but entry is concentrated in technical and two-year schools.

(2) 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.

(3) The short-run multipliers for two-year institutions are larger than for their four-year counterparts. Given their status and structure, we expect two-year institutions to be better able to respond quickly to changing market opportunities, relative to full four-year schools.

We test all these propositions about entry and numbers 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 numbers of institutions and for public vs. private institutions cover the period 1955 through 1997. For the four-year vs. two-year segments, the study period is 1965 through 1997, due to data limitations previously discussed. The model to be tested is essentially that derived in equation (3) above, subject to certain data transformations. Any attempt to estimate equation (3) 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 least-squares to be consistent, requiring the use of instrumental variables. Third and perhaps most fundamentally, the Y_t and X_t series are not stationary, as is apparent from Figure 1. Collectively, these problems will result in biased, 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 least-squares (without any correction for serial correlation) is efficient.

We do, however, wish to preserve one property exhibited by equation (3), 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–now the growth rate of Y_t–in the model to be estimated. This allows the time parth 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 $\beta(1 - \lambda)$–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 4. 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 four-year and two-year schools. All regression models include dummy variables for 1987, 1988, and 1989 controlling for a reporting change that affected the numbers of institutions in those years,[7] in addition to a dummy for 1996 as a result of a later change in reporting definitions. In addition, it should be noted that the enrollment numbers used in all models are total enrollments, not those 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.[8]

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 two-year institutions. The coefficient on current enrollment implies a short-run elasticity of numbers with respect to enrollment of about 20 percent. That is, the first-year rate of growth of two-year institution numbers is 20 percent as large as the enrollment increase they experience. Four-year institutions, by contrast, respond more slowly. Their impact elasticity of only 8.6 percent implies that a 10 percent enrollment increase causes a less than one percent increase in their numbers. This difference is consistent with the view that impediments

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[7] 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 three years only. Starting in 1996, the number of institutions jumps as a result of inclusion of schools accredited by an additional agency.

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

to entry into the ranks of four-year institutions are greater than for two-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 percent. 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 of 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. The long-run equilibrium multiplier is obtained by dividing the impact multiplier by one minus the coefficient on the lagged growth rate of numbers, as noted previously. In the case of all institutions in column (a), the equilibrium multiplier (elasticity) is obtained by dividing .110 by (1 -.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.

Contrast that with the nature of responses by public colleges and universities. Despite an impact multiplier that is only modestly greater than that for all institutions (.125 vs. .110), the equilibrium elasticity for public institutions is .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 .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, two-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 two-year institutions are very small–indeed, in one case negative--and statistically insignificant.[9] For these schools their equilibrium elasticity is given by their first-period elasticity, with no further effects in future periods. In the case of four-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 in Table 5.

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 two directions–considerations of endogeneity, and adjustment in size.

First, the process described thus far is initiated by a demand shock, which has been

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[9] The previously discussed coefficient on the lagged growth rate for all institutions is also insignificant, with a t-value of .01. We nonetheless used its value to illustrate the computation of equilibrium effects and to draw distinctions between impact and equilibrium values.

represented by the enrollment variable. But enrollment 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 3. The instruments employed are three in number:

•The number of high school graduates. This is the population from which demand for higher education arises.[10]

•Disposable personal income of the median household.[11]

•Percent females in institutions of higher education. There has been a large secular increase in female college participation in the postwar period.[12]

Because enrollment appears in this model as a growth rate, these instruments for

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[10] Alternatives such as the population of 17 year olds and total population were also experimented with. Further work on all instruments will be required.

[11] 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.

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

enrollment are expressed as rates of growth as well. The resulting IV regressions are reported in Table 6. Qualitatively these results tell much the same story as do those in Table 4. All impact elasticities are statistically significant except for that on private institutions. The largest elasticity is for two-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 four-year institutions. For public schools, it implies a long-run elasticity of numbers growth with respect to enrollment growth of .261, compared to the first-period elasticity of .162. For four-year schools, the negative sign mirrors that found in the OLS 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 4 results. On its face this would seem to support the view that enrollment data are subject to endogeneity in this model. On the other hand it is somewhat surprising that these corrected coefficients are larger than those that presumably incorporated both demand-side effects (as was the intent) and supply-side responsiveness. At present it is unclear what is responsible for this particular result.

The second extension concerns the dynamics of institution size. When subject to a demand shock, 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 differ from that explaining numbers. When demand shifts, the equilibrium number of firms should change, but there is no reason for their equilibrium size to do so since the latter is determined strictly by cost considerations. Rather, a demand increase and price rise will cause size to increase in the short-run, but as entry occurs, price declines and the size of existing institutions should revert to their equilibrium levels. This difference in the underlying process may imply some limits on the usefulness of the model of partial adjustment as applied to size changes.

It is nonetheless 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 7. 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 .899, implying that the growth rate of size is about 90 percent of that for enrollments. For public institutions, the estimated elasticity of 1.11 means that the initial size adjustment actually exceeds the growth in enrollments, whereas for private colleges and universities the elasticity is far less. The responsiveness of two-year institutions' growth rates also exceeds 100 percent, in contrast to the much slower growth response by four-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. While none 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 (c) 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 .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. Further modeling of the size adjustment process will be required in order to better understand the process. All of these elasticities are summarized in Table 8.

VI. Conclusions

Over the past fifty 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 two-year institutions respond more strongly both in the short and long runs. In 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.

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

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. *Q.E.D.*

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 which 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

$$\begin{aligned} E(N_t) &= E(N_1) + (1-p^*)^2 E(N_1) + \cdots + (1-p^*)^{2(t-1)} E(N_1) \\ &= E(N_1)\left[\frac{1-(1-p^*)^{2(t-1)}}{1-(1-p^*)^2}\right] \end{aligned} \tag{7}$$

implying the expected long-run equilibrium number of entrants is

$$E(N^*) = \lim_{t\to\infty} E(N_t) = \frac{2}{2-p^*}. \tag{8}$$

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

$$E(N_t) = \lambda_t \mathrm{E}(N_{t\text{-}1}) + (1\text{-}\lambda_t)\, E(N^*). \tag{9}$$

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 (9) is independent of *t*. Brute force calculations, substituting for $E(N_t)$ and $\mathrm{E}(N_{t\text{-}1})$ from (7) and for $E(N^*)$ from (8), imply $\lambda_t = (1\text{-}p^*)^2$, indeed independent of *t*. *Q.E.D.*

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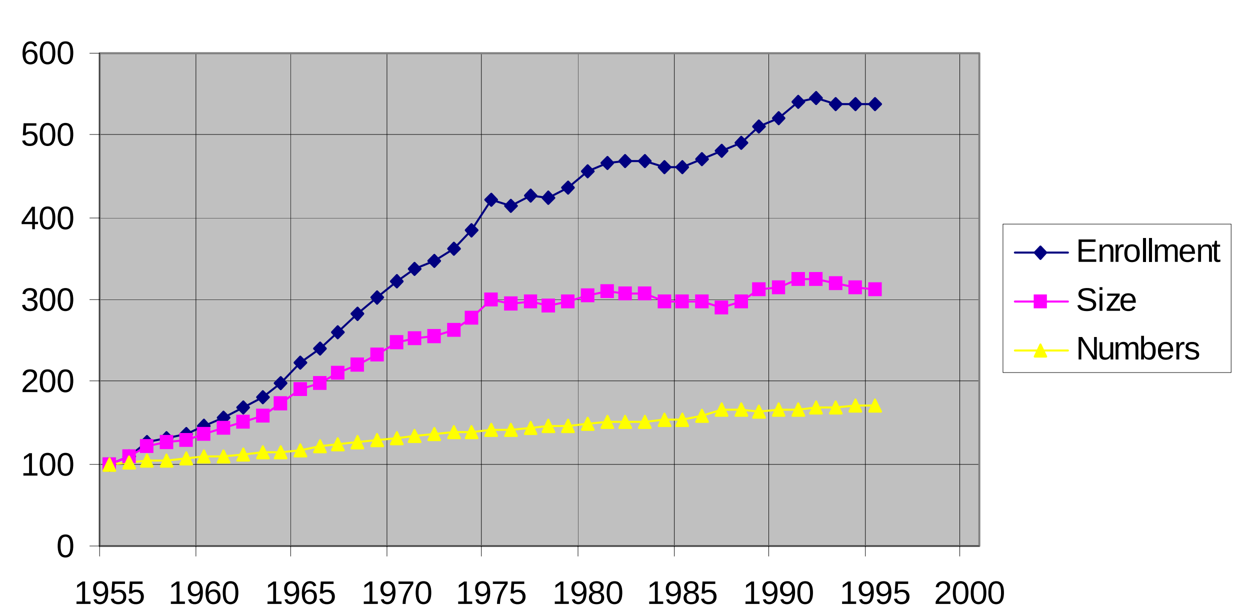
Figure 1



Note: 1955=100

TABLE 1

Year	Enrollments (000)		Institution Numbers		Average Size	
	Number (000)	Percent Change	Number	Percent Change	Number	Percent Change
1955	2653	-	2156	-	1230	-
1960	3706	39.7	2327	7.9	1593	29.5

1965	5921	59.8	2529	8.7	2341	47.0
1970	8581	44.9	2825	11.7	3037	29.7
1975	11,185	30.3	3026	7.1	3696	21.7
1980	12,097	8.2	3231	6.8	3744	1.3
1985	12,247	1.2	3340	3.4	3667	-2.1
1990	13,819	12.8	3559	6.6	3883	5.9
1995	14,262	3.2	3706	4.1	3848	-0.1
			Percent Change			
1955-95		437.6		71.9		212.8
1955-75		321.6		40.4		200.5
1975-95		27.5		22.5		4.1

TABLE 2

Year	Enrollments (000)		Numbers		Size	
	Public	Private	Public	Private	Public	Private
1955	1476	1177	927	1238	1592	950
1965	3970	1951	1088	1446	3647	1349
1975	8835	2350	1442	1584	6127	1484
1985	9479	2728	1498	1842	6328	1503
1995	11,092	3169	1655	2051	6702	1545
Percent Change						
1955-95	651.5	169.2	78.5	65.7	321.1	62.6
1955-75	498.6	99.7	55.6	27.9	284.9	56.2
1975-95	25.5	34.9	14.8	29.5	9.4	4.1

TABLE 3

Year	Enrollments (000) 4-Year	Enrollments (000) 2-Year	Numbers 4-Year	Numbers 2-Year	Size 4-Year	Size 2-Year
1965	4748	1173	1669	839	2845	1198
1975	7215	3970	1898	1128	3801	3520
1985	7716	4531	2029	1311	3803	3456
1995	8769	5493	2244	1462	3908	3757
Percent Change						
1965-95	84.7	368.3	34.5	74.3	37.4	213.6
1965-75	52.0	238.4	13.7	34.4	33.6	193.8
1975-95	21.5	38.4	18.2	29.6	2.8	6.7

TABLE 4

Regression Results for Growth Rate of Numbers (OLS)

	(a)	(b)	(c)	(d)	(e)
	All	**Public**	**Private**	**4 Year**	**2 Year**
GR Enrollment	0.110	0.125	0.044	0.086	0.199
	(3.47)**	(2.32)*	(0.93)	(3.86)**	(2.13)*
Lag GR Numbers	0.001	0.420	0.031	-0.245	-0.052
	(0.01)	(3.07)**	(0.35)	(1.64)	(0.50)
Year 1987	0.040	0.021	0.052	0.024	0.068
	(5.50)**	(1.84)	(4.75)**	(4.57)**	(3.16)**
Year 1988	-0.018	-0.028	-0.020	-0.007	-0.023
	(2.22)*	(2.34)*	(1.67)	(1.27)	(1.02)
Year1989	-0.022	-0.018	-0.017	-0.015	-0.039
	(2.87)**	(1.55)	(1.54)	(2.85)**	(1.80)
Year 1996	0.069	0.020	0.107	0.003	0.162
	(9.32)**	(1.78)	(9.63)**	(0.56)	(7.38)**
Constant	0.009	0.004	0.010	0.010	0.012
	(4.38)**	(1.28)	(3.34)**	(5.95)**	(2.13)*
R-squared	0.80	0.54	0.78	0.58	0.68
F	22.85	6.66	20.29	7.70	12.01
Observations	41	41	41	41	41

* significant at 5%; ** significant at 1%
Absolute value of t-statistics in parentheses

TABLE 5

Summary of Elasticities

Numbers of Institutions with respect to enrollments:

Institution	Impact	Equilibrium
All	0.110	0.110
Public	0.125	0.215
Private	0.044	0.046
Four-year	0.086	0.069
Two-year	0.199	0.189

TABLE 6

Regression Results for Growth Rate of Numbers (IV)

	(a)	(b)	(c)	(d)	(e)
	All	**Public**	**Private**	**4 Year**	**2 Year**
GR Enrollment	0.177	0.162	0.057	0.209	0.261
	(2.32)*	(1.17)	(0.58)	(2.67)*	(1.25)
Lag GR Numbers	-0.022	0.380	0.034	-0.496	-0.058
	(0.23)	(1.96)	(0.37)	(1.96)	(0.55)
Year 1987	0.042	0.022	0.052	0.029	0.069
	(5.26)**	(1.83)	(4.71)**	(3.72)**	(3.15)**
Year 1988	-0.016	-0.026	-0.019	-0.000	-0.022
	(1.79)	(2.00)	(1.65)	(0.01)	(0.93)
Year 1989	-0.022	-0.019	-0.017	-0.018	-0.039
	(2.72)*	(1.57)	(1.52)	(2.39)*	(1.79)
Year 1996	0.071	0.022	0.108	0.008	0.165
	(8.67)**	(1.76)	(9.21)**	(1.08)	(7.13)**
Constant	0.007	0.003	0.010	0.008	0.009
	(2.04)*	(0.65)	(1.96)	(2.86)**	(1.04)
R-squared	0.78	0.53	0.78	0.20	0.68
F	19.33	5.91	20.15	3.95	11.37
Observations	41	41	41	41	41

*significant at 5%; ** significant at 1%
Absolute value of t-statistics in parentheses

TABLE 7

Regression Results for Growth Rate of Size (OLS)

	(a)	(b)	(c)	(d)	(e)
	All	**Public**	**Private**	**4 Year**	**2 Year**
GR Enrollment	0.899	1.110	0.344	0.541	1.654
	(22.01)**	(16.87)**	(4.42)**	(9.55)**	(11.29)**
Lag GR Size	-0.014	-0.036	0.091	0.074	0.030
	(0.34)	(0.65)	(0.89)	(0.84)	(0.45)
Year 1987	-0.041	-0.024	-0.064	-0.013	-0.085
	(5.53)**	(2.02)	(3.95)**	(1.77)	(4.02)**
Year 1988	0.017	0.009	0.044	0.022	0.009
	(2.26)*	(0.74)	(2.50)*	(2.95)**	(0.41)
Year 1989	0.022	0.023	0.016	0.012	0.026
	(2.97)**	(1.90)	(0.98)	(1.58)	(1.24)
Year 1996	-0.069	-0.022	-0.102	0.000	-0.166
	(9.38)**	(1.82)	(6.22)**	(0.05)	(7.78)**
Constant	-0.009	-0.010	-0.004	-0.007	-0.013
	(5.21)**	(3.38)**	(1.08)	(4.01)**	(2.36)*
R-squared	0.97	0.94	0.76	0.88	0.92
F	178.23	82.47	17.68	30.50	48.27
No. Observations	41	41	41	31	31

* significant at 5%; ** significant at 1%
Absolute value of t-statistics in parentheses

TABLE 8

Summary of Elasticities

Size of Institutions with respect to enrollments:

Institution	Impact	Equilibrium
All	0.899	0.886
Public	1.110	1.071
Private	0.344	0.379
Four-year	0.541	0.584
Two-year	1.65	1.705