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Author(s): James F. Burgess, Jr. and Paul W. Wilson
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Hospital Ownership and Technical Inefficiency

James F. Burgess, Jr. • Paul W. Wilson
Management Science Group (518/MSG), *US Department of Veterans Affairs, Bedford, Massachusetts* 01730
Department of Economics, University of Texas, Austin, Texas 78712

The theoretical industrial organization literature cites varying factors which might influence the degree of technical efficiency achieved under different ownership structures in the US hospital industry. Unfortunately, this literature offers no consensus regarding the net direction and magnitude of these various effects. This study analyzes the four types of ownership structure in the US hospital industry—private nonprofit, private for-profit, federal, and state and local government. Distance functions are used to measure technical efficiency of hospitals producing multiple outputs relative to other hospitals in the sample, allowing comparisons among the different ownership types.

(*DEA; Distance Functions; Efficiency; Contract Failure; Ownership Structure*)

1. Introduction

The US hospital industry is one of the few examples of a market where nonprofit, for-profit, federal government, and state and local government producers exist simultaneously in significant proportions. While economic factors likely gave rise to the for-profit sector, Hansmann (1980) and Stevens (1991) suggest that historical factors may have caused nonprofit, federal, and state and local government ownership structures to develop. The existing theoretical literature offers conflicting views on which ownership structures might be more efficient from a social welfare perspective. For instance, Newhouse (1970) contends that nonprofit hospital managers expand the quality and quantity of hospital care beyond the socially optimal level, while Weisbrod (1975) uses public finance arguments to characterize nonprofit firms as contributing to social efficiency by providing levels of public goods that might be inadequately provided by government alone.

Putting aside questions of social welfare, it is natural to ask whether the four ownership structures differ in terms of their technical ability to convert inputs into outputs. Such differences might arise from different objectives faced by managers under different ownership structures, varying degrees of contract failure across ownership types, or perhaps other factors. Unfortunately, the existing theoretical literature offers conflicting and inconclusive evidence on this point as well. With respect to differences between nonprofit and for-profit organization, neoclassical theory suggests that nonprofits tend to select managers who are more interested in providing high-quality service than in earning profits. Hence, nonprofit hospitals might use more input to produce the same output as for-profit hospitals. In addition, the profit motive encourages efficient production among for-profit hospitals; nonprofits might be less vigilant in eliminating waste in the production process. On the other hand, the separation of ownership and control in large publicly held corporations may leave managers in for-profit hospitals as free as the management of nonprofit hospitals to select goals and to decide how efficiently the hospital will be run.

With respect to government ownership, competing interests in the political process, especially at the federal level, may lead to restrictions or mandates on government-owned hospitals that are not shared by their nonprofit and for-profit counterparts. Furthermore, government bureaucracy may be costly (partic-

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ularly if there are no large scale economies to be exploited) and may have little incentive to eliminate waste in production. While these effects imply that the productive efficiency of government hospitals may differ from that of nonprofit and for-profit hospitals, the magnitude and direction of the differences remain unclear.

In addition to the above neoclassical arguments, recent developments in the theory of incomplete contracts have been used to provide a rationale for the existence of the various ownership types in the hospital industry as well as to suggest differences in productive efficiency among the various types (e.g., see Hansmann 1980, Holtmann 1983, and Muurinen 1991a, 1991b). (Similar arguments have been made in the context of other industries by Easley and O'Hara 1983, Milgrom and Roberts 1990, and Sappington and Stiglitz 1987.) As with the neoclassical arguments, however, contract theory offers inconclusive results regarding differences in productive efficiency. Finally, to the extent that any differences in productive efficiency among the four ownership types in the hospital industry exist, these differences may be diminished over time by the widespread adoption of third-party payment systems for hospital reimbursement. Hansmann (1980) suggests that the incentives for hospital management created by third-party payment systems may dominate any differences that derive from the form of ownership.

Whether and to what extent any differences in productive efficiency among the four types of hospitals exist has implications for various policies currently being considered by federal as well as state and local governments under the guise of health care reform. Since existing economic theory offers unclear evidence on these differences, the question becomes an empirical one. We measure technical efficiency in production among hospitals in the four ownership classes using distance function techniques. Distance function techniques, along with other linear programming (LP) methods (which collectively have come to be known as data envelopment analysis, or DEA) have been widely applied in other industries (Lovell 1993) as well as the health care sector (e.g., Nyman and Bricker 1989, Färe et al. 1992, Burgess and Wilson 1993, Dusansky and Wilson 1994). Moreover, DEA methods easily allow treatment of multiple inputs and outputs and avoid the need for a priori specification of functional forms for technology. This is particularly important in the present application since aggregation issues and choice of functional form have been shown to lead to widely diverging results in previous work on hospital cost functions (Grannemann et al. 1986, Vitaliano 1987).

Several empirical studies have used DEA methods to examine differences in technical efficiency across ownership types in various industries. Efficiency and ownership of public utilities has been examined by Byrnes et al. (1986) and Hjalmarsson and Veiderpass (1992); Chang and Kao (1992) offer a similar analysis of transportation firms. Valdmanis (1992) compares technical efficiency among local public and nonprofit hospitals in Michigan. However, this study is the first to provide a comprehensive examination of differences in productive efficiency across the four ownership types in the US hospital industry. Comparing these ownership types on the basis of allocative or cost efficiency as well would require price information on the measured inputs. Although observations for some of these prices in the hospital industry exist, they frequently do not reflect marginal costs and thus contain little, if any, economic information.

The next section presents the distance functions used to examine technical efficiency in production. The third section describes the data which were obtained from various sources, and the fourth section presents the results of the efficiency estimation. Conclusions are discussed in the final section of the paper.

2. Methodology

DEA methods typically measure technical efficiency in one of two ways. Input oriented models measure how much each firm can proportionately reduce its inputs while producing the original level of output, while output oriented models measure how much each firm can proportionately expand its output while holding inputs unchanged. Since it is unclear whether all hospitals view either inputs or outputs as fixed, we measure efficiency in both the input and output orientations. Although the quantitative results are somewhat dependent on which orientation is used, our qualitative results are largely robust with respect to the choice of input or output orientation.

To begin, consider K hospitals which produce M outputs from N inputs. For the kth hospital, $k = 1, \ldots, K$, let $x_k \in \Re_+^N$ and $y_k \in \Re_+^M$ denote input and output vectors, respectively. The technology faced by the hospitals is the closure of the production set $\Psi = \{(x, y) | x$ can produce $y\}$. Assume (i) Ψ is closed, convex; (ii) all production requires use of some inputs, i.e., $y \neq 0 \Rightarrow x \neq 0$; and (iii) both inputs and outputs are strongly disposable.

The Shephard (1970) output distance function may be defined as

$$D_k^{\text{out}} \equiv \inf\{\theta > 0 | (x, y/\theta) \in \Psi\}. \tag{1}$$

Note that $D_k^{\text{out}} \leq 1$, with $D_k^{\text{out}} < 1$ denoting the presence of inefficiency. We follow convention and model the technology by the convex hull of the sample observations in input/output space, which yields the LP problem

$$(D_k^{\text{out}})^{-1} = \max\{\theta_k | Xq_k \leq x_k, \quad Yq_k \geq \theta y_k, \vec{1} q_k = 1, q_k \in \Re_+^K\}, \tag{2}$$

where $Y = [y_1 \cdots y_K]$, $X = [x_1 \cdots x_K]$, $\vec{1}$ is a $(1 \times K)$ vector of ones, and q_k is a $(K \times 1)$ vector of intensity variables which serve to form the technology. Solving (2) yields an estimate of the output distance function for hospital k, and hence an estimate of its inefficiency. The constraint $\vec{1} q_k = 1$ imposes variable returns to scale on the reference technology; other returns to scale may be imposed by modifying this constraint (e.g., see Grosskopf 1986). With variable returns, the technology may exhibit either increasing, constant, or decreasing returns to scale at different points along the technology.

The Shephard (1970) input distance function is defined as

$$D_k^{\text{in}} \equiv \sup\{\lambda > 0 | (x_k/\lambda, y) \in \Psi\}. \tag{3}$$

Again modelling the technology by the convex hull of the sample observations, the estimate of the input distance function in (3) for hospital k is obtained by solving the LP problem

$$(D_k^{\text{in}})^{-1} = \min\{\lambda | y_k \leq Yq_k, \quad \lambda x_k \geq Xq_k, \vec{1} q_k = 1, q_k \in \Re_+^K\}. \tag{4}$$

From (3), it is clear that $D_k^{\text{in}} \geq 1$, with $D_k^{\text{in}} > 1$ indicating technical inefficiency. Note that both D_k^{out} and D_k^{in} are independent of units of measurement used for both inputs and outputs since efficiency is measured radially from the origin. This is important since units of measurement may always be defined arbitrarily. Lovell (1993) observes that some DEA formulations do not share this property.

The distance function D_k^{in} measures the maximum feasible proportionate reduction of the kth hospital's inputs, holding output constant, given the production set Ψ, whereas the output distance function D_k^{out} gives the maximum feasible proportionate expansion of the kth hospital's outputs, holding inputs constant. In either case, hospitals that define the production set are regarded as efficient, and since (2) and (4) measure efficiency relative to the same technology, $D_k^{\text{in}} = 1$ if and only if $D_k^{\text{out}} = 1$. Those units not on the frontier ($D_k^{\text{in}} > 1$ or $D_k^{\text{out}} < 1$) are viewed as inefficient, perhaps due to managerial incompetence, incentives not to minimize inputs, or other factors.

In addition to the radial inefficiency measured by the distance functions computed from (2) and (4), the presence of slack in the constraints of the LP problems indicates additional sources of inefficiency. For hospital k, slack occurs when the optimal solution in (2) or (4) leaves the weak inequality constraints for particular inputs or outputs as strict inequalities; the quantity of slack is the amount of each input or output that would have to be added to the right-hand side of the inequality constraints in order for them to be satisfied as strict equalities. This measured slack represents an additional amount (beyond that indicated by the radial efficiency score) by which an input could be reduced or by which an output could be increased for hospital k while remaining within the measured production set, i.e., within the convex hull of the sample observations. The existence of slack in the input and output constraints is related to the assumption of strong disposability of inputs and outputs. Indeed, if inputs and outputs are assumed weakly disposable, the constraints in (2) and (4) become strict equalities, eliminating the possibility of slack. The assumption of strong disposability of inputs is appropriate for technologies where input congestion does not occur. Input congestion in any of the sectors to the degree necessary to observe the failure of this assumption is unlikely.

The distance function values obtained from (2) or (4) measure technical efficiency as the distance to the relevant isoquant, but do not consider where along the variable returns production frontier the hospital is situated. While the distance functions computed from (2) and (4) reflect the assumption of variable returns to scale, constant returns to scale may be imposed by dropping the constraint $\vec{1}q_k = 1$, or nonincreasing returns may be imposed by requiring $\vec{1}q_k \leq 1$, yielding the distance functions D_{CRS} and D_{NIRS}, respectively. Then if $D_{\text{CRS}} = D$ for a given hospital, the hospital must lie along the constant returns to scale portion of the production frontier. If $D_{\text{CRS}} \neq D$, then the hospital lies along the increasing returns portion of the frontier if $D_{\text{NIRS}} \neq D$ or the decreasing returns portion if $D_{\text{NIRS}} = D$. For inefficient hospitals, the direction of the path to the production frontier is critical; some hospitals may appear to have increasing returns in the input orientation and decreasing returns in the output orientation.

Alternatively, one could use the procedure suggested by Banker and Thrall (1992) for examining returns to scale. In the input orientation, the Banker and Thrall method involves examining the solution to the dual of (4), namely

$$\min\{\gamma_k y_k + \phi_k \mid Y'\gamma_k' - X'\delta_k' + \phi_k \leq 0,$$
$$\gamma_k x_k = 1,\ \gamma_k \in \Re_+^M,\ \delta_k \in \Re_+^N,\ \phi_k \in \Re^1\}, \qquad (5)$$

where γ_k and δ_k are $(1 \times M)$ and $(1 \times N)$ vectors of weights, respectively, to be computed by solving the LP problem (5). The LP problem (5) may have multiple optimal solutions for ϕ. To bound these, Banker and Thrall suggest solving two additional LP problems:

$$\min\{\phi_k \mid \gamma_k y_k + \phi_k = 1,\ Y'\gamma_k' - X'\delta_k' + \phi_k \leq 0,$$
$$\gamma_k x_k = 1,\ \gamma_k \in \Re_+^M,\ \delta_k \in \Re_+^N,\ \phi_k \in \Re^1\}, \qquad (6)$$

and

$$\min\{-\phi_k \mid \gamma_k y_k + \phi_k = 1,\ Y'\gamma_k' - X'\delta_k' + \phi_k \leq 0,$$
$$\gamma_k x_k = 1,\ \gamma_k \in \Re_+^M,\ \delta_k \in \Re_+^N,\ \phi_k \in \Re^1\}. \qquad (7)$$

Denoting the optimal solution in (6) as ϕ_k^+ and the optimal solution in (7) as ϕ_k^-, then hospital k lies on the increasing returns portion of the technology if $\phi_k^- > 0$, on the decreasing returns portion of the technology if $\phi_k^+ < 0$, and on the constant returns portion if $\phi_k^- \leq 0$ and $\phi_k^+ \geq 0$. As with the procedure we use for determining returns to scale, the Banker and Thrall approach involves solving two additional LP problems for each hospital. The approach we use involves merely modifying the constraint on $\vec{1}q_k$ in (4), whereas the Banker and Thrall approach involves substantial recoding to solve (6)–(7).

3. The Data

Data for this study were obtained from several sources. Data for the VA hospitals were obtained from the VA financial accounting systems, the VA national patient discharge and outpatient data files, VA nursing home discharge files, and the 1988 annual survey of hospitals by the American Hospital Association (AHA). The VA files contain information on 159 VA hospitals and several independent VA outpatient clinics. For purposes of this study, data were limited to the 137 nonpsychiatric hospitals in the VA system, excluding independent outpatient clinics. These data are annual and correspond to the 1988 federal fiscal year (FY88) which ran from October 1, 1987 through September 30, 1988.

Annual data for profit, nonprofit, and state and local government hospitals (hereafter referred to as PROFIT, NONPROFIT, and NONFED, respectively) were obtained from the AHA annual survey and the Medicare Cost Reports (MCR) submitted to the federal government by all hospitals receiving Medicare reimbursements. Unfortunately, for some hospitals, these data do not correspond to FY88; reporting periods may vary by as much as a year across hospitals, although the most common starting date is October 1, followed by January 1 and July 1. For purposes of analysis in cases where hospitals' reporting periods do not correspond to FY88, we use data from the reporting period beginning between April 1, 1987 and March 31, 1988. Thus, any temporal misalignment in the data does not exceed six months in either direction.

The technology and scope of services offered in small hospitals is typically much different from that of larger hospitals. In addition, PROFIT, NONPROFIT, and NONFED hospitals with fewer than 100 beds are allowed to have swing beds between acute and long-term care which would complicate the specification of a production technology that distinguishes between acute and long term beds. Since all VA hospitals have more than 100 beds, PROFIT, NONPROFIT, and NONFED hospitals with less than 100 beds are excluded from the sample to avoid complications in comparing these hospitals with VA hospitals.

Data errors may bias deterministic efficiency measures such as the one used in this study since the technical efficiency of individual hospitals is measured relative to other hospitals. If data errors are distributed inconsistently across observations, relative rankings of hospitals in terms of efficiency will be affected, in addition to efficiency scores being biased. The data used in this study were carefully scrutinized for both coding and measurement errors. In addition, incentives to misreport information were examined to indicate possible sources of inaccuracy in the data. Within the VA system, individual hospitals are the primary unit of budget account, so data at the hospital level do not have to be approximated from other sources. Where incentives to under- or over-report information occur, they likely occur across all hospitals. Nevertheless, the data were carefully analyzed to detect inaccurate observations. Summary statistics for each variable were examined and compared to those in immediately preceding years; average values as well as the range and variance were checked, revealing several inconsistent or impossible values. This analysis was repeated several times, removing observations containing inaccurate information or correcting information from original data sources where possible. Consistency checks were run on the data to ensure that changes in the average values and distribution of values across time were plausible. After omitting observations with missing or inaccurate information that could not be corrected, observations on 2246 hospitals remained, distributed over ownership types as follows: VA, 134; NONFED, 319; PROFIT, 254; and NONPROFIT, 1539. This distribution reflects the population; no systematic deletion of observations was detected.

Apart from different reporting periods, data collected by the VA for its hospitals differ from data on nonfederal hospitals collected by the AHA and MCR in several other respects. VA data are generated from actual operating accounts and patient records collected in a uniform national reporting system while nonfederal hospital data are generated from poorly audited survey information. The VA data collection system has flaws (for example, ancillary tests are not always recorded on the patient files), but information is aggregated and checked more carefully than in the AHA and MCR files. In addition, the incentives faced by VA and nonfederal hospitals in reporting data are different. VA data are used to generate workload projections and set budgets, while the direct connection of data collected by the AHA to resources garnered by a hospital is marginal at best. Hospitals, to some extent, view AHA reports as an unnecessary burden. Undoubtedly, some AHA data are little more than approximations, but there may be less incentive to intentionally misrepresent information. MCR data are used for reimbursement and are audited so that output quantity information is more likely to be correct, although some intentional misrepresentation is possible. The VA and MCR data bases are collected using similar methods.

In addition to differences in the ways in which data are reported, VA hospitals differ from nonfederal hospitals in several other important respects. First, the VA provides its patients with a much more comprehensive set of services than is common in nonfederal hospitals. For example, dental care, social work, and readjustment counseling services are routinely provided to VA inpatients. Such medical care not provided in the private sector is excluded from the data. Second, the mix of services provided in the VA is weighted more heavily toward services needed by war veterans such as spinal cord injury rehabilitation, treatment of post-traumatic stress disorder, inpatient substance abuse programs, and psychiatric services than in typical nonfederal hospitals. VA hospitals are distinguished by a significantly higher ratio of outpatient to inpatient care and more long-term care than nonfederal hospitals. Accounting for each of the various outputs produced by hospitals should allow the relative efficiency of hospitals to be estimated while controlling for differences in service mix. Third, the VA system is the largest health care system in the US, and its capitalization and organizational accountability have been shaped by centralized federal control. Maintaining efficient operation is complicated by Congressional micro-management, although a considerable amount of pressure has been placed on VA hospitals through slow growth of the VA medical care budget. For example, the 3.09% nominal increase in the VA medical care budget from 1985 to 1986 amounted to only 0.83% in real terms, while costs of medical care inputs were rising much faster than general inflation and pressure to provide increased services to an aging veteran population was increasing. Our analysis focuses only on the production technology itself which should be more or less independent of these cost concerns. Fourth, labor and capital constraints placed on VA hospitals may have hindered their ability to use inputs efficiently. National VA employment targets are set by Congress to guarantee federal jobs for constituents; these targets may lead to inefficient preferences for cheaper nonclinical labor inputs. Federal job regulations and salary structures may also constrain VA facilities more than their nonfederal counterparts, particularly in hiring registered nurses (whose opportunity costs often exceed federally determined salaries; this was particularly true over the period of our study). VA facilities are also mandated to provide backup bed capacity for military hospitals in event of war. Though the costs of this standby capacity could be substantial, these beds are not included in the measures we define below so that technical efficiency can be measured similarly across the various ownership types. Thus, we focus exclusively on technical efficiency while recognizing that chosen input allocations may not minimize costs.

Finally, physicians in VA hospitals are salaried by the hospital, which is uncommon among nonfederal hospitals. This important input is often ignored in studies of nonfederal hospitals because no reliable data exist; e.g., see Conrad and Strauss (1983) and Sherman (1984). Others such as Grosskopf and Valdmanis (1987) include a variable for the number of physicians, but this number adds active and associate physicians to the number of house staff. Many of those included in this heterogeneous total may spend little time performing work directly related to outputs produced by the hospital.

Since our goal is to compare different hospital ownership structures in terms of technical efficiency, our measurement of technical efficiency is limited by the availability of variables that are sufficiently accurate and consistently measured across VA, NONFED, PROFIT, and NONPROFIT hospitals. Consequently, the input-output mapping specified in this study focuses on the flow of patients through the hospital in inpatient, outpatient, and long term care settings, and the surgical procedures done to them. Six separate direct hospital outputs were specified: acute care inpatient days (HIND); case-mix weighted acute care inpatient discharges (HDIS); long-term care inpatient days (LTIND); number of outpatient visits (OPVIS); ambulatory surgical procedures (SAM); and inpatient surgical procedures (SIP). The surgical procedure variables (SAM and SIP) and the long-term care variable (LTIND) have minimum values of zero for each of the four types of hospitals; some of the smaller hospitals in the sample perform no surgical procedures and some of the hospitals do not offer long term care.

The surgical procedure variables were obtained from the AHA data base for all hospitals. Internal VA data on outpatient surgeries are possibly corrupt due to incentives to overreport the number of procedures performed—a problem that carries over to the AHA reporting, although probably to a lesser extent. All other output variables for the VA are obtained from internal VA sources. Outpatient visits for the non-VA hospitals were obtained from the AHA data, but the inpatient day and discharge variables were obtained from the MCR data. Since these inpatient variables are audited to match Medicare claim information and the ratio of Medicare to total inpatient activity is used for reimbursement purposes, the MCR data for these variables is presumed to be superior to the unaudited AHA information.

Variation in the intensity of care given to patients may reflect differences in quality across hospitals. Thus, we use the Medicare case mix index to weight discharges in computing the variable (HDIS). Since case mix severity is widely known to contribute to hospital costs, failure to account for differences in case mix across hospitals could lead to bias in our measurement of technical efficiency. The Medicare case mix index is an index for the average resource intensiveness of the average Medicare discharge in a given hospital. For the non-VA data, this information is obtained from the Medicare Cost Reports. VA facilities are not reimbursed under Medicare rules; hence, the case mix index for VA hospitals was calculated using VA data on patients aged 65 years or older (a detailed description of these calculations appears in US Department of Veterans Affairs, 1993).

Seven inputs were specified: the number of acute-care hospital beds, weighted by a scope-of-services index (BDH); the number of long-term hospital beds (BDLT); registered nurses (RNs) measured in full time equivalents (RNFTE); licensed practical nurses (LPNs) measured in full time equivalents (LPFTE); other clinical labor (excluding RNs and LPNs) measured in full time equivalents (XCFTE); nonclinical labor measured in full time equivalents (NCFTE); and long-term care labor measured in full-time equivalents (LTFTE). The labor inputs are taken from VA records for VA hospitals and from the AHA survey for all other hospitals. Full time equivalents are computed by counting full time employees as 1 FTE and part time employees as 0.5 FTE. Average values of the inputs and outputs are shown in Table 1 for each hospital type.

BDH and BDLT are included as proxies for capital used by the hospitals. Direct measurement of capital in the hospital industry is problematic; in addition to the usual problems with using book value of plant and equipment, accounting practices vary widely across the four ownership types. Data on beds are obtained from the AHA survey for all hospitals using the AHA definition of beds that are set up, staffed, and ready for use at the end of the reporting period. The intensity of acute care in hospitals can vary enormously and is related to capital differences among hospitals (by comparison, the intensity of long-term care is much less variable across hospitals). Furthermore, technological capabilities might serve as a proxy for quality, or at least the perception of quality on the part of patients. Thus, we use an index of the scope of services offered by hospitals to weight the number of acute care beds in computing BDH. The scope of services index was constructed using the methodology described by Klastorin and Watts (1982), who present evidence that the order in which hospitals acquire services and facilities tends to be systematic and hierarchical. Applying their methodology and using the service availability data from the 1988 AHA survey yielded 24 well-defined groups with a Guttman scale coefficient of reproducibility (McIver and Carmines 1981) of 0.89 as compared to the ideal 1.00 of a perfect hierarchy.

Table 1 **Average Input, Output Levels**

	VA	NONFED	PROFIT	NONPROFIT
Inputs:				
BDH	9237.6	3786.8	2755.8	5110.2
BDLT	91.2	19.9	8.6	14.4
XCFTE	449.7	277.7	168.5	339.5
RNFTE	213.8	195.9	129.1	249.5
LPFTE	63.5	49.8	37.1	50.0
NCFTE	505.2	309.5	164.2	384.1
LTFTE	84.7	14.5	5.8	11.4
Outputs:				
HIND	87166.6	49317.1	35782.6	64294.8
HDIS	7820.0	10624.3	7504.0	13218.5
LTIND	39725.8	9340.7	5030.8	9544.9
OPVIS	141639.2	73832.1	33676.7	81606.4
SAM	2341.6	2146.4	2046.4	3366.4
SIP	2319.9	2773.7	2279.9	3816.5

As noted above, physicians in VA hospitals are salaried by the hospital, which is uncommon among hospitals outside the VA system. Consequently, obtaining a measure of total medical staff that is consistent across the four hospital types is problematic. The AHA data contain a total medical staff variable, but this includes active and associate physicians as well as house staff, and thus overstates the physician input for NONFED, PROFIT, and NONPROFIT hospitals relative to VA hospitals. In order to avoid biasing the results in favor of VA hospitals, the results reported below were obtained without using total medical staff in the input vector. Adding total medical staff to the input vector changes the efficiency results as expected—measured efficiency for non-VA hospitals increases much less than for VA hospitals (since each hospital is made to look as good as it can, expanding the dimension of the input/output space tends to increase measured efficiency for all hospitals).

Direct measures of quality are conspicuously absent in the input/output specification described above. We note that our study is hardly unique among hospital efficiency studies in this respect, although this alone does not justify the omission. However, *quality* in connection with health care is frequently ill-defined, preventing its objective measurement. An obvious measure of quality in our context would be the incremental improvement in the health status of a patient resulting from a hospital stay or outpatient visit, but this would be virtually impossible to measure in any meaningful way. Moreover, measuring the quality of long term care in this way is not appropriate since the chronic nature of the medical problems of these patients frequently does not permit health status improvements. Alternatively, quality might be defined in terms of the perceptions of the patient, which would likely reflect their level of comfort during a particular episode of care. As in other areas of human capital, such as education, net long term improvements frequently cannot be obtained without short term costs that could be interpreted as poor quality under this definition. Unfortunately, no uniform data exist for constructing an index of quality that takes these factors into account for the hospitals in our sample.

To the extent that we are unable to directly measure quality differences among hospitals, we can anticipate the effects of this measurement problem and adjust our conclusions accordingly. If hospitals producing higher-quality output (regardless of how quality is defined) use more of all inputs, failure to measure quality completely will tend to cause high-quality hospitals to appear inefficient. However, if quality is defined in terms of the comfort levels of patients, we would expect high-quality hospitals to use more of the LPFTE input than low-quality hospitals since LPNs are often used in the "hotel" function provided by hospitals; use of more LPNs will likely result in greater comfort on the part of patients. We would not expect the number of beds or the other labor categories to be greatly affected by this type of quality; hence the primary effect on measured efficiency will likely be slack in the constraint for the LPFTE input, with minimal effects on the value of the distance function itself.

4. Results of Efficiency Measurement

To compute values of the input and output distance functions for the 2,246 hospitals in the sample, (2) and (4) must be solved for each hospital in the sample. In each case, the distance functions were computed using all other hospitals to comprise the reference set represented by the LP constraints in (2) and (4). The following discussion focuses on the various sources of technical inefficiency (radial, slack, and scale inefficiency) in turn.

4.1. Radial Inefficiency

Summary statistics on the distance function values computed from (2) and (4) are shown in Table 2. The results in Table 2 show that the ranking of the ownership types in terms of their average radial efficiency as measured by the distance functions computed from (2) and (4) is the same for both the input and output orientations. VA hospitals appear most efficient, followed by PROFIT, NONPROFIT, and NONFED hospitals, respectively. In the input orientation, average mean efficiencies for VA and PROFIT hospitals are insignificantly different, as is the case for NONPROFIT and NONFED hospitals (we use .05 significance throughout, unless otherwise noted). However, both VA and PROFIT hospitals have significantly greater average mean efficiency than either NONPROFIT or NONFED hospitals. In the output orientation, VA hospitals have significantly higher mean efficiency than either of the other three types, which are insignificantly different in terms of average efficiency.

We also tested whether the distributions of the distance function measures of efficiency differ across the four ownership types. In both the input and output orientations, there are six possible pairwise comparisons. We used the Kolmogorov-Smirnov two-sample test. In the input orientation, we reject the null hypothesis of no difference in the distributions at the .05 level when PROFIT hospitals are paired with either of the other three types, and we fail to reject the null hypothesis in the other three cases. In the output orientation, we reject

Table 2 Statistics on Estimated Inefficiency

	VA	NONFED	PROFIT	NONPROFIT
Mean (D_k^{in})	1.2142	1.2816	1.2320	1.2773
Std. Dev. (D_k^{in})	0.2201	0.2383	0.2365	0.2566
Max (D_k^{in})	1.8018	1.9826	2.0272	2.8678
Mean (D_k^{out})	0.8706	0.8158	0.8316	0.8286
Std. Dev. (D_k^{out})	0.1200	0.1372	0.1495	0.1369
Min (D_k^{out})	0.5911	0.4853	0.3925	0.3606
n	134	319	254	1539
% efficient	29.9	20.7	22.8	20.5

the null hypothesis of no difference in the distributions when testing VA versus NONFED hospitals and PROFIT versus NONFED hospitals, and we fail to reject the null hypothesis in the other four cases, again at the .05 level.

The fact that the Kolmogorov-Smirnov test fails to reject the null hypothesis of no difference in cases where we find significantly different means may be attributed to the low power of the Kolmogorov-Smirnov test (other tests of this type have similar low power). In any case, we find some evidence of differences in radial technical efficiency among the four ownership types. In particular, PROFIT and VA hospitals appear quite different from the other types as well as from each other, while NONFED and NONPROFIT hospitals seem most similar. Thus, Hansmann's (1980) suggestion that third-party payment systems may blur distinctions among the various ownership types as discussed in the introduction appears unsupported by the data. In addition, the notion that the separation of ownership and control in publicly held corporations may result in managers of PROFIT hospitals behaving like those of NONPROFIT hospitals is unsupported by these data.

Several variations of the input-output mapping along the lines of Valdmanis (1992) were tried to assess the sensitivity of our results, which appeared to be rather robust in terms of the qualitative conclusions we draw. With respect to the weighted measures of acute-care beds and hospital discharges, replacing HDIS with an unweighted measure of the number of hospital discharges caused little change in the results. Replacing BDH with an unweighted measure of the number of acute-care beds made hospitals within each ownership category appear more efficient on average, and reduced the difference between VA hospitals and the other types in terms of average efficiency.

4.2. Slack Inefficiency

While the distance functions computed from (2) and (4) indicate the amount by which *each* input (output) may be proportionately reduced (increased) to move a hospital onto the production frontier, slacks in the LP constraints in (2) and (4) represent additional sources of inefficiency. For each input and output, Table 3 shows total slack as a percentage of total input or output, by hospital type, for both the input and output orientations. In general, slack in the input constraints indicates additional amounts by which individual inputs could be reduced after eliminating radial inefficiency while holding output constant, while slack in the output constraints represents additional amounts by which particular outputs could be expanded after eliminating radial inefficiency while leaving inputs unchanged.

Among inputs, each ownership type has a large amount of slack in staffing for long term care (LTFTE), with the largest amount in NONPROFIT hospitals, followed by VA, NONFED, and PROFIT hospitals. This pattern is the same for both the input and output orientations, although the magnitude of the slack is larger in the output orientation. Unmeasured characteristics of the long term care output that differ across hospitals can cause slack in addition to radial inefficiency. In particular, slack may be associated with more complex patient conditions or more intensive patterns of care (this may correspond to some notions of quality differences among hospitals, with those providing more intensive care perceived as having higher "quality"). VA hospitals on average have a higher percentage of patients with severe psychiatric disabilities that require closer levels of monitoring and attention; the higher staffing levels that are required may show up as slack in the input constraints. NONPROFIT hospitals might be competing to acquire patients by offering more intensive patterns of care, which would explain the large amount of slack in the LTFTE input observed for these hospitals. PROFIT and NONPROFIT hospitals also have substantial slack in beds for long term care (BDLT) in the output orientation, which might be explained by similar considerations.

A large amount of slack also occurs for LPNs among NONFED and NONPROFIT hospitals in the output orientation, as indicated for the LPFTE input in Table 3. VA and PROFIT hospitals have relatively little slack in the LPFTE input. As noted previously, LPNs have less medical training than RNs, and provide much of the direct patient care which is sometimes viewed as the "hotel" function of hospitals. To the extent that part of the function of LPNs is to make patients more comfortable, and comfort is perceived as quality, then this result is consistent with the popular view that VA hospitals provide lower-quality care than other hospitals. Profitability considerations may lead PROFIT hospitals to

Table 3 **Total Slack as Percentage of Total Input, Output**

	Input Orientation				Output Orientation			
	VA	NONFED	PROFIT	NONPROFIT	VA	NONFED	PROFIT	NONPROFIT
BDH	3.36	4.19	8.36	3.63	4.64	5.44	10.38	4.77
BDLT	5.35	4.25	6.54	9.54	8.23	9.27	21.87	16.47
XCFTE	4.11	1.85	0.63	1.67	7.22	2.82	0.66	2.49
RNFTE	0.39	3.60	2.63	2.20	0.58	5.77	3.28	3.15
LPFTE	6.05	9.12	3.26	7.59	8.58	17.74	6.33	13.78
NCFTE	1.00	3.32	0.46	2.32	1.93	6.13	0.76	3.56
LTFTE	23.66	19.41	13.02	25.09	30.43	28.80	25.70	34.79
HIND	0.11	0.92	1.81	0.92	0.22	0.96	2.87	1.33
HDIS	27.63	2.19	4.47	3.85	32.60	3.74	5.43	5.16
LTIND	2.00	7.35	17.21	6.74	3.20	8.55	19.02	8.40
OPVIS	0.22	3.31	13.43	5.84	0.30	3.87	17.55	7.82
SAM	27.10	16.22	7.85	5.59	32.15	15.98	9.66	5.45
SIP	14.61	9.45	6.48	4.60	17.35	10.53	7.67	5.28

minimize their use of LPNs, as evidenced by the low level of slack in LPFTE for PROFIT hospitals. This effect apparently does not carry over to the more technical nursing input (RNFTE), as slack in RNs is quite low in all ownership groups. Eastaugh (1992) reviews the conflicting evidence on so-called registered nursing shortages during this period. The uniform technology for the employment of RNs and the absence of slack in this national study could be used to support either side of the argument on this issue. One could use this evidence to assert either that all hospitals are constrained to a minimum technological requirement lower than they would prefer by a labor shortage or that all hospitals are able to hire just as many nurses as they require.

Finally, VA hospitals have relatively large slacks in the XCFTE input. VA hospitals face two external constraints that may lead them to substitute other clinical personnel for more expensive nursing personnel. VA nursing salaries were set on a national level with little regard for local market wages during the period covered by our data, causing difficulties in hiring sufficient numbers of nurses in major urban areas (this policy has been changing since 1990). In addition, VA hospitals face clinical FTE targets that are subject to congressional influence and may be set too high in some cases, resulting in slack in the input constraint in (4) for the least costly labor type.

The patterns of slack in the output constraints shown in Table 3 are similar for both the input and output orientations. VA hospitals on average have a relatively large amount of slack in weighted hospital discharges (HDIS). Treatment practices in VA hospitals differ from those in other hospitals such that inpatients in VA hospitals tend to stay longer than patients in other hospitals. VA patients may receive more comprehensive treatment during each hospital stay or treatment that is delivered through the outpatient department by other hospitals since VA patients tend to travel longer distances to get to the hospital. Thus, while the measure of hospital discharges in VA hospitals we use to estimate technical efficiency may be comparable to other hospitals, VA hospitals tend to have fewer discharges than other hospitals. Moreover, average values of the case mix index are about 20 percent lower for VA hospitals than the other three ownership types. VA hospitals (and NONFED hospitals, to a lesser extent) also have relatively large amounts of slack in the surgical outputs SAM and SIP. Excess surgical capacity is maintained by VA hospitals as part of their reserve mission to military hospitals in case of war and their teaching mission in support of medical schools that demand surgical programs.

PROFIT hospitals have large amounts of slack in both LTIND and OPVIS, again suggesting excess capacity. In addition, NONFED and NONPROFIT hospitals have somewhat more slack in these outputs than do VA hospitals, although not as much as PROFIT hospitals. As substantial efforts have been made to hold down the cost and amount of services provided to inpatients through prospective payment mechanisms and other means, many of these services have been transferred to outpatient or long term care settings in the non-VA sector during recent years. These results suggest that non-VA hospitals have responded by creating excess capacity, perhaps to avoid queues in order to attract market share in these expanding, profitable settings. If this is the case, then it is not surprising that the effect is most prevalent among the PROFIT hospitals.

The presence of contract failure in the hospital industry offers another explanation for the presence of slack in the input/output constraints in (4) for particular hospital types. Variability in the uncertainty of demand could show up as input slack since greater uncertainty would require more standby capacity. This effect should be most obvious in fixed inputs such as inpatient beds, where we find moderate levels of slack. Other researchers, such as Friedman and Pauly (1981), have used cost functions to address the question of excess bed capacity and assert that the cost of maintaining empty beds is small, accounting for stochastic demand and variable quality.

Different levels of slack observed in personal-attention labor categories of long term care and LPNs may also be evidence of varying degrees of contract failure among the four ownership types. This result is consistent with Muurinen's (1991a) linkage between contract failure and the unverifiability of product quality in health care. If direct evidence of product quality is lacking, providing extra personal services can be used to signal higher quality of care and to compete for patients. In inpatient care, VA hospitals have the least amount of slack in LPNs, matching public perceptions that the VA does not compete actively for patients; however, VA hospitals have the most slack in long term care reflecting the VA's active promotion of its initiatives in treatments of patients with dementia and other mentally debilitating diseases.

4.3. Scale Inefficiency

Table 4 shows the percentage of hospitals within each ownership type that lie along either the increasing (IRS), constant (CRS), or decreasing (DRS) returns portion of the production technology. For hospitals that do not actually lie on the frontier, returns to scale are determined by where the hospital would lie if either its inputs were contracted or its outputs expanded, and so the results may differ for some hospitals depending upon whether the input or output orientation is used.

Table 4 **% Hospitals with Increasing, Constant, and Decreasing Returns to Scale**

	Input Orientation			Output Orientation		
	IRS	CRS	DRS	IRS	CRS	DRS
VA	19.4	13.4	67.2	10.4	13.4	76.1
NONFED	40.1	11.0	48.9	21.6	11.0	67.4
PROFIT	56.7	12.6	30.7	38.2	13.8	48.0
NONPROFIT	28.7	10.2	61.1	16.0	9.9	74.1

The results in Table 4 indicate that there are striking differences in terms of scale efficiency. The percentage of hospitals in each category lying along the CRS portion of the technology is roughly the same for each ownership category, varying between 10.2 and 13.4 percent in the input orientation and between 9.9 and 13.8 percent in the output orientation. In the input orientation, the percentage of VA hospitals lying along the DRS portion of the production frontier is more than three times that of VA hospitals lying along the IRS portion; in the output orientation, more than seven times as many VA hospitals lie on the DRS portion as on the IRS portion. NONPROFIT hospitals are also skewed toward decreasing returns in both the input and output orientations, although to a lesser degree than VA hospitals. NONFED hospitals are skewed toward decreasing returns in the output orientation, but much less so in the input orientation; PROFIT hospitals are skewed toward increasing returns in the input orientation, but toward decreasing returns in the output orientation. These results are consistent with the means of the inputs and outputs shown in Table 1, which indicate that VA hospitals are on average larger than the other types, and PROFIT hospitals are on average the smallest hospitals. These results are also consistent with Steinberg (1986), who presents empirical evidence that hospitals try to maximize their budgets (and hence their size).

The result that the size distribution of VA hospitals is skewed toward DRS is not surprising given the mean values of inputs and outputs in Table 1 by hospital type. The size of VA hospitals is affected by congressionally determined construction mandates that are not likely to be optimized with respect to efficient scale size. Furthermore, from the viewpoint of VA administrators, it is likely easier to monitor a smaller number of large hospitals than a larger number of smaller hospitals; hence the apparent scale inefficiency among VA hospitals may be offset to some degree by reduction in monitoring costs relative to a system with a larger number of smaller hospitals. Monitoring costs due to centralized control as in the VA are likely much lower or nonexistent among many hospitals in the other ownership categories. Only about a third of nonfederal community hospitals were part of multihospital systems during the period of our study; furthermore, the growth of nonfederal multihospital systems nearly stopped when the third party payment system in Medicare changed in 1983 (Ermann and Gabel 1984, Manheim et al. 1989). Nonfederal multihospital systems exist primarily because of financing considerations; reducing costs of capital acquisition is frequently cited as the primary benefit of these nonfederal systems of hospitals. Furthermore, unlike the VA system, they seldom have unified accounting or budgeting systems to implement a strong system of centralized control, reflecting the motivation to organize due to financing concerns rather than to achieve centralized control.

To test whether the pattern of scale inefficiency is significantly different among pairs of hospital types, define a (4×3) matrix $\mathcal{A}$ such that the element $\mathcal{A}_{ij}$ gives the number of hospitals of type i (in either the input or output orientation) with IRS if $j = 1$, CRS if $j = 2$, or DRS if $j = 3$. Let $\mathcal{A}_{i\cdot}$ denote the sum of the elements in the ith row of $\mathcal{A}$. Then the statistic

$$\sum_{k=1}^{3} \frac{[\mathcal{A}_{jk} - (\mathcal{A}_{ik}/\mathcal{A}_{i\cdot})\mathcal{A}_{j\cdot}]^2}{(\mathcal{A}_{ik}/\mathcal{A}_{i\cdot})\mathcal{A}_{j\cdot}}$$

is distributed chi-square with 2 degrees of freedom and tests whether the distribution of hospitals in row j is significantly different from that in row i (note that testing whether row j is different from row i produces a different value for the statistic than when testing whether row i is different from row j). For 4 hospital types taken 2 at a time, there are 12 permutations; for each permutation, computation of the chi-square statistic allows rejection of the null hypothesis of no significant difference in the distribution of hospitals by scale efficiency at 0.05 significance using either the input or the output orientation.

The results in Table 4 indicate that there is a shift away from IRS and toward DRS as one moves from the input orientation to the output orientation. The piecewise-linear best practice production frontier is made up of numerous facets in the input-output space; at most, only one of these facets can exhibit constant returns to scale, and in many cases, constant returns will occur only at the intersection of facets, or perhaps only at a single point in input-output space. Lovell (1993) notes that when radial inefficiency is measured in the input orientation as in (4), there is a higher probability of reaching a reference point that exhibits increasing returns to scale. Similarly, when radial inefficiency is measured in the output orientation as in (2), there is a higher probability of reaching a reference point that exhibits decreasing returns to scale. Thus, the apparent differences in scale efficiency across the input and output orientations are due to the geometry of the production frontier. Nevertheless, since the relative differences between ownership types are significant in both the input and output orientations, the data suggest that long run scale decisions of hospitals vary across ownership type. This result is not surprising since access to long-term debt financing varies considerably across the ownership types.

Eakin and Kniesner (1988) sum cost elasticities from a non-minimum cost function and find that hospitals in their sample are roughly evenly divided between increasing and decreasing returns (Eakin and Kniesner use a cross-section of 331 hospitals, but do not report the distribution of ownership types). Vitaliano (1987) estimates cost functions using data on (mostly nonprofit) New York hospitals and rejects a quadratic function that would allow decreasing returns to scale in favor of a continuously increasing returns specification. Most other studies in the hospital cost literature either estimate product specific economies of scale (Grannemann et al. 1986) or short run variable economies of scale (Vita, 1990). Our results differ from these earlier studies (except perhaps Eakin and Kniesner) in suggesting that both increasing and decreasing returns to scale exist among hospitals in the US.

5. Conclusions

As discussed in the introduction, the theoretical literature contains several, sometimes conflicting, suggestions that technical efficiency may differ across the four ownership types in the US hospital industry. As a result, there seems to be no theoretical consensus regarding the direction and magnitude of net differences across the ownership types. Our study is the first to examine technical efficiency throughout the US hospital industry as an empirical question, using data on hospitals from each of the four ownership types. We find empirical evidence of differences in technical efficiency across the types, although we are unable to test for the sources of these differences. Moreover, since technical inefficiency can be reflected in radial, slack, or scale inefficiency, it is difficult to say that one type is universally more or less efficient than another type. For instance, in terms of radial technical efficiency, VA hospitals on average are more efficient than NONFED or NONPROFIT hospitals, and in the output orientation are also more efficient than PROFIT hospitals. Yet, VA hospitals reveal relatively large inefficiency in slack and scale. In addition, PROFIT hospitals appear to have unique distinguishing characteristics in all three types of measured technical inefficiency that are consistent with an expected greater reliance on returns to investment. In any case, the argument by Hansmann (1980) that third-party payment systems may tend to homogenize hospital ownership types in terms of technical efficiency is not supported by our results. To the extent that the differences we find among the ownership types are due to different incentives and constraints faced by managers across the different types, any sensible attempt at health care reform should pay particular attention to incentive effects of new regulation.*

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