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THE BOREN AMENDMENT AND DATA ENVELOPMENT ANALYSIS

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I. INTRODUCTION

DATA ENVELOPMENT ANALYSIS (DEA) is a linear programming method used to measure the relative efficiency of firms.[1] Given a data set that contains information on the inputs and outputs of a series of firms, DEA will identify sets of firms producing output with a similar mix of inputs and calculate a measure of the degree to which each firm uses more inputs than the most efficient firm in that firm's set.

DEA has two features that make it ideal for determining the efficiency scores of healthcare firms. First, it is able to make efficiency comparisons across firms that produce multiple outputs. Because healthcare firms typically produce a variety of services or provide services to a number of different patient types, their efficiency scores can easily be calculated by DEA. Second, DEA can measure efficiency independent of input prices. This is useful if input prices are distorted or lacking, which is also often the case for healthcare institutions. Because DEA can so readily measure the efficiency of healthcare firms, its application to Boren amendment cases seems natural.

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1. For a complete description of this programming technique, refer to A. Charnes, et al., *Measuring the Efficiency of Decision Making Units*, 3 EUR. J. OPERATIONAL RES. 392-444 (1978).

The Boren amendment establishes "efficiency" as one of the basic criteria for determining whether the reimbursement rates that states set for hospitals and nursing homes are reasonable.[2] Specifically, the Boren amendment stipulates that states develop Medicaid reimbursement:

> [R]ates . . . which the State finds, and makes assurances satisfactory to the Secretary [of the Department of Health and Human Services], are reasonable and adequate to meet the costs which must be incurred by efficiently and economically operated facilities in order to provide care and services in conformity with applicable State and Federal laws, regulations, and quality and safety standards.[3]

Neither Congress nor the Health Care Financing Administration (HCFA), however, has been forthcoming with substantial additional guidance as to how to define or operationalize "efficiency" in practice.

Over the years, states and the courts have used a number of methodologies for satisfying the Boren amendment, but one methodology appears to have gained ascendance. This Article suggests that the methodology that states typically use to satisfy the Boren amendment is arbitrary and does not conform to conventional economic definitions of efficiency. This Article further suggests that DEA can provide a superior method for identifying efficient firms. In what follows, we discuss the methodology typically used by states to satisfy the Boren amendment and its weaknesses. We then show how DEA provides a superior methodology.

2. *See* 42 U.S.C. § 1396a(a)(13)(A) (1996).
3. *Id.*

II. THE PRESENT METHODOLOGY

A. *AMISUB (PSL), Inc. v. Colorado Department of Social Services*[4] Methodology

As is apparent from its language, the Boren amendment is a somewhat vague guideline for establishing an acceptable reimbursement system. In passing this legislation, Congress seemed to want to remove the constraints and regulations that had burdened states and providers under the previous law.[5] However, because of HCFA's refusal to further define the terms or procedures in its regulations, it has been left largely to the courts to interpret how the law is satisfied.[6]

Initially, courts were reluctant to comment on the appropriateness of the various substantive aspects of the reimbursement systems, perhaps because of the complexity of the issues involved.[7] Instead, early decisions revolved more around procedural issues—issues upon which the courts were more accustomed to ruling. The most important of these procedural rulings was *AMISUB (PSL), Inc. v. Colorado Department of Social Services*.[8] This case was crucial because by establishing procedures that states needed to perform in "finding" that its rates were reasonable and adequate to cover the costs of "efficiently and economically operated" facilities, it essentially

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4. 879 F.2d 789, 794 (10th Cir. 1989).

5. *See* Simonetti Samuels, *Interpreting Health Care Cost Containment Legislation: Good Samaritan Hospital v. Shalala and Relative Institutional Competence*, 4 SUP. CT. ECON. REV. 141, 173-76 (1995) (discussing the shortcomings and advantages of the judiciary, as well as alternative institutions, in order to evaluate which institution is best suited to address questions arising from Medicare reimbursement).

6. Gerard F. Anderson & Mark A. Hall, *The Adequacy of Hospital Reimbursement Under Medicaid's Boren Amendment*, 13 J. LEGAL MED. 205, 211 (1992) (explaining that the regulations did not, for example, attempt to define an "efficiently" and "economically" operated provider because the Secretary of the Department of Health and Human Services decided that Congress intended the states to define those terms).

7. *Id.* at 214 (stating that procedural issues have played a significant role in several cases, and as a result, resolutions of the procedural disputes imposed important constraints on the manner in which the substantive issues were viewed). *See also* Samuels, *supra* note 5, at 175 (stating that the compromise that most courts have reached in reviewing these claims is to focus on whether the state provided the appropriate procedural safeguards in modifying the state Medicaid program, thus, avoiding an inquiry into the definition of an efficient facility).

8. 879 F.2d 789, 794 (10th Cir. 1989) (stating that HCFA approval is based on state "assurances" of the state's "findings" that the state Medicaid plan is in compliance with federal Medicaid laws and regulations).

established an acceptable method by which each state could implicitly define what "efficiently and economically operated" meant.

In *AMISUB*, the State of Colorado's "findings" process was challenged by a consortium of hospitals.[9] The hospitals argued that to find that its rates were reasonable and adequate, the State of Colorado simply asserted that the current expenditure for Medicaid provider reimbursement was consistent with past budget appropriations. The court, however, did not deem this procedure to be acceptable, and instead, suggested that the plain language of federal Medicaid law mandates that the State Medicaid Agency, at a minimum, make findings which identify and determine:

> (1) the efficiently and economically operated hospitals [hereinafter step one]; (2) the costs that must be incurred by such hospitals [hereinafter step two]; and, (3) the payment rates which are reasonable and adequate to meet the reasonable costs that must be incurred by the efficiently and economically operated hospitals [hereinafter step three].[10]

This three-part *AMISUB* findings procedure has become the dominant standard for Boren compliance. Thus, rather than defining efficiency, the *AMISUB* decision establishes that it is sufficient to merely identify efficient providers.

States typically use some variant of the following methodology to identify efficient providers and thereby accomplish step one under *AMISUB*. The prototypical methodology is first to calculate some unit cost ratio (for example, long-run average costs per patient day, short-run marginal costs per patient day, or allowable costs under the state Medicaid reimbursement system per patient day) for each institution and then to rank the institutions according to this ratio. Accommodation is sometimes made for fundamental differences across institutions (for example, regional, urban/rural, or profit/non-profit differences) by ranking like institutions separately. Efficiency is then determined by establishing a cutoff at some percentile or percentage of the median (for example, the fiftieth percentile or one-hun-

9. *See id.* at 795.
10. *Id.* at 796.

dred percent of the median) below which an institution is designated as efficient.

Next, steps two and three of the *AMISUB* procedure are performed: the total cost of each efficient institution is computed and compared with the revenues that would be forthcoming under the state's Medicaid reimbursement system. If all, or almost all of the "efficient" providers' costs are covered, the state is deemed to be in compliance with the Boren amendment.

B. Economists' Definition of Efficiency

The central problem with this approach is that nowhere in economic theory is efficiency defined as firms with unit costs below a given percentile or percentage of the median. Thus, this definition is open to legal challenge because of its arbitrariness.

In economics (economics is primarily concerned with efficiency, therefore, it appears to be the discipline with the greatest claim on defining the term) the conventional definition of "technical efficiency" is to produce a level of output (or outputs) using a technology that does not waste resources. For example, consider three firms producing an identical ten units of output. Firm A uses three units of labor (L) and two units of capital (K) to produce that amount of output. Firm B uses two L and four K. Firm C uses three L and three K. Because we do not know prices, we cannot tell how much each of these technologies costs in total, but we do know that Firm C is inefficient because it could have used a technology with one less unit of K to produce the same output (as Firm A did). Thus, conventionally, Firms A and B are technically efficient, but Firm C is inefficient.

To put this in graphical perspective, Firms A and B would lie on the isoquant — the locus of points in K,L - space that represents all the combinations of L and K that produce ten units of output without wasting resources. Firm C would lie off the isoquant because it is inefficient.

Technical efficiency is the most fundamental level of efficiency for a firm. The next level of efficiency, "economic efficiency,"[11] is found by determining whether the firm has

adopted a technology that minimizes costs. Here the technology used is matched to the prices of inputs in the market in which the firm is operating. To be economically efficient, the firm chooses a technology that essentially uses more of the relatively cheaper inputs, and less of the relatively expensive inputs. If the firm is using the economically efficient input combination, it is minimizing the costs of production given the input prices in its market.

The technically and economically efficient firms in a market may differ from those which are deemed efficient by the unit-cost methodology. For example, some of the firms identified as efficient under the unit-cost methodology could actually be inefficient based on conventional definitions from the discipline of economics. A firm might waste resources in production or use the wrong input mix for the relative prices it faces in the market, but because the prices are so low absolutely, the firm falls in the efficient portion of the unit-cost distribution. For analogous reasons, some firms identified as inefficient under the unit cost methodology could actually be efficient using an economist's definition because they are not wasting resources or they use a cost-minimizing input mix, even though all prices they face are high. This implies that the unit-cost determination of efficient firms is not consistent with conventional economic definitions of efficiency, and therefore, are arbitrary.

C. Potential for Abuse

Not only is the unit-cost methodology arbitrary, but it can also lead to abuse. States often use a percentile of a unit-cost ranking to establish a maximum Medicaid payment. To satisfy the Boren amendment, the state may define efficient firms using the same unit-cost distributions, but at a slightly lower (i.e., a more restrictive one) percentile of that distribution. Because the percentile used to identify efficient firms is set lower than the percentile used to determine the maximum payment, the payment almost always covers the costs of the so-called efficient firms.

For example, the State of Minnesota uses its nursing home reimbursement rate setting method to calculate what it calls its

"standard rate."[11] EEO status is determined by all those nursing homes whose costs are covered by the standard rate.[12] (As long as at least fifteen percent of nursing homes are EEO, Minnesota deems its methods are reasonable). In calculating the standard rate, the limit is set at the sixtieth percentile for care-related operating costs and at one-hundred percent of the median for non-care related operating costs.[13] In calculating the reimbursement rates, the cost limits are set at 125% of the median for the care-related operating costs and 110% of the median for the non-care related operating costs.[14] It is, therefore, not surprising that almost all of the EEO nursing homes have their costs covered by their reimbursement rate. Clearly, under these circumstances, a measure of efficiency is needed that is independent of the unit-cost distribution.

III. AN ALTERNATIVE METHODOLOGY

A. DEA

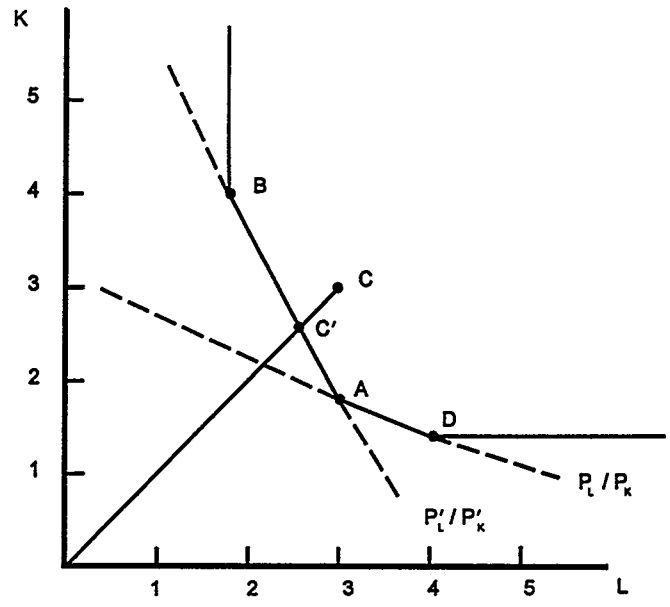
The DEA procedure for determining efficiency conforms exactly to the conventional textbook concept of technical efficiency. In brief, DEA identifies firms that are producing a given set of outputs with the fewest number of inputs, such as Firms A and B in Figure 1.

11. *See generally* STATE OF MINNESOTA, FINDINGS PROCESS FOR MINNESOTA NURSING FACILITIES (July 1, 1995) (on file with author).

12. *See id.*

13. *See id.*

14. *See id.*



Efficiency Using DEA Analysis
Figure 1

These technically efficient firms comprise the "reference set," or the firms on the isoquant. DEA then calculates technical efficiency scores for all the firms which are not on the isoquant but which produce similar outputs and use a comparable input mix. The efficiency score represents the ratio of the inputs used by the relevant firm on the isoquant to the inputs used by the firm in question. For example, in Figure 1 the efficiency score of Firm C is the ratio of distance OC' to OC. Firms A and B represent appropriate standards of comparison for Firm C because they produce similar outputs and use similar ratios of inputs. As firms become more efficient, their efficiency scores approach 1, the score of firms that lie on the isoquant.

For the purposes of Boren, however, it is the identification of the firms in the reference set that is important. Because no other firms produce similar outputs with fewer resources than the firms in the reference set, they are the technically efficient firms. As a result, the first step in the *AMISUB* procedure is satisfied using a methodology that is not arbitrary, but in keeping with the conventional textbook definition of efficiency. Despite this natural application of DEA, to our knowledge it

has not been used to meet the Boren amendment requirements. This no doubt stems in part from its complex technical nature, but in part, it may also be due to a number of misguided objections to its use in this context.

B. DEA Criticisms: Missing Output Variables

DEA has been criticized for not including, or at least holding constant, certain important output variables, such as case-mix severity or quality of care.[15] If, say, case-mix is not included, a nursing home might be considered inefficient because it has a low DEA efficiency score, but in reality, it uses more resources because it has a more severely dehibilitated clientele. In general, DEA would not accurately identify the efficient firms to the extent that these outputs[16] are either observable but not measured or not observable, and therefore, not included in the DEA.

If case-mix or quality data are not included in the DEA because these data were lacking, then such data could not be used in a unit cost ranking either. If so, both DEA and unit-cost analysis would yield similarly inaccurate results. DEA, however, would still have the advantage that it is based on a concept of efficiency that is more consistent with the conventional theoretical concept.

If, instead, case-mix data were available and different types of hospital or nursing home patients could be identified based on the services they received, then such multiple outputs could readily be incorporated into the DEA to determine the (globally) efficient firms. In contrast, it would be difficult to incorporate case-mix differences into a unit-cost ranking because, although different types of patients might be discernable, it would be difficult to disaggregate the expenditures associated with the various services each patient type received. Moreover, even if it were possible to disaggregate the expenditures and determine unit-cost rankings for each type of patient, the unit-

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15. Joseph P. Newhouse, *Frontier Estimation: How Useful a Tool for Health Economics?*, 13 J. HEALTH ECON. 317, 319-21 (1994) (stating that DEA estimations cause such severe problems that they should not be used for reimbursement measures).

16. Case-mix differences and quality of care can both be regarded as dimensions of output. *See id.* at 319-20.

cost ranking method simply does not suggest a way to aggregate the separate rankings to determine a globally efficient set of firms.[17]

If *quality* measures were missing instead of case-mix measures, again they would be missing regardless of whether DEA or unit-cost ranking were used. The Boren language, however, suggests that missing quality data may not matter. Quality is embedded in the amendment in two places. First, it is explicit in the requirement that nursing homes meet state and federal regulatory standards for quality. Thus, in identifying the EEO facilities, states often first exclude those facilities that have had code violations in the previous year. Of course, the number of violations and the period of time in violation that is necessary to disqualify a facility from consideration as EEO is subject to dispute, but if acceptable quality can be defined, then it is possible to identify the firms that satisfy this Boren condition.

Second, and perhaps more important, quality is implicit in the directive that those facilities that are used as the standard are not only efficiently, but *economically* operated as well. A number of experts would define "economically" in terms of quality: the states are not required to pay for luxury care or care above a certain minimal level of resource use. Thus, a facility that provides an opulent level of quality, and provides it efficiently would not satisfy both "efficiently *and* economically operated" criteria. In practice, this would mean that it is not necessary to distinguish efficiency from quality to satisfy

17. The exception to this is the case-mix indices used in the reimbursement of nursing homes. Patients are distinguished according the expected resource use and each type has an index number associated with it indicating the relative cost of those resources compared with some base patient type. Such an index could be used to determine global, unit-cost ranking for all patient types, where the units are calculated as the number of base patient equivalents.

A major problem with this approach is that it is not clear that the indices used to measure the relative expected resource consumption reflect actual resource consumption, especially after the system has been imposed and firms are able to respond to the incentive in these indices. For example, John A. Nyman and Robert A. Connor show that the actual expenditures by Minnesota nursing homes on the various patient types in its case-mix system are to a large extent uncorrelated with the case-mix index that Minnesota uses for paying its nursing homes. John A. Nyman & Robert A. Connor, *Do Case-Mix Adjusted Nursing Home Reimbursements Actually Reflect Costs? Minnesota's Experience*, 13 J. HEALTH ECON. 145-62 (1994). If the relative costs in the case-mix index are inaccurate, then the aggregation will also be inaccurate and, hence, arbitrary. *Id.*

the Boren amendment. Once the substandard facilities are eliminated, the nursing homes that spent the least in unit costs would be held up as meeting both criteria simultaneously. Similarly, with DEA, a technically efficient facility might appear off the frontier because it is providing higher quality care or because it is providing minimal care inefficiently. In either case, that facility would violate the Boren standard and correctly be excluded from the list of EEO facilities.

In sum, if case-mix or quality information were missing, it would not make DEA any less preferred to the unit-cost methodology, because both would be open to the same criticism. Moreover, if case-mix data were available, it could be more readily incorporated into a DEA methodology than into a unit-cost methodology. Finally, missing quality data may not be a problem under either methodology given the Boren amendment's requirement that the firms (representing the standard for the Boren test) be both efficiently *and economically* operated.

C. DEA Criticisms: Methodological Factors

DEA has also been challenged because of some of its methodological features. DEA is a mathematical, not statistical, method for constructing an isoquant or production frontier. Because of this, it has been criticized as being unrealistic. That is, according to DEA, firms in the reference set are "efficient," but according to the statistical approach, such firms might simply be lucky. That is, even for the most efficient manager, there are some aspects of the process of turning inputs into outputs that are beyond his or her control. Two efficient managers may make the same decisions, but because of random error, one will be on the production frontier and the other will not.

It has therefore been suggested that because of the existence of chance or random error, a statistical approach may be preferred. A statistical approach would estimate a cost or production function based on the average values of outputs and inputs. While only the outlying firms (the most efficient) determine the reference set with the DEA, the statistical approach uses all firms, efficient and inefficient, to construct the produc-

tion frontier. Deviation from this frontier is then decomposed into a portion that represents random error and a portion that represents managerial inefficiency. From this decomposition of the error, it is possible to determine the degree of inefficiency experienced by each firm.

The statistical approach may represent an improvement in theory, but in practice and for the purposes of satisfying the Boren amendment findings process, it is inferior to DEA. The central methodological problem with a statistical frontier is that it is based on the assumption that the random error is distributed normally and the managerial inefficiency is modeled by a half-normal distribution. This assumption, however, cannot be tested. Therefore, it can never be known whether the frontier-defined efficient firm is truly efficient because of skill or whether luck had something to do with it.

For Boren applications, however, the main problem with frontier estimation is the same arbitrariness as was encountered with the unit-cost distribution: firms can be ordered according to the statistical measure of how efficient they are, but the statistical approach does not embody a natural cut-off to distinguish the efficient firms from inefficient ones. Of course, one firm could be designated as efficient because it had the highest efficiency score of all firms in a state, but that is unrealistic. It is not even clear that this firm would necessarily lie on the estimated isoquant. That is, while a stochastic method might identify an isoquant, it would only be by chance that any of the firms in the state would lie on that isoquant. In contrast, DEA identifies the isoquant by tracing out the input combinations of each firm in the reference set. Each firm in the reference set represents the most efficient firm compared to all those other firms that use a similar production technology.

Moreover, the government use of a statistical estimation procedure would imply that some costs should be disregarded because they stem from luck. As a result, the costs attributed to a firm could be either higher or lower than they actually are. For example, in determining the efficient firms, some low-cost firms may be deemed inefficient because their costs "should be" higher than they actually are. Likewise, some high-cost firms might be considered efficient. Often, the government does not permit the substitution of hypothetical numbers for

actual numbers. For example, one cannot substitute "expected" income for "actual" income when determining income tax liabilities. This could be an important barrier to using a statistical approach.

Finally, it should be pointed out that the criticism that a mathematical approach is unrealistic because it ignores chance could also be leveled against a unit-cost ranking determination of efficiency. Unit-cost ranking is mathematical because it simply divides total expenditures by the number of units produced. A firm, however, might appear at the low or "efficient" end of the unit-cost distribution not because of efficiency, but because of luck.

D. Technical v. Economic Efficiency

We have noted that efficiency, as it is conventionally thought of by economists, has two dimensions: technical and economic. Technical efficiency refers to production that does not waste inputs, while economic efficiency refers to using a technology (input mix) that is sensitive to the relative prices in the market, that is, one that minimizes costs. DEA has historically only addressed the former.

DEA, however, can be used to address economic efficiency,[18] but to our knowledge only one empirical study has attempted to measure economic efficiency.[19] To determine whether a technically efficient firm is also economically efficient using DEA, it is necessary find the input prices faced by the firm in the market in which the firm is located and determine whether the relative prices are within a certain range, defined by the two reference set firms using the next most similar technologies. For example, in Figure 1, Firm A could face relative prices that range from a price ratio of P_L/P_K to P_L'/P_K' and still be considered economically efficient.

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18. Economic efficiency is sometimes referred to as allocative or input price efficiency.

19. *See generally* Merton D. Finkler & David D. Wirtschafter, *Cost-Effectiveness and Data Envelopment Analysis*, 18 HEALTH CARE MGMT. REV. 81, 81-88 (1993) (concluding that "the robustness of the cost-effectiveness results, along with the magnitude of the savings potential based on DEA and relative to that savings potential generated by averaging techniques, justifies DEA's inclusion in the cost manager's tool kit").

As a result, the existence of economic efficiency has both theoretical and practical implications for the Boren amendment. From a theoretical perspective, the addition of economic efficiency to technical efficiency raises yet another barrier for a firm being designated as "efficient." Thus, fewer firms would be efficient, and the Boren amendment standard would presumably be more easily met. From a practical perspective, however, the fact that each firm in the reference set could face a different relative price ratio makes it possible for all firms that are technically efficient to be economically efficient as well. Even more important, each firm in the reference set could face a range of input prices and still be considered economically efficient. As long as the price ratio that the firm actually faced fell in that range, it would be impossible to distinguish that firm from others on the basis of economic efficiency. From a practical perspective, therefore, the extension of the DEA to identify both technically and economically efficient firms is not likely to reduce the number of efficient firms substantially, compared with simply identifying the technically efficient ones. For legal purposes, the inclusion of economic efficiency in a DEA would not necessarily make the Boren requirements more easily met.

IV. CONCLUSION

Because neither Congress nor the Health Care Financing Administration was clear about what "efficiency" means, defining the term fell to the states and the courts. Over time, a standard methodology has been established that is based on measures of relative efficiency, but this methodology lacks the absoluteness that is embedded in the economists' conventional definition of the term. Data envelopment analysis, however, is a method for determining efficient firms that is consistent with the conventional economic definition of efficiency and lacks the arbitrariness of the standard methodology. Thus, the availability of DEA has rendered the standard unit-cost methodology inferior.

The substitution of DEA-determined efficient firms in the Boren findings process may or may not reduce the number of firms that are considered efficient compared to existing meth-

odologies. Because efficiency has been defined relatively, states may have included more firms in the ranks of efficient providers to stave off accusations that the concept has been too narrowly defined. For these states, converting from a unit-cost analysis to a DEA analysis may result in a more stringently defined group of firms and a greater likelihood that the existing reimbursement system will cover their costs.

On the other hand, existing studies[20] suggest that between forty and fifty percent of nursing homes would be in the reference set. These percentages probably are not all that different from the percentages found in states using unit-cost methods, and may even be greater.

The main advantages of DEA, however, are its lack of arbitrariness and its consistency with conventional definitions of efficiency. These features give DEA the potential to become the standard methodology for satisfying the Boren amendment.

20. *See, e.g.*, John A. Nyman & Dennis L. Bricker, *Profit Incentives and Technical Efficiency in the Production of Nursing Home Care*, 71 REV. ECON. & STAT. 586, 586-94 (1989) (concluding that for-profit nursing homes have significantly higher efficiency scores than non-profit homes); John A. Nyman et al., *Technical Efficiency in Nursing Homes*, 28 MED. CARE 541, 541-51 (1990) (concluding that relative technical efficiency is more commonly associated with for-profit and larger firms).