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HOSPITAL MERGERS AND EFFICIENCY

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Hospital Mergers and Efficiency

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Between 1980 and 1988, there were approximately two hundred hospital mergers. Hospitals may choose to merge to gain market power and / or to lower costs. To the extent that mergers produce gains in efficiency, they contribute to lowering the cost of health care. In evaluating proposals for hospitals to merge, lower cost is an important benefit to consider. However since efficiency gain is only one of a number of motivations for hospitals to merge, there is no assurance mergers will produce lower costs. The purpose of this paper is to examine hospital mergers over the period 1980 to 1988 and to determine the implications for efficiency and therefore cost savings.[1]

There is a literature on hospital mergers and a literature on hospital efficiency, but with the exception of some case studies, little work has been done which combines the two. Finkler (1985) and Francis (1992) examine the motives underlying merger, including efficiency gains; Woolley (1989, 1991) and Vita and Schumann (1991) consider the competitive effects. A few papers consider mergers and efficiency but employ a very different methodology than ours. For example,

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[1] Merger refers to a situation where a firm acquires one or more firms without creating a new entity. Consolidation, on the other hand, refers to a case where two or more firms combine to form a new firm. In this paper, the term "merger" refers to both merger and consolidation.

Francis (1992) is a case study of three rural hospitals in Ohio which merged into a healthcare system in 1989. The merger permitted specialization of services and consolidation of administrative functions, which resulted in gains in both efficiency and quality of care. Brown and Klosterman (1986) are interested in the characteristics of hospitals which merge and the characteristics of hospitals which do not merge. They compare twenty-four financial and operating ratios for a sample of Florida hospitals between 1979 and 82. Hospitals which merged tended to have higher expense ratios than hospitals which did not merge. Based on these ratio comparisons, they conclude that mergers do not produce gains in efficiency. However, this study does not compare the efficiency of merged hospitals to what the efficiency would have been had the merger not occurred. Greene (1992) analyzes two interview studies and concludes that mergers raise operating costs due to an expansion in the line of services, investment in advanced medical equipment, problems in restructuring the merged unit and additional personnel training. Greene also finds that hospital mergers improve the quality of care.

There is a large literature which investigates hospital efficiency using a nonparametric technique referred to as Data Envelopment Analysis (DEA). These studies vary in the specification of inputs and outputs[2], but all conclude that

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[2] Valdmanis (1992) and Ozcan (1993) focus on efficiency effects of input-output specifications. Valdmanis (1992) concludes that the DEA efficiency scores are robust in all 10 specifications used. Ozcan (1993) finds that efficiency scores are not sensitive to most of the input-output used, except for the use of inpatient days (instead of case-mix adjusted discharges). He suggests that researchers should avoid measuring hospital outputs as inpatient days if possible. This appears to be inconsistent with Grannemann, Brown and Pauly (1986) who, based on the parametric estimation of a hospital cost function, conclude that the multiple

hospitals are not, on average, productively efficient [Grosskopf and Valdmanis (1987), Valdmanis (1990), Valdmanis (1992), Burgess and Wilson (1993), and Ozcan (1993)]. To date, no study has related hospital mergers with DEA measures of efficiency.

This paper studies the impact of hospital mergers on productive and scale efficiencies using DEA. Specifically, Farrell technical efficiencies relative to different returns to scale frontiers are computed for hospitals that merged over the period 1980-88. The sample includes pre-merger observations and then subsequent observations on the merged unit. For each merger case, aggregate pre-merger and post-merger efficiency indexes are created.[3] The aggregate pre-merger index, which represents the predicted efficiency of the merged unit if merger has no effect on efficiency, is compared to the aggregate post-merger efficiency index to identify efficiency gain or loss due to merger. Scale efficiency is also computed.

The organization of the paper is as follows. Section 2 presents the DEA technique and the construction of aggregate indexes. Section 3 discusses the data set and presents the results. Section 4 summarizes the empirical findings and suggests directions for future research.

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output specification enhances the study of hospital cost structure as compared to the cost-per-adjusted patient-day measure.

[3] We exclude the year of merger from our analysis for a number of reasons. First, it is a chaotic year in which the hospital was restructured and its performance may not be atypical one. Second, the information on exact time of the year when the merger takes place is not available.

II. Methodology

The first step in measuring gain or loss in efficiency due to merger is to compute technical efficiency for each hospital relative to the peer hospitals in each year.[4] This provides a measure of hospital efficiency at the current scale of operation. Next, the year of merger is identified and average efficiency scores over the pre-merger period and post-merger period are computed. For each merger case, an aggregate pre-merger efficiency index is calculated as the weighted sum of average efficiency scores for all hospitals involved in the merger, where the weights are a hospital size proxy. This index is then compared to the post-merger efficiency index of the merged unit. The post-merger efficiency index is the simple average of the efficiency scores for the merged hospital over the sample period after merger, excluding the year of merger.[5]

For each year t, $t = 1, 2, ..., T$, there are K_t hospitals. Each hospital produces M different outputs using N different inputs. Let x_{kt} be an $(N \times 1)$ input vector used by hospital k, $k = 1, 2, ..., K_t$, to produce an $(M \times 1)$ output vector, y_{kt}, in year t. Let Y_t and X_t be $(M \times K_t)$ and $(N \times K_t)$ matrices of output and input in period t. The piecewise linear input requirement set is defined as:

$$L(y_t) \quad = \quad \{\, x_t : \; Y_t z_t \geq y_t,\, X_t z_t \leq x_t,\, I_t z_t = 1,\, z_t \in R_+^{K_t} \,\}, \qquad (1)$$

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[4] We do not combine all observations in all years to create a pooled frontier to which each hospital is evaluated against since we wish to avoid effects on efficiency of changes in technology over time.

[5] We do not need to use weighted average when creating the post-merger efficiency index since the number of beds for the merged hospital remains constant over the sample period after the merger takes place.

where z_t is a ($K_t \times 1$) vector of intensity variables and I_t is a ($1 \times K_t$) vector of ones. This is a set of all input vectors that are feasible to produce the output vector y_t, when technology exhibits variable returns to scale[6] (VRS) [Afriat (1972)]. The lower boundary of this input set is an isoquant or the reference frontier used in the computation of Farrell technical efficiency. For details, see Färe, Grosskopf and Lovell (1985).

For each hospital k, k = 1, 2, ..., K_t, Farrell technical efficiency in year t, TE^k, is computed as a solution to the following linear programming (LP) problem:

$$\begin{aligned} TE^k = \quad & \min_{\lambda,z} \lambda \\ \text{subject to} \quad & Y_t z_t \geq y_{kt} \\ & X_t z_t \leq \lambda x_{kt} \\ & I_t z_t = 1 \\ & z_t \in R_+^{Kt}. \end{aligned} \tag{2}$$

The left hand side of the constraint set contains information on the output and input combination used by all hospitals in year t in the sample. For each hospital k, the frontier hospital that uses the same input ratio as hospital k is created as a weighted sum of the best hospitals in year t. The values of the activity variable z for these best hospitals are positive while the rest are zero. The output-input combination used by hospital k appears on the right hand side. This output-input vector is compared with that for the frontier hospital. If it is possible to

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[6] Variable returns to scale refer to increasing, constant and decreasing returns.

proportionally reduce hospital k's current input, given its outputs, then hospital k is not technically efficient and TE^k is less than one. The value of TE^k gives the proportion of hospital k's current inputs that is sufficient to produce its current output level if all inputs were utilized efficiently. Put differently, one minus TE^k is the degree of inefficiency or the proportion of inputs that could be saved. If hospital k is on the frontier, TE^k is exactly one. The current input level is the minimum feasible level to produce the chosen output level. Since TE^k is evaluated against VRS frontier technology, it is the relative efficiency of hospital k at the current operational scale. This inefficiency is due to mis-management.[7]

For each merger case, the aggregate pre-merger efficiency index, IDX_B, is constructed as:

$$IDX_B = \Sigma_i w_i \overline{TE}^i, \tag{3}$$

where i indexes the pre-merger hospitals, $\overline{TE}^i$ is the average pre-merger efficiency of hospital i over pre-merger years and w_i is the weight (between 0 and 1) used to adjust for the size of hospital i. IDX_B is the predicted efficiency of the merged hospital if merger has no effect on efficiency. The aggregate post-merger efficiency index, IDX_A, is defined as:

$$IDX_A = \overline{TE}^j, \tag{4}$$

where $\overline{TE}^j$ is the average post-merger efficiency of the merged hospital j over the

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[7] We recognize that the source of inefficiency is not solely mismanagement, but includes misspecification of inputs and outputs and differences in the operating environment.

sample period after merger, excluding the year of merger.[8] Appendix A provides a numerical example of the computation of pre-merger and post-merger indexes.

IDX_A is compared to IDX_B to identify efficiency gain or loss from merger, given some time to adjust to the new environment. For example, if IDX_B is less than IDX_A, then there is a gain in efficiency. On the other hand, if IDX_B is greater than IDX_A, then an efficiency loss occurs.

Another source of efficiency gain or loss due to merger is a change in the scale of hospital operations. For example, hospitals on the decreasing portion of the long run average total cost curve have the potential to lower costs by taking advantage of economies of scale; hospitals on the increasing portion of the long run average total cost curve have the potential to raise costs by moving further away from the optimum scale. To investigate this question, we calculate a measure of scale efficiency for all pre and post merger hospitals. To avoid confounding inefficiency due to mismanagement with scale inefficiency, the first step is to eliminate managerial inefficiency by projecting each hospital onto the VRS frontier. The next step is to calculate the constant returns to scale (CRS) frontier to identify the input proportions associated with the minimum point on the long run average total cost curve. This eliminates both managerial and scale inefficiencies. It provides the benchmark to determine whether the hospital is

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[8] If the merger takes place during the last year of the sample period, IDX_A for that merger case cannot be computed.

scale efficient (operating under constant returns to scale) or scale inefficient (operating under decreasing or increasing returns to scale).

CRS technology is specified as in (1) without the unit restriction on the z variables. To evaluate each hospital relative to its hypothetical hospital which not only uses the minimal inputs but also operates at the optimal scale, the LP problem in (2) is solved with the constraint that $I_t z_t = 1$ dropped. This LP problem is solved K_t times for all K_t hospitals in year t.

Let $TE^{k,CRS}$ and $TE^{k,VRS}$ be hospital k's technical efficiency relative to CRS and VRS frontiers, respectively. Hospital k's scale efficiency, SE^k, is defined as:

$$SE^k = TE^{k,CRS} / TE^{k,VRS}. \tag{5}$$

This measure captures the difference between the CRS and VRS frontiers at hospital k's current output level.[9] Since the VRS frontier envelops the data points tighter than the CRS frontier, $TE^{k,CRS}$ is at most equal to $TE^{k,VRS}$ [Grosskopf (1986)]. SE^k is therefore less than or equal to one. If SE^k is one, hospital k is scale efficient and operates at the CRS technology. If SE^k is less than one, hospital k is scale inefficient. Within a group of scale inefficient DMUs that operate under decreasing returns, the value of SE^k indicates how far the current operation is from the optimal scale. The closer is the value of SE^k to one, the

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[9] This measure eliminates managerial inefficiency and captures the difference between the hospital projected onto the VRS frontier and the CRS frontier. The denominator is the projection onto the VRS frontier and eliminates managerial inefficiency. The numerator is the projection onto the CRS frontier and eliminates both managerial and scale inefficiency. Where the ratio is less than one, the VRS projection is not scale efficient.

closer is the hospital to the optimal scale. Similar interpretation also holds for scale inefficient DMUs that operate under increasing returns.

A scale inefficient hospital operates under either increasing or decreasing returns. To separate these two cases, technical efficiency is calculated relative to nonincreasing (i.e., constant and decreasing) returns (NIRS) technology for each hospital. This is accomplished by solving the LP problem in (2), replacing the equality on the third constraint by less than or equal to. The solution to this LP problem is hospital k's technical efficiency relative to the NIRS frontier, denoted as $TE^{k,NIRS}$. For each scale inefficient hospital k, if $TE^{k,VRS} = TE^{k,NIRS}$, then hospital k operates under decreasing returns; otherwise, it operates under increasing returns.

III. Empirical Application

The original data consist of all general and surgical hospitals that merge with hospitals in the same market area during the period of 1980-88. The data come from the American Hospital Association tapes and the hospital change file from Abt Associates, Inc. Merger cases are excluded where: (1) the data in the year of merger or at least one observation for a pre-merger hospital is not available; (2) the data from the AHA and the information in the hospital change file are inconsistent. This reduced the sample size from 112 to 79 merger cases; our sample represents 70 percent of the original data set.

The purpose of a hospital is to combine sick people with capital and labor and make them healthy (if possible). It is difficult to move from this conceptualization to a specification of inputs and outputs for which data are available. Some early literature uses discharges as the only output measure. This variable not only includes patients who are discharged dead, but also fails to capture the severity of symptoms. Later, several researchers adopted multiple outputs, classified by type of treatment: acute care inpatient days, intensive care inpatient days, other care inpatient days, number of surgical operations, and number of emergency and ambulatory visits. This multiple output measure captures the fact that different treatments require different amounts of resources and accounts for case mix differences, but it is an intermediate output and not the ultimate output, which is a healthy person. Nevertheless, we follow this precedent in our output specification.

The specification of hospital inputs is equally challenging. Production theory is formulated in terms of inputs that are measured in physical units. For a hospital, typical inputs are physicians, nurses, aides, beds, medical supplies and equipment. Previous studies include full time equivalent physicians, nurses and aides with varying degrees of disaggregation to reflect differences in human capital. Although physicians are clearly one of the most important inputs, the number of physicians associated with a hospital turns out to be a poor measure. The difficulty arises because most physicians have privileges to practice at several hospitals and their time is distributed across hospitals non-uniformly. Data are not available on hours of physician time by hospital. The number of physicians associated with a hospital over-represents the physician input. Capital is proxied by beds and/or equipment.[10] Medical supplies are very difficult to measure in physical units and in general are aggregated and measured in monetary terms. Consistent with the view that hospitals transform sick persons to healthy persons, patients should be included as an input, typically measured by total number of admissions.

Table 1 contains descriptive statistics. The minimum values of output variables suggest that some hospitals in the sample do not provide all types of inpatient care and that all provide emergency and ambulatory services. The average numbers of other care inpatient days, intensive care inpatient days and outpatient visits are relatively similar across hospitals and years. However, the number of surgical operations, total hospital discharges and total number of admissions vary widely across hospitals, but are stable across years.

Average acute care inpatient days dips during the first half of the sample period with the trough in 1986 and begins to rise afterward. Average number of visits fluctuates over time with an increasing trend. All other variables exhibit increasing trend at the mean, especially after 1986. These numbers suggest that the demand for health care is rising and more care is being provided in outpatient

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[10] Grosskopf and Valdmanis (1987) conclude that number of beds is a reliable capital proxy.

settings.[11]

This study experiments with four different combinations of inputs and outputs (see Table 2). All four specifications include the five disaggregated outputs and total cost as an input.[12] The variation focuses on total admissions as an input and total discharges as an output. Total admissions is intuitively appealing since it is necessary to achieve the outputs. Total discharges is an appealing output since it controls for volume. However, there is considerable overlap in the information contained in total discharges and the disaggregated intermediate outputs which have the advantage of capturing somewhat differences in the severity of case mixes.

For each specification, we compute efficiency scores for each hospital by minimizing inputs used in providing the given level of care, relative to their peers

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[11] The medicare prospective payment system (PPS) was implemented on January 1, 1984. This system classifies patients into diagnosis related groups (DRGs) and reimburses a hospital at a pre-set rate. Under PPS, if the cost of providing care is less than the reimbursement rate, the hospital keeps the difference. Otherwise, the hospital absorbs the loss. The PPS encourages hospitals to substitute less expensive outpatient care for more expensive inpatient care, where possible. This may explain the increase in the number of outpatient visits over time.

[12] Some may object to our use of total costs as reported by hospitals as a proxy of input for two reasons. First, these costs are lower than the "true" costs of providing care because physicians are paid mostly by insurers or third-party payers and may not be part of the hospital's payroll. Second, input prices such as wage rate for nurses vary across cities and the un-adjusted total costs would make a hospital in the high cost of living city appears inefficient.

Since our efficiency index is a relative measure of hospitals in the sample, we would argue that a systematic bias in total costs would not affect our measure. Should the data on benefits paid to physicians are available in all years and the amount of time physicians spent in each hospital is available, it would be desirable to include the adjusted number of physicians as an input and total costs excluding benefits paid to physicians as another input. Similarly, the use of un-adjusted total costs would not affect our conclusion since we are interested in the comparison of efficiency before and after acquisitions. Most mergers occur between hospitals in the nearby location (some are within the same ZIP code) which are likely to experience similar cost of living. The bias, if any, would offset each other in the comparison.

in the same year. These efficiency scores are calculated under three types of returns to scale as solutions to the LP problems in (1), (3) and (4). We also calculate scale efficiency for each hospital using (2). The results are remarkably similar in all specifications; only those from specification 4 which has five outputs and one input are reported here.

Table 3 summarizes average efficiency scores for all three types of returns to scale. On average, hospitals in our samples are not efficient. The average productive efficiency (TE^{VRS}) ranges from 71 percent in 1986 to 84 percent in 1988. This indicates that total costs could be reduced by 16 to 29 percent if resources were utilized efficiently, possibly through better management. In general, we find that average productive efficiency is relatively stable with a slightly increasing trend. The higher average efficiency scores can partly be attributable to mergers since with each subsequent year, the proportion of merged to unmerged hospitals increases.[13] Similar patterns are found for technical efficiency scores under CRS and NIRS technologies. The average scores reach the lowest point in 1986 and peak in 1988.

The last column of Table 3 is average scale efficiency by year which is consistently higher than technical efficiency, suggesting that mismanagement

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[13] Since the sample size becomes smaller as we move toward the end of the sample period, one might think that DEA would produce a higher efficiency score. We would argue that small sample size in this case does not necessarily imply that the DEA efficiency scores will be higher. A merged hospital is not just the sum of pre-merged units in the mathematical sense. It involves some reorganization in terms of management and personnel training, among others. The performance of the newly form hospital is not necessary the same as that of any of the pre-merged hospital.

contributes more to total inefficiency than not operating at the optimal scale. There is no apparent pattern in the behavior of average scale efficiency over time so mergers do not appear to have an effect on scale efficiency.

Table 4 stratifies efficiency scores by merger class and year. For example in 1983 under CRS technology, there were 106 unmerged hospitals with an average efficiency score of 0.706, there were 7 hospitals which merged prior to 1983 with an average post-merger efficiency score of 0.743. We exclude average efficiency for the year of merger. Comparing average pre-merger efficiency to average post-merger efficiency within each year when these hospitals are evaluated relative to the same frontier, we find that, on average, pre-merger hospitals tend to be less efficient than merged hospitals. The all-year average pre-merger efficiency scores is significantly less than the all-year average post-merger efficiency at the 1 percent level in NIRS and VRS technologies, based on nonparametric tests.[14] This confirms our earlier conclusion that merger contributes positively to efficiency.

Average scale efficiency tends to move away from optimal scale after mergers since it takes time to restructure their operations to the optimal size. For the period of 1980-1988, average scale efficiencies between the two merger classes differ at the 1 percent level.

Table 5 focuses on VRS technology and summarizes the effects of mergers

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[14] We perform the nonparametric tests for the average efficiency over the entire sample period, i.e., 1980-1988, not the average in each year. The tests used are analysis of variance, Wilcoxon scores (rank sums), median scores, Van der Waerden scores and Savage scores.

on productive efficiency (TE^{VRS}). Recall that the efficiency effect of merger is computed as the difference between IDX_A and IDX_B. Thirty-nine hospitals experience a post merger gain of 9.8%, on average. Twelve hospitals experience an average loss of 9.41%. Two hospitals experience neither gain nor loss in their efficiency. On average, there is a 5-percent net efficiency gain from mergers as compared to their predicted efficiency had they not merged.

Table 6 stratifies the results according to returns to scale and year. Although most hospitals operate close to the optimal scale, the majority of hospitals fall into the decreasing returns region. In general, small hospitals, i.e., those that fall in the increasing returns range, are less productively efficient, but closer to the optimal scale than larger hospitals. This suggests that larger hospitals are able to restructure their operations efficiently. As seen in earlier tables, there is no obvious pattern in scale efficiency over time. Analysis of the change in scale efficiency over the sample period for individual merger cases indicates that most hospitals do not change their operating regions after mergers. Hospitals that operate in the increasing returns range remain in that region after mergers and similarly for large hospitals in the decreasing returns region. Only a small proportion of merged hospitals adjusted their operations toward optimal scale. These results suggest that economies of scale are not one of the motives for merger.

IV. Concluding Remarks

This study uses DEA to evaluate efficiency effects of hospital mergers and to examine possible exploitation of scale economies, based on a sample of 79 merger cases during 1980-88. On average, there is a 5 percent net gain in productive efficiency as a result of mergers. The magnitude of efficiency gain increases as merged hospitals have time to adjust their operation and overcome problems associated with restructuring and training personnel. Most inefficiency is due to mis-management, rather than due to not operating at the optimal scale.

To make policy recommendations, we need to further investigate the direction in which the merged unit departs from the optimal scale. We also need to find a way to summarize the information for each merger case. It might be possible to create an aggregate index similar to the pre- and post-merger efficiency indexes for the scale measure. Another point is to redefine our measure of total cost to accounts for different cost of living across sample and to repeat the entire empirical procedures to see how sensitive our results are.

References

Afriat, S. (1972) "Efficiency Estimation of Production Functions," International Economic review 13: 568-598.

Brown, K.J., and Klosterman, R.E. (1986) "Hospital Acquisitions and Their Effects: Florida, 1979-1982," in For-Profit Enterprise in Health Care ed. by B.H. Gray (Washington, D.C.: National Academy Press), 303-321.

Burgess, J.F., Jr., and Wilson, P.W. (1993) "Technical Efficiency in Veterans Administration Hospitals," in The Measurement of Productive Efficiency: Techniques and Applications eds. by H.O. Fried, C.A.K. Lovell and S.S. Schmidt (New York: Oxford University Press), 335-351.

Färe, R., Grosskopf, S. and Lovell, C.A.K. (1985) The Measurement of Efficiency of Production (Boston: Kluwer-Nijhoff Publishing).

Farrell, M.J. (1957) "The Measurement of Productive Efficiency," Journal of the Royal Statistical Society 120(part III): 253-282.

Finkler, S.A. (1985) "Merger and Consolidation: The Motives Behind Healthcare Combinations," Healthcare Financial Management 15 (February): 67-74.

Francis, J.M. (1992) "Merger Boosts Quality and Service," Healthcare Financial Management 46 (November): 21-28.

Grannemann, T.W., Brown, R.S., and Pauly, M.V. (1986) "Estimating Hospital Costs: A Multiple-Output Analysis," Journal of Health Economics 5: 107-127.

Greene, J. (1992) "The Cost of Hospital Mergers," Modern Healthcare (February 3): 36-43.

Grosskopf, S. (1986) "The Role of the Reference Technology in Measuring Productive Efficiency," The Economic Journal 96 (June): 499-513.

Grosskopf, S., and Valdmanis, V. (1987) "Measuring Hospital Performance: A Nonparametric Approach," Journal of Health Economics 6: 89-107.

Ozcan, Y.A. (1993, forthcoming) "Sensitivity Analysis of Hospital Efficiency Under Alternative Output/Input and Peer Groups: A review," Knowledge and Policy

Valdmanis, V. (1990) "Ownership and Technical Efficiency of Hospitals," Medical Care 28(6): 552-561.

Valdmanis, V. (1992) "Sensitivity Analysis for DEA Models: An Empirical Example Using Public vs. NFP Hospitals," Journal of Public Economics 48: 185-205.

Vita, M.G., and Schumann, L. (1991) "The Competitive Effects of Horizontal Mergers on the Hospital Industry: A Closer Look," Journal of Health Economics 10: 359-372.

Woolley, J.M. (1989) "The Competitive Effects of Horizontal Mergers in the Hospital Industry," Journal of Health Economics 8: 271-291.

Woolley, J.M. (1991) "The Competitive Effects of Horizontal Mergers in the Hospital Industry: An Even Closer Look," Journal of Health Economics 10: 373-378.

Table 1: Descriptive Statistics

Year	N	Variable	Mean	Std. Dev.	Minimum	Maximum
1980	136	**Outputs:**				
		ACUTE	58621.54	53334.01	3452.00	282657.00
		ICU	4125.66	5913.50	0	42469.00
		OTHER	4246.54	11510.53	0	55394.00
		DCTOT	8517.12	7187.24	334.00	38083.00
		SURG	4650.63	3976.59	12.00	19973.00
		VISIT	78886.12	118112.73	750.00	772470.00
		Inputs:				
		TC	19381277.64	21176492.96	525041.00	115367000.00
		ADMTOT	8521.38	7173.77	333.00	37692.00
1981	129	**Outputs:**				
		ACUTE	60199.75	54809.86	3450.00	283537.00
		ICU	4521.48	6026.32	0	39905.00
		OTHER	4209.18	10659.52	0	55927.00
		DCTOT	8784.20	7313.91	357.00	35987.00
		SURG	4763.43	3979.28	66.00	19358.00
		VISIT	55858.78	82465.92	851.00	697018.00
		Inputs:				
		TC	23753073.29	25151008.08	590575.00	133815000.00
		ADMTOT	8774.89	7309.34	357.00	37043.00
1982	126	**Outputs:**				
		ACUTE	59177.36	53960.41	3594.00	285948.00
		ICU	4724.21	6195.81	0	39955.00
		OTHER	5545.51	12371.82	0	64086.00
		DCTOT	8872.43	7372.94	448.00	35986.00
		SURG	4987.90	4300.52	25.00	21681.00
		VISIT	67660.76	103740.24	1372.00	751758.00
		Inputs:				
		TC	27205894.14	28041517.41	634843.00	155615000.00
		ADMTOT	8874.15	7383.87	470.00	35922.00
1983	119	**Outputs:**				
		ACUTE	58310.71	54395.68	2812.00	287950.00
		ICU	5055.48	6583.17	0	39659.00
		OTHER	5691.56	11933.91	0	61642.00
		DCTOT	8919.80	7538.36	574.00	39186.00
		SURG	4993.59	4439.33	11.00	25960.00
		VISIT	95448.39	150021.23	1027.00	925278.00
		Inputs:				
		TC	30659200.58	32483466.73	653013.00	175202000.00
		ADMTOT	8888.10	7483.43	574.00	39080.00

Table 1: Descriptive Statistics (cont.)

Year	N	Variable	Mean	Std. Dev.	Minimum	Maximum
1984	116	**Outputs:**				
		ACUTE	57959.79	53997.55	2711.00	274632.00
		ICU	5507.96	7183.84	0	39479.00
		OTHER	6081.09	12319.83	0	62921.00
		DCTOT	9246.64	7688.51	572.00	40441.00
		SURG	5332.56	4383.73	6.00	27883.00
		VISIT	65722.84	92312.99	1129.00	761803.00
		Inputs:				
		TC	36555804.97	38197642.39	639688.00	210402297.00
		ADMTOT	9205.52	7656.36	571.00	40379.00
1985	107	**Outputs:**				
		ACUTE	55357.50	54678.01	2011.00	345792.00
		ICU	5707.07	7753.06	0	41627.00
		OTHER	4610.53	11001.31	0	58137.00
		DCTOT	9079.66	7828.05	367.00	40130.00
		SURG	5447.15	4262.66	5.00	17939.00
		VISIT	68589.67	101581.55	1168.00	816856.00
		Inputs:				
		TC	38982011.20	42822034.02	538041.00	247831210.00
		ADMTOT	9083.71	7843.26	380.00	40108.00
1986	119	**Outputs:**				
		ACUTE	53092.10	56695.48	0	330878.00
		ICU	5454.02	7390.75	0	35980.00
		OTHER	4425.43	10298.84	0	45908.00
		DCTOT	9223.71	8225.45	270.00	41729.00
		SURG	5823.62	4844.84	0	24830.00
		VISIT	73466.92	110995.03	1368.00	844363.00
		Inputs:				
		TC	42819997.20	45669148.47	511586.00	253631671.00
		ADMTOT	9230.33	8256.86	273.00	41967.00
1987	99	**Outputs:**				
		ACUTE	60293.25	63787.71	0	333301.00
		ICU	6456.55	8190.84	0	36037.00
		OTHER	5865.01	10935.41	0	46676.00
		DCTOT	10634.19	9030.69	244.00	41448.00
		SURG	7286.63	6145.91	0	29144.00
		VISIT	83228.35	103441.41	1668.00	840306.00
		Inputs:				
		TC	55009067.93	56333386.61	529623.00	269716974.00
		ADMTOT	10683.14	9053.26	253.00	41466.00

Table 1: Descriptive Statistics (cont.)

Year	N	Variable	Mean	Std.Dev.	Minimum	Maximum
1988	79	**Outputs:**				
		ACUTE	72275.77	68299.45	0	343524.00
		ICU	9447.91	10863.46	0	48612.00
		OTHER	8550.92	13813.86	0	64573.00
		DCTOT	13215.99	10270.77	1172.00	56096.00
		SURG	8876.41	7281.72	540.00	43101.00
		VISIT	113575.00	124292.75	4007.00	854155.00
		Inputs:				
		TC	75222481.15	70416171.46	5568234.00	318121645.00
		ADMTOT	13265.85	10369.96	1174.00	57141.00

Legend:

ACUTE:	Acute care inpatient days
ICU:	Intensive care inpatient days
OTHER:	Subacute and other inpatient days
DCTOT:	Total number of hospital discharges
SURG:	Total inpatient and outpatient surgical operations
VISIT:	Emergency, Ambulatory and other visits
TC:	Total costs in dollars
ADMTOT:	Total number of admissions

Table 2: Model Specifications

Type	Variable	Specification			
		1	2	3	4
Outputs	ACUTE	X	X	X	X
	ICU	X	X	X	X
	OTHER	X	X	X	X
	SURG	X	X	X	X
	VISIT	X	X	X	X
	DCTOT	X	X		
Inputs	TC	X	X	X	X
	ADMTOT	X		X	

Note: X indicates that the variable is included in the model.

Table 3: Average Efficiency Scores

Year	Average			
	TE^{CRS}	TE^{NIRS}	TE^{VRS}	SE
	No. of 1's	No. of 1's	No. of 1's	
1980(N=136)	0.715	0.767	0.771	0.936
	14	25	25	
1981(N=129)	0.695	0.747	0.754	0.925
	12	20	21	
1982(N=126)	0.709	0.771	0.771	0.923
	9	25	25	
1983(N=119)	0.715	0.772	0.776	0.926
	12	25	25	
1984(N=116)	0.713	0.791	0.795	0.902
	10	24	24	
1985(N=107)	0.736	0.781	0.782	0.944
	13	24	24	
1986(N=119)	0.624	0.703	0.709	0.896
	9	24	24	
1987(N=99)	0.684	0.792	0.793	0.867
	6	30	30	
1988(N=79)	0.744	0.814	0.842	0.888
	10	26	29	
1980-1988 (N=1030)	0.702	0.768	0.774	0.914
	95	223	227	

Table 4: Average Efficiency Scores by Class

Variable	Class	1980	1981	1982	1983	1984	1985	1986	1987	1988	All Years*
TE^{CRS}	Pre-merger	0.715 (N=136)	0.701 (N=123)	0.710 (N=117)	0.706 (N=106)	0.711 (N=99)	0.732 (N=83)	0.627 (N=84)	0.679 (N=46)	- (N=0)	0.701 (N=794)
	Year of merger	- (N=0)	0.570 (N=6)	0.707 (N=3)	0.837 (N=6)	0.723 (N=4)	0.689 (N=6)	0.597 (N=10)	0.694 (N=18)	0.707 (N=26)	0.689 (N=79)
	Post-merger	- (N=0	- (N=0)	0.685 (N=6)	0.743 (N=7)	0.723 (N=13)	0.769 (N=18)	0.622 (N=25)	0.686 (N=35)	0.762 (N=53)	0.717 (N=157)
TE^{NIRS}	Pre-merger	0.767 (N=136)	0.749 (N=123)	0.769 (N=117)	0.761 (N=106)	0.781 (N=99)	0.766 (N=83)	0.686 (N=84)	0.761 (N=46)	- (N=0)	0.756 (N=794)
	Year of merger	- (N=0)	0.713 (N=6)	0.727 (N=3)	0.908 (N=6)	0.829 (N=4)	0.788 (N=6)	0.754 (N=10)	0.846 (N=18)	0.760 (N=26)	0.791 (N=79)
	Post-merger	- (N=0	- (N=0)	0.832 (N=6)	0.824 (N=7)	0.851 (N=13)	0.846 (N=18)	0.740 (N=25)	0.806 (N=35)	0.841 (N=53)	0.817 (N=157)
TE^{VRS}	Pre-merger	0.771 (N=136)	0.756 (N=123)	0.769 (N=117)	0.765 (N=106)	0.786 (N=99)	0.768 (N=83)	0.693 (N=84)	0.762 (N=46)	- (N=0)	0.760 (N=794)
	Year of Merger	- (N=0)	0.713 (N=6)	0.727 (N=3)	0.910 (N=6)	0.829 (N=4)	0.788 (N=6)	0.755 (N=10)	0.846 (N=18)	0.807 (N=26)	0.807 (N=79)
	Post-merger	- (N=0)	- (N=0)	0.832 (N=6)	0.824 (N=7)	0.851 (N=13)	0.847 (N=18)	0.743 (N=25)	0.807 (N=35)	0.858 (N=53)	0.824 (N=157)
SE	Pre-merger	0.936 (N=136)	0.930 (N=123)	0.927 (N=117)	0.927 (N=106)	0.908 (N=99)	0.954 (N=83)	0.915 (N=84)	0.893 (N=46)	- (N=0)	0.926 (N=794)
	Year of Merger	- (N=0)	0.834 (N=6)	0.968 (N=3)	0.916 (N=6)	0.869 (N=4)	0.889 (N=6)	0.810 (N=10)	0.817 (N=18)	0.881 (N=26)	0.860 (N=79)
	Post-merger	- (N=0)	- (N=0)	0.842 (N=6)	0.914 (N=7)	0.864 (N=13)	0.918 (N=18)	0.864 (N=25)	0.858 (N=35)	0.892 (N=53)	0.880 (N=157)

* Based on the nonparametric tests, the average technical efficiency scores for all three classes relative to CRS technology are not statistically different at the 5 percent level, while those for NIRS and VRS technologies as well as scale efficiency, on average, are significantly different at the 1 percent level.

Table 5: Effects of Mergers on Productive Efficiency

	Total
Gain	9.81 39
Loss	-9.41 12
No change	0.0 2
Total	5.09 53
Merger occurs in 1988	-- 26

Note:

The first line of each cell is the average percentage change in post-merger productive efficiency, compared to the pre-merger efficiency, i.e., (IDX_A - IDX_B). The second line is the number of merger cases in that cell.

Table 6: Average Productive and Scale Efficiency
By Type of Returns to Scale

Year	Type of Return to Scale	N	TE^{CRS}	TE^{VRS}	SE
1980	IRS	45	0.697	0.710	0.981
	CRS	14	1.000	1.000	1.000
	DRS	77	0.674	0.765	0.898
1981	IRS	34	0.702	0.728	0.965
	CRS	12	1.000	1.000	1.000
	DRS	83	0.647	0.729	0.898
1982	IRS	6	0.685	0.690	0.993
	CRS	9	1.000	1.000	1.000
	DRS	111	0.687	0.757	0.914
1983	IRS	15	0.624	0.652	0.956
	CRS	12	1.000	1.000	1.000
	DRS	92	0.693	0.766	0.912
1984	IRS	13	0.676	0.713	0.949
	CRS	10	1.000	1.000	1.000
	DRS	93	0.687	0.784	0.885
1985	IRS	24	0.673	0.680	0.988
	CRS	13	1.000	1.000	1.000
	DRS	70	0.708	0.777	0.919

Table 6: Average Productive and Scale Efficiency By Type of Returns to Scale (Cont.)

Year	Type of Returns to Scale	N	TE^{CRS}	TE^{VRS}	SE
1986	IRS	37	0.566	0.583	0.967
	CRS	9	1.000	1.000	1.000
	DRS	73	0.606	0.736	0.847
1987	IRS	13	0.615	0.620	0.986
	CRS	6	1.000	1.000	1.000
	DRS	80	0.672	0.806	0.837
1988	IRS	21	0.691	0.794	0.880
	CRS	10	1.000	1.000	1.000
	DRS	48	0.714	0.829	0.869
1980-88	IRS	208	0.659	0.685	0.963
	CRS	95	1.000	1.000	1.000
	DRS	727	0.676	0.769	0.889

Appendix A

Consider a hypothetical merger case which involves two local hospitals: C and D. Both hospitals operate independently during 1980 and 1982. Hospital C has 200 beds and hospital D has 100 beds. In 1983, they merge to form hospital CD which has 300 beds. Technical efficiency of these hospitals were computed for each year relative to the VRS frontier created by all hospitals in the sample for that year. Table A.1 presents the technical efficiency scores for the merger case.

Table A.1

TECHNICAL EFFICIENCY OF HOSPITALS C, D AND CD

Hospital	1980	1981	1982
C	0.7	0.8	0.8
D	0.8	0.6	0.75

Hospital	1983	1984	1985	1986	1987	1988
CD	0.8	0.85	0.9	0.93	0.92	0.98

The first step to compute IDX_B is to obtain average TE scores for hospitals C and D prior to the year of merger (which in this case is 1983). Average TE score for hospital C for 1980 - 1982 is:

$$TE^C = (0.7 + 0.8 + 0.8)/3 = 0.767.$$

Similarly, average TE score for hospital D for 1980 - 1982 is:

$$TE^D = (0.8 + 0.6 + 0.75)/3 = 0.717$$

Next, we compute the weight, w_i, $i = C, D$, based on the size of the hospital as proxied by the number of beds. Since total number of beds for hospitals C and D is 300 and hospital C has 200 beds, $w_C = 2/3$. By the same token, $w_D = 1/3$.

The pre-merger index, IDX_B, is computed as:

$$\begin{aligned} IDX_B &= \Sigma_i\, w_i\, TE^i \\ &= w_C TE^C + w_D TE^D \\ &= 2/3 * 0.767 + 1/3 * 0.717 \\ &= 0.734. \end{aligned}$$

To compute the post-merger index, we only need to take average TE scores from 1984 to 1988 since the number of beds for the merged hospital remains constant.

$$\begin{aligned} IDX_A &= (0.85 + 0.9 + 0.93 + 0.92 + 0.98)/5 \\ &= 0.916. \end{aligned}$$

Note that in the computation of post-merger index we exclude TE score in 1983, the year in which the merger takes place. Since the merged hospital underwent the restructure and operated under a new environment, its performance in that year may not be reliable.

Based on the numerical example, hospital CD has improved its efficiency after merged.

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