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A Stochastic Frontier Analysis of California Safety-Net Hospital Cost Inefficiency through the Great Recession

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Abstract: In the United States, safety-net hospitals play a major role in the provision of low-margin services and medical care access for the poor. These integral providers have been shown to be financially disadvantaged compared to their peers. Their weaker financial status may hinder their ability to uphold their valued mission and underscore the importance of cost-efficiency improvements. Using stochastic frontier analysis, with controls for hospital process-of-care quality and patient burden of illness, we estimated California safety-net hospitals' cost inefficiency for the years 2005 to 2013. The average estimated level of hospital cost inefficiency increased from 10.06 percent to 14.25 percent during the Great Recession and leveled off at 14.03 percent in succeeding years. In recognition of safety-net hospitals' vital role in the health care system, the uncertainty surrounding uncompensated care, and the planned erosion of disproportionate-share hospital payments, it is pertinent to assess their cost inefficiency through the Great Recession.

Keywords
Great Recession, cost efficiency, safety-net hospitals, stochastic frontier analysis

JEL Classification Codes: I11, L80, D22, D24

Introduction

United States (U.S.) safety-net hospitals' commitment to the provision of medical services for the most vulnerable populations, in spite of compensation uncertainty, makes them critical to the mission of fostering health care accessibility. The related empirical evidence suggests that the presence of these providers weakens the barriers to care access that uninsured and Medicaid patients face.[1] Their provision of less profitable services, such as trauma, pediatric and neonatal intensive care, further accentuates the importance of their role in the U.S. health care system.[2]

Safety-net hospitals' inherent financial disadvantage and valuable contributions to U.S. health care warrant the extra consideration dedicated to their wellbeing in the literature. The Great Recession has been shown to be associated with substantial reductions to patient volume, changes in patient mix, and patients' postponement of preventative care which may have had detrimental effects on providers' financial wellbeing.[3-7] As a result of the corresponding rise in unemployment, safety-net hospitals faced significant changes in the types of patients served. Job losses led to decreases in the amount of privately-insured patients and increases in Medicaid-enrolled and uninsured patients.[4] Felland et al. (2010)[5] found that the increased demand for safety-net services during the recent recession was primarily driven by patients without insurance coverage. Due to increased state and federal budget deficits, the resultant increase in uncompensated care may have been inadequately offset by government support.[4,6] Patients' postponement of preventative care, associated with the rising unemployment and their concurrent budget constraints, led to an increase in the demand for acute care services.[3] Given their distinct role in the provision of low-margin specialty services, this deferment of care may have particularly destabilized safety-net hospitals' finances. The combination of these demand shocks and government budget deficits may have further weakened safety-net providers' sustainability. In their recent national study, Reiter et al. (2014)[7] caution that though their findings suggest that safety-net hospitals' financial performance was not incommensurately weakened through the Great Recession relative to their peers, their innate financial disadvantage persists. These conclusions corroborate a national study that emphasizes the need for continued attention to safety-net hospitals' due to their restricted coping abilities during the recent recession.[8]

Some strategies that are implemented by hospitals under financial duress, albeit effective at overcoming budget pressures, are detrimental to patient wellbeing.[9] Strategies that limit access to care, such as service restrictions and reductions to the provision of uncompensated care, are ideally less likely to be employed by safety-net hospitals.[10] These providers may instead cope with restricted financial support by improving efficiency, which could have been the case during the 1980s.[10,11] Improvements in cost efficiency could benefit both patients and hospitals by allowing for the reduction of safety-net hospitals' costs and the expansion of access to medical care.[1,12] In fact, Hsieh et al. (2010)[13] found that more efficient hospitals typically provide higher amounts of uncompensated care.

If safety-net hospitals' were able to reduce cost inefficiency in the recent past, the forthcoming Patient Protection and Affordable Care Act (PPACA) Medicaid disproportionate-share payment reductions may be partially offset by improvements to cost efficiency.[1,10] Zuckerman et al. (2001)[10] hypothesize that safety-net hospitals may improve cost efficiency in response to elevated financial pressure stemming from market cycles and government policy. While previous studies have assessed safety-net hospitals' finances through the recent recession, using measures such as total and operating margins, there is an absence of analysis pertaining to providers' cost efficiency performance during that period.

New Contribution

In light of the forthcoming disproportionate-share payment reductions, Reiter et al. (2014)'s findings, and Zuckerman et al. (2001)'s[10] hypothesis, this study contributes by informing policymakers of safety-net hospitals' abilities, or lack thereof, to increase efficiency in response to financial challenges. Specifically, we employ stochastic frontier analysis (SFA) to assess how California (CA) safety-net hospitals' cost efficiency fared through the Great Recession. To our knowledge, this is the first study to explicitly assess safety-net hospital cost efficiency over time. It is uniquely informative to assess CA safety-net providers given the state's selective disproportionate-share payment targeting and quality improvement efforts.[6] Further, these providers receive ten percent of the federal government's disproportionate-share funds allocated to states.[14]

Stochastic Frontier Framework

We employed SFA, a parametric technique independently developed by Aigner, Lovell, and Schmidt (1977)[15] and Meeusen and Van den Broeck (1977)[15], to evaluate safety-net hospitals' costs and cost inefficiency through the Great Recession. This parametric approach allows for the estimation of cost inefficiency by separating the positive deviations from the theoretical best-practice cost frontier (BPF) into random and deterministic components. Hospitals operating on the BPF have no cost inefficiency, as the BPF indicates the full efficiency cost level given the specific set of input prices and outputs. Thus, a hospital's cost efficiency is the ratio of the corresponding BPF cost level to the hospital's observed total operating expenses. Given this definition of cost efficiency, a hospital approaching full cost efficiency would have a ratio close to one.

The technique utilizes a neo-classical cost function, in which total operating costs are a function of output and input prices, for the estimation of the BPF. Following Kumbhakar and Lowell's (2000)[16] theoretical framework and employing vector notation, hospital *i*'s total operating expenses are described by the following function:

$$TC_{it} = f(\boldsymbol{Y}_{it}, \boldsymbol{P}_{it}, \boldsymbol{X}_{it}, \boldsymbol{\beta}) + v_{it} + u_{it}, \tag{1}$$

where TC is the total cost for the *i*th hospital at time t, $i = 1, \ldots, 61$ and $t = 1, \ldots, 9$, $\mathbf{Y}_{it}$ is a vector of outputs, $\mathbf{P}_{it}$ is a vector of input prices, $\mathbf{X}_{it}$ is a vector of hospital specific characteristics, and $\boldsymbol{\beta}$ is a vector of parameters to be estimated. The variable v_{it} is the random error component, which is assumed to be normally distributed with zero mean and constant variance (i.e., $N(0, \sigma^2)$). The final term in equation (1), u_{it}, is the component that represents the individual hospital's time-varying cost inefficiency, and is made up of positive deviations from the BPF. This deterministic error term is the percentage by which hospital *i*'s observed total operating expenses exceed what they would be if the hospital were fully cost efficient (Lovell, 1993). [16] We followed Battese and Coelli (1995) and specified the functional form of the time-varying cost inefficiency as:

$$u_{it} = \alpha + \sum_{l=1}^{L} \boldsymbol{X}_{lit}\, \delta_l + w_{it}, \qquad (2)$$

where u_{it} is bounded by zero and one, $\boldsymbol{X_{lit}}$ is a vector of hospital-specific explanatory variables corresponding with the inefficiency effects and w_{it} are unobservable random variables.

In recognition of the persisting ambiguity in the literature surrounding the specification of the statistical distribution of the time-varying cost inefficiency variable, u_{it}, we determined the appropriate specification for our dataset with a log-likelihood restriction test.[17] To date, the four accepted probability distribution functions in the literature are the half-normal, gamma, exponential, and truncated-normal.[17] Frequently the term is assigned the half-normal or the less restrictive truncated-normal distribution.[18]

It is well established in the literature that the existence of output heterogeneity across hospitals is a critical empirical issue to address.[17] Hospital output heterogeneity, referring to the variation in conditions treated and the quality of medical services provided, may charade as cost inefficiency.[12,17] This means that inadequately controlling for the heterogeneity of hospital outputs may result in overestimated cost inefficiency for hospitals that treat relatively large amounts of patients requiring complex treatments, and underestimated cost inefficiency for those hospitals that deliver lower quality care. Including controls for hospital quality of care and case severity is a well-recognized method of sizably reducing the output heterogeneity induced bias in cost-inefficiency estimates.[17,19] We included summary performance scores and collected case mix indexes as measures of hospital clinical process of care quality and patient burden of illness, respectively.

We built upon Mutter et al. (2008)[17] and applied a translog functional form to equation (1), which is econometrically specified as follows:

$$lnTC_{it} = \alpha_0 + \sum_{m=1}^{M} \alpha_m\, lnY_{m,it} + \sum_{n=1}^{N} \alpha_n\, lnP_{n,it} + 0.5 \sum_{m=1}^{M}\sum_{k=1}^{K} \alpha_{mk}\, lnY_{m,it} lnY_{k,it} + 0.5 \sum_{n=1}^{N}\sum_{j=1}^{J} \alpha_{nj}\, lnP_{n,it} lnP_{j,it} + \sum_{m=1}^{M}\sum_{n=1}^{N} \alpha_{mn}\, lnY_{m,it} lnP_{n,it} + \sum_{r=1}^{R} \alpha_r X_{r,it} + v_{it} + u_{it} \qquad (3)$$

We estimated equation (3), following Battese and Coelli's (1995)[20] framework, and applied a maximum likelihood approach, which allows for time-varying cost inefficiency. The generated BPF, indicating fully efficient cost levels (where u_{it} is equal to one) is expressed as follows:

$$CE_{it} = \frac{f(\boldsymbol{Y}_{it}, \boldsymbol{P}_{it}, \boldsymbol{X}_{it}, \boldsymbol{\beta}) + v_{it}}{f(\boldsymbol{Y}_{it}, \boldsymbol{P}_{it}, \boldsymbol{X}_{it}, \boldsymbol{\beta}) + v_{it} + u_{it}} = \exp(-u_{it}), \qquad (4)$$

where CE, which represents cost efficiency, is the ratio of the estimated stochastic frontier cost to the observed total operating costs at time t.[21] Equation (4) indicates that this measure is between zero and one. The reciprocal of this measure is u_{it} and represents cost inefficiency.

Data

We acquired the hospitals' financial data for the years 2005-2013 from the CA Office of Statewide Health Planning and Development (OSHPD)'s System for Integrated Electronic Reporting and Auditing (SIERA) and pivot profiles. We obtained the additional hospital-reported quality and output descriptor data from the Centers for Medicare and Medicaid Services (CMS)'s Hospital Compare and impact files. Our balanced panel consists of CA safety-net hospitals, a subset of the state's disproportionate-share hospitals, with sufficient quality and financial data for the sample period. Hospitals such as Veteran Administration, psychiatric, military and critical access hospitals were excluded from this study. As there is not an established definition of what precisely constitutes a safety-net hospital, we followed prior studies and identified safety-net hospitals to be those with disproportionate-share hospital (DSH) indexes in the seventy-fifth percentile of CA hospitals.[14,22] For this analysis, we followed Reiter et al. (2014)[7] and determined safety-net hospitals to be those with DSH indexes in the highest percentile in 2005 (assigning the initial year of the sample as the base year). The following formula describes CMS' calculation of the DSH patient percent:

DSH Index = (Medicare Supplemental Security Income Days / Total Medicare Days) + (Medicaid, Non-Medicare Days / Total Patient Days) (5)

Previous studies note the key benefit of using the DSH index is that it accounts for poor patients regardless of their age (Jha et al. 2009a; Chatterjee et al., 2012; Gilman et al., 2014; Gilman et al., 2015).[23,22,14]

Cost Variables

The cost equation is normalized by an input price to apply the common assumption of linear homogeneity in input prices.[12,14] We therefore created the dependent variable (LNTOTOPEXP) by dividing the natural logarithm of total hospital operating expenses by the average price of capital (PRICECAPITAL). We used this average price of capital, calculated by dividing the sum of depreciation and interest expenses by the number of licensed beds in the hospital, to normalize the input prices in this study.[a] The labor input price (PRICELABOR), which was constructed by

[a] The results of the estimation do not depend on the input price chosen for normalization.

dividing the sum of total salaries, wages, and benefits by the number of full-time equivalents for all staff categories, was included in its log-transformed and normalized form (LNPRICELABOR). Due to the particular level that the hospital financial data is aggregated to, further classification of total salaries, wages, and benefits by staff type was not feasible. We included log-transformed total discharges (DISCH) and outpatient visits (OPVISITS) as outputs in the cost function. We also controlled for the number of licensed beds (LICBEDS).

We controlled for hospital output heterogeneity by including the Medicare Case-Mix Index (CASEMIX), the percent of outpatient surgical care visits (OPSURG%), the proportion of outpatient visits that were emergency department visits (ERVISITS%), and calculated summary performance scores (PERFSCOREAMI, PERFSCOREHF, and PERFSCOREPN) based on reported measures of clinical process of care quality. The additional value of including these particular quality measures rests in their presence in the HVBP's Clinical Process of Care domain, which is integral to the determination of hospitals' reimbursements. Following the proposed methodology of the Joint Commission on Accreditation of Healthcare Organizations, we used the quality measures pertaining to the conditions of acute myocardial infarction (AMI), heart failure (HF), and pneumonia (PN) for the performance score calculation.[25] These measures include the summary quality indexes for each health condition: aspirin at arrival, aspirin at discharge, beta-blocker at discharge, and angiotensin-converter enzyme (ACE) inhibitor for left ventricular systolic dysfunction for AMI; left ventricular function assessment and ACE inhibitor for left ventricular systolic dysfunction for HF; and appropriate initial antibiotics within four hours of arrival, blood culture performed prior to first antibiotic, smoking cessation advice, and pneumococcal vaccination for PN. For each health condition, we calculated the ratio of the number of times an appropriate action was performed to the total number of applicable cases.[25] For example, Table 1 indicates that, on average, appropriate actions were taken for PN approximately seventy percent of the time. Similar to previous studies, we did not calculate summary scores for those hospitals that did not have a minimum of thirty patients for at least one of the measures for each condition. The included clinical process-of-care quality measures constitute a substantial domain in the Hospital Value-Based Purchasing program, a recently implemented pay-for-performance policy.

To account for changes in safety-net hospitals' costs through the Great Recession, we followed Chen et al. (2014)[26], and constructed an indicator variable with the Great Recession (2008-2009) as the reference category. The variables for pre- and post-Great Recession (PRE_{2005_2007} and $POST_{2010\_2013}$) pertain to the periods 2005-2007 and 2010-2013, respectively.

Table 1. Descriptive Statistics (Cost Variables)

Variable Name	Description	Mean	SD
Cost function Variables			
TOTOPEXP (000)	Total operating costs	237,000	245,000
DISCH	Total inpatient discharges	11,347	7,833
OPVISIT	Total outpatient visits	169,472	197,173
PRICELABOR	(Salaries + wages + benefits)/FTE	87,512	21,504
LICBEDS	Total number of licensed beds	266.73	178.32
PRICECAPITAL	(Depreciation + leases + rentals)/LICBEDS	90.118	60.788
CASEMIX	Medicare case-mix idex	1.0749	0.2230
ERVISIT%	(Total emergency department visits / OPVISIT)*100	43.675	34.585
OPSURG%	(Total outpatient surgeries / OPVISIT)*100	4.5239	7.8032
PERFSCOREAMI	Process of care quality summary score for AMI	0.9064	0.1120
PERFSCOREHF	Process of care quality summary score for HF	0.8906	0.1476
PERFSCOREPN	Process of care quality summary score for PN	0.7189	0.1333
PRE_{2005_2007}	Binary variable (1, 0) for pre Great Recession years	0.4444	0.4974
$POST_{2010\_2013}$	Binary variable (1, 0) for post Great Recession years	0.3333	0.4718

Inefficiency Effects Variables

In addition to the cost variables, we included variables particularly associated with cost inefficiency to estimate equation (2). These additional controls include hospital's ownership status (FORPROFIT and GOVT), degree of market concentration (HHIDISCH), percent of patient discharges with a health maintenance organization (HMO) insurance plan (HMODISCH), percent of Medicaid patient discharges (MEDICAID%), Medicare patient discharges (MEDICARE%), and uninsured patient discharges (UNINSURED%).

The binary variable we included to indicate hospital ownership status has nonprofit as its base category. Ambiguity exists in the empirical literature with regard to the impact of for-profit status on hospitals' cost efficiency.[27] Property Rights Theory suggests a negative relationship between for-profit classification and cost-inefficiency as a result of profit-maximizing behavior.[28] However, a recent Rosko and Mutter (2011) review of frontier analysis studies reports mixed findings.

The importance of controlling for hospital budget pressures that stem from market concentration, payer mix, and reimbursement regulation is well established in the literature.[27] Following Mobley et al. (2009)[29], who studied hospital price competition in CA, we used the reported hospital's Health Facility Planning Area (HFPA) to identify its relevant market. The variable HHIDISCH is the sum of the squared market shares of discharges for all hospitals in its corresponding HFPA. A market characterized by monopolistic competition would be indicated by an HHIDISCH near one, while an HHIDISCH approaching zero describes a highly competitive market. With regard to payer mix, past studies have found a negative association between patient HMO enrollment and hospital cost inefficiency.[30] To test whether this relationship holds for our safety-net sample, we included HMODISCH to account for hospitals' efforts to decrease costs and cost inefficiency when treating high amounts of patients with managed care. The variable HMODISCH, defined as the percentage of total patient discharges enrolled in an HMO plan, is the sum of a provider's reported discharges from Medi-Cal, Medicare, and private-party managed care divided by the hospital's total discharges for each corresponding year. Other studies have noted cross-boundary issues that arise from the aggregation of HMO enrollment data to predetermined regions such as county.[1,30] In acknowledgement of this concern, we used reported hospitals' HMO patient discharges instead of relying on HMO enrollment. This determination of HMODISCH relaxes the assumption that patients within the predetermined boundaries only seek healthcare services from the hospitals in the corresponding region. Due to the regulatory pressure inherent to the prospective payment system it is critical to also control for the extent that hospitals depend on public-payer reimbursement. These reimbursements typically do not meet hospitals costs and may incentivize cost inefficiency reduction.[27,31] To test this hypothesis, we included MEDICARE% and MEDICAID% in our estimation of cost inefficiency. Lastly, it is valuable to recognize the proportion of a hospital's patients that lack insurance and still receive medical services. This is especially true for safety-net providers in light of their mission to care for highly-vulnerable patients. We do so by including UNINSURED%, which is defined as the ratio of indigent and "other" discharges to total discharges. The variables accounting for time-varying inefficiency through the Great Recession (PRE_{2005_2007} and $POST_{2010\_2013}$) were also included in this estimation.[12]

Table 2. Descriptive Statistics (Inefficiency Variables)

Variable Name	Description	Mean	SD
Inefficiency Effects Variables			
GOVT	Binary variable (1, 0) for government, non-federal hospitals	0.2259	0.4185
FORPROFIT	Binary variable (1, 0) for investor-owned hospitals	0.3661	0.4822
HHIDISCH	Herfindahl-Hirschman Index of discharges for the HFPA	0.2849	0.2168
HMODISCH	(Managed Care discharges / total discharges)*100	28.308	14.315
MEDICAID%	(Medicaid discharges / total discharges)*100	44.945	15.095
MEDICARE%	(Medicare discharges / total discharges)*100	31.485	16.501
UNINSURED%	(Indigent and other discharges / total discharges)*100	5.6463	5.0914
PRE_{2005_2007}	Binary variable (1, 0) for pre Great Recession years	0.4444	0.4974
$POST_{2010\_2013}$	Binary variable (1, 0) for post Great Recession years	0.3333	0.4718

Results

The preferred model and estimation technique for our dataset were selected based on the log-likelihood restriction tests reported in Table 3. In the first case, we assessed whether deviations from the best-practice cost frontier stemmed only from statistical noise. As shown in Table 3, we rejected the null hypothesis that the ordinary least squares parameters are consistent. Thus, SFA is the preferred approach.

The second test pertains to the determination of the most appropriate functional form of the cost frontier for our dataset. The translog functional form for the cost frontier, which is less restrictive than the Cobb-Douglas specification, was selected based on the corresponding chi-squared (χ^2) value in Table 3. In the third test, the statistical distribution of the inefficiency variable u_{it} was determined by comparing half-normal and truncated-normal specifications. The rejection of the null hypothesis indicated that a truncated-normal was preferred. The fourth hypothesis relates to the empirical validity of the inclusion of the inefficiency variables that are shown in Table 2. The chi-squared (χ^2) value for this joint test supports the inclusion of these variables. Based on these diagnostic tests, we used the SFA approach to estimate a translog cost function with a truncated-normal distribution.

Table 3. Model Identification Process

Model	H_0	χ^2	Implications
OLS vs. SFA (translog)	Deviations from the best practice cost frontier are only due to statistical noise	156.32	Use SFA approach
SFA Cobb-Douglas vs. SFA translog (Truncated)	Parameters of the squared and interaction terms equal to 0	204.71	Specify a translog cost function
SFA half-normal vs. SFA truncated-normal	Inefficiency residuals follow a half-normal distribtion	95.76	Specify a truncated-normal distribution
SFA no efficiency effects vs. efficiency effects	Inefficiency parameters are not statistically different from 0	48.63	Include inefficiency effect variables

The parameter estimates for the translog cost function are reported in Table 4. We estimated this preferred model using the maximum likelihood approach outlined in Battese and Coelli (1995). The sign of the coefficients for outpatient visits (LNOPVISIT) and price of labor (LNPRICELABOR) do not correspond to our ex-ante expectations. This may be due to the presence of multicollinearity from the inclusion of squared and interaction terms.[12,30,b] The estimated coefficient for total discharges (LNDISCH) is significant and has the expected sign. The coefficients of the product descriptor variables accounting for output heterogeneity (CASEMIX, ERV%, and OPSURG%) are positive and significant with the exception of ERV%. These suggest a positive association between Medicare-patients' illness severity and hospital operating expenses. The coefficients for the summary performance scores (PERFOSCOREAMI, PERFOSCOREHF, PERFOSCOREPN) are all positive with the exception of the process of care score for pneumonia. However, that of heart failure is the only significant performance score ($p < 0.01$). This suggests that higher hospital costs may be an unintended consequence of the implementation of protocols designed to improve care quality. This is an important finding considering the passage of new PPACA pay-for-performance policies intended to reconcile healthcare cost growth and quality. The 2013 Institute of Medicine (IOM) cited concern for safety-net hospitals' abilities to effectively respond to such provisions.[32]

The coefficients for PRE_{2005_2007} and $POST_{2010\_2013}$ are positive and statistically significant. This association suggests that hospitals' operating costs in real terms were higher before and after the Great Recession (2008-2009). A new type of medical arms race may be afoot in which hospitals engage in "retail strategy" practices, such as the expansion of more profitable service lines via

[b] The estimated coefficients assuming a Cobb-Douglas cost function for the output and input variables are positive and significant ($p < 0.05$).

technology acquisition.[12, 33] The signs of these estimated coefficients lend support for this "retail strategy" hypothesis. Indeed, Cunningham et al. (2008)[33] found that safety-net hospitals, located in many communities that participated in the Community Tracking Study, adapted to demand shocks by upgrading facilities and offering more profitable services to attract patients with more generous insurance coverage.

Table 4. Estimation Results

Variable Name	Coefficient	t-statistics	Probability
Cost Function Variables			
Intercept	10.7760***	3.5650	0.0004
LNDISCH	0.9282**	2.0290	0.0425
LNOPVISIT	−0.5184**	-2.0534	0.0400
LNPRICELABOR	−1.1390***	-3.0717	0.0021
LN(DISCHSQ)	0.0021	0.0432	0.9656
LN(DISCH * OPVISIT)	−0.0297	-1.1534	0.2488
LN(DISCH * PRICELABOR)	−0.0233	-0.6231	0.5332
LN(OPVISITSQ)	0.0527***	2.9155	0.0036
LN(OPVISIT * PRICELABOR)	0.0446**	1.9893	0.0467
LN(PRICELABORSQ)	0.2171***	6.0327	0.0000
LICBEDS	0.0038***	12.1570	0.0000
CASEMIX	0.3351***	7.8519	0.0000
ERV%	0.0001	0.3610	0.7181
OPSURG%	0.0050***	3.4257	0.0006
PERFSCOREAMI	0.0399	0.3830	0.7017
PERFSCOREHF	0.3644***	4.9560	0.0000
PERFSCOREPN	−0.0408	-0.5536	0.5798
PRE_{2005_2007}	0.0683**	2.2256	0.0260
$POST_{2010\_2013}$	0.0575**	2.2322	0.0256
Inefficiency Effects Variables			
Intercept	0.2033**	2.3560	0.0185
GOVT	0.1480*	1.6484	0.0993
FORPROFIT	0.2039**	2.1447	0.0320
HHIDISCH	−0.3693***	-2.9454	0.0032
HMODISCH	−0.0038*	-1.8708	0.0614
MEDICAID%	0.0056**	2.1119	0.0347
MEDICARE%	−0.0114***	-3.3849	0.0007
UNINSURED%	−0.0062*	-1.6631	0.0963
PRE_{2005_2007}	−0.1526**	-2.2482	0.0246
$POST_{2010\_2013}$	−0.0109	-0.1863	0.8522
σ^2	0.1409***	5.7958	0.0000
γ	0.8975***	7.1096	0.0000

Note: *, **, and *** denote significance at the 10, 5, and 1 percent levels, respectively.

The estimated coefficients for the inefficiency-effects variables are also reported in Table 4. The coefficients for ownership status (GOVT and FORPROFIT) are both positive. These findings are consistent with those of previous studies that assess hospital cost efficiency.[13,34] Strategies that providers implement to grow profits involve cost reductions and revenue increases. These revenue increases can be achieved by employing "retail strategy" practices such as attracting greater amounts of insured patients and preferentially providing higher margin services. The latter is often identified as "cream-skimming", which in this context refers to the allocation of resources towards lower-cost services. Thus, successful cost reductions may not be associated with improved cost efficiency and the practice of "cream skimming" may resolve the apparent contradiction with Property Rights Theory that this result presents.[34]

The coefficient for MEDICARE% is negative and significant. This is expected given that reimbursement from Medicare is based on a prospective payment system and is usually below cost. This result evidences that hospitals respond to financial pressure from reimbursement policies by decreasing their cost inefficiency. The Medicaid caseload percentage is inversely related with hospital cost efficiency, while a greater proportion of uninsured patients is associated with higher cost efficiency. Hsieh et al. (2010)[13] also found Medicaid percentage to be negatively related with hospital cost efficiency. Safety-net hospitals rely heavily on Medicare and Medicaid DSH subsidies, which only covered half of hospitals' uncompensated care costs nationwide in 2008.[35] Thus, it is reasonable to assume that these providers will adapt to higher uncompensated care burdens with improvements to cost efficiency. Compared to the provision of uncompensated care, there is a relatively lower degree of financial uncertainty in the provision of care to Medicaid patients. This significantly diminished uncertainty is likely a product of the combination of being both subsidized and reimbursed for treating these patients. Thus, it is not incongruous that Medicaid caseload is inversely related with cost efficiency. It is worth noting that while hospitals DSH payments also depend on the amount of Medicare patients treated, the Medicare dependent portion of the subsidy is restricted to those patients who are eligible for the Supplemental Security Income program.

The negative coefficient for the HHI variable indicates that intensified market competition is associated with higher cost inefficiency. Despite the counterintuitive nature of this finding, it is in accord with the above inferences that these safety-net providers employed "retail strategy" practices and engaged in service-based competition. Previous studies have also noted the existence of service-based competition in the industry.[34,37]

The coefficient representing the years before the Great Recession (PRE_{2005_2007}) is negative and significant. This suggests that safety-net hospitals were more cost inefficient throughout the years of heightened financial pressure. We found no statistically significant increase in safety-net hospital cost inefficiency following the Great Recession ($POST_{2010\_2013}$). This may be reflective of safety-nets' characteristically vulnerable finances; their margins offer less of a buffer from financial turmoil than those of their peers. This inherent limitation may have necessitated that they attempt to halt any further substantial falls to cost efficiency. In view of the forthcoming reductions to DSH subsidies and other unique challenges for these safety-net providers, these findings bear valuable information for policy creation and refinement.

Table 5 reports the study's mean cost inefficiency estimates and the statistics of variables frequently used to measure hospital financial performance.[12,30] Throughout the study period, safety-net hospitals experienced an increase in their average cost inefficiency from 10.06 to 14.03 percent. Our finding that the average operating margin[c] for these providers is negative aligns with previous studies pertaining to this time period and reflects their inherent financial disadvantage.[7] Despite the negative mean operating margin, it is worth noting the substantial improvement in this measure since the Great Recession. The combination of this finding with that of the mean trend in cost inefficiency may suggest CA safety-net providers implemented other methods of promoting financial viability. Some of these practices may include "cream-skimming" and other strategies that are detrimental to the well-being of safety-net hospitals' patients.

Table 5. Summary Statistics for Performance Measures

	All Years		Pre Great Recession		Great Recession		Post Great Recession	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Cost inefficiency	0.1239	0.0854	0.1006	0.0786	0.1425	0.1112	0.1403	0.106
Operating cost per adj. day	2,389	966	2,146	839	2,322	957	2,663	1,027
Operating margin	-0.058	0.163	-0.075	0.151	-0.072	0.181	-0.037	0.155
FTE per adj. day	0.014	0.005	0.013	0.004	0.014	0.005	0.015	0.006
Total asset turnover	1.543	0.845	1.573	0.803	1.442	0.811	1.381	0.798
Fixed asset turnover	3.843	2.120	3.855	2.123	3.697	2.124	3.793	2.088
Current asset turnover	1.033	0.273	1.044	0.343	1.039	0.306	1.023	0.184

Note: The mean values for the variables listed above are statistically different at the 1 percent level when compared across periods (except for cost inefficiency during and after the Great Recession).

Table 6 shows Pearson correlation coefficients between the estimated cost-inefficiency scores and several standard financial measures. The reported positive correlation for operating costs per adjusted day, a general measure of cost inefficiency, supports the use of SFA for hospital cost-efficiency analysis.

[c] Operating margin is defined as: (net patient revenue - operating expenses) / net patient revenue.

Table 6. Pearson Correlations between SFA Cost Inefficiencies and Financial Measures

Variable	Pre Great Recession	Great Recession	Post Recession
Operating cost per adjusted day	0.571***	0.513***	0.549***
Operating margin	-0.421***	-0.382***	-0.395***
FTE per adjusted day	-0.207***	-0.268***	-0.284***
Total asset turnover	-0.327**	-0.276**	-0.305**
Fixed asset turnover	-0.174**	-0.189**	-0.178**
Current asset turnover	-0.164**	-0.162**	-0.157**

Note: *, **, and *** denote significance at the 10, 5, and 1 percent levels, respectively.

The negative correlation coefficient for operating margin, a measure of hospital profitability, suggests that hospital profitability suffers as efficiency falls. The number of full-time-equivalent employees per adjusted day, interpreted as the inverse of labor productivity, has a positive correlation with cost inefficiency. The signs of the correlation coefficients for the other reported financial measure were also anticipated given the SFA estimates.

Conclusion

U.S. safety-net hospitals are commissioned to support access to the nation's most financially vulnerable. Communities depend on these hospitals for the provision of specialty services that are typically low margin but vital to the promotion of health. While many of these hospitals survived economic downturns and reductions to their DSH subsidies, they are inherently financially disadvantaged.[7] If these hospitals maintained their commitment to uphold greater access and provide low-margin services, their coping strategies may have involved efficiency improvement.[10] Using SFA, we assessed changes to safety-net hospitals' cost efficiency through the years 2005 to 2013 with controls for process-of-care quality and patient burden of illness. Based on a translog cost function, the average estimated safety-net hospital cost inefficiency worsened from 10.06 percent before the Great Recession, to 14.25 percent during the downturn, and fell to 14.03 percent in its immediate aftermath. However, the cost inefficiency between the recession and post-recession years were not statistically different from each other. Though this suggests that safety-net hospitals prevented further attrition of their cost efficiency, it remains well below that of the pre-recession years.

The above results have important policy implications given safety-net hospitals' previous behavior under increased financial restriction, their performance in recently enacted PPACA provisions, and forthcoming DSH-subsidy reductions. The Balanced Budget Act instituted nationwide DSH allotment cuts of $10.4 billion between 1998 and 2003 were shown to have negatively affected uncompensated-care provision in CA.[37] Recent studies found that safety-net hospitals fared worse financially in newly-established reimbursement policies (Gilman et al., 2014; Gilman et al., 2015).[14,22] Gilman et al. (2014)[14] found that CA safety-net hospitals were more likely to be penalized by Electronic Health Record Meaningful-Use criteria and the Hospital Value-Based Purchasing and Hospital Readmissions Reduction programs. Additional budget concerns spring from the anticipation of the PPACA seventy-five percent reduction to traditional DSH payments.[38] Neuhausen et al. (2014)[39] find in their national study that forthcoming reductions to disproportionate-share payments will exacerbate the burden of uncompensated care for safety-net hospitals, even after consideration for the increased patient volume stemming from insurance expansion.

In response to the aforementioned budget pressures, safety-net hospitals may reorient towards profit-maximization strategies that do not require efficiency improvements. These include the directing of available resources to supply higher-margin services and attract insured patients without improving efficiency. Often described as “cream-skimming”, this may have been a mechanism by which these providers achieved profit increases and survived the Great Recession. “Cream-skimming” is a deviation from the primary purpose of safety-net hospitals to serve those patients that rely on uncompensated care. Our result that for-profit safety-net hospitals were less efficient than their nonprofit peers, combined with the lack of significant cost-efficiency improvements since the recent recession, suggests the presence of “cream-skimming” practices. Further, certain CA safety-net hospitals will be shifted to a cost-based reimbursement in the near future which could deteriorate the already worsened cost efficiency.[30,39]

The selection of safety-net hospitals for our studied sample and the restricted perspective that SFA gives of health production are two limitations to this analysis. As there is no established definition for what constitutes a safety-net hospital, we followed previous studies and selected the providers with Medicare DSH percentages in the highest quartile (Chatterjee et al., 2012; Gilman et al., 2014; Gilman et al., 2015).[14,22] Similar to Reiter et al. (2014)[7], we restricted the panel to hospitals that had safety-net status in 2005 and remained open throughout the study period. Therefore, generalizing the findings that are based on this group of safety-net survivors should be done after careful consideration. The second limitation is that SFA provides insight into the efficiency of the provision of medical care, which is only an intermediate good in healthcare production; medical care is one of many determinants of health.[40]

The value of safety-net hospital cost-efficiency analysis is clear in light of the Great Recession, newly-implemented pay-for-performance policies, and imminent DSH payment reductions. Restrictive payments and the PPACA’s insurance expansion remain critical issues for U.S. health care’s safety net.[41] These extra sources of budget pressure may intensify the prevalence of practices among safety-net hospitals that compete with their designated mission. Therefore, as new policies are developed, consideration must be taken for the implications of providers’ concurrent responses that may inadvertently construct barriers to healthcare access for the poor.

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