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Author
Frech, Ted E

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EFFICIENCY, GROWTH AND CONCENTRATION: AN EMPIRICAL ANALYSIS OF HOSPITAL MARKETS*

H. E. FRECH III
ECONOMICS DEPARTMENT
UNIVERSITY OF CALIFORNIA
SANTA BARBARA, CA 93106
PHONE OR FAX (805) 893-2124
EMAIL FRECH@ECON.UCSB.EDU

LEE RIVERS MOBLEY
ECONOMICS DEPARTMENT
SCHOOL OF BUSINESS ADMINISTRATION
OAKLAND UNIVERSITY
ROCHESTER, MICHIGAN 48309
PHONE (248) 370-3277
FAX (248) 370-4275
EMAIL MOBLEY@OAKLAND.EDU

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Efficiency, Growth and Concentration: An Empirical Analysis of Hospital Markets

Abstract

Taking an evolutionary view of markets, Harold Demsetz hypothesized that firms differ persistently in efficiency and that industry concentration results from growth of efficient firms at the expense of inefficient ones. We test the hypothesis with high quality microdata from the US hospital industry, an industry of keen policy and scientific interest. We measure efficiency by firm in the early 1980s and relate it to subsequent growth of efficient firms, to the persistence of profit differences and to changes in the concentration of markets. Initial hospital efficiency and subsequent growth (and profitability) are significantly and positively related. Also, greater initial variation in hospital efficiency within local markets is positively related to subsequent growth in market concentration. These findings support the logic of Demsetz's evolutionary efficiency hypothesis, though they cannot confirm the stronger idea that variation in firm efficiency is the dominant explanation for changes in concentration.

Key Words: Efficiency; Growth; Concentration; Evolution; Demsetz; Hospitals

JEL Classifications: L11; L84; Ill; L31; L20

Efficiency, Growth and Concentration: An Empirical Analysis of Hospital Markets

I. Introduction

In 1973, Harold Demsetz provided aggregate, cross-industry statistical support for his hypothesis that industry concentration is largely the result of growth of relatively efficient firms. In this paper, we provide the first known test of this hypothesis using microdata from a single industry: the hospital industry. The hospital industry is a good one to study for both scientific and policy reasons.

Recently, hospital mergers have received much attention, and efficiencies have been claimed for them. But the courts have remained skeptical, perhaps due to contradictory findings regarding hospital scale economies (Frech and Mobley, 1995; Lynk, 1995). The Demsetz hypothesis does seem to explain cross-sectional results from older studies -- that costs are lower in more concentrated hospital markets.[1] We apply the hypothesis to the hospital industry, using California data, 1983/84 -1990/91. The first part of the paper places the Demsetz hypothesis in context. The second part is an empirical test. Using this excellent data and sophisticated techniques, we estimate firm-specific efficiency early in the sample period, and relate it to subsequent growth, the persistence of profits and change in market concentration.

[1] This result has been reversed in studies using later data. See, e.g., Zwanziger and Melnick (1988).

We use several kinds of statistical analysis, including cross-tabulations (closely following Demsetz), and two different methods of efficiency assessment. One method uses a deterministic frontier, while the second uses a newer stochastic frontier technique. We employ different output measures and geographic market definitions as sensitivity tests.

II. Demsetz's Efficiency Hypothesis in Context

The structure-conduct-performance paradigm dominated industrial organization in the early seventies, and was the subject of many empirical investigations (Weiss, 1974). It largely ignored efficiency explanations for concentration, perhaps because existing theoretical literature assumed homogeneous firms and the existing empirical literature concluded that minimum efficient scale is generally small (McGee, 1988, p. 334).

Influential dissenters began to be heard in the mid-60s (Bork and Bowman 1965; and Bork 1967; McGee 1971). Among them was Demsetz (1973), who argued that concentration is largely endogenous, and results from more efficient firms growing faster. Contrary to the older tradition, Demsetz stressed persistent heterogeneity among firms. His analysis is similar in spirit to the survival analysis of Stigler (1958) and to the evolutionary models of Nelson and Winter (1982).

Demsetz (1973) conducted an indirect, cross-industry test to distinguish efficiency from market power effects. He reasoned that, if tacit or explicit collusion caused high rates of return in concentrated industries, it would also benefit small firms -- implying a positive correlation between the rate of return and industry concentration. In a 1963 sample of firms from 95 industries, no such correlation was found for small firms, while the largest firms exhibited higher rates of return, more so in the most concentrated industries. He concluded that the overall correlation between concentration and profits must be caused by superior efficiency in larger firms.

Peltzman (1977) conducted a major statistical study across industries and over time to directly test the idea. Using a panel of 165 industries, 1947-1967, he allocated the total effect of concentration on price between a market power effect and a cost/supply effect. The estimated efficiency effects dominated the market power effects. Peltzman concluded that the observed increase in profits with concentration is due to prices falling less than costs do. Although some scholars disagree with Peltzman's conclusions (Scherer 1979; McGee, 1988, p. 336), this study raises further questions.

III. Hospital Markets as a Testing Ground

We provide the first known tests of the efficiency hypothesis using microdata from a single industry. Our approach has many advantages over Demsetz's (and Peltzman's). It is not clear that different industries represent different observations from a common distribution, as is the implicit assumption in cross-industry analyses. The alternative is to analyze a single industry. The hospital industry is ideal for this. By looking at many local hospital markets, we exploit the considerable variation that exists in efficiency, firm size, rate of return, and local market structure. But, we avoid the large differences in technology and consumer information that are inherent in cross-industry studies.

There is no consensus on geographic market definitions for hospitals.[2] Not taking a stand, we use two geographic areas. The smaller areas are health facility planning areas (HFPAs) designated by the state, and used in setting Medicaid rates. The larger areas are counties, which are typically large in the West.[3] Happily, the findings are robust to the alternatives.

The relatively short temporal span of our data has both advantages and disadvantages. As noted by Peltzman (1977, p. 243), the ideal panel of data must be short enough to hold constant technological change, while long enough to allow for sufficient change in market structure.

Our cost data are from 1983/84, the year in which two major policy reforms were implemented. The reforms were: Medicare's Prospective Payment System, which changed hospital reimbursement from retrospectively determined (based on costs) to

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[2] Most of the empirical approaches to defining hospital geographic markets have used a shipments (Elzinga-Hogarty 1973) approach applied to patient origin data (Morrisey, Sloan, and Valvona, 1988; Baker 1988; Garnick, Luft, Robinson, and Tetreault, 1987). But large cross flows may overstate markets, especially where urban hospitals are perceived to be of higher quality or offer a wider range of services than the rural ones (Werden 1989). In the general literature, price tests (Horowitz, 1981; Stigler and Sherwin, 1985) and residual demand elasticity (Scheffman and Spiller 1987) have been suggested. These latter methods depend on price data, which are often unreliable for hospitals.

[3] There are 58 counties and 139 HFPAs in California. The HFPAs are generally much smaller than counties, except in some rural areas.

prospectively determined (based on diagnoses), and the California Medicaid Reform Act of 1982 (implemented in 1983), which gave insurers legal sanction to contract selectively with health care providers. The former mimics competition by making price exogenous and the latter increases it. Both reforms appear to have increased hospital efficiency in California's urban markets (Zwanziger and Melnick, 1988).

The annual data are for individual California short-term general hospitals, 1983/84 -1990/91, taken from annual financial and discharge data tapes, provided by the California Office of Statewide Health Planning and Development (OSHPD).[4] Kaiser hospitals are excluded, due to incomplete reporting.[5] The only other exclusions are federal and long term hospitals, specialty hospitals, and hospitals with missing data, leaving a sample of 378 short-term general hospitals in 1983/84 (from a universe of 423 hospitals). In the computation of changes in market concentration over time (1983/84-1990/91), all short-term general hospitals that report utilization data in any period are included.

IV. Cross-Tabulations

Table 1 presents rate of return by firm size, following Demsetz's approach. The

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[4] Reporting periods range from the year ending 1983/84 (Fiscal Year 9) to the year ending June 1990/91 (Fiscal year 17).

[5] The market share of HMOs was initially included as a control variable in the cost equation, along with other payor shares, but these were insignificant as a block and dropped from the final specification.

rate of return is net income before taxes divided by total assets. The measure of market structure is the Herfindahl index (HHI) defined over market shares in net patient revenue, presumably the best measure of output.[6] County and the HFPA market definitions are used. Size is measured by staffed beds. Hospitals were classified into three roughly equal groups, based on HHI. The results are shown in Table1.

(Table 1 about here)

According to the structuralist model, collusion would generate a positive correlation between the rate of return and concentration among small firms. In our data, no clear correlation is found for small firms, except in 1990/91 at the county level. This is supportive of Demsetz's earlier findings across industries. We also find that the rate of return generally increases with firm size. But, within the most concentrated markets, the ROR is generally not the highest for the largest firms. The indirect evidence presented here for hospitals is not at all clear. We need to go beyond simple cross-tabs.

V. Econometric Models

A. Measuring Inefficiency

We use two econometric approaches to measure firm inefficiency. The first

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[6] Other traditional output measures are: inpatient discharges, inpatient days, or inpatient days and outpatient visits combined.

approach is deterministic, as the entire error term in the cost function is assumed to represent inefficiency; analogous to corrected ordinary least squares (Greene, 1993; Lovell and Schmidt, 1988). The second approach employs the stochastic frontier estimator of Aigner, Lovell, and Schmidt (1977), which allows costs to deviate from the minimum due to both systematic and stochastic perturbations. While the first method has been criticized as including too much in the estimate of firm inefficiency, the second has been criticized for the strong assumptions needed in separating the stochastic from the systematic inefficiency components in the error. While the methods are imperfect, the results are robust. The firm-specific inefficiency measures are highly correlated and perform essentially the same in subsequent analyses.

B. The Cost Function

The cost function is a generalized flexible-form as described in Breyer (1987) and used by, e.g. Grannemann, Brown, and Pauly (1986). Starting with a traditional cost function, more variables are added to capture the heterogeneous nature of hospital products and markets, while maintaining linear homogeneity in factor prices.

We use a short-run, multiproduct variable-cost function. Following Cowing and Holtman (1983), we include fixed capital and fixed admitting physician stock as inputs.[7]

[7] This overstates the full-time-equivalent (FTE) physician stock, because physicians work in multiple hospitals, especially in larger markets. To check for sensitivity to this, we re-estimated weighting physician stock by the hospital's market share. This reduced the coefficient by about 50 percent, but it remained highly statistically significant (p-values of

Inclusion of fixed capital and physician stock allows us, in principle, to test whether hospitals are in long-run equilibrium. In long-run equilibrium, the coefficient on capital should be equal to (minus) the cost of capital. A smaller negative coefficient implies overinvestment. We find that both the capital and physician stock coefficients are actually positive (Table 4). This finding, taken literally, implies overinvestment to the point where the marginal productivity of capital is negative. Instead, we believe that capital (and physician) stock is correlated with quality of output and severity of illness.

To control for heteroskedasticity, we use a log-log specification.[8] We address the problem posed by zero outputs in two ways: 1) replacing zero outputs with a very small number (10^{-15}), then taking logs, and 2) adopting a Box-Cox metric for variables with zero outputs, while retaining the log metric for strictly positive output variables. This hybrid translog cost function is in common use (e.g. Grannemann, Brown, and Pauly, 1986).[9]

The objective is to obtain firm-specific inefficiency measures, not traditional cost function measures. Thus, we eliminate second-order and cross-product terms to reduce multicollinearity and avoid convergence problems in estimation. Testing for nonlinearity showed the second-order terms to be unimportant.

.000). The rest of the equaition was essentially unchanged.

[8] Heteroskedasticity can affect stochastic frontier estimates, overstating inefficiency for small firms and understating inefficiency for large ones (Caudill, Ford, and Gropper, 1995).

[9] The zero-output problem is pervasive only for TDIS5, the number of indigent patient discharges.

Factors which might affect the shape of the cost frontier are included in the cost function. Initially, we included income per-capita, market-level payor mix, and hospital ownership.[10] On a priori grounds, income is particularly important. It is probably a proxy for both the level of demand and quality (Braeutigam and Pauly 1986; Grannemann, Brown and Pauly 1986). The measurement of quality and other product dimensions is an important issue, because it may bias the estimates of firm inefficiency.

A related issue is that of endogenous outputs. It has been argued that insurance coverage weakens the relationship between prices and quantity demanded, so that endogeneity of hospital outputs is not a serious concern (Grannemann, Brown, and Pauly, 1986, p. 109). This is probably becoming less true over time, because of the increase in managed care (HMOs and PPOs).

Output endogeneity can bias estimates from both methods. In this regard, Breyer (1987, p. 152) reasons that the number of individuals treated cannot be as readily influenced by the hospital as the length of a stay. Accordingly, we measure output using discharges.[11] The cost function is:

$$\ln C_i = \ln A + \sum \alpha_i \ln P_i + f(Y_i, CM_i, Q_i, X_i, Z_i) + \varepsilon$$

where

[10] Market-level payor mix and hospital ownership were found to be statistically insignificant individually and as a block. For simplicity, we exclude them. The simple correlation of the OLS measure, between restricted and unrestricted models, is .940.

[11] There are not enough exogenous instruments available to perform endogeneity tests.

C_i = total operating expense,
P_i = input prices,
Y_i = output: inpatient discharges by 6 payor types, outpatient visits, and teaching output
CM_i = casemix and other complexity variables,
Q_i = hospital quality,
X_i = factors which affect the level of costs, like ownership and market factors,
Z_i = fixed inputs: capital stock and stock of admitting physicians.

Efficiency and Scale Economies

The efficiency hypothesis refers to the lowest cost firms, without specifying whether the lower cost is due to efficiency (contingent on scale) or to large size in the presence of scale economies. However, on a priori grounds, the efficiency differences that are not scale-dependent seem to be the persistent ones. In the evolutionary view, an organization can change its scale easier than it can change its efficiency. (As in computers and genetics, the software is more persistent than the hardware.) Indeed, the relatively efficient firms are expected to change their scale by growing at the expense of the less efficient firms. Therefore, in our cost function analysis, we hold scale constant, so that our resulting inefficiency measure reflects only the non-scale aspects of cost.

As a sensitivity test to determine whether this judgement is correct, we also estimate a cost function that imposes constant returns ex-ante on the output elasticities, and re-derive firm-specific inefficiency measures. (We estimated four versions as a robustness check: with/without LOSS defined as an output; with/without scale variables NPPEQ, DOCS). The constrained inefficiency measures from these four models are highly correlated with each other (95 percent +) but only 73 to 78 percent correlated with the unconstrained inefficiency measures used in the paper. We also experimented with the constrained measures in the next stage of the analysis, explaining firm level growth. They performed qualitatively similar to the unconstrained inefficiency measures, but with substantially less explanatory power.

The Variables

As an input price variable, we include HCFA's county-wide wage index for hospital workers.[12] We use multiple output measures, payor-specific measures of casemix complexity and other variables to control for output heterogenity. See Table 2 for descriptions and Table 3 for sample statistics.

(Table 2 about here), (Table 3 about here)

There are many hospital outputs, including discharges by six payor groups: Medicare, Medicaid, private insurance, self-pay, medically indigent adults (MIAs), and various other government programs (aggregated).[13] Other outputs are number of outpatient visits, and teaching output.

[12] This avoids the endogenity problem of using actual wages from the individual firm.

[13] MIAs are medically indigent adults who do not qualify for Medicaid, but are eligible for county assistance.

Casemix indices are used for the payor groups: Medicare, Medicaid, private insurance, self-pay, and an aggregate over all patients (a proxy where payor-specific indices were unavailable).[14] The casemix variables were used to scale discharges: each discharge variable was multiplied by the appropriate casemix index.[15]

Another control variable is LOSS: dollar amount of expenditures on charity care, net of any gifts designated for charity. LOSS may be especially important, because we do not have a separate casemix index for MIAs or those in other government programs, who have usually been found to be more costly (Thorpe, 1988; Campbell, 1990; Epstein, Stern, and Weissman, 1990).[16] Inadequate controls for the extra costs of treating the poor may cause an artificial finding that public hospitals are inefficient. Other output heterogeneity controls include: the proportion of discharges that are newborns, sub-acute care, acute medical/surgical care or intensive care.

Quality of care is proxied by several variables, including a hospital-specific infant

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[14] Casemix indices by payor were reported by California OSHPD, following the method used by HCFA for the national Medicare Casemix Index, using resource-weighted Diagnostic-Related Groups. See Case-mix Indices for California Hospitals, December 31, 1985, California OSHPD. Comprehensive data were only collected for 1983/84. The data are not sufficient to derive the separate casemix indices for the MIAs or other government programs.

[15] Other specifications were used to test for robustness. These included entering payor-specific casemix separately (rather than scaling outputs), and also entering both casemix and average length of stay (ALOS) by payor. There were no statistically significant differences.

[16] Contradictory evidence exists. See Dor and Farley (1996).

mortality index,[17] income per capita in the city, and physicians (MDs) per capita in the county. More physicians per capita enables more specialization. We also include a scope of services index, SCOPE. It is a weighted sum of 33 services provided.[18] The index increases over time as new technologies are introduced. Many variables already mentioned also control for quality differences: hospital-specific casemix and payor mix, hospital size, capital stock and physician stock.[19]

C. Inefficiency at the Firm Level: Empirical Methodology

Least squares is used to estimate the deterministic frontier cost function. The stochastic frontier cost function is estimated using an algorithm based on the model developed by Aigner, Lovell, and Schmidt (1977) and applied to cost functions by Jondrow et. al. (1982). The method assumes that the error term is composed of a half-

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[17] The index is defined using data on all hospital births in the state, and adjusts actual reported mortality for both risk and chance (sample size) factors, as described in Williams (1979) and Blumberg (1986).

[18] The weights are: 0 if service not provided, .5 if available through arrangement with nearby hospital or as part of a broader hospital unit, and 1 if offered in a separate unit. The 33 services include: computed tomography, magnetic resonance imaging, diagnostic and therapeutic radioisotope, positive emission tomography, ultrasonography, megavoltage radiation therapy, histocompatibility lab, neonatal intensive care, and trauma services.

[19] The coefficients on ownership are small and statistically insignificant, and these variables are dropped. Recent evidence suggests that hospitals of different ownership type located in the same markets behave very much alike (Mobley and Bradford, 1995; Banks, 1993; Norton and Staiger, 1994; Hultman, 1991). Because we control for market characteristics, the partial effect of ownership on costs is expected to be small.

normal distribution (distance from the frontier) and a random shock. For both methods, we express inefficiency as a percentage of total cost.

To derive inefficiency measures from the deterministic frontier, we use the approach described by Greene (1993, p. 74) and Lovell and Schmidt (1988, p. 18). The most efficient firm is assumed to exhibit the largest (in absolute value) negative residual, 'min e_i'. To find the cost frontier, the fitted equation is shifted down by this 'min e_i'. Firm-specific inefficiency ε is calculated by adding the absolute value of 'min e_i' to each firm's residual. For the most efficient firm, the calculated inefficiency is thus 0 by construction, and the estimated inefficiencies are a positive series.

VI. Results and Discussion

A. Estimates of Relative Efficiency

Table 4, below, contains the results from estimation of the four empirical models. As mentioned earlier, the models labeled OLS and FRONT are estimated by replacing zero realizations of output variables with the number 10^{-15}, then taking logs. In the models labeled BOXCOX and FRONT/BOXCOX, output variables containing zero realizations (like X) are replaced with the expression: $(X^{\lambda}-1)/\lambda$, where λ is the Box-Cox parameter estimate from maximum likelihood estimation of the model (the estimate of λ is

.12276, labeled 'LAMBDA BOXCOX' in Table 4).[20] The variable 'LAMBDA FRONTIER' in the FRONT and FRONT/BOXCOX models is a stochastic frontier parameter, from which relative inefficiency is derived.

(Table 4 about here), (Table 5 about here)

The estimates of firm-level inefficiency are quite reasonable. For the frontier approaches, the means are about 0.20 (20 percent), indicating that the average firm incurs costs about 20 percent above the most efficient. (Remember, this is the hospital industry, and the measure includes both technical and allocative inefficiency.) The range goes from zero or near zero for the most efficient firms to about 80 percent for the least efficient firms. Inefficiency is higher for the OLS method because it attributes the entire error term to inefficiency, while the frontier method attributes only the non-stochastic part of it to inefficiency.

Most importantly, firm-level inefficiency is quite robust. The simple (Pearson) correlation matrix (Table 5) shows that cardinal ranking of a firm's inefficiency is robust to model specification. Not surprisingly, the effect of inefficiency in subsequent modeling is also robust. Henceforth, we report only the results from the frontier method. The other results can be found in Frech and Mobley (1997).

[20] The MLE estimate of LAMBDA BOXCOX taken from the OLS-based BOX model is used as the estimate for the FRONT/BOX model as well. Full information estimation of the LAMBDA BOXCOX and LAMBDA FRONTIER variables was not possible.

B. Efficiency and Growth

The growth rate is calculated between 1983/84 and 1990/91, in both levels and market share (county and HFPA markets). All short-term general hospitals who report output data are included in the calculations of market share in each year. The growth rate is a hospital-specific measure of internal growth only; growth by multihospital chain affiliation or merger is excluded.[21]

We measure output by two methods that account for outpatient services: net patient revenue (net of contractual adjustments) and a more physical measure, inpatient days adjusted for outpatient care.[22,23] The former measure best reflects market valuation of services provided, while the latter measure is confounded by variation in case complexity and intensity of care.

Table 6 contains the estimated coefficients (and p-values) from a simple regression of growth rate 1983/84-1990/91 on inefficiency measured in 1983/84. The empirical

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[21] In the Herfindahl index, market shares do reflect multihospital chain affiliation; hospitals owned by the same chain in the same market are considered a single firm.

[22] The adjustment follows the American Hospital Association's suggestion in Hospital Statistics. Revenue per outpatient visit is divided by revenue per inpatient day. This result is multiplied by the number of outpatient visits, and then added to the number of inpatient days.

[23] As a check for robustness, we used two different measures of output the excluded outpatient services entirely: inpatient days and inpatient discharges. The results were quantatively similar, though less precise (Frech and Mobley 1997).

model is of the form:

$$\text{Growth Rate}_{1983/84\text{-}1990/91} = \alpha + \beta \ \text{Inefficiency Measure}_{1983/84} + \varepsilon$$

The results (Table 6) show a clear negative relation between inefficiency in 1983/1984 and subsequent growth, which supports Demsetz's hypothesis. The relation is not sensitive to different measures, though the effects are slightly larger and more precisely estimated using net patient revenue.

(Table 6 about here)

The R squared measures are low (about 5 percent using the net patient revenue measure), because of idiosyncratic growth at the micro level. Also, variables used in generating the measures of inefficiency are excluded.[24] But, the large sample size allows detection of the effect of efficiency on growth, in spite of the idiosyncratic noise. The regressions were checked using the White statistic and associated non-linearity test statistic, and no significant evidence of heteroskedasticity or nonlinearity was found.[25]

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[24] Other research finds that larger hospitals grow faster than smaller ones, e.g. (Frech and Mobley 1995).

[25] The White statistic (White, 1980) is not sensitive to departures from normality and it does not require specification of the form of heteroskedasticity (Kmenta, 1986, pp. 295-296). The nonlinearity statistic tests the joint hypothesis that all possible interactions, including squared regressors, have zero coefficients (Engle, 1984).

Quantitatively, inefficiency is an important predictor of growth. For example, doubling the mean of the frontier/Box Cox inefficiency measure (from 19.4 percent to 38.8 percent) reduces growth in net patient revenue by about 20 percent and reduces growth in market share by about 6 percent. The effect on shares is naturally smaller than the effect on levels because share is compressed by construction (allowing for entry, growth in market shares is constrained to sum to less than one).

Alternative Monopoly Interpretation

There is an alternative interpretation of the results that doesn't rely on a true relation between efficiency and growth. Consider the possibility that an apparently inefficient hospital is actually efficient, but it has a local monopoly and is effectively controlled by doctors. The hospital spends its monopoly rents on perquisites and amenities which the physicians value. If so, the accounting data overstates costs. Since monopoly hospitals tend to be located in slower-growing regions, the data will exhibit spurious relationship between inefficiency and growth. To check for this possibility, we added population growth to the model in table 6. Adding this variable does not change the strong negative relationship between inefficiency and subsequent growth. The monopoly, non-efficiency interpretation doesn't seem to work.

Overall, the result is supportive of the efficiency hypothesis. More efficient firms grow and gain share. And the magnitude of the effect is economically meaningful. But, the results have another interesting, and non-conflicting, interpretation as well.

The Inefficiency Measures are Valid

Some observers have been skeptical of hospital cost functions, believing that unobserved quality and product differences are hopelessly confounded with inefficiency. The results here shows that the skepticism has been overdone. If, contrary to our view, apparent inefficiency primarily captured unmeasured high quality, it would hardly be associated with slower growth. The hospital market appears to be demanding higher quality over time, not lower quality (Frech and Mobley 1995).

C. Efficiency and the Persistence of Profits

Firms that were relatively efficient in 1983/84 subsequently grew faster. This is consistent with evolutionary view of persistent heterogeneity among firms. Another way to examine persistence is to look at profit rates over time.

To do so, we compare the profitability on sales (net income divided by total revenue) over time for the most efficient and least efficient quarter of the firms. Not surprisingly, the more efficient firms were more profitable in the year of measurement 1983/84. (See Table 7). The difference is large, 5.6 versus 1.2 percent or 6.4 versus 2.5 percent. The differences are statistically significant at high levels for most years. Over time, the profitability of the hospital industry has declined. But, the difference in profitability among the most efficient and the least efficient firms in 1983/84 persisted.[26]

(Table 7 about here)

The evidence on profitability supports the belief that superior performance persists. Also, it further supports for the validity of the inefficiency measures themselves. Next we turn to the relationship between efficiency and concentration.

D. Efficiency and Market Concentration

In this section, we calculate the standard deviation of inefficiency within each local market in 1983/84. This standard deviation is then used to explain the subsequent rate of change in market concentration, 1983/84-1990/91. Demsetz's hypothesis suggests that a greater initial variance in inefficiency will lead to unequal growth, thus to increased concentration.

The standard deviation of inefficiency is calculated from firm-specific inefficiency measures. The standard deviation is weighted for firm size; weights are market shares in the output measures. Growth rate in concentration of output (the Herfindahl index) is also calculated for the two output measures.[27] The growth rate in concentration is then

[26] Results are virtually identical using the OLS-based efficiency measures.

[27] The Herfindahl index is constructed for each of the two different output measures. The index is scaled to reflect proportions, not percentages, so it ranges between 0 and 1.

regressed on the market-wide weighted standard deviation in 1983/84 inefficiency.[28]

Population growth might also affect concentration, so we investigate this as well. The initial empirical model is of the form:

$$\text{Growth Rate in Concentration}_{'83/84-'90/91} = \alpha + \beta \text{ Standard Deviation in Inefficiency}_{'83} + \delta \text{ Population Growth Rate}_{'80-'90} + \varepsilon$$

We found that population growth rate added nothing and altered no other coefficients. For ease of interpretation, therefore, we report the results from two simple regressions instead: one on the standard deviation of inefficiency and the second on population growth as simple regressors.

Variation of inefficiency is much more important than population growth in explaining changes in concentration. Compare the R squared values of up to 5.3 percent for the former versus only up to 0.1 percent for the latter (Table 8). Even so, R squared values are fairly low. The results are robust to both market and output definition (including measures not shown here, but reported in Frech and Mobley, 1997). Even with some smoothing at the market level, idiosyncratic factors are evidently still very important.

(Table 8 about here)

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[28] Weighting by market share changes the definition from hospital to output units. Similar results were found using unweighted measures.

Quantitatively, the effect of variation in inefficiency is important. For example, for net patient revenue, doubling the standard deviation of inefficiency (the independent variable) from its mean increases the rate of change in concentration (the dependent variable) about 4.2 percent to 6.7 percent in the HFPA and about 5.6 percent to 8.2 percent in the county market. This almost doubles the dependent variable.

(Table 9 about here)

Variation in efficiency is a systematic determinant of changes in concentration. The Demsetz efficiency hypothesis, following the chain of causation all the way to changes in concentration, is verified. On the other hand, the effect of variation in inefficiency cannot be said to dominate. While the basic hypothesis has been verified in our microdata, the study does not verify what might be called the strong version of the hypothesis: that concentration is mostly determined by variation in inefficiency.

VII. Summary and Conclusions

In the first study using single-industry microdata, the Demsetz efficiency-growth hypothesis has done well. We use four different statistical models to derive firm-specific inefficiency in 1983/84, and find that these four measures are highly correlated. We find that relatively efficient firms subsequently grew faster. Also, more efficient firms were persistently more profitable. This supports the fundamental evolutionary idea that efficient firms grow faster, and that the return to superior performance persists.

Because we carefully control for product heterogeneity and quality, our efficiency measures are not simply indicators of unmeasured low quality. If so, they would not predict subsequent growth unless the market exhibited increasing preference for low quality!

Next, we analyzed two aspects of the relationship between efficiency and concentration. Demsetz's view suggests that a greater initial variation in inefficiency would lead to unequal growth of firms in the market and, therefore, to increased concentration. We found robust statistical support for this hypothesis.

Our findings using firm-level data for the hospital industry are generally supportive of the efficiency hypothesis. Industry structure is endogenous and can be explained, in part, by differential growth of heterogeneous firms. While the logic of the hypothesis is confirmed, the analysis cannot support the strong version of the hypothesis: the idea that variation in concentration is dominated by efficiency factors. Further research would be very useful. While our results are not conclusive for the ultimate policy issues (perhaps no results will be), they do provide an economic rationale for the cautious antitrust policy towards hospital mergers that has, in fact, been adopted by the enforcement agencies.

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Appendix: Data Sources

Casemix indices by payor for 1983 are provided by the OSHPD in Case-Mix Indices for California Hospitals, December 31, 1985 (California Health Facilities Commission). Data on infant mortality used as a quality index are from the Maternal and Child Health Data Base, Community and Organization Research Institute (CORI), UC Santa Barbara. The hospital chain data are compiled from the AHA's annual series: Directory of Multihospital Systems and Hospital Guide. County level demographic data are from the Area Resource File, March 1988, the 1990 US Census of Populations and the City and County Data Book, 1992. Market level payor mix data are from the annual individual hospital discharge data for California, available from the OSHPD. The hospital wage index used by HCFA in adjusting Medicare PPS rates is available for 1984 as reported in the Federal Register, Tuesday September 1, 1987, pp 33095-33100.

Table 1

Hospital Rate of Return by Market Structure and Size

1983/84

N = 454	HHI:	HFPA		HHI:	COUNTY	
SIZE	< .28	.28 to .47	> .47	< .06	.06 to .20	> .20
<50	-.051	.009	-.079	-.212	-.085	.014
50-99	.091	.056	-.012	.046	.045	.029
100-199	.037	.072	.101	.067	.052	.067
200-299	.043	.065	.038	.012	.065	.145
300-399	.075	.099	.065	.100	.075	.059
400+	.033	.103	.085	.044	.066	.094

1990/91

N = 393	HHI:	HFPA		HHI:	COUNTY	
SIZE	< .28	.28 to .47	> .47	<.06	.06 to .20	> .20
<50	-.376	.061	-.064	-.312	-.107	-.006
50-99	.003	.040	.024	.005	.020	.038
100-199	-.020	.009	.034	-.043	.020	.061
200-299	.011	.025	.020	-.039	.049	.057
300-399	.024	.054	.040	.015	.049	.097
400+	.025	.085	.032	.015	.047	.087

Table 2

Variable Names and Descriptions

Dependent Variable

TOPEX : total annual operating expenditures, net of interest and depreciation

Fixed Inputs

NPPEQ : net (of depreciation and amortization) plant property and equipment at the beginning of the period, a proxy for fixed capital stock

DOCS : number of licensed physicians with admitting privileges (fixed physician stock)

Outputs

TDIS1 - TDIS6 : total inpatient discharges in each of 6 payor categories: 1) Medicare, 2) Medicaid, 3) Private Insurance (Blue Cross/Blue Shield, HMO, PPO, etc.) 4) Self Pay and No Charge, 5) Medically Indigent Adults, 6) Everyone Else (several government programs like SSI)

LOUT: number of outpatient visits

TERNBED : number of FTE interns and residents per staffed bed (teaching output)

Casemix

MCRCASE:OSHPD's Medicare casemix index for 1983

CALCASE : OSHPD's Medicaid casemix index for 1983

PVTCASE: OSHPD's private payor casemix index for 1983

SELFCASE : OSHPD's self/no charge payor casemix index for 1983

ALL : OSHPD's all payors casemix index for 1983

OUT : proportion of outpatient visits that are non-surgical

PBIRTH : proportion of discharges that are newborns

PSUBACT : proportion of discharges that are sub-acute care

PMEDSURG : proportion of discharges that are medical surgical acute care

PINTENSE : proportion of discharges that are from intensive care units

LOSS: dollar amount of expenditures on charity care, net of any gifts or funds designated for charity

Output Heterogeneity and Quality

INFMORT : infant mortality index, larger meaning more deaths, adjusted for risk and chance (sample size)

SCOPE : scope of services index

HOSWAGE: HCFA's 1984 county-specific hospital-worker wage index (used in setting PPS rates)

PCI: income per capita in the city in which the hospital is located

MDPC : medical doctors per capita in the county

RUR : binary variable indicating that a hospital is located in a rural county

Table 3

Sample Statistics for Cost Functions

	natural logs*		levels (Box Cox models)**	
Variable	Mean	Std.Dev.	Mean	Std.Dev.
TOPEX	16.635	1.071		
TDIS1	7.311	1.056	2328.5	2094.6
TDIS2	5.577	3.963	1099.6	2940.1
TDIS3	7.515	1.142	3227.6	3796.5
TDIS4	5.259	3.165	505.63	1126.8
TDIS5	-16.270	19.036	139.15	950.73
TDIS6	3.959	2.372	132.56	248.81
TERNBED	-10.364	3.065		
NPPEQ	15.636	1.429		
DOCS	4.425	1.250		
PBIRTH	.087	.072		
PINTENS	.041	.066		
PSUBACT	.005	.026		
PMEDSUR	.682	.184		
LOUT	9.577	1.626		
OUT	.978	.108		
LOSS	13.108	2.023		
SCOPE	7.022	3.922		
INFMORT	1.001	.077		
PCI	9.204	.237		
HOSWAGE	1.214	.113		
MDPC	.223	.093		
RUR	.132	.339		

* 0 discharges replaced with 10^{-15}, then discharges are logged

** discharges (X) replaced with the expression: $(X^{\lambda}-1)/\lambda$, where λ is the Box-Cox parameter estimate: .12276

Table 4

Hospital Cost Function Estimates 1983/84, (n=378)

	OLS		OLS/BOXCOX		FRONT		FRONT/BOXCOX	
Variable	Coeff	P-val	Coeff	P-val	Coeff	P-val	Coeff	P-val
Constant	8.915	.000	9.711	.000	8.728	.000	9.617	.000
TDIS1	.283	.000	.122	.000	.338	.000	.125	.000
TDIS2	.003	.268	.015	.000	.005	.187	.014	.008
TDIS3	.270	.000	.093	.000	.284	.000	.097	.000
TDIS4	.004	.285	.021	.002	.002	.740	.015	.024
TDIS5	.001	.057	.005	.030	.001	.109	.003	.077
TDIS6	.004	.394	.022	.007	.007	.108	.025	.000
LOUT	.037	.005	.043	.000	.040	.001	.040	.000
OUT	.103	.475	.233	.108	.015	.896	.137	.417
TERNBED	.034	.000	.024	.000	.023	.000	.018	.000
NPPEQ	.087	.000	.074	.000	.073	.000	.086	.000
DOCS	.029	.018	.026	.020	.033	.000	.035	.000
PBIRTH	-.105	.760	-.126	.696	.107	.772	-.070	.838
PINTENSE	.418	.060	.399	.051	.566	.047	.524	.102
PSUBACT	.461	.351	.012	.978	.635	.251	.304	.744
PMEDSUR	-.190	.174	-.170	.186	-.120	.399	-.157	.251
LOSS	.027	.000	.018	.008	.034	.000	.023	.000
SCOPE	.031	.000	.021	.000	.026	.000	.019	.001
INFMORT	.047	.769	.025	.863	-.038	.797	-.026	.873
PCI	.121	.047	.141	.017	.064	.245	.110	.067
HOSWAGE	.218	.251	.379	.037	.212	.218	.313	.095
MDPC	.832	.000	.834	.000	.792	.000	.824	.000
RUR	-.076	.123	-.084	.072	-.014	.768	-.047	.341
LAMBDA BOXCOX			.123	.000				
LAMBDA FRONTIER					3.886	.000	2.137	.000
Adjusted R-Sq	.951		.959		.959		.956	
Diagnostic Log-Likelihood			40.36		51.45		40.26	

Table 5

The Inefficiency Measures are Similar

Simple Pearson Correlations Among the Four Inefficiency Measures

	OLS	BOXCOX	FRONT
BOXCOX	.937		
FRONT	.896	.843	
FRONT/BOXCOX	.873	.889	.948

Sample Statistics for Four Inefficiency Measures

	OLS	BOXCOX	FRONT	FRONT/BOXCOX
MINIMUM	.000	.000	.030	.027
MAXIMUM	.875	.867	.805	.678
MEAN	.506	.612	.222	.194
STANDARD DEVIATION	.108	.084	.133	.104

Table 6

The Effect of Firm-Specific Inefficiency on Growth 1983/84--1990/91

Model:

$$\text{Growth Rate}_{1983/84\text{-}1990/91} = \alpha + \beta \text{ Inefficiency Measure}_{1983/84} + \varepsilon$$

GROWTH IN OUTPUT

Measure of Growth Rate		Measure of Inefficiency	
		FRONT	FRONT/ BOXCOX
	N	coeff (pval)	coeff (pval)
GROWPR	344	-.713 (.000)	-1.056 (.000)
GROWADJ	344	-.301 (.187)	-.422 (.124)

GROWPR is growth rate in net patient revenue
GROWADJ is growth rate in adjusted inpatient days (adjusted for outpatient visits)

GROWTH IN MARKET SHARE

Measure of Growth Rate		Measure of Inefficiency	
HFPA (Smaller Markets)		FRONT	FRONT/ BOXCOX
	N	coeff (pval)	coeff (pval)
GROWPRMSHARE	359	-.203 (.092)	-.289 (.079)
GROWADJMSHARE	359	-.121 (.407)	-.167 (.383)

GROWPRMSHARE is growth rate in market share of net patient revenue.
GROWADJMSHARE is growth rate in market share of adjusted inpatient days.

Measure of Growth Rate		Measure of Inefficiency	
COUNTY (Larger Markets)		FRONT	FRONT/ BOXCOX
	N	coeff (pval)	coeff (pval)
GROWPRCTSHARE	359	-.252 (.043)	-.341 (.043)
GROWADJCTSHARE	359	-.279 (.062)	-.349 (.074)

GROWPRCTSHARE is growth rate in market share of net patient revenue.
GROWADJCTSHARE is growth rate in market share of adjusted inpatient days.

Table 7

Firm-Specific Inefficiency and the Persistence of Profits, 1983/84-1990/91

	Measure of Inefficiency					
	FRONT			**FRONT/BOXCOX**		
Year	Quartile 1 (least inefficient) mean profit	Quartile 4 (most inefficient) mean profit	Mean difference t-test p-value	Quartile 1 (least inefficeint) mean profit	Quartile 4 (most inteffcient) mean profit	Mean difference t-test p-value
1983/84	.056	.012	(.028)	.064	.025	(.001)
1984/85	.055	.009	(.007)	.058	.020	(.004)
1985/86	.053	.016	(.054)	.047	.018	(.145)
1986/87	.018	-.009	(.076)	.016	-.001	(.136)
1987/88	.019	-.045	(.000)	.020	-.042	(.001)
1988/89	.019	-.028	(.002)	.024	-.025	(.001)
1989/90	.013	-.045	(.044)	.035	-.039	(.002)
1990/91	.013	-.036	(.018)	.016	-.022	(.060)

Profit on sales is net income divided by total revenue (operating and non-operating sources).

Table 8

Effect of Standard Deviation* of Inefficiency (1983/84) and Population Growth (1980-1990) on Growth Rate in Concentration (1983/84-1990/91), (p-values in parenthesis)

Model:
Growth Rate in Concentration $_{'83/84-'90/91}$
$= \alpha + \beta$ Standard Deviation in Inefficiency$_{'83} + \varepsilon$

HFPA (Smaller Markets)

Output Measure	Measure of Inefficiency	
	FRONT	FRONT/ BOXCOX
Net Patient Revenue	1.120(.012)	1.092(.050)
R Squared	.043	.022
Adj Inpatient Days	.592 (.190)	.558 (.340)
R Squared	.005	.000

COUNTY (Larger Markets)

Output Measure	Measure of Inefficiency	
	FRONT	FRONT/ BOXCOX
Net Patient Revenue	1.209 (.051)	1.280(.120)
R Squared	.053	.028
Adj Inpatient Days	.301 (.644)	.263(.842)
R Squared	.000	.000

Model:
Growth Rate in Concentration $_{'83/84-'90/91}$ =
$\alpha + \delta$ Population Growth Rate$_{'80-'90} + \varepsilon$

Output Measure	Market Definition	
	HFPA	COUNTY
Net Patient Revenue	-.125 (.403)	-.062 (.786)
R Squared	.006	.001
Adj Inpatient Days	-.024 (.876)	.031 (.895)
R Squared	.000	.000

* Using market-share weighted standard deviation of the inefficiency measure, where weights are market shares of net patient revenue or adjusted inpatient days, as appropriate.

Table 9

Sample Statistics for Standard Deviation of Inefficiency (1983/84), and Growth Rate in Concentration (1983/84-1990/91), (standard deviations in parenthesis)

Standard Deviation of Inefficiency Across HFPAs (Smaller Markets)

Output Measure	Inefficiency Measure	
weight:	FRONT	FRONT/BOX
Net Pt Rev	.051(.056)	.038(.044)
Adj Indays	.051(.056)	.039(.043)

Standard Deviation of Inefficiency Across Counties (Larger Markets)

Output Measure	Inefficiency Measure	
weight:	FRONT	FRONT/BOX
Net Pt Rev	.067(.055)	.050(.042)
Adj Indays	.069(.055)	.051(.042)

Growth Rate in Herfindahl Indexes and Population Growth Rate

	County Markets		HFPA Markets	
	mean	st.dev.	mean	st.dev.
POP GROWTH RATE	.279	(.153)	.296	(.166)
%ΔHERF (net pt rev)	.093	(.247)	.099	(.278)
%ΔHERF (adj indays)	.013	(.251)	.040	(.287)