WORKING
PAPER

Comparing For-Profit and Not-for-Profit Health Care Providers

A Review of the Literature

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EXECUTIVE SUMMARY

This report summarizes a literature review examining the relationship between ownership status and facility costs. Our systematic review covered hospitals, nursing homes, and dialysis centers as well as four post-acute care settings: Skilled Nursing Facilities (SNFs), Long-Term Care Hospitals (LTCHs), Institutional Rehabilitation Facilities (IRFs), and Home Health Agencies (HHAs). We examined journals, annals, published studies from public and private health services research organizations, and conference papers and presentations for this review, focusing on those published in the last ten years (1996-2006).

As part of this review, we responded to the questions derived from the original Statement of Work provided by MedPAC. Specifically, we addressed the following inquiries:

1) What are the most commonly used forms of regression analysis used to model facility-level per case costs? What are the strengths and limitations of these models?
2) What are the most widely used standardized costs per case measures? What are the strengths and limitations of these measures?
3) What are the most widely used severity adjusters? What are the strengths and limitations of these adjusters?
4) What assumptions about providers as economic actors (profit maximizers, etc.) are customarily part of the analysis of providers' costs?
5) Which variables explained significant differences between for-profit and not-for-profit providers' costs?

In addition to addressing these issues, we also reviewed the different types of model specifications in terms of the included covariates, the relationship of these covariates to costs, and the strengths and limitations of these measures.

In total, we identified 33 papers that met our inclusion criteria, from which we abstracted information about 38 models of costs. The majority (23 papers presenting 27 models) focused on acute-care hospitals as the unit of analysis. Nursing homes were the unit of analysis in eight articles presenting 9 models. We also identified one paper focusing on costs in dialysis centers. Only one paper was identified that focused on a post-acute care setting (HHAs). No publications were found for the other post-acute care settings (SNFs, LTCHs, IRFs).

The reviewed papers provide conflicting evidence on whether and how for-profit ownership affects hospital costs, but provide consistent evidence that costs are lower among for-profit nursing homes. This review summarizes a number of factors that might affect the findings including: the approach, functional form, relevant assumptions regarding errors and efficiency, assumptions regarding behavior, the specification of output, input prices, quality, case mix, and the included provider and market controls. The report also discusses other relevant factors associated with the approach including the use of panel vs. cross-sectional analyses, and the use of state vs. national samples.

To some extent, the conflicting findings for hospitals may result from differences in methodology: the approach (i.e., statistical modeling using multivariate regression, stochastic frontier regression, etc.), the functional form (e.g., translog, Cobb-Douglas, etc.), the

specification and the data used to analyze the relationship of for-profit ownership to costs. There was no consistent pattern in the results for profit status by the analytic approach or by the functional form used. There was substantial variation in the specification (i.e., included covariates) in the hospital models although we did not detect a strong relationship between how well-specified a model was and the conclusion of the study effect of profit status on costs. Cross-sectional analyses of hospitals were more likely to yield inconsistent results than panel data; state-level data were more likely to yield a significant negative finding than national-level data.

Multivariate regression was also the primary approach for analysis of the nursing home industry. Still, there was no particular relationship between approach and functional form for nursing homes. There was also less variation in specification among nursing home models. Nursing home models favored state-level cross-sectional analyses over panel data methods and national data.

In this report, we first provide a brief background on the issues related to profit status and provider costs and describe the objectives of this literature review. We then discuss the methods used to identify the literature and the results from our review efforts. Additional results are shared, organized primarily around the five questions proposed in the Statement of Work provided by MedPAC. Finally, we provide a summary and a discussion of the implications of these findings for future work on the relationship between profit status and provider costs, particularly in the post-acute care setting.

I. BACKGROUND

Medicare payments for post-acute care have increased dramatically in recent years despite the implementation of prospective payment systems aimed at promoting efficiency and controlling costs. Post-acute care now comprises 13% of Medicare spending [1]. In 1999, Medicare spending for post-acute care was only $25 billion, but just six years later had increased 68% to $42 billion [2]. Increases in Medicare expenditures occurred in all four post-acute settings: skilled nursing facilities (9% annually), inpatient rehabilitation facilities (9%), home health agencies (7%), and long-term care hospitals (18%). The increase in payments cannot be fully accounted for by increases in costs. Since the implementation of the prospective payment systems, increases in Medicare payments per case have far outpaced increases in costs.

The rapid increases in Medicare payments relative to industry costs have raised concerns about profit margins and whether payments should be adjusted to more accurately reflect facility costs in each of these settings. In 2004, margins for all four post-acute care settings were substantial: 14% for skilled nursing facilities (SNFs), 16% for home health agencies (HHAs), 16% for inpatient rehabilitation facilities (IRFs), and 9% for long-term care hospitals (LTCHs) [2]. For some settings, such as home health, margins have exceeded 12% since the implementation of prospective payment systems [3].

But these large average margins mask substantial variation within each setting, as for-profit providers tend to be much more profitable than not-for-profit providers [2]. In 2004, for-profit SNFs earned a 16% margin relative to 4% for not-for-profit agencies. For-profit HHAs earned 18% while not-for-profit HHAs earned 8%. The pattern is similar for long-term care facilities, where for-profit providers earned 10% margins relative to 6% for not-for-profit providers. Finally, for-profit inpatient rehabilitation facilities earned margins (24%) approximately twice as large as not-for-profits (13%).

A key policy question is whether higher margins for for-profit providers are justified, because those providers are more efficient (i.e., manage their costs better) or not justified because they reflect a superior ability of for-profit providers to exploit the incentives inherent in the payment methodology. A number of empirical studies in the health economics literature have attempted to explain variability in costs based on a variety of factors including observable and unobservable provider and market characteristics. But drawing conclusions from this literature is difficult because the methodologies used to disentangle the determinants of cost variability are likely to impact their findings. Indeed, there is a substantial literature comparing the results of various approaches and specifications (e.g., Linna [4]; Folland and Hofler [5]; Bryce, Engberg and Wholey [6]). This literature indicates that results can be sensitive to the use of alternative models, specifications, and assumptions; however, the results with respect to broad groupings of firms (e.g., not-for-profit providers) are less sensitive than results with respect to individual firms. Similar issues regarding sensitivity have undermined the literature comparing the performance of for-profit versus not-for-profit providers [7]. Consequently, future efforts to examine facility-level costs and the variability in costs across type of control must acknowledge the impact of the assumptions imposed by the chosen methodology as well as their strengths and limitations particularly when the results may be used to inform payment policies [8].

Objectives

MedPAC is concerned with the appropriateness of payment levels for post-acute care (e.g., SNFs, HHAs, IRFs, and LTCHs). Current payment structures do not account for profit status. For-profit and not-for-profit providers are paid by Medicare using the same methodology although, as cited above, the margins for these providers differ substantially by profit status. Our primary objective is to provide MedPAC with a comprehensive and critical review of the literature, including the strengths and weaknesses of the commonly used forms of cost models and of the comparisons of for-profit versus not-for-profit health care providers. Although the focus of MedPAC's future efforts will be the four post-acute settings, there are few studies that speak directly to these industries. Therefore, our literature review encompasses empirical analyses of hospitals, nursing homes, and dialysis centers and attempts to identify and review literature addressing the four post-acute care settings. We examined journals, annals, published studies from public and private health services research organizations, and conference papers and presentations for this review. The estimation of cost functions has a long history in the health economics literature, but we concentrated our efforts on research conducted within the last ten years.

In the following sections, we respond to the questions derived from the original Statement of Work provided by MedPAC. Specifically, we address the following inquiries:

1) What are the most commonly used forms of regression analysis used to model facility-level per case costs? What are the strengths and limitations of these models?
2) What are the most widely used standardized costs per case measures? What are the strengths and limitations of these measures?
3) What are the most widely used severity adjusters? What are the strengths and limitations of these adjusters?
4) What assumptions about providers as economic actors (profit maximizers, etc.) are customarily part of the analysis of providers' costs?
5) Which variables explained significant differences between for-profit and not-for-profit providers' costs?

In addition to addressing these issues, this report also provides discussions of model specification in terms of the included covariates, the relationship of these covariates to costs, and the strengths and limitations of these measures. Finally, we present a summary and discussion of the findings from this review, concentrating on lessons learned for future research on profit status among health care providers.

II. METHODS

The approach to this literature review was built on RAND's experience in conducting literature reviews and meta-analyses through the RAND Southern California Evidence-Based Practice Center (EPC). We conducted a comprehensive environmental scan and searched the peer-reviewed literature, as well as other sources described below, to identify relevant publications for this review. The environmental scan covered the traditional health literature databases: Medline, EMBASE and Cinahl. In addition, we searched Social Science Abstracts and Econlit, a database that includes economic journals, books, dissertations, and working papers.

Acknowledging that many studies may not have been published in academic journals, we also searched for "grey" literature from outside the world of peer-reviewed journals. The following are sources we searched for documents describing relevant studies:

- New York Academy of Medicine (NYAM) Grey Literature Collection – NYAM publishes a bimonthly online publication of the New York Academy of Medicine Library featuring documents related to public health and medicine. This online resource includes conference proceedings, discussion papers, government documents, issue briefs, research reports, statistical reports, and white papers in the areas of health and science policy, public health, and general medicine and disease. The Grey Literature Report contains materials published from 2000 to the present by government agencies, non-profit non-governmental agencies, universities, and independent research centers.
- Conference Papers Index – Preliminary results from studies are often presented at scientific or business conferences before or instead of publishing in journals.
- Worldcat – This catalogue is maintained collectively by over 9,000 member institutions around the world. It is the leading bibliographic database in the world, and contains books, web sites, recordings, films, and magazines.

Databases were searched using search terms entered alone and in combination with each other. Table 1 provides the list of search terms.

In addition to the databases described above, we had access to a previous literature search conducted by RAND through the EPC on issues related to the efficiency of the health care system. We reviewed all citations identified for this previous EPC study in the current review to supplement our original-search efforts.

Inclusion criteria for the search included:

1) articles published in the last 10 years (1996-2006);
2) articles written in English;
3) articles about the United States health care system; and
4) articles presenting multivariate analysis results.

Papers focusing on provider types other than those specified in Table 1 were excluded from further consideration. Similarly, papers that used data older than 1990 were excluded as older

data may not reflect the more recent policy environment in which the providers of interest work.[1] Furthermore, we excluded papers that did not compare similar provider types with for-profit and not-for-profit status; for example, we excluded papers that only compared providers within a single profit status category (e.g., religious vs. secular not-for-profit providers). Lastly, we excluded papers that did not include outcomes related to financial performance, specifically cost.

Table 1. Search Terms for Review of the Literature

Cost Search Terms

- Efficiency, Organizational
- Costs & Cost Analysis
- Cost Allocation
- Cost Control
- Hospital Costs
- Cost Function (keyword)
- Financial Performance (keyword)

Model Search Terms

- Models, Econometric
- Models, Statistical
- Stochastic Processes
- Regression Analysis
- Statistics & Numeric Data
- Stochastic frontier (keyword)
- Data envelopment analysis (keyword)

Profit Status Search Terms

- Organizations, Nonprofit
- Health Facilities, Proprietary
- For profit (keyword)
- Not-for-profit (keyword)

Provider Type Search Terms

- Hospital
- Hospital Administration
- Skilled Nursing Facilities
- Home Care Agency
- Home Health Agency
- Rehabilitation Centers
- Long-Term Care
- Nursing Home
- Hemodialysis Units, Hospital
- Dialysis facilities (keyword)
- Inpatient rehabilitation facilities (keyword)
- Long term care hospitals (keyword)
- SNF (keyword)
- HHA (keyword)
- IRF (keyword)
- LTCH (keyword)

We initially reviewed the titles and abstracts produced from the database searches in order to identify the subset of papers or reports that merited full review by the study team. Each title and abstract was then reviewed by at least two researchers. Where there was a lack of consensus regarding whether a study merited full review, the abstract was reviewed by the third researcher and discussed by the team to reach a decision regarding inclusion. In all cases that a title or abstract did not yield sufficient detail to determine its appropriateness for inclusion in the review, we erred on the side of caution and moved the citation to the next step in the review.

Due to the large number of citations in the EPC internal database (N=630 titles), we reviewed them first in title form. The union of titles selected by the review team was moved on to a review of abstracts.[2] Likewise, we first processed results from the CINAHL and Grey

[1] For papers that used multiple years of data, at least one year had to be at least as recent as 1990.
[2] That is, the title was selected by at least one member of the review team.

literature databases with titles only, as there was a fee associated with obtaining the full citation associated with each title.

All relevant articles and reports obtained through our searches were "reference mined," i.e., the reference lists were reviewed for additional articles that were relevant to the review but not identified through the database searches. This included articles fitting all selection criteria as well as review studies such as the paper by Shen et al. (2005), which were utilized as background.

Once all papers were selected, we developed a coding form for abstracting relevant information from each article. Basic information collected from each publication included the following: authors, title, publication date, data source, sampling frame characteristics (e.g., covered years, covered regions, sample size), analysis method (e.g., approach and functional form), setting, covariates, and conclusions related to profit status.

III. RESULTS

Through the various literature searches, 743 articles were identified by title only. Of these, 86 (11.6%) progressed to have their abstracts reviewed. Of the 657 titles which were dropped, the most common reason was that the study was not relevant to our study purposes (n=301). Other articles were dropped due to a non-U.S. focus (n=113), a date of publication before 1996 (n=95), other facility type (n=73), a lack of cost outcomes (n=33), no profit-status comparison (28), no multivariate analyses described in the study (n=12), or study data were collected prior to 1990 (n=2).[3]

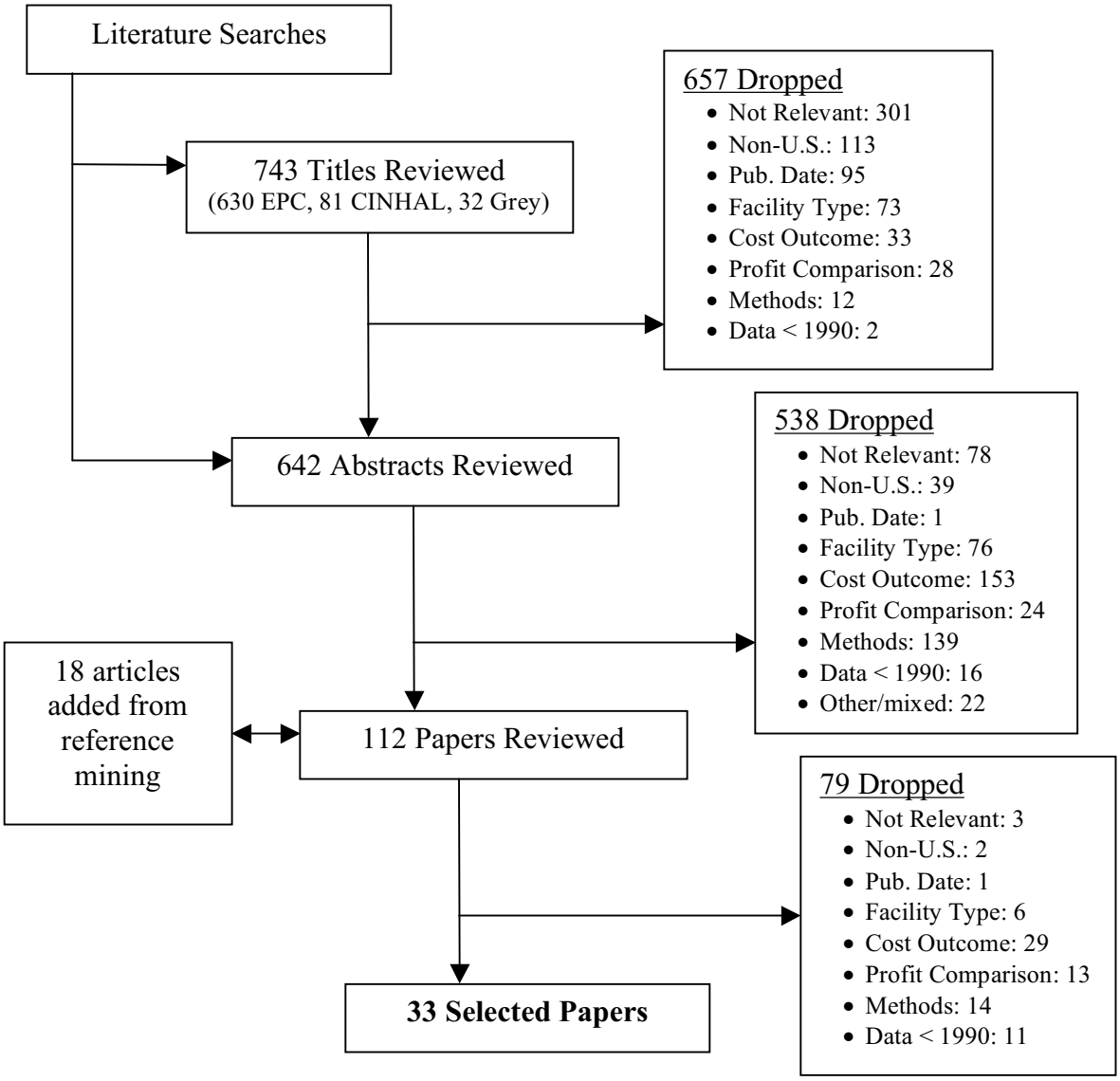

Figure 1. Literature Search Progression

[3] Some papers failed on several inclusion criteria. When there were multiple issues in addition to cost, failure to focus on cost was recorded as the cause.

Including the 86 articles selected from the title search as well as abstracts obtained directly from database searches, 642 abstracts were reviewed. Of these, 538 (83.8% were excluded for reasons described above. After adding 18 articles found via reference-mining, 112 full articles were reviewed. Of all reviewed articles, 33 articles fit all inclusion criteria and were selected for analysis.

Several papers reported results for more than one multivariate regression; from these 33 papers, we abstracted information for a total of 38 models. We included multiple models in our review from a single paper only when the models differed in a substantial way; i.e., the approach or the functional form must differ. Smaller changes in specification, such as changes in the number of covariates, were not deemed substantive changes. In such cases, we selected the authors' preferred specification: the profit status findings were generally not sensitive to these minor changes.[4]

Table 2. Data Coverage Analyzed by Facility Type

Data Coverage	Hospital	Nursing Home	Dialysis Center	Home Health Agency
National (or continental domestic)	15 papers with 18 models	2 papers with 2 models	1 paper with 1 model	--
California	1 paper with 1 model	--	--	
Connecticut	--	--	--	1 paper with 1 model
Florida	3 papers with 4 models	--	--	--
Kentucky	--	1 paper with 1 model	--	--
Missouri	--	1 paper with 1 model	--	--
New York	1 paper with 1 model	1 paper with 1 models	--	--
Texas	--	2 papers with 3 models	--	--
Virginia	1 paper with 1 models	--	--	--
Washington	2 papers with 2 model	--	--	--
Set of States	--	1 paper with 1 model		--
Totals	23 papers with 27 models	8 papers with 9 models	1 paper with 1 model	1 paper with 1 model

Table 2 presents summary information about the papers and models by data source (national vs. state) and provider setting. The majority (23 papers presenting 27 models) focused

[4] In addition, two papers regressed elements of costs separately (Mukamel et al., 2005; Shukla et al., 1997). In these cases, the finding was not sensitive to the element of cost. We include only a single model in the review of results.

on hospitals as the unit of analysis. Although our primary interests were to identify the literature studying costs in post-acute care settings, the prominence of the hospital setting in the literature relative to post-acute care facilities prompted us to include them in hopes of extrapolating lessons to these settings. Nursing homes were analyzed in eight articles presenting 9 models. Other providers included in the review were home health agencies (one paper) and dialysis centers (one paper).

Twenty-one models used national data. Most hospital papers utilized national data, while most nursing home papers focused on state level data. The dialysis center model is national, while the HHA model was limited to Connecticut data. The majority the 38 models used data that were collected prior to 1997.

Each facility-type analysis focuses on a few common data sources. Hospitals rely most often on the American Hospital Association Annual Survey, the Area Resource File, and HCFA cost reports. Nursing homes often utilize the Minimum Data Set and the Online Survey Certification and Reporting System (OSCAR), followed by the Area Resource File and Medicaid cost data. No trend can be reported for dialysis centers or home health agencies due to their small representation.

Appendix A presents full details of our abstraction, but for convenience we also present summary information about these models in Tables 3a through 3c (for simplicity, we present Table 3 in three segments by facility type: hospital, nursing home and other). The unit of analysis for the review is the model rather than the paper to account for some authors' use of multiple modeling strategies within the same paper. We include in these tables a brief citation, the type of data used (cross-section or panel), the scope of sample (e.g., state versus national), the years of the data, the approach, and functional form used, for-profit status' relationship with costs, and an overview of covariate types used in each model. [5,6] We present the results below organized by the five questions described in the Statement of Work by MedPAC. We defer any discussion regarding the models' findings with respect to profit status until after the review of the approach, functional form and specification.

[5] For this document, we will refer to approach as the use of multivariate regression, data envelopment analysis, or stochastic frontier regression. The term functional form will speak to the choice of a particular form for the model such as the translog, Cobb-Douglas or ad hoc. And the term specification refers to the inclusion of particular covariates in the regression.

[6] The characteristics of data sources employed in these analyses are described in Appendix A and not in the summary tables.

Table 3a-1. Summary of Models and Profit Status Findings for Hospitals

Citation	Panel vs. Cross Section	Location	Years of Data	Approach[a]	Specification[b]	For-Profit Status Impact on Costs	Covariates: Outputs	Input Prices	Market	Provider	Quality	Severity Adjusters
Bazzoli (2000) [9]	Cross-section	National	1995	MR[c]	Translog	ns	⬭	⬭	⬭	⬭		⬭
Becker (2002) [10]	Cross-section	National	1994	MR	Ad Hoc	–			⬭	⬭		
Carey (1997) [11]	Cross-section	National	1987-1991	MR	Ad Hoc	ns	⬭	⬭	⬭	⬭		⬭
Carey (1997) [11]	Panel	National	1987-1991	MR	Ad Hoc, Corr. RE	ns	⬭	⬭	⬭	⬭		⬭
Carey (2000) [12]	Panel	National	1987-1992	MR	Ad Hoc, Corr. RE	–	⬭	⬭		⬭		⬭
Carey (2000) [12]	Panel	National	1987-1992	MR	Ad Hoc, RE	–	⬭	⬭		⬭		⬭
Chirikos (1998) [13]	Panel	FL	1982-1993	Two-Stage: 1. SFR 2: χ^2	Translog	–[d]	⬭	⬭				⬭[e]
Chirikos (2000) [14]	Panel	FL	1982-1993	Two-Stage: 1. DEA 2: χ^2	Output-Cost	–[d]	⬭					⬭[e]
Chirikos (2000) [14]	Panel	FL	1982-1993	Two-Stage: 1. SFR 2: χ^2	Translog	–[d]	⬭	⬭				⬭[e]
Clement (1997) [15]	Cross-section	National	1994-1995	MR	Ad Hoc	+		⬭	⬭	⬭		

⬭ Model included at least one variable construct in this class of covariates.

[a] MR: Multivariate Regression; SFR: Stochastic Frontier Regression; DEA: Data Envelopment Analysis; $\chi 2$: Chi-Square Test; RDL1: Robust Distance L1 Regression; AMOS: Analysis of Moments Structures; MLR: Multivariate Logistic Regression.

[b] RE: Random Effects; FE: Fixed Effects; CES: Constant Elasticity of Substitution; GLF: Generalized Leontief Function.

[c] Heckman correction for endogenous affiliation type.

[d] The results from this study presented efficiency by profit status but without statistical testing.

[e] Hospital admissions or discharges were adjusted by the facility-level average Medicare DRG case mix index; case mix was not included as a separate regressor.

[f] First stage probit for endogenous chain membership.

[g] This multivariate regression was estimated with endogenous output. Other models were tested with and without endogenous HMO penetration and prices but the direction of the coefficient on profit status was not affected by these alternate specifications.

[h] The author modeled five types of cost in this paper: total costs per admission, total costs less taxes per admission, labor costs per admission, non-labor costs per admission, and capital costs per admission. Each model was specified the same and the direction of the effect of profit status was also similar across all models.

[i] One or more variables in this class of covariates was included only in the second stage of this analysis.

[j] Costs per admission were adjusted by a hospital-wide case mix index. Case mix was not included as a separate regressor.

Table 3a-2. Summary of Models and Profit Status Findings for Hospitals

Citation	Panel vs. Cross Section	Location	Years of Data	Approach[a]	Specification[b]	For-Profit Status Impact on Costs	Covariates: Outputs	Input Prices	Market	Provider	Quality	Severity Adjusters
Connor (1998) [16]	Cross-section	National	1986, 1994	MR	CES	−	⬭	⬭	⬭	⬭		⬭
Gautam (1996) [17]	Cross-section	National	1990-1992	MR	Ad Hoc	+		⬭	⬭	⬭		⬭
Li (2001a) [18]	Panel	WA	1988-1993	MR	GLF, Hybrid Diewert RE	−	⬭	⬭		⬭		⬭
Li (2001b) [19]	Panel	WA	1988-1993	MR	GLF, Hybrid Diewert RE	−	⬭	⬭		⬭		⬭
McKay (2002) [20]	Cross-section	National	1986, 1991	Two-Stage: 1. SFR 2: MR	Translog	+	⬭	⬭	⬭[i]	⬭		
McKay (2005) [21]	Cross-section	FL	1999-2001	Two Stage: 1. SFR 2. χ^2	Translog	−	⬭	⬭		⬭	⬭	⬭
Menke (1997) [22]	Cross-section	National	1990	MR[f]	Translog	ns	⬭	⬭	⬭	⬭	⬭	⬭
Potter (2001) [23]	Cross-section	National	1980, 1985, 1990, 1994	MR	Ad Hoc	+	⬭		⬭	⬭		
Potter (2001) [23]	Panel	National	1980, 1985, 1990, 1994	MR	Ad Hoc	+	⬭		⬭	⬭		

⬭ Model included at least one variable construct in this class of covariates.

[a] MR: Multivariate Regression; SFR: Stochastic Frontier Regression; DEA: Data Envelopment Analysis; χ2: Chi-Square Test; RDL1: Robust Distance L1 Regression; AMOS: Analysis of Moments Structures; MLR: Multivariate Logistic Regression.

[b] RE: Random Effects; FE: Fixed Effects; CES: Constant Elasticity of Substitution; GLF: Generalized Leontief Function.

[c] Heckman correction for endogenous affiliation type.

[d] The results from this study presented efficiency by profit status but without statistical testing.

[e] Hospital admissions or discharges were adjusted by the facility-level average Medicare DRG case mix index; case mix was not included as a separate regressor.

[f] First stage probit for endogenous chain membership.

[g] This multivariate regression was estimated with endogenous output. Other models were tested with and without endogenous HMO penetration and prices but the direction of the coefficient on profit status was not affected by these alternate specifications.

[h] The author modeled five types of cost in this paper: total costs per admission, total costs less taxes per admission, labor costs per admission, non-labor costs per admission, and capital costs per admission. Each model was specified the same and the direction of the effect of profit status was also similar across all models.

[i] One or more variables in this class of covariates was included only in the second stage of this analysis.

[j] Costs per admission were adjusted by a hospital-wide case mix index. Case mix was not included as a separate regressor.

Table 3a-3. Summary of Models and Profit Status Findings for Hospitals

Citation	Panel vs. Cross Section	Location	Years of Data	Approach[a]	Specification[b]	For-Profit Status Impact on Costs	Covariates: Outputs	Input Prices	Market	Provider	Quality	Severity Adjusters
Rosko (1999) [24]	Cross-section	National	1994	Two Stage: 1. SFR 2. Tobit	Translog	–	⬭	⬭	⬭[i]	⬭		⬭
Rosko (2001a) [25]	Panel	National	1990-1996	SFR[g]	Translog, RE	+	⬭	⬭	⬭	⬭		⬭[e]
Rosko (2001b) [26]	Cross-section	National	1997	SFR	Translog	–	⬭	⬭	⬭	⬭		⬭[e]
Rosko (2004) [27]	Panel	National	1990-1999	SFR	Translog, RE	+	⬭	⬭	⬭	⬭		⬭
Rosko (2005) [28]	Cross-section	National	1998	SFR	Translog	ns	⬭	⬭	⬭	⬭		⬭
Shukla (1997) [29]	Cross-section	VA	1993	MR[h]	Ad Hoc	+				⬭		⬭[j]
Vitaliano (1996) [30]	Cross-section	NY	1991	Two Stage: 1. SFR 2. MR	Cobb-Douglas	ns	⬭	⬭		⬭[i]		⬭
Zwanziger (2000) [31]	Panel	CA	1980-1997	MR	Translog, FE	–	⬭	⬭	⬭	⬭		⬭

⬭ Model included at least one variable construct in this class of covariates.

[a] MR: Multivariate Regression; SFR: Stochastic Frontier Regression; DEA: Data Envelopment Analysis; $\chi 2$: Chi-Square Test; RDL1: Robust Distance L1 Regression; AMOS: Analysis of Moments Structures; MLR: Multivariate Logistic Regression.

[b] RE: Random Effects; FE: Fixed Effects; CES: Constant Elasticity of Substitution; GLF: Generalized Leontief Function.

[c] Heckman correction for endogenous affiliation type.

[d] The results from this study presented efficiency by profit status but without statistical testing.

[e] Hospital admissions or discharges were adjusted by the facility-level average Medicare DRG case mix index; case mix was not included as a separate regressor.

[f] First stage probit for endogenous chain membership.

[g] This multivariate regression was estimated with endogenous output. Other models were tested with and without endogenous HMO penetration and prices but the direction of the coefficient on profit status was not affected by these alternate specifications.

[h] The author modeled five types of cost in this paper: total costs per admission, total costs less taxes per admission, labor costs per admission, non-labor costs per admission, and capital costs per admission. Each model was specified the same and the direction of the effect of profit status was also similar across all models.

[i] One or more variables in this class of covariates was included only in the second stage of this analysis.

[j] Costs per admission were adjusted by a hospital-wide case mix index. Case mix was not included as a separate regressor.

Table 3b. Summary of Models and Profit Status Findings for Nursing Homes

Author	Panel vs. Cross Section	Location	Years of Data	Approach[a]	Specification	For-Profit Status Impact on Costs	Covariates: Outputs	Input Prices	Market	Provider	Quality	Severity Adjusters
Anderson (1996) [32]	Cross-section	National	1995	Two Stage: 1. SFR 2. χ^2	Ad Hoc	–	⬭					
Chen (2002) [33]	Cross-section	National	1994	MR[b]	Translog	–	⬭	⬭	⬭	⬭	⬭	⬭
Davis (1998) [34]	Cross-section	KY	1989, 1991	MR	Ad Hoc	–	⬭		⬭	⬭	⬭	⬭
Hicks (2004) [35]	Cross-Section	MO	1999	MR	Ad Hoc	–	⬭	⬭	⬭	⬭		⬭[d]
Knox (2000) [36]	Cross-section	TX	1994	MR	Cobb-Douglas	–	⬭	⬭		⬭		⬭
Knox (2003) [37]	Cross-section	TX	1998	MR	Cobb-Douglas	–	⬭	⬭		⬭	⬭	⬭
Knox (2003) [37]	Cross-section	TX	1998	RDL1	Cobb-Douglas	–	⬭	⬭		⬭	⬭	⬭
Mukamel (2005) [38]	Panel	NY	1991, 1996, 1999	MR[c]	Ad Hoc	–	⬭	⬭	⬭	⬭		⬭[e]
Weech-Maldonado (2003) [39]	Cross-section	Six States	1996	AMOS	Ad Hoc	–		⬭	⬭	⬭	⬭	⬭

⬭ Model included at least one variable construct in this class of covariates.

[a] MR: Multivariate Regression; SFR: Stochastic Frontier Regression; DEA: Data Envelopment Analysis; $\chi 2$: Chi-Square Test; RDL1: Robust Distance L1 Regression; AMOS: Analysis of Moments Structures; MLR: Multivariate Logistic Regression.

[b] The authors modeled endogenous outputs and quality and tested another model without controlling for the endogeneity of quality. There was no difference in the interpretation of profit status in this sensitivity model.

[c] The authors modeled three types of cost: clinical costs, hotel costs, and administrative costs. The direction of the for-profit coefficient was the same in all three models.

[d] Resident days were adjusted by the facility-level RUG-III case mix index. Case mix was not included as a separate regressor.

[e] Inpatient days were adjusted by the facility-level average RUG-II case mix index for the analysis of clinical costs (not included in the models of hotel or administrative costs). Case mix was not included as a separate regressor in this model.

Table 3c. Summary of Models and Profit Status Findings for Other Providers

Citation	Panel vs. Cross Section	Location	Years of Data	Approach[a]	Specification	For-Profit Status Impact on Costs	Covariates: Outputs	Input Prices	Market	Provider	Quality	Severity Adjusters
DIALYSIS CENTERS												
Ozgen (2002) [40]	Cross-section	National	1997	Two Stage: 1. DEA 2. MLR	Output-Cost[d]	–	⬭		⬭[c]	⬭[c]		
HOME HEALTH AGENCIES												
Gonzales (1997) [41]	Panel	CT	1987-1992	MR[b]	Ad Hoc	–	⬭			⬭		

⬭ Model included at least one variable construct in this class of covariates.

[a] MR: Multivariate Regression; SFR: Stochastic Frontier Regression; DEA: Data Envelopment Analysis; $\chi 2$: Chi-Square Test; RDL1: Robust Distance L1 Regression; AMOS: Analysis of Moments Structures; MLR: Multivariate Logistic Regression.

[b] Costs were modeled with and without a quadratic measure of scope of services. The direction of the for-profit coefficient was the same for both models.

[c] One or more variables in this class of covariates was included only in the second stage of this analysis.

[d] The model includes input costs as well as input levels in the specification of the DEA.

1) What are the most commonly used forms of regression analysis used to model facility-level per case costs? What are the strengths and limitations of these models?

In this section, we review the primary approaches and functional forms used in the papers to examine for-profit ownership and discuss their strengths and weaknesses. There is a substantial literature comparing the results of various approaches and specifications (e.g., Linna 1998 [4]; Bryce, Engberg and Wholey 2000 [6]). For example, Bryce and colleagues [6] find that the various approaches provide similar results for industry-wide trends, but different results for individual providers. The literature does not provide definitive evidence that one particular approach should be preferred. For example, some authors argue that parametric approaches may work better for industries with well-defined technologies and non-parametric for those that are less precisely defined (such as health services) [6]. However, Kooreman [42] suggests that the various approaches should be viewed as complements.

The reviewed papers provide conflicting evidence on whether and how for-profit ownership affects hospital costs.[7] To some extent, the conflicting findings may result from differences in methodology: the approach, the functional form, the specification, and the data used to analyze the relationship of for-profit ownership to costs. Summary Tables 3a-3c display

[7] The detail on profit status findings are presented in a later section of this report.

the models, functional forms and details on the specification for each of the reviewed models. Among the twenty-seven hospital models, sixteen used multivariate regression.[8] Ten models relied on stochastic frontier regressions. And the final hospital model relied on the data envelopment analysis approach. The use of particular approaches was associated with particular functional forms: stochastic frontier models were more likely to use functional forms derived from economic theory while multivariate regression used a mix of ad hoc and theory-based functional forms. There was substantial variation in the specification (i.e., included covariates) in the hospital models.

Multivariate regression was also the primary approach for analysis of the nursing home industry. Six of the nine models used multivariate regression while robust distance (RDL1), analysis of moments structures (AMOS), and stochastic cost frontier (SFR) approaches were each used by only one model. But there was no particular relationship between approach and functional form for nursing homes. There was also less variation in specification among nursing home models.

Approach: The papers in our sample used a variety of approaches to analyze facility-level costs. The utility of various approaches and functional forms has long been debated and the introduction of new efficiency models in the 1990s stimulated further debate [8]. The primary approaches used to examine costs include multivariate regression (MR), stochastic frontier regression (SFR), and data envelopment analysis (DEA). In the summary tables, we collapse a number of different multivariate regression techniques such that this is our broadest category. It includes estimation techniques such as seemingly unrelated regression, weighted least squares, generalized least squares and other approaches. Additional detail on each model's precise estimation technique is available in Appendix A.

Data Envelopment Analysis. While both DEA and SFR identify a least cost mix of inputs for a given output, they have different strengths and weaknesses [8]. DEA is a non-parametric frontier approach that measures only technical inefficiency [42, 43]. Technical inefficiency focuses on whether the same output could be produced while reducing all inputs proportionally [44].[9] The DEA approach identifies a best-practice frontier by comparing the levels of outputs produced to the input costs.[10] DEA uses actual observations on each of the providers' input costs and outputs to trace out the frontier (see Equation 1) [13, 42].[11] In this model, the providers produce multiple outputs (Y) indexed by i and multiple costs (C) indexed by j. The ratio for provider n* is compared to the ratio for all other providers. The μ_i and ν_j are non-negative variable weights. The θ_{n*} term represents the weighted output/cost ratio for provider n* [13].

(1) $\quad \text{Max } \theta_{n*} = (\Sigma_i \mu_i Y_{in*} / (\Sigma_j \nu_j C_{jn*})$

$\quad\quad \text{Subject to: } (\Sigma_i \mu_i Y_{in} / (\Sigma_j \nu_j C_{jn}) < 1$

[8] We differentiate stochastic frontier regressions from the typical multivariate regression because they identify a frontier.
[9] Technical inefficiency indicates that the provider is operating above the unit isoquant (Vitaliano and Toren, 1994).
[10] We focus on this specification for this report, but the DEA can also analyze outputs vs. input levels.
[11] We review this particular form of the DEA. Alternatively, the DEA model can be specified with outputs and inputs.

$(\mu_i, \nu_j \geq O)$

The estimated inefficiency is based on how far below the efficient frontier the provider operates. The error term, calculated as deviations from the "frontier", is deterministic and allocated entirely to inefficiency. There is no allowance for measurement error, omitted variable bias, or randomness in estimating the frontier or the individual provider's inefficiency. This assumption has called into question the reliability of DEA efficiency scores. The concern is that DEA is sensitive to outliers and allows random shocks to determine efficiency [44, 45]. As shown in Equation 1, the DEA approach allows only for costs and outputs, though the model may specify multiple outputs and costs. Other factors, such as for-profit ownership, can only contribute if there is a second stage where the resulting inefficiencies are regressed on provider and market characteristics [13]. Although DEA was a common technique in the early 1990s, we have only two DEA models in our sample because of our review period (1996-2006) and because of the focus on ownership.

Stochastic Frontier Regression. On the other hand, SFR is a parametric frontier approach that measures both allocative and technical inefficiency [42].[12,13] Allocative inefficiency refers to an inappropriate mix of inputs [44]. SFR estimates costs as a function of outputs and input prices as in Equation 2, though in practice, many specifications include other provider and market characteristics. The error term is decomposed into two parts: random shocks (ν) and inefficiency (υ). The random shock (ν) is two-sided; this stochastic (i.e., random) shock is not allocated to inefficiency because it is out of the provider's control. But the inefficiency (υ) is one-sided because it measures shortfalls in reaching expected output [6]. This approach requires specific assumptions about the distribution of the error term. Skinner [46] notes that SFR may falsely identify inefficiencies if key assumptions regarding the error terms are violated.[14] But, contrary to concerns, varying assumptions on the error term has been shown to have little impact on the results [27]. Like any parametric approach, the validity of the results is dependent on the proper specification of the model. There is greater risk of misspecification in service industries such as health care than industries with well-defined technologies such as the production of standardized goods [6]. As with other approaches, omitted variables may inappropriately influence the estimated inefficiencies [8, 45].

(2) $C = C(Y, P)\, e^{\nu+\upsilon}$

Unlike the DEA, the SFR approach can include for-profit ownership in the cost function [25-28].[15] In practice, the majority of models chose not to include this measure in the cost function. Instead, they used the SFR to produce inefficiency measures from a specification that

[12] Allocative inefficiency indicates that the provider is at the wrong place on the isoquant given the least-cost isocost line (Vitaliano, 1994).

[13] SFR models appear to be fairly robust across estimation techniques (e.g., maximum likelihood, corrected OLS, generalized least squares and the fixed effects estimator) (Cormwell, Schmidt, and Sickles, 1990 cited in Bryce, Engberg and Wholey, 2000 [6]).

[14] Skinner (1994) focuses on the assumption that the error term (ν) has zero skewness.

[15] An exception is a standard fixed effects approach, which will fail to identify time-invariant provider characteristics. But the estimated fixed effects could then be regressed on time-invariant characteristics including for-profit status.

did not include profit status. The resulting inefficiency measures were then examined by for-profit status in a second-stage multivariate regression or using a chi-squared test [13, 14, 20, 21, 24, 30, 32]. There are differences in the potential implications of this choice. Regressing for-profit status on the error component allows the characteristics in the equation to take precedence. If profit status is correlated with those characteristics, however, then the coefficient estimates will be biased and the inferences regarding the relationship between profit status and efficiency will also be biased.

Technically, both the DEA and SFR approaches can be used to identify individual firms' inefficiency scores relative to some efficient frontier. One paper in our review did a side-by-side comparison of DEA and SFR, which generated similar findings with respect to the relative efficiency by ownership [14].[16] There has been some concern that results for individual firms are highly sensitive whereas results for larger partitions (e.g., for-profit providers) are more stable [6]. Both approaches have been adapted to allow for longitudinal data.

Multivariate Regression. Multivariate regression techniques differ from the frontier approaches because they examine whether there are differences between two ownership groups on *average*. There is concern that this approach is inconsistent with cost minimization [44]. Results present a comparison between the firm and some average rather than the industry best practice. In multivariate regression, for example ordinary least squares (OLS), the error term has a mean of zero. As a result, random deviations can be below the average or above the average [13]. Unlike the SFR approach, multivariate regression does not distinguish deviations due to idiosyncratic shocks from inefficiencies in the cross-sectional models. But, more recently, the use of panel data methods, such as fixed effects and random effects, have been used to address these concerns. Like SFR, multivariate regressions are parametric and thus subject to bias from misspecification. Skinner [46] argues that panel data allow for a more robust determination of inefficiency than frontier estimation. But the use of SFR and panel data are not mutually exclusive.

The focus of these models is whether the output levels are being produced in the most efficient (i.e., least cost) manner [43]. But this assumes that output is well-specified. This is not easy to do with health services, where providers offer a multitude of complex services that may differ in observable and unobservable quality. Likewise, there may also be sorting across hospitals in case mix severity that are not captured by facility-level case mix and yet may influence the cost of providing care. If these differences are correlated with profit status and not fully accounted for in the model, the results may be suspect. Of course, it is also the case that misspecification of multivariate regression models can bias results. But there may be greater concern with frontier methods because the bias influences both the individual and the frontier [8, 13]. In two papers, Rosko [26, 27] tested the choice of approach and found that the SFR was more appropriate than the multivariate regression.[17]

Table 4 summarizes the key attributes of each approach in terms of the requirements for functional form, the identification of a best practice frontier, and the treatment of and distributional assumptions on the error term. To summarize, the primary difference among these

[16] Bryce, Engberg and Wholey (2000) [6] and other papers also make comparisons across approaches, but these were not included in the review because there was not a focus on ownership.

[17] In these cases, the test examined whether the variance of the inefficiency-effects (υ) represented a non-zero share of the total variance of the error ($\upsilon+\nu$).

approaches is that DEA and SFR identify "efficient" best practice frontiers, while multivariate regression techniques identify an average efficiency. But SFR and MR are parametric: they impose a functional form on costs that may incur bias if specified incorrectly. However, flexible functional forms (such as the translog) can limit the potential harm from misspecification.[18] By contrast, the DEA is non-parametric. With respect to the error term, DEA treats the error as deterministic so that any deviations are completely allocated to inefficiency; there is no allowance for random shocks. But DEA does not impose strict distributional assumptions on the error. By contrast both SFR and MR allow for idiosyncratic or random shocks, but SFR imposes a distribution on the error term that may or may not be appropriate.

Table 4: Attributes of Technical Efficiency Models

	DEA	SFR	MR
Imposes Functional Form	N	Y	Y
Defines best-practice frontier	Y	Y	N
Treats error term as stochastic	N	Y	Y
Imposes distribution on error	N	Y	N

Source: Adapted from Bryce, Engberg and Wholey (2000) [6].

Functional Form: The most common functional forms found in the literature review are the translog, Cobb-Douglas and ad hoc forms. These are broad categories, which we use to summarize the forms used in the included papers. However, some authors used variations on these models by including additional variables and restricting certain coefficients (in order to reduce the number of parameters estimated). In other cases, the models were adapted to longitudinal (panel) data by including fixed or random effects. In this section, we briefly describe how the general forms are related, their strengths and weaknesses, and how their specifications of costs might influence the findings.

A provider's efficiency can be considered in two ways: the provider maximizes his output (Y) given a particular budget constraint, or the provider minimizes costs for a given output level. A simple production function may be specified as a function of its inputs, which can consist of elements such as capital (K) and labor (L) as in Equation 4.

(4) $Y = f(K,L)$

The primary problem with using the production function to determine relative efficiency or productivity is that the inputs are not exogenously determined – providers can choose the mix of inputs they use. A common solution to this endogeneity issue is to estimate a cost function (C) instead of the production function. For a well-behaved neoclassical production function, there exists a unique cost function such that cost is a function of the input prices (P_K, P_L) and of output levels as in Equation 5.[19,20]

[18] We discuss the translog in the next section on functional forms.
[19] The duality of production and cost is based on Shephard's Duality Theorem.

(5) $C = f(P_K, P_L, Y)$

Estimation of the cost function is preferable to the production function in industries where it is reasonable to assume that the variables in the cost function are exogenously determined. This assumption makes two requirements. First, the provider is a price-taker – that is, any single provider is unable to influence input prices. Second, the level of output is exogenous because the provider must supply services to everyone at a price that is predetermined, difficult to change, and often not determined by the provider.[21] In reality, the exogeneity of many regressors is not a foregone conclusion. For example, the provider can indirectly set output by varying the quality of output. That is, to the extent that patients make decisions about their consumption of a particular service based on the quality, then a provider's decision to lower quality will lower its demand and consequently output.

Given that the authors are focusing on costs rather than production, the specification of a particular functional form also requires consideration because it may impose restrictions on the findings. For example, the Cobb-Douglas functional form, which includes only a linear function of outputs and prices, is restrictive in that it implies that the elasticity of total cost with respect to output is constant regardless of provider size. As a result, if there are economies of scale, there will be economies of scale for all output levels and the average cost schedule will be declining for all outputs. On the other hand, the translog is a more flexible functional form. But it imposes more significant data requirements to estimate the greater number of parameters, data on input prices and shares, as well as more sophisticated estimation techniques for the simultaneous estimation. We describe the three main functional forms below.

Transcendental Logarithmic (Translog). A flexible functional form for costs is the transcendental logarithmic (translog) function. This is a second order Taylor approximation that allows interactions between multiple outputs and inputs [47].[22] Equation 6 demonstrates a translog cost function for a multiproduct firm.[23] This flexible form has been preferred in a

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[20] That is, the function must be monotonically increasing in inputs, continuous, concave, and have the property that only the null output is producible from zero inputs.

[21] This is parallel to the common carrier condition in the railroad industry where many cost models were developed.

[22] A concern with a multiproduct translog is that some providers may not produce some of the outputs. In such cases, a Box-Cox transformation can be used. Alternatively, a dummy for zero output can be used (Engberg, Wholey, Feldman, and Christianson 2004 [47]).

[23] This translog functional form requires constraints to guarantee a proper cost function. To insure linear homogeneity in input prices (that is, doubling output doubles costs and all interaction effects with prices are zero):

$\Sigma_i^n \beta_i = 1$ for all i
$\Sigma_j^n \gamma_{ij} = 0$ for all i,
$\Sigma_i^n \beta_i = 0$ for all j.

The coefficients must also be symmetric to insure that the function is well-behaved in its second derivatives:

$\alpha_{ij}=\alpha_{ji}$ for all i and j, and
$\beta_{ij}=\beta_{ji}$ for all i and j

number of studies because it eases concerns regarding misspecification in parametric approaches [6]. This is important for SFR and multivariate regression. Subject to the restrictions imposed by the model, coefficients on output measures can be used to assess returns to scale and scope.[24] The inclusion of second-order terms in the translog allows the cost elasticities for output and for input prices to vary as output and prices change, thus easing the restriction imposed by the Cobb-Douglas form. Economies of scale can vary based on the operating point.[25] A potential issue with the translog is the number of parameters that must be estimated. Newhouse [8] notes that this is particularly problematic for the health industry where providers produce multiple outputs. Knox and colleagues [36], Chirikos [13], and Vitaliano and Toren [30] cite problems with estimating the translog form such as poor fit and the inability to generate precise parameter estimates.

$$(6)\quad c = \alpha_0 + \Sigma_i^m \alpha_i y_i + \Sigma_i^n \beta_i p_i + \tfrac{1}{2} \Sigma_i^m \Sigma_j^m \alpha_{ij} y_i y_j + \tfrac{1}{2} \Sigma_i^n \Sigma_j^n \beta_{ij} p_i p_j + \Sigma_i^m \Sigma_j^n \gamma_{ij} y_i p_j + \varepsilon$$

where:

c = log total cost

y = log of output i (e.g., days, discharges)

p = log price of input j (e.g., wages, prices of capital)

Cobb-Douglas. The Cobb-Douglas cost-function is a special case of the translog cost function where the coefficients on the interaction terms, α_{ij}, β_{ij}, and γ_{ij}, are set equal to zero. The resulting cost function is simply a linear function of output and input prices with no interaction terms. For a provider that produces multiple outputs and uses multiple inputs, the Cobb-Douglas form is specified as in Equation 7. The key benefit of the Cobb-Douglas is that it significantly reduces the number of coefficients and consequently the necessary sample size.

$$(7)\quad c = \alpha_0 + \Sigma_i^m \alpha_i y_i + \Sigma_i^n \beta_i p_i$$

The preceding discussion focuses on the most basic forms of translog and Cobb-Douglas cost functions. Equations 6 and 7 are the simplest forms of these functional forms and follow directly from the production function. However, in the reviewed papers, the specifications are often adapted or simplified functions. In practice, the models also include regressors, other than

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If available, the input share equations should be estimated simultaneously to improve the precision of the estimates. The input share equation is:

$$\delta c/\delta p_i = (\delta c/\delta p_i)\,(p_i/c) = (p_i x_i/c) = s_i$$
$$s_i = \alpha_i + \Sigma_j^n \beta_{ij} y_j + \Sigma_j^n \gamma_{ij} y_j$$

[24] Economies of scale measure how costs change relative to changes in output; economies of scope measure production synergies across multiple outputs.

[25] It is possible to allow DEA to address variable returns to scale (Bryce et al., 2000).

input prices and outputs, which are hypothesized to influence costs. These typically include characteristics of the output (e.g., percent Medicare) as well as behavioral factors describing the provider and market. Profit status of the providers is one example. Other manipulations are also apparent. Some authors simplify the translog form in order to reduce the number of parameters for estimations by eliminating some of the higher order terms. In some cases this is partly motivated by inadequate sample size. In cases with longitudinal data, authors have also included random or fixed effects to control for unobservables.

Three papers explicitly tested the choice of functional form to determine if the restrictions imposed by Cobb-Douglas were appropriate. Rosko [26-28] found that translog was more appropriate than the Cobb-Douglas.

Ad Hoc. A number of papers did not rely on the economic theory of cost minimization. These "ad hoc" models did not evolve from the theory of the duality of production and costs. Rather, the ad hoc specifications simply test hypothesized behavioral relationships. This is a much more informal approach to estimating costs, but the models often do rely on some theory. For example, some papers cite the market structure-conduct-performance (SCP) paradigm [48, 49] to support the inclusion of market competition measures (e.g., Ozgen and Ozcan [40]; Rosko [24]).

In addition to the assumptions underlying their cost specification, many papers using a variety of approaches and functional forms implicitly or explicitly call on property rights theory to support the inclusion of profit status as a determinant of costs (e.g., Rosko [24]).

Fixed and Random Effects. So far, the discussion of the approach and functional form has ignored the issue of time. But longitudinal data on the same provider across years creates opportunities to use more sophisticated techniques for identifying the relationship of interest. Skinner [46] and Dor [45] argue that panel data techniques can be used to develop more robust estimate of inefficiencies. The methods described above have all been adapted to allow for panel data. Two options are common: fixed effects and random effects. With multiple observations on each provider, it is possible to estimate a fixed effects specification. The fixed effects are essentially provider-specific intercepts. The provider-specific intercepts allow the authors to remove the time-invariant unobservable component of the error term thereby distinguishing time-invariant inefficiencies from idiosyncratic shocks. Fixed effects estimation has the advantage of not requiring that the time-invariant unobservables are uncorrelated with the covariates. But this approach also assumes that all of the time-invariant unobservable is inefficiency.[26]

An alternative to fixed effects is random effects.[27] Random effects may be more suited for panel data with larger samples, but shorter time periods [11]. However, it relies on the stringent assumption that the firm unobservables (e.g., managerial ability) are not correlated with other regressors (e.g., output, quality). This is a more restrictive assumption than that required for fixed effects. In fact, Carey [12] performs a Hausman test that rejects the assumption of no correlation for her standard random effects model. But two additional models use correlated

[26] Later papers use "enhanced fixed effects". For example, Bryce et al. (2000) add fixed effects and a firm-specific time trend.

[27] Random effects is also called 'variance components' and is similar to a hierarchical linear model in that it requires the same more restrictive assumption than fixed effects.

random effects (instead of standard random effects) to address correlation between observables and the individual effect [11, 12].

The use of panel data also touches upon the issue of specification. Not all characteristics that influence costs can be observed or measured. For example, there is no variable to capture managerial ability. Yet clearly, this influences costs. Panel datasets offer an opportunity to address some unobservable influences; in effect the time-invariant unobservables are differenced out. There is only one fixed effects model described in this review [31]. A number of papers we included in this review also reported the results of fixed effects models but because they did not include profit status in those models, we do not discuss them here. As ownership is generally a time-invariant characteristic, it was excluded from the standard fixed effects specification because it could not be identified. The model we report by Zwanziger and colleagues [31] is an exception because this model interacted ownership with dummy variables for year. It would also be possible to regress ownership type on the inefficiencies calculated in panel frontier models in a second-stage analysis, but we did not find any models that did so.

2) What are the most widely used standardized costs per case measures? What are the strengths and limitations of these measures?

Most models use total cost as a dependent variable. Not all authors define this term, but Chirikos [13, 14] specifies "total cost" as a composition of wage and salary payments, other expenses in patient care, capital costs, and interest. Knox [36, 37] also denotes in this category the inclusion of contract personnel, utilities, maintenance, taxes and insurance. Variable (operating) costs are also common, defined by Hicks [35] as related to patient care, ancillary services and administration. The key difference between total and variable costs is generally fixed costs. A subset of models used average cost measures – these measures normalize (i.e., divide) facility costs by varying units (e.g., number of admissions, discharges or patient days). Two authors break costs down by expense type, estimating separate models for several cost components. Shukla [29] estimates models for labor, non-labor, capital, and other costs. Mukamel [38] breaks costs out by clinical activities (patient-related costs), hotel activities, and administrative activities. Cost operationalization does not seem to vary by facility type, as illustrated in Table 5.

The use of average cost measures, such as per case costs, can be useful in addressing problems of multicollinearity and heteroskedasticity. But they impose restrictions on the relationship between costs and output that are particularly troublesome in multiproduct industries [50]. For example, if a provider produces both patient days and patient discharges, is the proper measure cost per day or cost per discharge? This can have implications for the results if hospitals differ systematically in their length of stay.

Using total or variable costs as the dependent variable and including both output measures as regressors allows for more flexibility.[28] Cost measures, such as facility-level total or variable costs, are often used in cost studies to avoid imposing a specific and potentially inappropriate cost-output relationship. Not surprisingly, these measures are most common in our review. Earlier, we outlined why a cost function can potentially be useful to examine efficiency because of the duality with the production function. A necessary assumption to validate the cost

[28] In the majority of cases, costs were transformed into logs.

analysis is that the provider minimizes long-run costs. This assumption depends on whether providers are able to optimize with respect to capital. Capital investment may be a long-run process that does not allow for changes within the usual observation windows or the industry may be undergoing changes which limits the ability to optimize [51, 52]. If the providers are not in long-run equilibrium, the duality of production and long-run costs does not hold. A solution is to specify a model where the provider minimizes short-run costs (generally, variable costs or operating costs) conditional on a level of capital. The basic difference in the model is that the regression should include the level of capital rather than the cost of capital.

Table 5. Operationalization of Costs by Provider Type

Operationalization	Hospitals	Nursing Homes	Other
Total Costs	Bazzoli (2000) [9]; Chirikos (1998) [13]; Chirikos (2000) [14]; Li (2001a) [18]; Li (2001b) [19]; McKay (2002) [20]; McKay (2005) [21]; Menke (1997) [22]; Zwanziger (2000) [31]; Rosko (2001a) [25]; Rosko (2001b) [26]; Rosko (2004) [27]; Rosko (2005) [28]	Anderson (1999) [32]; Knox (2000) [36]; Knox (2003) [37]	Gonzales (1997) [41]
Variable Costs	Carey (1997) [11]; Carey (2000) [12]	Chen (2002) [33]; Hicks (2004) [35]	Ozgen (2002) [40]
Costs per Unit	Becker (2002) [10]; Clement (1997)* [15]; Connor (1998)* [16]; Gautam (1996) [17]; Potter (2001) [23]	Davis (1998) [34]; Weech-Maldonado (2003) [39]	NA
Area-specific Costs**	Shukla (1997)* [29]	Mukamel (2005) [38]	NA

* Variable cost

**Models' cost measures (long or short-run) vary by model.

3) What are the most widely used severity adjusters? What are the strengths and limitations of these adjusters?

In this section, we begin by describing the types of case mix/severity adjusters included in the models we reviewed and address the strengths and limitations of the different approaches to measuring case mix. We also include a discussion of the model specifications more generally, describing commonly used model covariates within the following classes: outputs, inputs, provider characteristics, market characteristics, and quality. We then describe their general association with costs and the strengths and limitations of different specification approaches.

Table 6 summarizes the types of case mix indices included in the models we reviewed, organized by provider setting. Although we generally treat the regression model as the unit of analysis in this review, this table summarizes case mix information at the level of the paper. If more than one model was included in the paper and both controlled for case mix, the case mix measure was operationalized the same in all models. Therefore, we do not distinguish specification at the model level here. Of the 23 papers focusing on the hospital industry, 19 included some form of case mix adjustment. The most common case mix adjustor was the facility-level Medicare DRG case mix index; nine papers used this measure. One paper included a case mix adjustor but did not describe how it was operationalized. Five papers did not include

case mix as a separate regressor in the model; rather, they adjusted hospital admissions or discharge by the facility-level case mix index. Operationally, this means that the authors multiplied the average case mix index for the facility by the total number of discharges or admissions. In addition to, or in place of traditional case mix adjustment, several papers included other measures that capture the intensity of care provided in the hospital setting (as described in Table 6).

Table 6. Summary of Case Mix Measure Specifications by Provider Setting*

Hospital Setting	
Medicare DRG Case Mix Index	Bazzoli (2000) [9]; Gautam (1996) [17]; Carey (1997) [11]; Carey (2000) [12]; Li (2001a) [18]; Li (2001b) [19]; Menke (1997) [22]; Rosko (1999) [24]; Rosko (2001b) [26]
Case Mix Measure – Not Otherwise Specified	Connor (1998) [16]
Other Case Mix Measure:	
- Proportion of inpatient discharges for acute care	Menke (1997) [22]
- Proportion of inpatient discharges for intensive care	Menke (1997) [22]
- Proportion of outpatient visits for ER	Menke (1997) [22]; Rosko (1999) [24]; Rosko (2001a) [25]; Rosko (2001b) [26]; Rosko (2005) [28]
- Proportion of outpatient visits for outpatient surgery	Rosko (1999) [24]; Rosko (2001a) [25]; Rosko (2001b) [26]; Rosko (2004) [27]; Rosko (2005) [28]
- NY all-payer case mix index based on DRGs (includes pediatric and other care not generally provided by Medicare)	Vitaliano (1996) [30]; Zwanziger (2000) [31]
- Case mix index used to adjust hospital admissions/discharges	Chirikos (1998) [13]; Chirikos (2000) [14]; Rosko (2001a) [25]; Rosko (2005) [28]; Shukla (1997) [29]
No Case Mix Index Included	Becker (2002) [10]; Clement (1997) [15]; McKay (2002) [20]; Potter (2001) [23]
Nursing Home Setting	
Resource Utilization Groups (RUGs-III)	Hicks (2004) [35]; Weech-Maldonado (2003) [39]
Case Mix Index – Not Otherwise Specified	Knox (2000) [36]
Other Case Mix Measure:	
- Facility-weighted ADL-specific case mix index	Chen (2002) [33]
- Kentucky Case Mix Assessment Reimbursement (CMAR) index	Davis (1998) [34]
- Texas Index for Level of Effort (TILEs)	Knox (2003) [37]
- RUGs-II case mix index used to adjust inpatient days	Mukamel (2005) [38]
No Case Mix Index Included	Anderson (1999) [32]

*We only include case mix measures included in the papers estimating hospital and nursing home costs. Papers focused on dialysis center and home health costs did not adjust for case mix.

All but one paper estimating nursing home costs controlled for case mix. Authors used either the Resource Utilization Groups (RUGs), a case mix measure that is currently used to reimburse Medicare-funded stays in a skilled nursing facility and which has been adopted by many states for Medicaid nursing home reimbursement or they employed a state-specific case mix index. Mukamel and colleagues [38] did not include a case mix measure as a separate regressor in the model; rather, the authors adjusted one of the output measures by the RUGs case mix index. Another paper included a weighted ADL-specific case mix index, which was developed by summing weighted ADL performance measures for residents (ADLs: eating, dressing, bathing, toilet use, and transferring) to the facility level and dividing by the number of residents to estimate a facility-level measure of case mix [33].

In almost all cases, more severe case mix was associated with higher costs, both in the hospital and nursing home settings. In only a few models was the case mix measure not statistically associated with costs. Among papers focusing on the hospital setting, the proportion of discharges for acute care was not statistically significant. The measure reflecting the proportion of outpatient visits for the ER was significant in two models and not significant in two. In the paper by Zwanziger and colleagues [31], the all-payer case-mix index was not statistically significant.

Given the relative lack of variation in measuring case mix across papers estimating hospital costs, little can be said about the merits of one approach over another in terms of predicting costs. Most of the papers that incorporated a case mix measure included the Medicare DRG case mix index in the model or adjusted output measures by that index. The Medicare DRG case mix index is the most pragmatic covariate choice given that this case mix index is available in the public domain, its derivation and meaning are generally understood, and it is the basis for Medicare reimbursement. The New York case mix index is similar to the Medicare DRG case mix index but it is tailored to an all-payer system.

Most of the case mix specifications for the nursing home models are similar; these measures generally rely upon Activities of Daily Living (ADL) measures and include additional information about the resident. For example, the RUGs case mix index includes measures of physical and cognitive functioning, clinical diagnoses, behavior problems, depressive symptoms, and therapy time received [53, 54]. The case mix measure employed in the analyses by Chen and Shea [33] relies solely on ADLs and while highly correlated with the RUGs case mix index, it is likely inferior to the RUGs measure as the RUGs case mix index includes much more information about the resident.

One of the major concerns regarding case mix controls is that facility-level case mix may be too aggregate a measure or fail to capture within-DRG variation. As Newhouse [8] notes, variation within DRG is not random by hospital and one might presume this to be the case also for case mix in nursing facilities. Patients that are attractive candidates for specific treatments (e.g., open heart surgery) may be more likely shuttled to specific hospitals that are well-equipped to do the procedure rather than just going to the facility that is nearest their home. To the extent that severity within DRG varies systematically across hospitals by ownership type, lack of adequate controls for case mix can bias results. Although each DRG/RUG is generally paid the same regardless of the provider, variation at the patient level can influence provider costs. To the extent that for-profit and not-for-profit facilities differ with respect to specialization in specific types of treatments or patients/residents, case mix and profit status may be intertwined in ways that cannot easily be controlled for in these models.

Other factors such as market-level competition may also influence the relationship between case mix and costs [55]. In areas with excess demand, facilities may be more capable of "skimming" (i.e., selecting patients that are least costly within a specific category of reimbursement). This incentive however, may be more likely among nursing home providers than hospitals [56]. While patients/residents generally choose a provider that is close to their home, those in need of hospital care may be more willing to travel farther for their care than would nursing home residents. As a result, hospitals may be more likely to compete for patients than would nursing homes. Thus, the interaction between market-level competition and case mix may be more relevant to the hospital setting than to the nursing home setting.

Other Elements of the Model Specification

In an earlier section, we described functional forms that rely primarily on input prices and outputs. But empirically, we find that most of the models we reviewed include a host of other provider and market characteristics that are hypothesized to influence costs. We have already discussed case mix and its influences in the preceding section. We categorized the remaining potential regressors into five categories: outputs, input prices, provider characteristics, market characteristics, and quality.

Output Measures. Because of the focus on theory-based models of cost-minimization, most papers included at least output and input price measures, but this is not required of the ad-hoc specification. It is important to keep in mind, however, that hospitals, nursing homes and other health care providers do not produce a single output. Rather, they provide an array of complex services that are often differentiated in some form. This makes it necessary to include a number of variables to measure and characterize outputs.

The most commonly-used output specifications in the models of hospital costs we reviewed include the volume of inpatient admissions or discharges, the number of inpatient days, average length of stay and the volume of outpatient visits (total or partitioned by ER/other outpatient). The most commonly-used output specifications in the models of nursing home costs were resident days (overall, Medicare days, Medicaid days, and/or private pay) and the number of resident discharges. Output measures were almost universally associated with higher provider costs, regardless of the cost specification. The single exception was that nursing home discharges were not significantly associated with costs.

Of the 38 models, five did not control for any output measures and six models included only one output measure. The remainder included two or more output measures. While the inclusion of multiple measures is useful, it would be difficult to capture all the relevant dimensions [8]. Zuckerman and colleagues [43] found that failure to include controls for output heterogeneity led to higher inefficiency estimates. This concern may be significant in studies that compare for-profit and not-for-profit providers. For example, not-for-profit providers may provide substantial uncompensated care, while some for-profit providers may produce zero levels of uncompensated care. Two providers may also produce the same service, but differ so much in quality that a simple output measure would be misleading and the results potentially biased without a measure of quality [8]. Unfortunately, very few of the hospital papers include any controls for the quality of the output (see below).[29]

[29] Case-mix is a related issue.

A final issue with respect to output is exogeneity. As highlighted in our discussion of functional form, output may not be an exogenous regressor, thus violating a required assumption for unbiased estimation. Few models address this issue [24-26, 33].[30] If the output measures are endogenous, then it is possible to instrument (or model) using demand factors and then to estimate costs within a system of equations. Rosko [24, 26, 27] tests output exogeneity for hospitals, but finds that output is exogenous. Chen [33], on the other hand, assumes endogeneity of output in her analysis of nursing homes.

Input Prices. Input measures can be levels or prices (e.g., number of RN FTEs or RN wages). The choice is partly determined by the approach and functional form. For example, the translog and Cobb-Douglas forms of cost-minimization models rely on input prices. In this section, we focus on input prices. The most commonly included input price was the area wage index. Models of nursing home costs also included specific staff class wage indices such as nurse, nurse aide, licensed vocational nurse, licensed practical nurse, or other staff wages. In addition to labor prices, some models included capital costs. But the use of input prices was not universal nor well-developed. Eight models did not include any input prices and most models that did, included only one. Input prices were assumed exogenous, but not tested (e.g., Rosko [25]). As with the output measures, input prices were almost universally associated with higher hospital or nursing home costs.

Indeed, input prices have been described as the "weak link" in this literature [5]. Input prices may be excluded due to data limitations, but omission may bias the results. This is cause for concern [8]. Clearly there are cost differences in terms of compensation across hospitals. The price of capital was often missing and some authors simply assumed that it did not vary in a way that might bias the results. For example, Knox and colleagues [36] and Menke [22] assumed capital markets were national so that there was no variation across providers. But Knox [36] notes that including the price of capital did not change his results. Another concern is the way in which input prices are measured. Provider-specific prices may be endogenous if providers are not price-takers. The models do not test the endogeneity of prices though some models use area-specific rather than provider-specific input prices. But there is also the issue that prices may reflect differences in input quality. The use of third-party price data (e.g., MSA wages) may bias the results if, for example, there is sorting of inputs by quality across for-profit and not-for-profit providers. For example, not-for-profit hospitals might pay a wage premium in order to attract and retain more qualified staff. The issue of input price is not trivial; some results have been shown to be sensitive to the precise measure of input prices.[31]

Some models such as those using ad hoc functional forms may use input levels (e.g., staffing levels, etc.). In our analyses, we categorized any non-price input as a provider characteristic in order to more easily examine specifications associated with specific model or functional form choices. We describe these measures in the next section on provider characteristics.

Provider Characteristics. The focus of this review is the relationship between profit status and provider costs. While all of the studies included in the review include profit status, how the measure is operationalized is not standard. Some papers compare for-profit providers

[30] But Mukamel (2005), for example, assumes exogeneity because of certificate of need and high occupancy in the nursing home industry.

[31] Folland and Hofler (2001) test for sensitivity to the exact the exact measure of capital price.

with not-for-profit providers, while others make more precise comparisons based on religious affiliation and government ownership. Usually, for-profit status is included in the main cost analysis [9-12, 15-19, 22, 23, 29, 31, 33-39, 41]. In other cases, it comprises a second stage either because of the preferences of the authors or because the model specification could not support identification in the first stage [13, 14, 20-22, 24-28, 30, 32, 40]. For example, for-profit ownership cannot be included in the DEA as part of the first stage because that is simply a ratio of providers' outputs and costs (see Equation 1). Instead, these models rely on the specification of a second stage to examine the relationship of inefficiency to for-profit ownership. Some authors evaluated estimated inefficiencies by profit status using bivariate statistical analyses (e.g., Chi-square tests) while others used regression-based techniques. We present the findings related to profit status in the last section of the paper.

Measures characterizing providers are more heterogeneous than are output or input measures. The most commonly applied hospital provider measures included chain membership, having a managed care contract, geographic location (e.g., census region or region of the state) or urban/rural location, number of beds, occupancy rate, payor sources (proportion of patient days paid for by Medicare, Medicaid or private insurance), teaching status (either COTH member or other teaching hospital), and staffing levels or ratios (e.g., ratio of LPNs to RNs). There was significant variation in costs by urban/rural location or other geographic variation measures: urban-located hospitals and nursing homes tended to have higher costs than rurally-located providers. Higher staffing levels, higher cost staffing ratios, teaching hospital status, chain membership, and more beds were associated with higher hospital costs. A higher occupancy rate was associated with lower hospital costs. The proportion of hospital activity or patients paid for by different payor sources had more inconsistent associations with hospital costs. For example, the proportion of patient days paid for by Medicare was negatively associated with costs in five models, positively associated with costs in three models and not statistically significant in one model. The measure of Medicaid patient days as a proportion of all patient days was also inconsistently associated with hospital costs. There was no statistically significant association between non-government payor days and costs.

Fewer measures were used to characterize nursing home providers. The most commonly included measures were chain membership, hospital-based facility, geographic location (e.g., census region or state regional dummies) or urban/rural location, number of beds, and occupancy rate. Similar to the relationships between hospital characteristics and costs, nursing homes with higher occupancy rates and being hospital-based had lower costs. Chain membership and bed size were nursing home characteristics generally associated with higher costs. And, as with hospitals, nursing home costs differed substantially by region of the state/country or by urban/rural status (urban providers tended to have higher costs).

A few of the papers took into account that some of the provider characteristics are choice variables and so should not be considered exogenous regressors [9, 22]. For example, chain membership and strategic hospital alliance (SHA) membership are modeled in a first-stage or Heckman correction, and then costs are estimated in a second stage [22].

Market Characteristics. A number of paper authors hypothesized that the characteristics of the local area impact provider costs. The most common factors included socio-economic characteristics and industry composition that influence the supply or demand for the service and the nature of competition in the industry. The authors sometimes relied on theory to

motivate these factors. For example, inclusion of the Herfindahl index follows from the structure-conduct-performance paradigm in the industrial organization literature [48].

Specific measures included in the models estimating hospital costs were the Herfindahl Index and HMO/IPA penetration, which were the most common. Other less common measures included measures of employment in the market area (e.g., percent unemployed, percent employed in large firms, percent white collar jobs, etc.), per capita income, the number of providers per capita, the number of hospitals in the market, and average occupancy rates for the market. Lower costs were associated with greater market competition, higher managed care penetration, and larger numbers of consumers in the market area working in large firms or in manufacturing. Higher costs were associated with higher per capita income and higher physician to population ratios. The unemployment rate was included in ten equations but produced mixed results; four equations demonstrated a positive and significant association between unemployment and hospital costs, four demonstrated a negative association, and two did not produce a statistically significant association.

Nursing home models relied on fewer market measures than did those for the hospital. In addition, the relationship between the market variables and costs were not quite as consistent as they were for the analyses of hospital costs. For example, the Herfindahl Index was included in seven nursing home cost models. Of these, the Herfindahl Index demonstrated a negative association with costs in three models, a positive association in two models, and was not statistically significant with relation to costs in two models. Other measures of market activity included the type of state payment policy the nursing home was subject to (e.g., a combined retrospective/prospective payment system, facility-specific prospective payment system, and a prospective payment system based on groups of facilities), excess capacity in the market, and home health use in the market. None of these measures produced a consistent relationship with costs across equations; in most cases, the association between these measures and costs was not statistically significant.

Quality. The inclusion of quality controls is a potentially critical factor in estimating cost differences between for-profit and not-for-profit providers. Greater quality of care may be confounded with cost inefficiency if not adequately controlled for in the model because the provision of good quality is generally costly (Zuckerman et al. 1994; Kooreman 1994a). Quality, though, is difficult to measure and so often ignored in cost models. This calls into question results regarding efficiency and for-profit ownership. In our sample, only two of the hospital cost models even consider quality measures. Both of those models use mortality rates, which at best may be a very imprecise measure of quality. Only one of the models [21] includes risk-adjusted excess mortality rates as a covariate in the model (which was not statistically significant); the other model stratified hospitals based on efficiency scores and on risk-adjusted excess mortality rates to identify the most efficient hospitals [22].

For the nursing home models, quality controls are more common and somewhat more precise. Still, there is little consensus regarding the relationship between costs and quality. Quality of care can be confounded by a number of other characteristics of nursing facilities. In a review of nursing home quality, Davis [57] argues that facility size could influence quality as an increase in size is theorized to be associated with various efficiencies. A facility's payor mix may also confound quality; the proportion of resident days paid by Medicaid may be negatively correlated with better quality [34]. Yet Davis [57] notes that the Medicaid-quality relationship may be confounded by bed supplies.

All but one nursing home equation controlled for at least one measure of quality. These measures reflected both good and poor quality. The measures were not standardized across papers; several of the papers we identified in this review were published before quality measures, such as those used by CMS to monitor quality of care, were widely available. In most cases, the authors of these papers relied in part or in whole on quality measures derived from the Online Survey, Certification, and Reporting (OSCAR) database. The quality controls included nurse and other personnel staffing mix, prevalence of catheterization, prevalence of physical restraints, prevalence of drug errors, incidence of mood decline, incidence of cognitive decline, degree of facility involvement in organized groups for residents and families and the number of regulatory, inspection and code deficiencies.

Three papers included quality measures defined as a composite of various other measures. Chen and Shea [33] developed seven quality measures from 19 measures available in OSCAR data. Two of these measures were composites of staffing measures grouped by responsibility for quality of care (e.g., RNs, LPNs, nurse aides, and pharmacists) and quality of life (e.g., mental health professionals, social workers, food service staff, dieticians, housekeeping staff, activity staff, and various therapy staff). These measures were presented as FTE staffing mix per resident. Other measures included prevalence of catheterization, physical restraints, and drug errors, the degree of facility involvement in organized groups for families and residents, and the number of regulatory deficiencies. This is the only model to treat any of the quality measures as endogenous. Davis and colleagues [34] created a single poor quality composite based on five measures: the drug error rate, psychotropic medication use, use of physical restraints, prevalence of pressure ulcers, and catheterization. Knox and colleagues [37] used the quality data as reported by the Quality Reporting System (QRS), a quality rating of each nursing facility in Texas created by the Texas Department of Human Services from facility cost reports. This composite is an average of four measures: a facility-level summary score on quality measures reflecting "good" quality, a facility-level summary score on quality measures reflecting "poor" quality, and state certification reports of deficiencies in response to complaints and in the course of regular inspections.

The relationship between quality and cost in the models we reviewed is inconsistent at best. Measures of good and poor quality were almost equally likely to predict higher or lower costs. Nurse staffing mix and FTE personnel involved in quality of care per resident (higher levels of both considered measures of "good" quality) were both positively associated with nursing facility costs. The prevalence of catheterization and drug errors (both examples of poor quality) were also positively associated with higher costs. The prevalence of restraints was associated with lower costs in one model and not significantly associated with costs in another. The relationship between counts of regulatory deficiencies and facility costs did not produce a consistent story; in the three models that included this measure as a separate indicator produced one positive, one negative, and one non-significant association with facility costs. The QRS quality measure was negatively associated with costs (e.g., an improvement in quality was associated with a decline in costs) [37].

4) What assumptions about providers as economic actors (profit maximizers, etc.) are customarily part of the analysis of providers' costs?

Many of the papers in the sample did not make their assumptions about the behavior of the providers in an explicit manner. But, as outlined in the review of the approaches, some of the approaches and forms make implicit assumptions about cost minimization while others rely on behavioral assumptions (e.g., the structure-conduct-performance and market competition). Consistent with property rights theory, many authors generally hypothesized that for-profit providers are more proactive about minimizing costs in order to maximize profits for their stakeholders [24, 58]. That is, the corporate mission to provide profits to stakeholders created greater incentives to increase revenues and reduce costs. Some authors acknowledged that not-for-profits may have different objective functions such as maximizing social welfare. But consistent with others, we found that this was not often formalized in the model [58]. The studies we reviewed pooled for-profit and not-for-profit providers. This is a more restrictive approach in terms of allowing behavior to vary; however, this approach was driven by the nature of the comparison across profit status. For-profit ownership was simply allowed to act as a cost-shifter in the models.

Model specification and estimation approaches used in the analyses also assumed that the providers are behaving in a rational manner, for example, by minimizing costs. Three papers [26, 28, 32] allowed for a mix of rational and irrational behavior based on X-efficiency theory. X-efficiency theory posits that environmental pressures can influence provider's effort and performance discontinuously. For example, similar to the structure-conduct-performance, X-efficiency posits that providers may be more lax about cost-minimization behavior when competition is low. However, this theory suggests that when competition reaches a particular threshold, the provider will become more efficient (i.e., lower costs).

5) Which variables explained significant differences between for-profit and not-for-profit providers' costs?

Differences in the financial performance, particularly in terms of profits, of for-profit versus not-for-profit providers have been well-documented [2]. But the empirical evidence regarding whether those differences are causal, the direction of the difference, and the underlying causes is mixed [5, 7]. In their review of the empirical literature on the financial performance of hospitals by type of control, Shen and colleagues [7] found that assumptions regarding the underlying theoretical frameworks, functional form, and model specifications likely explain much of the variation in findings for type of control among hospitals. Because weaker methods and functional forms are more likely to find significant differences, the authors conclude that there are only minor differences in costs by type of control. In this section of the report, we first present our findings regarding the question of whether or not provider costs vary by ownership type. We then characterize how differences between for-profit and not-for-profit providers may influence our findings.

Variation of Costs by Ownership Status: In this section, we review the findings from the papers selected for our review related to profit status. Specifically, we focus on whether for-profit hospitals had significantly different costs than their not-for-profit counterparts. For-profit ownership was not always the focus of the papers; however, most papers reported a coefficient for a for-profit dummy relative to the excluded not-for-profit group. In some instances, the reference group for profit status comparisons was either defined as "public" or "government-owned" providers. In these cases, we used the coefficient estimates and standard errors (or t-

statistics) to generate tests of statistically significant differences between for-profit and not-for-profit providers. Still, other papers reported how estimated efficiencies or inefficiencies (rather than costs) varied by profit status. To make the results comparable, we report only the direction of the relationship; that is, whether for-profit providers were less costly or less inefficient than not-for-profit providers. We summarize the findings by setting with a focus on hospitals and nursing homes because the majority of models were concentrated in these two settings and because of the dramatic differences in findings across these settings. Because the review produced only one model for each of the other settings, it is not possible to draw any conclusions. The summary tables at the beginning of this report (Tables 3a-3c) present the direction of the coefficients for each model considered.

Hospitals. The results for hospitals showed no consistent relationship between for-profit ownership and costs. Among the twenty-seven models estimated, for-profit ownership was associated with significantly lower costs in only ten models. But eight models found the opposite result: a statistically significant positive relationship between costs and for-profit ownership. In the remaining six models, the relationship was not statistically significant. It was not possible to determine statistical significance in the three models estimated by Chirikos et al. [13, 14], though they do suggest a negative relationship. The lack of consensus is consistent with other literature reviews of for-profit ownership in the hospital industry [7].

There was no consistent pattern in the results by the analytic approach or by the functional form used. However, the six models that found no statistically significant relationship contained at least one regressor from most covariate categories (e.g., output, input prices, provider, market, quality and case mix characteristics). Four contained regressors from five covariate categories, one from only four categories, and one from each of the six categories. There was much more variation in models that found either a significant positive or significant negative result; each of these findings had models ranging from two categories to five categories of covariates.

Results from cross-sectional data were more likely to present conflicting results. Of the fifteen cross-sectional analyses, five had a negative coefficient on for-profit ownership, five had a positive coefficient, and five had no significant finding. By contrast, the panel analyses were more likely to show that costs were lower among for-profit providers. Eight of the twelve models had a significant negative coefficient; only three had a positive coefficient and only one had a coefficient that was not significant. Panel data may be preferable because the use of fixed effects can reduce the potential bias from omitted variables and requires fewer distributional assumptions about the error term [45]. But most of the reviewed models used random effects to improve precision rather than fixed effects.

The coverage of the data – national vs. state – also had implications for the findings regarding ownership. In general, analysis of data from a single state was more likely to find that for-profit providers had lower costs. Seven of the nine analyses of state hospital data demonstrated a significant negative coefficient using data from Florida (4 models) [13, 14, 21], Washington (2 models) [18, 19] and California (1 model) [31]. Only one model (Virginia) [29] had a significant positive coefficient and the final model (New York) [30] produced a coefficient that was not significant. By contrast, the eighteen models that used national data found results that were entirely mixed. Six models found significant negative relationships, seven had significant positive relationships, and five had no significant finding on for-profit status.

There is some concern that changes in policies might influence cost containment incentives. We examined whether our findings were related to the analysis years. The start date for analysis periods ranged from 1980 to 1991, but there did not appear to be a pattern in the findings based on the year(s) of data used. Still, most studies included data collected prior to 1997; more recent policy changes might influence the relationship between costs and profit status but we are unable to test this hypothesis at this point in time.

We also did a statistical analysis of whether the findings with respect to for-profit status were associated with the approach, functional form, specification, cross-section versus panel data, and national versus state data for the hospital models. None of these factors were significant at the 5% level, in part likely due to the small sample. The one exception was that the use of state data was significantly associated with a negative finding in univariate analysis only. We could not perform a similar analysis for nursing homes because there was no variation in the findings.

Nursing Homes. The results are dramatically different for nursing homes. All nine models examining for-profit status in the nursing home setting reported that costs were significantly lower among for-profit providers. There was less variation in the approach for nursing homes. Six models used multivariate regression analyses, one used SFR, one AMOS, and one robust distance. There was variation, however, in specifications, which included ad hoc (5), Cobb-Douglas (3), and translog (1) cost functions. In addition, the nursing home models were much more fully specified. All but two models included at least one measure in each of five covariate categories.

There was also more consistency in terms of data. State data was far more common than national data in the nursing home models: only two of these models were based on national data.[32] The prevalence of significant negative coefficients using state-level data is consistent with the findings for hospitals. All models except that using data from New York were based on cross-sectional analyses.

Although the findings for nursing homes are consistent in our sample, there are exceptions in older papers not included in our review. For example, Vitaliano and Toren [44] found no differences in inefficiencies across ownership types.[33] However, the authors noted that their finding were at odds with the general consensus in the literature at the time.

The robustness of the results in the nursing home industry stand in stark contrast to the mixed results for hospitals. Clearly, there are differences in the type of analyses conducted. Nursing home models were more likely to use state-level data and cross-sectional analyses. The use of state-level data was also associated with negative findings in the hospital models. Nursing home models also tended to use more recent data.

Of course, there may be other contributing factors that this literature review cannot speak to. There are differences in the environment in which these providers operate and the policies regulating them, which may in turn impact costs. For example, cost efficiency may be related to the degree and nature of competition in an industry. The hospital and nursing home industry differ dramatically in this respect. Nursing homes historically face excess demand because of

[32] One paper included state data from six different states.

[33] Vitaliano and Toren (1994) use a stochastic frontier approach to examine cost data for nursing homes in New York state in 1987 and 1990.

restrictions on capacity expansion based on certificates of need [59]. Excess demand for limited services may mean that providers need not compete for patients on the basis of quality. Indeed there is concern that the combination of for-profit ownership and capacity constraints is the cause of low quality among nursing homes. But not-for-profit providers may provide higher quality regardless of excess demand because of their mission [58, 59]. Three other factors may also contribute. First, quality may be difficult to evaluate – especially for seniors and those with limited support [58, 59]; however, a number of our papers address quality to a limited extent. Second, price sensitivity is likely to be greater among nursing home patients because there is a higher share of self-pay relative to hospitals. Price-sensitivity among potential residents reinforces the focus on costs rather than quality. Third, potential nursing home residents and their families may prioritize proximity to home, which in and of itself imposes constraints on choice.

This is not the environment hospitals face. For hospitals, competition may take the form of quality or other mechanisms to attract patients, which in turn are likely to increase costs.

How For-Profit and Not-for-Profit Providers Differ. Given that profit status was generally not the primary focus of the models we considered, the papers included in this review did not provide much insight into the reasons for the findings we observed related to profit status. We review the available evidence from our papers in this section, but note that a literature search that focused on issues such as quality or staffing (rather than cost) would provide additional insight. We focus on multivariate results because cross-tabulations by profit status can be misleading. But we also note that our available evidence is limited to the papers that examined cost differences by profit status. Other papers that were outside the scope of this literature review may provide more clarity.

Three hospital papers [10, 23, 29] and two nursing home papers [33, 39] included in this review evaluated other outcomes in addition to costs using similar covariates. These additional analyses allowed us to evaluate the influence of profit status on other measures while controlling for covariates; these auxiliary analyses may help us understand why we see the differences we observed on profit status related to costs.

Table 7 below provides a list of the additional outcomes evaluated in these five papers. The measures can be roughly divided into three categories: measures of social responsibility, measures of staffing and operating characteristics, and measures of quality. We only found analyses evaluating quality of care against profit status in the nursing home papers; measures of social responsibility were only found in papers about hospitals. Measures of social responsibility were negatively associated with for-profit status; meaning, for-profit hospitals were less likely to provide these services. This relationship was generally significant for the ratio of outpatient days to total adjusted inpatient days, community assessment and reports, provision of uncompensated care, ratio of ER visits to total adjusted inpatient days, and teaching commitment. However, profit status was not significantly associated with Medicaid days as a proportion of total inpatient days. We observed a negative association between for-profit hospitals and the number of FTE employees per bed (or adjusted census). The FTE result is difficult to interpret because lower FTEs can be a sign of efficiency and/or low quality. However, for-profit status was positively and significantly associated with licensed bed occupancy and case-mix adjusted length of stay. Among nursing homes, those facilities that were for-profit had poorer outcomes quality but no significant differences were reported for process quality or nurse staffing.

Table 7. Additional Outcomes Evaluated Against Profit Status
Hospital
Measures of Social Responsibility
Medicaid inpatient days as a proportion of total inpatient days
Ratio of outpatient days to total adjusted inpatient days
Hospital has a community assessment
Hospital reports to the community
Amount of uncompensated care provided
Ratio of ER visits to total adjusted inpatient days
Ratio of hospital's teaching commitment
Measures of Staffing and Operating Characteristics
Full-time equivalent hospital employees per bed (or adjusted census)
Licensed bed occupancy
Case mix adjusted length of stay
Nursing Home
Outcomes Quality
Process Quality
RN Staffing

Although not exhaustive, the results presented here do provide some insight into why we might observe the differences in costs by profit status. As reported previously, higher staffing ratios, teaching status and higher proportions of outpatient visits relative to inpatient stays (overall or for ER only) are associated with higher costs. Higher occupancy is generally associated with lower costs. In addition, other measures of social responsibility are generally associated with higher costs such as providing uncompensated care. For-profit status was generally positively associated with measures that reflect lower costs and negatively associated with measures that reflect higher costs. It is important to note here that several of the social responsibility measures were not included in the full model evaluating hospital costs; therefore we do not know how their presence in that model might impact the coefficient on for-profit status.

IV. SUMMARY AND DISCUSSION

We reviewed 33 papers including a total of 38 models that fit our inclusion criteria in order to evaluate the association between profit status and health care provider costs. The providers included in this review were predominantly hospital and nursing home providers. We were only able to identify one each of papers that fit our inclusion criteria in other care settings – dialysis centers and home health agencies. Given that there was only one paper identified for each of these providers, we did not include these in further analyses.

In the nursing home setting, for-profit ownership was always negatively associated with facility costs. As a result there was no variation in findings with respect to approach, functional form, specification, type of data, and other factors. However, nursing home models did favor cross-sectional analyses of state-level data.

In the hospital setting, the results were mixed. Years in which data were collected did not appear to substantially influence this relationship. There also does not seem to be a particular statistical approach or functional form that explained the relationship between profit status and costs. Finally, there was little differentiation in the operationalization of costs. Most models relied on total or variable costs rather than an average cost measure; this is consistent with allowing greater flexibility in modeling providers that produce multiple outputs.

But there were some important differences. Cross-sectional and state-specific datasets produced more negative associations between for-profit status and costs. It is difficult to draw a conclusion about model specification. Highly-specified models were slightly more likely to result in no significant finding. But these were generally only cross-sectional analyses. Also, to the extent that the specification includes more covariates, it should be clear that profit status is more narrowly defined. For example, consider a model where not-for-profit providers are typically smaller than for-profit providers. If size is not included in the specification, then the coefficient on the profit status variable will pick up the cost differences due to both ownership and size. But if there are economies of scale, the not-for-profits may simply be more costly because of their size and not because of ownership per se. A potentially critical concern in the reviewed models was the lack of quality controls and the lack of precision with respect to case mix, which we discussed in detail.

There is a large amount of within-DRG category variation and quality of care can also vary substantially. There are many factors at play that influence this variability that are not well-specified in the models. In all cases where case mix was included as a covariate, it was operationalized as a facility average case mix. Whether included as a separate regressor or used to adjust an output measure as several models did, the approach is conceptually similar. However, including the case mix measure in the model as a separate regressor allows for more model flexibility. Still, greater flexibility could be introduced into these models that could better control for case mix. One such approach might include entering dummy variables into the model for each DRG or groups of related DRGs or for each RUG category, rather than averaging the intensity of care across all categories as is most-commonly done. This approach offers a more precise approach to controlling for case mix but requires a substantial number of degrees of freedom, which are generally not available in facility-level analyses. Including case mix in quadratic form, etc. can also introduce additional flexibility to the model and may better specify the model with regard to facility costs. In effect, including higher order terms assumes that costs

do not increase linearly with increases in case mix severity. Interacting profit status and case mix can also provide more insight into the relationship between these two facility characteristics while controlling for other measures in the model.

Quality measures were lacking in the hospital data and, were often poorly specified in the nursing home setting. Poor quality may be associated with lower or higher costs. Lower provision of quality can reduce costs, but complications resulting from poor quality can increase costs. Given the importance of quality and case mix relative to costs and given the potential for significant variation in these measures by profit status, future analyses need to more consistently include these measures and further work needs to be done to identify the best measures for specifying the models.

The characteristics of the sample motivate some of the differences in approach and may contribute to the conflicting findings related to profit status. These included the geographic area (e.g., state versus national), panel vs. cross-sectional data, pooled vs. partitioned samples, and sample size. With respect to state vs. national data, individual states may be subject to different policies that influence cost containment incentives; the influence of these policies may not be as apparent in national samples. As a result, the findings may not be generalizable to other areas. The use of panel versus cross-sectional data has important implications for the proper specification of the model as discussed above. All of the models in our review used samples which pooled all ownership types. Zuckerman et al. (1994) found significant differences in estimated inefficiencies when a pooled vs. partitioned sample was used. However, a partitioned sample in a frontier approach means that the relative efficiencies of the two groups cannot be compared (because the reference for efficiency is specific to each group). As a result, comparisons of ownership type rely on pooled estimation so that the frontier is consistent. For multivariate regressions, pooling the sample effectively constrains all coefficients to be identical across ownership types. Finally, the size and the characteristics of the sample also matter. Sample size constrained some models requiring them to simplify models to limit the number of parameters estimated. In at least one case, the author's decision to constrain the sample appeared to influence the findings: Carey [11, 12] used similar techniques and data in two different papers. In the earlier paper [11], she opted to exclude smaller hospitals from her sample and the coefficient on profit status was not statistically significant. In the later publication [12], a more inclusive sample produced a negative and significant association between for-profit status and costs.

To date, the largest bodies of literature on profit status and costs focus on the hospital and nursing home industries. It is not clear how profit status will operate in post-acute care settings (other than nursing homes) and future analyses will need to gather data from these other providers (e.g., long-term care hospitals, home health agencies, skilled nursing facilities, and inpatient rehabilitation facilities). We have a lot to learn from the models based on nursing homes, but the outlook for hospitals in relation to post-acute care providers is less clear. Hospitals differ substantially in the incentives and policies that govern them relative to these other providers, which calls into question how useful they are as a model for thinking about payment policies in these settings.

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APPENDIX A1: METHODOLOGICAL APPROACH – HOSPITALS

Citation	Data	Panel v Cross Section	Regression Model			Cost Measurement		Profit Status Findings
			Model	Specification	Notes	Operation-alization	Form	
Bazzoli (2000) "The Financial Performance of Hospitals Belonging to Health Networks and Systems"	1995; n=1980 Location: National Sources: • HCFA Cost Reports; • AHA Annual Survey; • Area Resource File; • InterStudy	Cross-section	Multivariate Regression (1)	Translog	Endogenous covariate(s)	Total cost less bad debt expense	Log	Nonprofit and for-profit hospitals are found to be more expensive than public hospitals in networks and in systems (with one exception). For hospitals in networks: church-based 0.25***; for-profit 0.20***; other nonprofit 0.15***. For hospitals in a system: church-based 0.09**; for-profit 0.05; other nonprofit 0.07***. (Relative to public hospitals.)
Becker (2002) "Organizational Rationality, Performance, and Social Responsibility: Results from the Hospital Industry"	1994; n=4705 Location: National Sources: • AHA Annual Survey; • Area Resource File	Cross-section	Multivariate Regression	Ad Hoc	--	Total cost per bed	Dollars	Public hospitals with no major out-of-state relationship are found to be more expensive than other hospital types. For-profit hospitals are significantly less expensive per bed than community facilities with no major out-of-state relationship (-$41,214*** for for-profit with a relationship, -$12,557*** with no relationship). Community facilities with a significant out-of-state relationship are more expensive per bed than community facilities with no relationship (-$16,327***). Government facilities are less expensive than community facilities with no relationship (-$9,663*** for government facilities with no relationship, -$22,046*** for government facilities with a relationship).

Citation	Data	Panel v Cross Section	Regression Model			Cost Measurement		Profit Status Findings
			Model	Specification	Notes	Operation-alization	Form	
Carey (1997) "A Panel Data Design for Estimation of Hospital Cost Functions"	1987-1991; n=1733 Location: National Sources: • AHA Annual Survey; • HCFA Cost Reports	Cross-section	Multivariate Regression	Ad Hoc	--	Total variable cost	Log	For-profit and nonprofit facilities are not significantly more or less expensive than other facilities in all years (1987: nonprofits -0.0283, for-profits -0.0275; 1988: nonprofits -0.0198, for-profits -0.020; 1989: nonprofits -0.0106, for-profits 0.00552; 1990: nonprofits -0.0156, for-profits 0.0198; 1991: nonprofits -0.0195, for-profits -0.009).
Carey (1997) "A Panel Data Design for Estimation of Hospital Cost Functions"	1987-1991; n=1733 Location: National Sources: • AHA Annual Survey; • HCFA Cost Reports	Panel	Multivariate Regression	Ad Hoc, Correlated Random Effects	Seemingly Unrelated Regression (Generalized Least Squares)	Total variable cost	Log	For-profit and nonprofit facilities are not significantly more or less expensive than other facilities in all years (1987: nonprofit -0.0101, for-profit -0.0618; 1988: nonprofit -0.00568, for-profit -0.0495; 1989: nonprofit -0.00402, for-profit -0.0243; 1990: nonprofit -0.0083, for-profit 0.00611; 1991: nonprofit -0.0113, for-profit -0.0168).
Carey (2000) "Hospital Cost Containment and Length of Stay: An Econometric Analysis"	1987-92; n=2792 Location: National Sources: • AHA Annual Survey; • HCFA Cost Reports	Panel	Multivariate Regression	Ad Hoc, Correlated Random Effects	--	Total variable cost	Log	Nonprofit facilities are more costly than for-profit facilities (0.047***).

Citation	Data	Panel v Cross Section	Regression Model			Cost Measurement		Profit Status Findings
			Model	Specification	Notes	Operation-alization	Form	
Carey (2000) "Hospital Cost Containment and Length of Stay: An Econometric Analysis"	1987-92; n=2792 Location: National Sources: • AHA Annual Survey; • HCFA Cost Reports	Panel	Multivariate Regression	Ad Hoc, Random Effects	Seemingly Unrelated Regression (Generalized Least Squares)	Total variable cost	Log	Nonprofit facilities are more costly than for-profit facilities across time (1987: 0.045***; 1988: 0.046***; 1989: 0.047***; 1990: 0.035***; 1991: 0.050***; 1992: 0.053***).
Chirikos (1998) "Identifying Efficiently and Economically Operated Hospitals: The Prospects and Pitfalls of Applying Frontier Regression Techniques"	1982-1993; n=186 Location: Florida Sources: • Florida Admin Reports	Panel	Two-Stage: 1. Stochastic Frontier Regression 2: Chi-square test	Translog	--	Total cost	Log	Conclusions are drawn through a comparison of hospital ownership type representation in the top and bottom efficiency quartiles after model estimation. 22% of the most efficient hospitals are government versus 11%*** of the least efficient. For for-profits, this is 43% vs. 39%. For nonprofits, 36% versus 50%***.
Chirikos (2000) "Measuring Hospital Efficiency: A Comparison of Two Approaches"	1982-1993; n=186 Location: Florida Sources: • Florida Admin Reports	Panel	Two-Stage: 1. Data Envelopment Analysis 2: Chi-square test	Output-Cost	--	Total cost	Log	Conclusions are drawn through a comparison of hospital ownership type representation in the top and bottom efficiency quartiles after model estimation. 19% of the most efficient quartile is government versus 13% of the least efficient***. This comparison for for-profits is 40% vs. 31%***, and 41% vs. 56%*** for voluntary.

Citation	Data	Panel v Cross Section	Regression Model			Cost Measurement		Profit Status Findings
			Model	Specification	Notes	Operation-alization	Form	
Chirikos (2000) "Measuring Hospital Efficiency: A Comparison of Two Approaches"	1982-1993; n=186 Location: Florida Sources: • Florida Admin Reports	Panel	Two-Stage: 1. Stochastic Frontier Regression 2: Chi-square test	Translog	--	Total cost	Log	Conclusions are drawn through a comparison of hospital ownership type representation in the top and bottom efficiency quartiles after model estimation. 22% of the most efficient quartile is government versus 11% of the least efficient***. This comparison for for-profits is 44% vs. 41%, and 35% vs. 58%*** for voluntary.
Clement (1997) "Strategic Hospital Alliances: Impact on Financial Performance"	1994-1995; n=2492 Location: National Sources: • HCFA Cost Reports • SHA information (Williamson Institute)	Cross-section	Multivariate Regression	Ad Hoc	--	Operating cost per case-mix-adjusted and out-patient adjusted discharge	Log	For-profit hospitals have higher adjusted expenses per discharge than private nonprofit facilities (0.045***). Catholic hospital expenditures are not significantly different from private nonprofit expenditures (0.029). Public hospitals have higher adjusted expenditures than private nonprofit facilities (0.083****).

Citation	Data	Panel v Cross Section	Regression Model			Cost Measurement		Profit Status Findings
			Model	Specification	Notes	Operation-alization	Form	
Connor (1998) "The Effects of Market Concentration and Horizontal Mergers on Hospital Costs and Prices"	1986, 1994; n=3500 Location: National Sources: • HCFA Cost Reports; • AHA Annual surveys; • Area Resource File	Cross-section	Multivariate Regression	Constant Elasticity of Substitution	--	Average operating cost per admission	Log	For the log of cost per admission, for-profits are more expensive than nonprofits in both years: 0.0187* in 1986; -0.0827**** in 1994. A change in profit status does not have a significant impact in costs: -0.034.
Gautam (1996) "Financial performance of safety-net hospitals in a changing health care environment"	1990-1992; n=275 Location: National Sources: • AHA Annual Surveys; • Health Care Investment Analysts Data	Cross-section	Multivariate Regression	Ad Hoc	Stepwise Linear Regression	Total cost per discharge	Dollars	For-profit hospitals have higher total costs than nonprofit (private and church-based) hospitals (9.18***). Government-owned hospitals have lower costs (-3.16*) relative to nonprofit hospitals.

Citation	Data	Panel v Cross Section	Regression Model			Cost Measurement		Profit Status Findings
			Model	Specification	Notes	Operation-alization	Form	
Li (2001a) "Cost Inefficiency in Washington Hospitals: A Stochastic Frontier Approach Using Panel Data"	1988-1993; n=90 Location: Washington Source: • WA State Department of Health Reports	Panel	Multivariate Regression	Generalized Leontief Function: Hybrid Diewert Random Effects	Feasible Generalized Least Squares	Total cost	Dollars (divided by mean)	For-profit hospitals are run with greater efficiency; the average difference of inefficiencies between for-profits and nonprofits hospitals is about 9%*. For-profits hospitals paid less for most types of labor. Capital and other costs were lower for nonprofits. Both ownership types saw large increases in costs and labor prices over time, but the nonprofits' percentage cost increase was 2x that of for-profits hospitals in this time.
Li (2001b) "Estimating Hospital Costs with a Generalized Leontief Function"	1988-1993; n=90 Location: Washington Source: • WA State Department of Health Reports	Panel	Multivariate Regression	Generalized Leontief Function: Hybrid Diewert Random Effects	Feasible Generalized Least Squares	Total cost	Dollars (divided by mean)	For-profit hospitals are run with greater efficiency; the average difference of inefficiencies between a for-profit and a nonprofit hospital is about 1%**. *Other cost conclusions repeat those of Li (2001a).*

Citation	Data	Panel v Cross Section	Regression Model			Cost Measurement		Profit Status Findings
			Model	Specification	Notes	Operation-alization	Form	
McKay (2002) "Ownership and Changes in Hospital Efficiency, 1986-1991"	1986, 1991; n=4075 Location: National Sources: • AHA Annual Survey; • Area Resource File	Cross-Section	Two-Stage: 1. Stochastic Frontier Regression 2: Multivariate Regression	Translog	--	Total cost	Log	Overall inefficiency regardless of ownership was 0.141 (1986) and 0.148 (1991) - a statistically significant increase over time***. Nonprofits were less inefficient in each year (0.135***; 0.141***) than FP (0.163 and 0.167). Government hospitals were more inefficient than nonprofits (0.147***; 0.156***), but less inefficient than FP in each year (***, **).
McKay (2005) "Comparing High- and Low-Performing Hospitals Using Risk-Adjusted Excess Mortality and Cost Inefficiency"	1999-2001; n=140, 139 and 137 by year Location: Florida Sources: • Florida State discharge data; • Florida financial and utilization data	Cross-Section	Two Stage: 1. Stochastic Frontier Regression 2: Chi-square test	Translog	--	Total cost	Log	The highest-performing hospitals (by mortality outcomes and efficiency) had a higher percentage of for-profit hospitals than other facilities (all except high-performing) in all three years. (1999: 76.9% vs. 47.2%**; 2000: 80.0% vs. 45.2%***; 2001: 88.9% vs. 47.7%**). There were a lower number of for-profits in the lowest-performing section versus all other hospitals in two of the three years (20.0% vs. 53.6% in 1999**; 18.2 vs. 51.6 in 2000**, 40.0 vs. 51.2 in 2001). Government and nonprofit facility percentages were not significantly different from the whole in either performance bin, although the trends show fewer nonprofits in the high group, and more in the low-group. There were no high-performing government hospitals; the trend is for a high percentage in the low-performing group.

Citation	Data	Panel v Cross Section	Regression Model			Cost Measurement		Profit Status Findings
			Model	Specification	Notes	Operation-alization	Form	
Menke (1997) "The Effect of Chain Membership on Hospital Costs"	1990; n=2200 Location: National Sources: • AHA Annual Survey; • Area Resource File; • HCIA Guide to Hospital Performance	Cross-section	Multivariate Regression (2)	Translog	Endogenous covariates(s); Second stage: Weighted Least Squares	Total cost	Log	Among non-chain hospitals, for-profits (0.25***) and nonprofits are more costly (0.10***) than government hospitals. There are no statistically significant differences by ownership type among chain hospitals (for-profits -0.01; nonprofits -0.04). Among all hospitals (chain and independent), for-profits (0.09***) and non-profits (0.04***) are more costly than government hospitals.
Potter (2001) "A Longitudinal Analysis of the Distinction between For-Profit and Not-for-Profit Hospitals in America"	1980, 1985, 1990, 1994; n=4385 Location: National Sources: • AHA Survey data; • Area Resource File	Cross-section	Multivariate Regression	Ad Hoc	--	Total cost per adjusted admission	Dollars	In 1994, nonprofit hospitals' costs were an average of $279.85*** less than for-profits' expenses per adjusted admission. Government facilities' expenses were $98.23*** more than for-profits'. In 1990, these differences were -$744.41*** and -$476.31***, respectively. In 1985, they were $614.04*** less and $498.98*** less. In 1980, $334.88*** less and $259.14*** less.

Citation	Data	Panel v Cross Section	Regression Model			Cost Measurement		Profit Status Findings
			Model	Specification	Notes	Operation-alization	Form	
Potter (2001) "A Longitudinal Analysis of the Distinction between For-Profit and Not-for-Profit Hospitals in America"	1980, 1985, 1990, 1994; n=4385 Location: National Sources: • AHA Survey data; • Area Resource File	Panel	Multivariate Regression	Ad Hoc	Latent growth curve model (Analysis of Moment Structures)	Total cost per adjusted admission	Dollars	For-profits reduced costs the least over time; there is convergence over time by ownership type. Five models were presented with for-profits as the reference category. Nonprofits (-0.028, 0.021, -0.065***, -0.085***; 0.007) and government facilities (-0.258***, 0.122***,-0.76***,-0.106***; -0.71***) generally had lower costs per adjusted admission. The yearly slope coefficients for nonprofits were (-0.014***, -0.015***, -0.015***, -0.014***, -0.016***); and for government they were (-0.011***, 0.06***, -0.012***, -0.011***, -0.013***). Quadratic growth coefficients (ownership*quadratic time trend) for nonprofits were (0.119***, 0.138***, 0.122***, 0.122***, 0.122***); for government they were (0.136***, -0.003, 0.138***, 0.138***, 0.138***).
Rosko (1999) "Impact of internal and external environmental pressures on hospital inefficiency"	1994; n=3262 Location: National Sources: • AHA Annual Survey; • HCFA Cost Reports; • Area Resource File; • Managed Care Data	Cross-section	Two-Stage: 1. Stochastic Frontier Regression 2. Tobit	Translog	--	Inefficiency score	Log	For-profit ownership is associated with greater inefficiency than nonprofit hospitals. Tobit coefficients on the second stage vary from 0.065*** to 0.075*** (depending on the error assumption made).

Citation	Data	Panel v Cross Section	Regression Model			Cost Measurement		Profit Status Findings
			Model	Specification	Notes	Operation-alization	Form	
Rosko (2001a) "Cost Efficiency of US Hospitals: A Stochastic Frontier Approach"	1990-1996; n=1731 Location: National Sources: • AHA Annual Survey; • HCFA Cost Reports; • Area Resource File	Panel	Stochastic Frontier Regression (3)	Translog Random Effects	Endogenous covariate(s)	Total cost less physician expenses, divided by wage rate	Log	For-profit facilities are more inefficient than other facilities (0.462***). Mean inefficiency for all hospitals has steadily decreased throughout the timeframe of the study.
Rosko (2001b) "Impact of HMO Penetration and Other Environmental Factors on Hospital X-Inefficiency"	1997; n=1966 Location: National Sources: • AHA Annual Survey; • HCFA Cost Reports; • Area Resource File	Cross-section	Stochastic Frontier Regression	Translog	X-inefficiency	Total cost divided by wage rate	Log	Not-for-profit facilities have a higher X-inefficiency than for-profit facilities (0.451***). In addition, nonprofit facilities in highly competitive areas were even more inefficient (0.0308***).

Citation	Data	Panel v Cross Section	Regression Model			Cost Measurement		Profit Status Findings
			Model	Specification	Notes	Operation-alization	Form	
Rosko (2004) "Performance of U.S. Teaching Hospitals: A Panel Analysis of Cost Inefficiency"	1990-1999; n=4732 Location: National Sources: • AHA Annual Survey; • Medicare Cost Reports; • Area Resource File	Panel	Stochastic Frontier Regression	Translog Random Effects	--	Total cost divided by wage rate	Log	For-profit ownership is associated with increased inefficiency compared to other facilities (0.8487*** for the model incorporating the number of residents trained, 0.4042*** for the model incorporating COTH membership).
Rosko (2005) "Impact of Network and System Use on Hospital X-Inefficiency"	1998; n=1368 Location: National Sources: • AHA Annual Survey • Medicare Cost Reports • Area Resource File	Cross-section	Stochastic Frontier Regression	Translog	X-inefficiency	Total cost divided by wage rate	Log	For-profit dummy has no significant impact on inefficiency scores of hospitals (-0.0299).

Citation	Data	Panel v Cross Section	Regression Model			Cost Measurement		Profit Status Findings
			Model	Specification	Notes	Operation-alization	Form	
Shukla (1997) "A Comparative Analysis of Revenue and Cost-Management Strategies of Not-for-Profit and For-Profit Hospitals"	1993; n=83 Location: Virginia Source: • Virginia Health Services Cost Review Council Data	Cross-section	Multivariate Regression	Ad Hoc	--	Total operating cost per case-mix adjusted admission	Dollars	For-profits are more costly than nonprofits in terms of total cost per admission (0.175**).
Shukla (1997) "A Comparative Analysis of Revenue and Cost-Management Strategies of Not-for-Profit and For-Profit Hospitals"	1993; n=83 Location: Virginia Source: • Virginia Health Services Cost Review Council Data	Cross-section	Multivariate Regression	Ad Hoc	--	Total cost per admission, less taxes	Dollars	For-profits have higher costs than nonprofits in terms of total cost less taxes per admission (0.129*).

Citation	Data	Panel v Cross Section	Regression Model			Cost Measurement		Profit Status Findings
			Model	Specification	Notes	Operation-alization	Form	
Shukla (1997) "A Comparative Analysis of Revenue and Cost-Management Strategies of Not-for-Profit and For-Profit Hospitals"	1993; n=83 Location: Virginia Source: • Virginia Health Services Cost Review Council Data	Cross-section	Multivariate Regression	Ad Hoc	--	Labor cost per admission	Dollars	For profits' labor cost per admission are not statistically different than nonprofits' (0.036).
Shukla (1997) "A Comparative Analysis of Revenue and Cost-Management Strategies of Not-for-Profit and For-Profit Hospitals"	1993; n=83 Location: Virginia Source: • Virginia Health Services Cost Review Council Data	Cross-section	Multivariate Regression	Ad Hoc	--	Non-labor cost per admission	Dollars	For-profits' non-labor cost per admission are higher than nonprofits' (0.140*).
Shukla (1997) "A Comparative Analysis of Revenue and Cost-Management Strategies of Not-for-Profit and For-Profit Hospitals"	1993; n=83 Location: Virginia Source: • Virginia Health Services Cost Review Council Data	Cross-section	Multivariate Regression	Ad Hoc	--	Capital cost per admission	Dollars	For-profits' capital cost per admission are higher than those of nonprofits (0.205**).

Citation	Data	Panel v Cross Section	Regression Model			Cost Measurement		Profit Status Findings
			Model	Specification	Notes	Operation-alization	Form	
Vitaliano (1996) "Hospital Cost and Efficiency in A Regime of Stringent Regulation"	1991; n=219 Location: New York Source: • NY State Department of Health Data	Cross-section	Two-Stage: 1. Stochastic Frontier Regression 2. Multivariate Regression	Cobb-Douglas	--	Inefficiency score	--	Profit status is not significant in explaining inefficiency residuals. Government hospitals show a trend of being less efficient than nonprofits (0.027); For-profits show a trend of being more efficient (-0.006).
Zwanziger (2000) "The Effect of Selective Contracting on Hospital Costs and Revenues"	1980-1997; n=421 Location: California Sources: • CA Office of Statewide Health Planning & Dev. Annual Disclosure & Discharge Data; • Price Index Data	Panel	Multivariate Regression	Translog Fixed Effects	--	Total cost	Log	For-profit hospitals' costs fell relative to nonprofits after 1983 and continued to stay below nonprofits' costs at an increasing distance through the study period to 1997: (-0.002, -0.021; -0.045***; -0.061***; -0.043***; -0.052***; -0.045***; -0.036***; -0.034***; -0.018; -0.036***; -0.034**; -0.061***; -0.064***; -0.031*).

Significance levels: * p<0.10, ** p<0.05, *** p<0.01, **** p<0.001

(1) Heckman correction for endogenous affiliation type.

(2) First stage probit for endogenous chain membership.

(3) This multivariate regression was estimated with endogenous output. Other models were tested with and without endogenous HMO penetration and prices but the direction of the coefficient on profit status was not affected by these alternate specifications.

APPENDIX A2: METHODOLOGICAL APPROACH – NURSING HOMES

Citation	Data	Panel v Cross Section	Regression Model			Cost Measurement		Profit Status Findings
			Model	Specification	Notes	Operation-alization	Form	
Anderson (1999) "The Efficiency of Nursing Home Chains and the Implications of Non-profit Status"	1995; n=653 Location: National Sources: • Nat.Center for Health Statistics • National Nursing Home Surveys	Cross-section	Two Stage: 1. Stochastic Frontier Regression 2. Chi-square test	Ad Hoc	Bayesian statistics	Total cost	Log	Mean efficiency for for-profit nursing homes is 90.1%; for non-profits the mean is 72.5%***
Chen (2002) "Does Prospective Payment Really Contain Nursing Home Costs?"	1994; n=4635 Location: National Sources: • Minimum Data Set • Online Survey Certification and Reporting Database • Area Resource File • Hospital Wage Indices File	Cross-section	Multivariate Regression (1)	Translog	Endogenous covariate(s)	Total operating cost	Log	Compared to government homes, for-profits are less costly (-0.26***) and nonprofits' costs are not statistically different (0.02).

Citation	Data	Panel v Cross Section	Regression Model			Cost Measurement		Profit Status Findings
			Model	Specification	Notes	Operation-alization	Form	
Davis (1998) "Nursing Home Performance Under Case-Mix Reimbursement: Responding to Heavy-Care Incentives and Market Changes"	1989, 1991; n=165 Location: Kentucky Sources: • Medicaid certification inspection surveys • Medicaid Cost Reports	Cross-section	Multivariate Regression	Ad Hoc	--	Per diem cost; Cost per case-mix unit	Level	In 1989, for-profit nursing homes had lower costs than other facilities (-7.851***). In 1991, for-profits again had lower costs than other facilities (-3.204**). For-profit homes are found to have lower costs ($3 to $8/day) and higher efficiency ($3 less per case mix).
Hicks (2004) "Nursing Home Costs and Quality of Care Outcomes"	1999; n=442 Location: Missouri Sources: • Medicaid Cost Reports • Minimum Data Set	Cross-Section	Multivariate Regression	Ad Hoc	--	Total variable cost	Log	Tax-exempt facilities (nonprofit and government) are found to be more costly than for-profits (0.09***). This coefficient increases to 0.10*** if regressions include some quality measure: linear, quadratic, and cubic of decline in ADL, Weight Loss, or Psychotropic Drug Use; but increases to 0.11*** if pressure ulcers binary variable is the quality measure.

Citation	Data	Panel v Cross Section	Regression Model			Cost Measurement		Profit Status Findings
			Model	Specification	Notes	Operation-alization	Form	
Knox (2000) "A Cost Model for Texas Nursing Facilities"	1994 (n=1,017) Location: Texas Sources: • Texas Medicaid Nursing Facility Cost Reports	Cross-section	Multivariate Regression	Cobb Douglas	--	Total costs	Log	For-profits have lower costs than nonprofits (-0.121***). Other models have the same conclusion with coefficients varying from -0.096*** to -0.164***.
Knox (2003) "Organizational Efficiency and Quality in Texas Nursing Homes"	1998; n=983 (OLS), n=940 (RDL) Location: Texas Sources: • Texas Department of Human Services' Quality Reporting System • Texas Medicaid Nursing Facility Cost Reports	Cross-section	Multivariate Regression	Cobb Douglas	--	Total cost	Log	Whether controlling for quality or not, for-profits are more costly than nonprofits in 1998 (-0.126*** consistent). In 1994, the same trend holds without controlling for quality (-0.137***). No quality measure was included for the 1994 models.

Citation	Data	Panel v Cross Section	Regression Model			Cost Measurement		Profit Status Findings
			Model	Specification	Notes	Operation-alization	Form	
Knox (2003) "Organizational Efficiency and Quality in Texas Nursing Homes"	1998; n=983 (OLS), n=940 (RDL) Location: Texas Sources: • TX Dept. of Human Services' Quality Reporting System • Texas Medicaid Nursing Facility Cost Reports	Cross-section	Robust Distance L1 Regression	Cobb Douglas	--	Total cost	Log	Whether controlling for quality or not, for-profits are more costly than nonprofits in 1998 (-0.116***). In 1994, the same trend holds without controlling for quality (-0.114***). No quality measure was included in the 1994 models.
Mukamel (2005) "Nursing Home Spending Patterns in the 1990s: The Role of Nursing Home Competition and Excess Demand"	1991, 1996, 1999; n=465 Location: New York Sources: • Annual financial reports • Patient Review Instrument • Medicare enrollment data	Panel	Multivariate Regression	Ad Hoc	--	Clinical activities cost (2)	Log	For-profits' clinical costs are less expensive than private nonprofits (-0.073***). Public nonprofits' clinical costs are higher than private nonprofits (0.073***). For-profits located within New York City were even less expensive (-0.107***) based on an interaction term.

Citation	Data	Panel v Cross Section	Regression Model			Cost Measurement		Profit Status Findings
			Model	Specification	Notes	Operation-alization	Form	
Mukamel (2005) "Nursing Home Spending Patterns in the 1990s: The Role of Nursing Home Competition and Excess Demand"	1991, 1996, 1999; n=465 Location: New York Sources: • Annual financial reports • Patient Review Instrument • Medicare enrollment data	Panel	Multivariate Regression	Ad Hoc	--	Hotel activities cost (3)	Log	For-profits' hotel costs were less expensive than private nonprofits (-0.074***). Public nonprofits' hotel costs were less expensive than private nonprofits (-0.105***). For-profits located within New York City were even less expensive (-0.116***) based on an interaction term.
Mukamel (2005) "Nursing Home Spending Patterns in the 1990s: The Role of Nursing Home Competition and Excess Demand"	1991, 1996, 1999; n=465 Location: New York Sources: • Annual financial reports • Patient Review Instrument • Medicare enrollment data	Panel	Multivariate Regression	Ad Hoc	--	Admini-strative activities costs (4)	Log	For-profits' administrative costs were less expensive than private nonprofits' (-0.045*). Public nonprofits were more expensive than private nonprofits (-0.141***). For-profits located within New York City were even less expensive (-0.166***) based on an interaction term.

Citation	Data	Panel v Cross Section	Regression Model			Cost Measurement		Profit Status Findings
			Model	Specification	Notes	Operation-alization	Form	
Weech-Maldonado (2003) "Does Quality of Care Lead to Better Financial Performance?: The Case of the Nursing Home Industry"	1996; n=706 Location: 6 states Sources: • HCIA Nursing Home Database • Minimum Data Set • Online Survey Certification and Reporting Database • Area Resource File	Cross-section	Analysis of Moment Structures	Ad Hoc	--	Total patient care cost per resident day	Dollars	For-profit status is negatively related to patient cost per day (-0.088) ***.

Significance levels: * p<0.10, ** p<0.05, *** p<0.01, **** p<0.001

(1) The authors modeled endogenous outputs and quality and tested another model without controlling for the endogeneity of quality. There was no difference in the interpretation of profit status in this sensitivity model.

(2) Clinical costs are related to labs, electrocardiology, electroencephalogy, radiology, inhalation therapy, podiatry, dental, psychiatric, physical therapy, speech therapy, occupational therapy, pharmacy, central service supply, medical staff, ancillary services, activities programs, non-physician education, medical education, medical director's office, medical records, social services, RHCF, special pediatrics, traumatic head injury, AIDS, long-term ventilator, dependents, respite care, adult care facilities, ICF mental retardation, and independent living expenses.

(3) Hotel costs are related to depreciation on leases/rentals, depreciation on major movable equipment, interest on capital debt, plant operation/maintenance, grounds, security, laundry and linen, housekeeping and patient food expenses.

(4) Administrative costs are related to fiscal services, administration, nursing administration, utilization review, transportation, cafeteria for non-patients, housing for non-patients, and other expenses.

APPENDIX A3: METHODOLOGICAL APPROACH – OTHER SETTINGS OF CARE

Citation	Data	Panel v Cross Section	Regression Model			Cost Measurement		Profit Status Findings
			Model	Specification	Notes	Operation-alization	Form	
HOME HEALTH AGENCIES								
Ozgen (2002) "A National Study of Efficiency for Dialysis Centers: An Examination of Market Competition and Facility Characteristics for Production of Multiple Dialysis Outputs"	1997; n=784 Location: National Sources: • Independent Renal Facility Cost Report Data File • Area Resource File	Cross-Section	Two Stage: 1. Data Envelopment Analysis 2. Multivariate Logistic Regression (1)	Output-Cost	Output-costs (and inputs) in variable returns to scale model; Second stage: logistic	Total variable cost	--	21.1% of facilities were found to be "efficient". Inefficient facilities could increase efficiency by an average of 21% (ranging from a possible increase of 1% to a maximum of 77%). [Significance levels not reported.]
DIALYSIS CENTERS								
Gonzales (1997) "An Empirical Study of Economies of Scope in Home Healthcare"	1987-1992; n=488 facility-years Location: Connecticut Source: • HCFA Cost Reports	Panel	Multivariate Regression (2)	Ad Hoc	--	Total cost deflated by CPI	Log	For-profits are found to be less costly than non-profit HHAs (-.309***).

Significance levels: * p<0.10, ** p<0.05, *** p<0.01, **** p<0.001

(1) Specification of DEA includes outputs relative to costs and inputs

(2) Costs were modeled with and without a quadratic measure of scope of services. The direction of the for-profit coefficient was the same for both models.

APPENDIX B1: MODEL SPECIFICATIONS – HOSPITALS

Citation	Output Measures	Input Prices	Market Measures	Provider Measures	Quality Measures	Case Mix/Severity Adjusters
Bazzoli (2000) "The Financial Performance of Hospitals Belonging to Health Networks and Systems"	Admissions; inpatient days; emergency outpatient visits; non-emergency outpatient visits; Medicare inpatient days; Medicaid inpatient days	Area wage index	HMO penetration; physicians per capita	Residency program; church-affiliation; Northeast location; urban; selectivity (from first stage)	None	Medicare DRG case-mix index
Becker (2002) "Organizational Rationality, Performance, and Social Responsibility: Results from the Hospital Industry"	None	None	Proportion population 65+; percent population unemployed; per capita income; proportion population non-white; HHI	Major out-of-state relationship (part of a multi-hospital system or managed under management contract from out-of-state company); number of beds; teaching hospital (COTH); medical school affiliation; intern or residency program; proportion technologically sophisticated services; department ratio; ratio of inpatient surgical operations to total surgical operations; ratio of full-time LPNS to RNs; ratio of surgical care physicians to total patient care physicians; urban; census region	None	None

* All variable specifications noted with an asterisk (*) were included in the second stage of a two-stage model.

Citation	Output Measures	Input Prices	Market Measures	Provider Measures	Quality Measures	Case Mix/Severity Adjusters
Carey (1997) "A Panel Data Design for Estimation of Hospital Cost Functions"	Discharges; outpatient visits; average length of stay	Area wage index	Urban (large urban, small urban, rural); HHI	Teaching status (heavy, light, none); urban; total fixed assets	None	Medicare DRG case-mix index
Carey (2000) "Hospital Cost Containment and Length of Stay: An Econometric Analysis"	Discharges; outpatient visits; average length of stay	Area wage index	None	Staffed beds; teaching hospital (COTH); urban; total fixed assets	None	Medicare DRG case-mix index

* All variable specifications noted with an asterisk (*) were included in the second stage of a two-stage model.

Citation	Output Measures	Input Prices	Market Measures	Provider Measures	Quality Measures	Case Mix/Severity Adjusters
Chirikos (1998) "Identifying Efficiently and Economically Operated Hospitals: The Prospects and Pitfalls of Applying Frontier Regression Techniques"	DRG-adjusted admissions; Medicare post-admission days; Medicaid post-admission days; Other (Blue Cross, private, self-pay) post-admission days; case-equivalent outpatient index; emergency room-equivalent outpatient index	Mean wage/salary of FTE personnel in inpatient and ambulatory care centers; mean wage/salary of FTE ancillary personnel in patient-care centers; mean wage/salary of personnel in administrative cost centers; depreciation charges for plant; depreciation charges for fixed/movable equipment; long and short term interest (all prices adjusted for local market and inter-temporal changes)	None	None	None	Hospital admissions were Medicare DRG case-mix adjusted
Chirikos (2000) – Model 1 "Measuring Hospital Efficiency: A Comparison of Two Approaches"	DRG-weighted admissions; Medicare inpatient days; Medicaid inpatient days; Other (Blue Cross, private, self-pay) days; special tests/procedures composite index; ambulatory center activity; length of stay*	Wages for inpatient/ambulatory care; ancillary patient care, and administrative personnel; annual depreciation plant (buildings and land); annual depreciation for fixed and movable equipment; total interest payments by the value of total current tangible and intangible assets	None	Beds*; Occupancy rate*; teaching facility; DRG weight versus local average*; service weight versus local average*; wage rates versus local average*	None	Hospital admissions were Medicare DRG case-mix adjusted

* All variable specifications noted with an asterisk (*) were included in the second stage of a two-stage model.

Citation	Output Measures	Input Prices	Market Measures	Provider Measures	Quality Measures	Case Mix/Severity Adjusters
Chirikos (2000) – Model 2 "Measuring Hospital Efficiency: A Comparison of Two Approaches"	DRG-weighted admissions; Medicare inpatient days; Medicaid inpatient days; Other (Blue Cross, private, self-pay) days; special tests/procedures composite index; ambulatory center activity	None	None	Wage and salary payments for patient care personnel; wage and salary payments non-patient care centers; other expenses in patient care cost centers; adjusted depreciation charges for plant assets (i.e., building and land); adjusted depreciation charges for fixed and movable equipment; and interest expense on long-term and short-term borrowings and all other expenses not elsewhere classified; Beds*; Occupancy rate*; teaching facility; DRG weight versus local average*; service weight versus local average*; wage rates versus local average*	None	Hospital admissions were Medicare DRG case-mix adjusted

* All variable specifications noted with an asterisk (*) were included in the second stage of a two-stage model.

Citation	Output Measures	Input Prices	Market Measures	Provider Measures	Quality Measures	Case Mix/Severity Adjusters
Clement (1997) "Strategic Hospital Alliances: Impact on Financial Performance"	None	Area wage index	HMO penetration; proportion elderly enrolled in a Medicare HMO; proportion employees at large corporations; proportion patient days provided by SHAs; MSA occupancy rate; HHI; proportion physicians in large group practices; primary care physicians per capita; proportion population 65+; unemployment rate	Occupancy rate; staffed beds; number of services offered; teaching status (COTH); SHA membership	None	None
Connor (1998) "The Effects of Market Concentration and Horizontal Mergers on Hospital Costs and Prices"	Admissions; proportion total charges from outpatient services; hospital days	Area wage index	Physicians per capita; IPA and group HMO penetrations; population; per capita income; unemployment rate; percent population 65+; percent population young women; percent population white-collar workers; percent population manufacturing workers; market area size; percent patient out-migration; HHI	Medicare days proportion; Medicaid days proportion; Medicare disproportionate share payments adjusted by total Medicare PPS payments; occupancy rate; proportion total days special care; proportion total days sub-acute; teaching status (COTH); urban-rural code (9 levels); percentage capital costs	None	Case mix index *(no additional detail provided)*

* All variable specifications noted with an asterisk (*) were included in the second stage of a two-stage model.

Citation	Output Measures	Input Prices	Market Measures	Provider Measures	Quality Measures	Case Mix/Severity Adjusters
Gautam (1996) "Financial performance of safety-net hospitals in a changing health care environment"	None	Depreciation per staffed bed	State Medicaid DRG system	Proportion beds sub-acute; AIDS unit; community health services; managed care contract; physicians per staffed bed; ratio of part-time to full-time employees	None	Medicare DRG case-mix index
Li (2001a) "Cost Inefficiency in Washington Hospitals: A Stochastic Frontier Approach Using Panel Data"	Patient days; outpatient visits	Mean wages by type of service (core inpatient; psych inpatient; other inpatient; surgery; radiology; therapies; outpatient; administrative; other); capital price (sum of depreciation and leases/rentals divided by the square footage of the hospital); price other inputs (sum of professional fees/supplies by adjusted patient days)	None	Beds; Medicare days proportion; Medicare outpatient visits proportion; western region of state (i.e., Seattle); urban	None	Medicare DRG case mix index (for all patients; averaged over panel for each hospital)

* All variable specifications noted with an asterisk (*) were included in the second stage of a two-stage model.

Citation	Output Measures	Input Prices	Market Measures	Provider Measures	Quality Measures	Case Mix/Severity Adjusters
Li (2001b) "Estimating Hospital Costs with a Generalized Leontief Function"	Patient days; outpatient visits	Mean wages by type of service (core inpatient; psych inpatient; other inpatient; surgery; radiology; therapies; outpatient; administrative; other); capital price (sum of depreciation and leases/rentals divided by the square footage of the hospital); price other inputs (sum of professional fees/supplies by adjusted patient days)	None	Beds; Medicare days proportion; Medicare outpatient visits proportion; western region of state (i.e., Seattle); urban; University of WA (medical school); Internal HHI-like measure	None	Medicare DRG case-mix index
McKay (2002) "Ownership and Changes in Hospital Efficiency, 1986-1991"	Admissions; inpatient days; outpatient visits	Depreciation and interest cost per bed; average annual salary for FTE employee; proportion Medicare days 1991*; proportion Medicaid days 1991*;	Number of hospitals in MSA/county*; area occupancy rate*; population change 1986 to 1991 in MSA/county; change in income in MSA/county 1986 to 1991; rural*	Hospital accreditation; FTE residents per bed; percentage beds intensive care; inpatient surgical operations per admission; percent outpatient visits surgical; percentage outpatient visits emergency; percentage high technology services offered measure; relative inefficiency score 1986*; market share in MSA/county 1986*; number FTE residents 1986; beds in 1986*; system membership*; under contract management*; HMO contract 1991*; PPO contract 1991*	None	None

* All variable specifications noted with an asterisk (*) were included in the second stage of a two-stage model.

Citation	Output Measures	Input Prices	Market Measures	Provider Measures	Quality Measures	Case Mix/Severity Adjusters
McKay (2005) "Comparing High- and Low-Performing Hospitals Using Risk-Adjusted Excess Mortality and Cost Inefficiency"	Admissions; adjusted inpatient days; outpatient visits; proportion admissions Medicare; proportion admissions Medicaid; proportion admissions private pay; proportion admissions private HMO-PPO; proportion admissions self-pay	Average salary/benefits per FTE patient-care employee; depreciation/interest per bed; price of other support services (non-patient care and non-capital expenses per bed)	None	Transplant program; percentage admissions open-heart surgery cases; staffed board certified physicians per bed; FTE medical residents per bed; FTE personnel per admission; FTE personnel per bed; Board certified staff per bed; COTH membership; beds; occupancy rate	Risk-adjusted excess mortality	Overall hospital case-mix index (no further detail available); ICU days/total inpatient days; ER visits/total outpatient visits
Menke (1997) "The Effect of Chain Membership on Hospital Costs"	Discharges; inpatient days; outpatient visits	Average annual salary hospital employees	Physician per capita; HHI	Unionized; hospital size; number available services	Mortality rates below, within, or above the range expected based on clinical risk of patients	Medicare case-mix index; proportion inpatient discharges by acute, intensive care, and sub-acute stays; proportion outpatient visits emergency

* All variable specifications noted with an asterisk (*) were included in the second stage of a two-stage model.

Citation	Output Measures	Input Prices	Market Measures	Provider Measures	Quality Measures	Case Mix/Severity Adjusters
Potter (2001) – Model 1 "A Longitudinal Analysis of the Distinction between For-Profit and Not-for-Profit Hospitals in America"	Average length of stay; surgical operations per adjusted inpatient day	None	Proportion population 65+; five-year change in 65+ proportion; per capita income; five-year change in per capita income; unemployment rate; HMO penetration; HHI; number hospitals in state involved in mergers	Beds; Medicaid days proportion; Medicare days proportion; ratio of technology services; five-year change in ratio of specialists to patient care physicians; ratio full-time LPNs to full-time RNs; ratio of specialist to patient care physicians	None	None
Potter (2001) – Model 2 "A Longitudinal Analysis of the Distinction between For-Profit and Not-for-Profit Hospitals in America"	Average length of stay; surgical operations per adjusted inpatient day	None	Unemployment rate; proportion population 65+; number hospital mergers in state; per capita income; HMO penetration; HHI	Profit status interacted with time trend and time trend squared; beds; ratio of technology services; Medicaid days proportion; Medicare days proportion; ratio full-time LPNs to full-time RNs	None	None
Rosko (1999) "Impact of internal and external environmental pressures on hospital inefficiency"	Discharges; outpatient visits; post-admission days	Depreciation and interest expenses per bed; average annual salary per FTE employee	Unemployment rate*; Medicare HMO penetration* (for beneficiaries); HHI*	Medicare days proportion*; Medicaid days proportion*; COTH membership; non-COTH teaching hospital	None	Medicare DRG case-mix index; percentage outpatient visits emergency

* All variable specifications noted with an asterisk (*) were included in the second stage of a two-stage model.

Citation	Output Measures	Input Prices	Market Measures	Provider Measures	Quality Measures	Case Mix/Severity Adjusters
Rosko (2001a) "Cost Efficiency of US Hospitals: A Stochastic Frontier Approach"	DRG-adjusted discharges; outpatient visits	Price of capital	HMO penetration (MSA); HHI	COTH membership (not a teaching hospital reference); Medicaid discharges proportion; Medicare discharges proportion	None	Discharges adjusted by Medicare DRG case-mix index; percentage outpatient visits emergency; percentage outpatient visits surgical
Rosko (2001b) "Impact of HMO Penetration and Other Environmental Factors on Hospital X-Inefficiency"	Discharges; outpatient visits; other patient days (from LTC, burn units, etc)	Area average annual salary per FTE employee; depreciation/interest expenses per bed	HMO penetration (MSA); high HHI; unemployment rate	COTH membership (not a teaching hospital reference); Medicaid discharges proportion; Medicare discharges proportion; system membership	None	Medicare DRG case-mix index; percentage outpatient visits emergency; percentage outpatient visits surgical
Rosko (2004) "Performance of U.S. Teaching Hospitals: A Panel Analysis of Cost Inefficiency"	DRG-adjusted discharges; outpatient visits; FTE residents trained	Depreciation and interest expense per bed; area annual salary per FTE	HMO penetration; HHI; unemployment rate	COTH membership; Medicare discharges proportion; Medicaid discharges proportion	None	Percentage outpatient visits surgical

* All variable specifications noted with an asterisk (*) were included in the second stage of a two-stage model.

Citation	Output Measures	Input Prices	Market Measures	Provider Measures	Quality Measures	Case Mix/ Severity Adjusters
Rosko (2005) "Impact of Network and System Use on Hospital X-Inefficiency"	Medicare DRG case-mix adjusted discharges; outpatient visits; days in long-term units, skilled nursing facilities, hospice, etc	Depreciation/interest expenses per bed; average annual salary per FTE employee	Highly competitive market (based on HHI); unemployment rate; HMO penetration rate	COTH membership (not a teaching hospital is reference); network use (low/med/high); system use (low/med/high); Medicare discharges proportion; Medicaid discharges proportion	None	Discharges adjusted by Medicare DRG case-mix index; percentage outpatient visits emergency; percentage outpatient visits surgical
Shukla (1997) "A Comparative Analysis of Revenue and Cost-Management Strategies of Not-for-Profit and For-Profit Hospitals"	None	None	None	System affiliation; located in Northern Virginia; urban; Medicare days proportion; Medicaid days proportion; other government days proportion; non-government days proportion	None	Costs per admission adjusted by hospital-wide case-mix index (no further description available)
Vitaliano (1996) "Hospital Cost and Efficiency in A Regime of Stringent Regulation"	Patient days; emergency room visits; outpatient visits; Medicare discharges*; Medicaid Discharges*; Blue Cross Discharges*	Wages for RNs; wages for radiologists	None	Technology Index; occupancy rate; teaching hospital; unionized*; facility size* (small, medium or large); malpractice liabilities*	None	Case-mix index

* All variable specifications noted with an asterisk (*) were included in the second stage of a two-stage model.

Citation	Output Measures	Input Prices	Market Measures	Provider Measures	Quality Measures	Case Mix/ Severity Adjusters
Zwanziger (2000) "The Effect of Selective Contracting on Hospital Costs and Revenues"	Discharges; outpatient visits; Medicaid days proportion	Medicare area wage index	Medicare Pressure Index (to gauge the pressure to cut costs as a result of PPS); HHI	Profit status interacted with years; teaching hospital; beds	None	Case-mix index estimated using all payer discharge data and NY State all-payer DRG weights

* All variable specifications noted with an asterisk (*) were included in the second stage of a two-stage model.

APPENDIX B2: MODEL SPECIFICATIONS – NURSING HOMES

Citation	Output Measures	Input Prices	Market Measures	Provider Measures	Quality Measures	Case Mix/Severity Adjusters
Anderson (1999) "The Efficiency of Nursing Home Chains and the Implications of Non-profit Status"	Admissions in 1995	None	None	None	None	None
Chen (2002) "Does Prospective Payment Really Contain Nursing Home Costs?"	Medicare days; Medicaid days; private payer days	Area wage index	State Medicaid payment method (state reimburses facilities under a combination of retrospective and prospective payment methods, state reimburses facilities under a facility-specific PPS, state reimburses groups of facilities by selected characteristics under PPS); HHI	Chain membership; hospital-based; urban; geographic region of country	Per resident ratio of FTE personnel contributing to quality of care; per resident ratio of the FTE personnel contributing to quality of life; prevalence of catheterization; prevalence of physical restraints; prevalence of drug errors; degree of facility involvement in organized groups for residents and families; number of regulatory deficiencies	Facility-level weighted, ADL-specific case mix index (based on eating, dressing, bathing, toilet use, and transferring).

* All variable specifications noted with an asterisk (*) were included in the second stage of a two-stage model.

Citation	Output Measures	Input Prices	Market Measures	Provider Measures	Quality Measures	Case Mix/Severity Adjusters
Davis (1998) "Nursing Home Performance Under Case-Mix Reimbursement: Responding to Heavy-Care Incentives and Market Changes"	Discharges	None	County's average excess capacity; number of home health patients in the county	Facility-specific excess capacity; beds; chain membership; Medicaid residents percentage; Medicaid reimbursement rate; RNs per resident	Code deficiencies count (from Medicaid certification reports); poor quality composite index (from five measures: drug error rate, psychotropic medication usage, use of physical restraint, prevalence of pressure ulcers, and urethral catherization)	Kentucky's case mix assessment reimbursement (CMAR) measure (based on 8 ADLs, special nursing needs, behavioral problems, and clinical monitoring)
Hicks (2004) "Nursing Home Costs and Quality of Care Outcomes"	RUGs case-mix adjusted days	Wages/benefits of RNs; wages/benefits of nursing assistants (aides and orderlies)	HHI	Facility size (small, medium, large); urban	None	RUGs-III used to adjust resident days
Knox (2000) "A Cost Model for Texas Nursing Facilities"	Resident days	Average hourly wage for licensed vocational nurses; average hourly wage for nursing aides; price of capital	None	Chain membership; occupancy rate	None	Case-mix index that measures the medical care and supervision provided to residents (no further detail provided)

* All variable specifications noted with an asterisk (*) were included in the second stage of a two-stage model.

Citation	Output Measures	Input Prices	Market Measures	Provider Measures	Quality Measures	Case Mix/Severity Adjusters
Knox (2003) "Organizational Efficiency and Quality in Texas Nursing Homes"	Resident days	Hourly wage rate for licensed vocational nurses and aides	None	Occupancy rate (average resident days per bed/365 days); chain membership; urban	Quality Reporting System (based on facility-measured quality performance and state inspection deficiencies)	Texas Index for Level of Efforts (11 categories based on ADL criteria)
Mukamel (2005) "Nursing Home Spending Patterns in the 1990s: The Role of Nursing Home Competition and Excess Demand"	RUG-III case-mix adjusted inpatient days; adult daycare visits; outpatient clinic visits; home care visits	Wages for aides, licensed practical nurses, registered nurses, technicians, environmental staff, clerical, and management personnel	Measure of excess demand in market (if average number of empty beds <=5); HHI	New York City location	None	Resource Utilization Groups (RUGs) used to adjust inpatient days for clinical expenditures model

* All variable specifications noted with an asterisk (*) were included in the second stage of a two-stage model.

Citation	Output Measures	Input Prices	Market Measures	Provider Measures	Quality Measures	Case Mix/Severity Adjusters
Weech-Maldonado (2003) "Does Quality of Care Lead to Better Financial Performance? The Case of the Nursing Home Industry"	None	Salary/benefits per FTE employee	Excess capacity in the county; HHI	Private-pay market share in county; beds; Medicare resident proportion; occupancy rate; chain affiliation; urban; NY location	RN staffing mix (as percentage of total RNS+LPNs+aides), prevalence physical restraint use; prevalence catheter use; prevalence pressure ulcers; incidence pressure ulcers; incidence mood decline; incidence cognitive decline [all process and outcome measures risk-adjusted and used to create two indices]	RUG-III case-mix index

* All variable specifications noted with an asterisk (*) were included in the second stage of a two-stage model.

APPENDIX B3: MODEL SPECIFICATIONS – OTHER SETTINGS OF CARE

Citation	Output Measures	Input Prices	Market Measures	Provider Measures	Quality Measures	Case Mix/ Severity Adjusters
HOME HEALTH AGENCIES						
Ozgen (2002) "A National Study of Efficiency for Dialysis Centers: An Examination of Market Competition and Facility Characteristics for Production of Multiple Dialysis Outputs"	Outpatient dialysis; dialysis training; home dialysis	Labor inputs (physicians, RNs, other); dialysis machines; A&G costs; supply costs; drug costs; laboratory costs; maintenance costs	HHI*; Proportion population 65+*; proportion African American*; proportion populations <9 years education*; region*; urban*; population density*	Reused dialyzers*, non-reused dialyzers; chain affiliation* (with size of chain	None	None
DIALYSIS CENTERS						
Gonzales (1997) "An Empirical Study of Economies of Scope in Home Healthcare"	Home care visits	None	None	Medicare patient proportion; visits per patient; urban; types of services offered	None	None

* All variable specifications noted with an asterisk (*) were included in the second stage of a two-stage model.