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The Cost And Technical Efficiency Of Nursing Homes: Do Five–star Quality Ratings Matter?

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THE COST AND TECHNICAL EFFICIENCY OF NURSING HOMES:
DO FIVE–STAR QUALITY RATINGS MATTER?

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DEDICATION

To my parents, daughter, and wife

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CHAPTER 1 INTRODUCTION

1.1 The Importance of Nursing Home Quality

With the aging of the baby-boomers, the quality of long-term care for the elderly has become an urgent concern. The quality of care services provided in nursing homes, however, is very poor. For example, about 36% of all US nursing homes in 2014 have overall rating of 1 or 2 stars and it accounts to 39% of all nursing homes residents [1]. This implies more than one-third nursing homes provide very low quality of care. On the other hand, the nursing homes in US are costly. As of 2015 in US, the annual median cost of a semi-private room in a nursing home is $80,300 and that of a private room is $91,250 [2].

Cost, quality of care, and access to health care are closely linked. Performance changes in one area may affect the others. For example, a nursing home may reduce the cost of care by reducing the quality of care. So, the measurement of quality of care, and finding its association with cost and access to care are crucial.

This dissertation contains two completed essays on nursing home quality, both using a database of California nursing homes. Essay 1 seeks to investigate whether there exists a tradeoff between cost reduction and quality improvement. The study also seeks to find out a possibility of quality improvement without raising cost or even with a lower cost. The impacts of quality adjustment on the estimate of economic performance i.e., cost efficiency is also being investigated. In order to address these queries, the study employs stochastic frontier approach with inefficiency effects for panel data to investigate the associations among cost, quality of care, and cost efficiency of nursing homes. For quality of care, the study uses three five-star quality ratings of nursing homes. Cost refers to the average annual cost of a nursing from the sample. The cost efficiency measures the ability of a nursing home to produce the given output at the minimum expenditure.

The second essay seeks to compare the economic performance i.e., technical efficiency of nursing homes before and after quality adjustment. In other words, it tries to find out the impacts of quality on care process of nursing homes. The paper also seeks to find whether a higher staff per resident always leads to a better care process. The possibility of improving care quality without requiring additional input or even with fewer inputs is also being investigated. To address the above queries (issues), the study employs two-stage data envelopment analysis to find the relationship between technical efficiency and three five-star quality ratings of nursing homes. In the first stage, the study applies input oriented variable returns to scale model. With this approach, it tries to estimate the technical efficiency of nursing homes with and without quality adjustment. In the second stage, the study uses left censored Tobit regression model. At this stage, the paper seeks to investigate the effects of various environmental variables on technical efficiency. Technical efficiency measures the ability of a nursing home in producing given output with the minimum inputs.

Following this opening brief chapter, I present the two essays. Chapter 4 discusses the findings and the limitations, and provides suggestions for future research on this important topic.

CHAPTER 2 COST EFFICIENCY OF NURSING HOMES: DO FIVE-STAR QUALITY RATINGS MATTER?[1]

2.1 Introduction

Nursing homes are under increasing pressure to reduce costs. This has increased interest in estimating inefficiency and identifying ways to reduce it. At the same time, long term care (LTC) providers are under increasing pressure to improve quality of care. This paper investigates the association between costs and quality of care in nursing homes and between cost inefficiency and quality of care.

Since health care markets are not perfectly competitive [3], health-care firms may exhibit inefficiencies. Cost inefficiency aggregates technical, allocative, and scale inefficiencies. Technical inefficiency occurs when a firm is not maximizing output given its set of inputs. Allocative inefficiency arises when a firm is not using the lowest cost combination of inputs given its level of output. Scale inefficiency results when a firm departs from the minimum point of its long- run average cost curve.

Quality of care is a multi-dimensional concept that is challenging to define and quantify. One widely used approach developed by Donabedian [4] maintains that quality of care has three main dimensions: structural characteristics, processes used in care, and the outcomes of care. Since December 2008, the Center for Medicare and Medicaid Services (CMS) has maintained a publicly-available five-star quality rating system for nursing homes that participate in Medicaid or Medicare. On its website, *Nursing Home Compare*, CMS reports on three aspects of quality: health inspection ratings, quality measures ratings and staffing ratings. This apparently simple five-star rating system is based on complicated behind-the-scenes computations. The CMS quality rating

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system attempts to capture the multi-dimensional nature of quality, and provide incentives for nursing homes to improve their performance.

Cost, quality of services, and access to health care are closely intertwined. Performance changes in one area may affect the performance of others. Quality improvement achieved through additional resource allocation may increase costs and reduce access [5]. Similarly, cost containment may occur through reduction in quality of services. For example, Konetzka and colleagues [6] find that the introduction of Medicare's Prospective Payment System (PPS) for skilled nursing facilities (SNFs) had unintended negative effects on quality of care, although the goal of the policy change was cost reduction. Still, it might be possible to achieve higher quality of care with the existing resources or the same quality of care with fewer resources. This could be achieved by either the use of better processes or by better process execution. Hence, it warrants an integrative perspective that explores the association between efficiencies and quality of services.

Most previous studies of nursing homes have treated costs, quality and efficiency as separate dimensions of performance. Some scholars have studied the relationship between costs and quality, but few quantify the association between efficiency and quality. This is the first empirical study (to my knowledge) to investigate the relationship of cost inefficiency with five star quality ratings of nursing homes.

2.2 Literature Review

A growing number of scholars have estimated the inefficiency of health care organizations, including nursing homes. Anderson et al. [7] employ stochastic frontier analysis (SFA) to study the cost efficiency of 653 nursing homes surveyed in 1995.Their results suggest that for-profit facilities are more cost efficient than non-profits, and independent facilities are more cost efficient than chain-affiliated facilities. Bjorkgren and colleagues [8] use data envelopment analysis (DEA)

to measure the cost efficiency of 64 long term care units in Finland in 1995. They find considerable variation in cost efficiency across units in the sample and also between units of the same main care facility. They suggest this implies that it may be possible to improve the cost efficiency of nursing homes through better management and a reallocation of resources.

D'Amico et al. [9] employ SFA to estimate the cost inefficiency of long-term care facilities in the U.K. using a panel dataset covering 2002-2007. They find a slight decrease in inefficiency over the study period. They also find the cost-output elasticity of independent care-providers is greater than that of community care service facilities. Duffy and Colleagues [10] use the DEA as a benchmarking methodology for estimating efficiency of 69 long-term care facilities. Their results suggest that for-profits are more efficient than non-profits. Heimeshoff and colleagues [11] estimate both the cost and technical inefficiency of physician practices using a panel data of 3,126 physicians in Germany for the years 2006-2008. Interestingly, their results suggest that the technical efficiency of group practices is higher than that of solo practices, whereas the opposite is true for cost efficiency. These findings illustrate the usefulness of investigating *both* the cost efficiency and the technical efficiency of healthcare organizations. Efficiency in one realm does not imply efficiency in the other.

Knox and colleagues [12] use modified translog cost and profit-function regression analysis to examine differences in economic efficiency among various non-profit nursing homes in Texas. Using panel data from 1994, 1998 and 1999 they compare three types of non-profit nursing homes: government facilities, religious-affiliated nursing homes, and private non-profit nursing homes. Their findings reveal significant difference in efficiency across these types of non-profit nursing homes. Private sector non-profit nursing homes are the most cost-efficient, followed by religious-affiliated and then government facilities.

Only a few studies have attempted to incorporate quality of care into their analysis of the cost efficiency of healthcare providers. Murillo-Zamarano and Petraglia [13] employ SFA to study the impact of adjusting for quality on estimates of technical efficiency among 85 primary care centers in Spain in 2006. They find that the average efficiency of primary care centers fall from 84% to 58% after adjusting for quality. Rosko and colleagues [14] use DEA techniques to estimate the determinants of cost efficiency among 461 nursing homes in Pennsylvania in 1987. Their findings show that cost efficiency is unrelated to either process or outcome measures of quality, but it is associated with managerial and environmental factors. Laine et al. [15] investigate the association between quality of care and cost efficiency in institutional long-term care wards in Finland in 2001. They estimate an SFA cost function with inefficiency effects. Their results suggest that a higher prevalence of pressure ulcers is associated with higher costs. They also find that a greater use of depressants and hypnotics decrease cost efficiency.

More recently, Zhang et al. [16] employ DEA methods to study the impact of the introduction of Medicare PPS on the cost efficiency of SNFs. They study 8,361 SNFs over the period, 1997 to 2003, and find that the switch to PPS had a significant negative impact on efficiency. Higher nurse staffing is associated with lower efficiency only when quality is not incorporated into the analysis. Shimshak and colleagues [17] estimate the efficiency of 38 nursing homes in Massachusetts in 2003 using DEA methods, and investigate the impact of different measures of quality on the estimation of efficiency. Their findings reveal that quality of care is critical to assessing efficiency and its impact depends upon the weight assigned to the quality. Garavaglia and colleagues [18] also use DEA methods to study the association of care quality with the efficiency of 40 nursing homes in Italy during 2005-2007. They find that quality of care is positively associated with efficiency when nursing homes can implement a labor cost containment

strategy. Delellis and Ozcan [19] employ DEA in a study of U.S. nursing homes in 2008. They examine the relationship between quality of care and the efficiency of nursing homes and find mostly favorable quality outcomes for efficient nursing homes. They also find that efficiency in nursing homes is positively related to being located in an urban area, being in a market with greater competition, and being a non-profit or government facility.

With a few exceptions, such as Rosko and Colleagues [14, 20], analysis/review show that most studies have ignored measures of care quality in their analysis of cost efficiency estimation. Inclusion of numerous quality dimensions can potentially improve efficiency estimation. Similarly, most of the studies that use the SFA approach and explore association between efficiency and quality in nursing homes are restricted to cross-sectional data. Applying SFA to panel data, however has some potential advantages, such as an increase in degrees of freedom and possible relaxation of the strong distributional assumptions that are required for cross-sectional data [21, 22].

This study estimates the cost efficiency of nursing homes and investigates its association with the recently launched five star quality ratings. The ratings incorporate multiple quality dimensions and should improve the precision of estimates. The use of recent panel data covering 2009 through 2013 not only brings the research up-to-date but also increases the robustness of the results.

2.3. Theoretical Framework

2.3.1 Cost efficiency

Cost efficiency measures the ability of a firm to produce a given output with minimum expenditure. It can be expressed as the ratio of estimated minimum cost to the firm's actual cost of producing its output. Cost efficiency results when a firm achieves technical, allocative, and

scale efficiencies. In other words, a firm is considered cost efficient only if the firm chooses the right mix of inputs, uses them in a technically efficient manner, and produces at the minimum point of long-run average cost curve.

2.3.2 Stochastic frontier analysis (SFA)

SFA is an increasingly popular method for estimating the cost efficiency of healthcare organizations. The method was developed independently by Meeusen and van den Broeck [23] and Aigner et al. [24] in 1977. SFA decomposes a firm's deviation from the best-practice cost or production frontier into two terms, a randomly distributed shock term and a deterministic error term, the later of which reflects inefficiency. Following the literature of healthcare organizations [20], this study posits that nursing home costs can be described by a hybrid cost function:

$$TC_{it} = f(Y_{it}, W_{it}, PD_{it}) + e_{it}, \qquad\qquad (1)$$

where TC is total costs; Y is a vector of multiple outputs; W is a vector of input prices; PD is a vector of product characteristics or descriptors; i indexes nursing home; t indexes the year of observation, and e is the composite error term, which can be decomposed as:

$$e_{it} = v_{it} + u_{it} \qquad\qquad (2)$$

where v is the random shock, assumed to be distributed as $N(0, \sigma^2)$, and u is a positive deviation from the cost-frontier and reflects cost-inefficiency.

Critics have argued that SFA methods offer no prior justification or theoretical reasoning for the choice of particular distribution of u [22]. However, the specification of a more general distribution, such as the truncated normal which is used in this study, partially addresses this concern [25]. Additionally, the literature [20] has shown that the choice of a particular distribution has little effect on the estimated relative inefficiency of different firms in the sample.

Greene [21] and Rosko and Mutter [20] underscore the importance of controlling for product characteristics when measuring inefficiency. In the case of healthcare, failure to control for variation in the amount or type of care required by patients can lead to biased estimates of inefficiency [20, 21]. This study uses a range of product descriptors, including resident case mix and multiple dimensions of quality of care.

2.3.3 Five-star quality ratings

Since December 2008, CMS has published a set of quality ratings for each nursing home that participates in Medicare or Medicaid. The ratings are in the form of "star" rating and are available from the *Nursing Home Compare* website maintained by CMS [26]. A one-star rating is the worst a nursing home can receive whereas a five-star rating is the best. The overall rating is based on a nursing home's performance in three areas of quality: how it scored during its heath inspection, its staffing levels, and its scoring on quality measures (QMs) obtained from the minimum data set (MDS) [27].

2.3.3.1 Health inspection rating

The health inspection component of the five-star rating is based on the number, scope and severity of deficiencies identified during the most recent annual health inspection surveys. Unannounced and conducted by a team of state surveyors, these standard surveys provide a comprehensive assessment of the facility's performance in areas such as medication management, skin care, resident needs, nursing home administration, environment, residents' rights, kitchen/food services, etc. Deficiencies are weighted by their scope and severity. The rating also encompasses any substantiated findings from complaint investigations conducted during a recent 36 month period.

2.3.3.2 Staffing rating

Nursing homes ratings for staffing are based on its Registered Nurse (RN) hours per resident day and total nursing hours per resident day. Total nursing hours is the sum of Registered Nurse (RN), Licensed Practical Nurse (LPN) and Nurse Aide (NA) hours. Both staffing measures are equally weighted and are adjusted for resident case-mix using data from the MDS.

2.3.3.3 Quality measures rating

A facility's rating for the quality measures (QMs) are based on its performance on quality measures in the MDS. Up until June 2012, the rating was based on 10 out of 19 MDS 2.0 quality measures. Since June 2012, the rating has been based on 9 out of 18 MDS 3.0 quality measures, which are posted on the Nursing Home Compare Website. Out of 9 quality measures, 7 pertain to long-stay residents and 2 pertain to short stay residents (Appendix A).

2.4. Research Design and Method

2.4.1 Data

Data covering 2009-2013 from three sources are utilized: (1) the Nursing Home Compare website maintained by CMS; (2) CMS's Online Survey, Certification and Reporting or Certification And Survey Provider Enhanced Reports (OSCAR/CASPER), and (3) nursing home cost reports from the Office of Statewide Health Planning and Development (OSHPD) in California. The Nursing Home Compare website provides facility-level data on the five star quality ratings for each nursing home in each year. Similarly, the OSCAR/CASPER datasets are used to calculate a case-mix index for each nursing home in each year (Appendix B). Finally, cost reports from OSHPD include annual financial reports submitted by all nursing homes in California during these years.

The final analytic dataset is an unbalanced panel database spanning 2009-2013, with the number of nursing homes ranging from a low of 761 in 2009 to a high of 919 in 2012. Each year's

sample is the result of merging data from the three sources described above, and cleaning of the data. During the data-cleaning process, nursing homes with ratings values greater than 50 are dropped from the sample. In computing star-ratings, CMS assigns the rating values 10, 20, 30, 40 and 50 as one, two, three, four and five stars respectively. Thus, ratings greater than 50 imply either a wrong data entry or insufficient data. Similarly, nursing homes with zero hours of registered nurse (RN) are also excluded.

2.4.2 Model specification

Following previous researchers [12, 28], a hybrid translog cost function is employed for the stochastic frontier:

$$ln TC_{it} = \alpha_0 + \sum_{m=1}^{M} \alpha_m ln Y_{mit} + \sum_{n=1}^{N} \beta_n ln W_{nit} + .5 \sum_{m=1}^{M} \sum_{r=1}^{R} \gamma_{mr} ln Y_{mit} ln Y_{rit} +$$

$$.5 \sum_{n=1}^{N} \sum_{l=1}^{L} \delta_{nl} ln W_{nit} ln W_{lit} + \sum_{m=1}^{M} \sum_{n=1}^{N} \eta_{mn} ln Y_{mit} ln W_{nit} + \sum_{s=1}^{S} \theta_s PD_{sit} + v_{it} + u_{it} \qquad \textbf{(3)}$$

where *TC*, *Y*, *W*, *PD*, *v* and *u* are as described earlier. M is the number of output variables; N is the number of input variables; S is the number of product descriptor variables; and *α, β, γ, δ, η* and *θ* are parameters to be estimated.

Cost inefficiency is modeled using a time-varying inefficiency effects model for panel data, as suggested by Battese and Coelli [29]:

$$u_{it} = \sum_{n=1}^{N} k_n Z_{it} + X_{it}, \quad u_{it} \geq 0 \qquad \textbf{(4)}$$

where Z_{it} is a vector of N explanatory variables associated with the inefficiency effects; *k* is a vector of unknown parameters to be estimated; and X_{it} are unobservable random variables. Of interest is the impact of firm-specific and environmental factors on inefficiency. The inclusion of

time indicators along with other variables in *Z* facilitates examining how inefficiency changed over the 2009-2013 period.

Parameters of the cost frontier in (3) and the inefficiency effects model in (4) are simultaneously estimated by maximum likelihood methods using STATA. After estimating cost inefficiency (the u_{it}'s) using the above methods, the cost efficiency of each nursing home is then calculated as:

$CE_{it} = exp(-u_{it})$ **(5)**

where CE_{it} is cost efficiency and u_{it} is cost inefficiency defined earlier [30].

2.4.3 Cost function variables

A cost frontier must be linearly homogenous in input prices. I use the average full time equivalent (FTE) wage of RNs, one of the input prices, to normalize the cost function. The literature shows estimation results do not depend upon the input price chosen for normalization [31]. Hence, the dependent variable in equation (3) is log (total expense/wage rate). All continuous input prices and output variables are log-transformed, and the outputs are assumed to be exogenous, consistent with previous cost studies of healthcare organizations [32].

The price of capital is approximated by the sum of depreciation, lease and interest expenses per bed. Prices for the following labor inputs are also included in the cost function: Management (MGT), Registered Nurses (RN), Licensed Practical Nurses (LVN) and Nurse Aides (NA). For each category, input price is approximated by the annual salary per full-time equivalent employee in that category, and is calculated as:

FTE wage = (Total annual wage and salaries / annual productive hours) * 2080

Two outputs and three product descriptor variables are included in the cost function. The two outputs are annual inpatient days and the annual number of discharges. The three product

descriptors are the case-mix index, the star rating for quality measures (QMs), and the star rating from the health inspection. Donabedian [4] defines an outcome measure of quality as "a change in the patient's current and future health status that can be attributed to antecedent health care" (Donbedian, 1980, p.83). Since two of the quality ratings, specifically the rating on quality measures and health inspection rating, fit well with this definition, they are treated as outcome measures of quality and are included in the cost function as product descriptors. These product descriptors reflect output heterogeneity because providing care to more needy patients typically requires more resources, as does providing higher quality care. The quality measure for staffing levels is not included in the cost function because it reflects an input level more than it reflects output heterogeneity. The case mix index is expressed in minutes and is estimated using weights based on the management minutes system designed by Thoms and Schlesinger and used by Cohen and Spector [33] (Appendix B). The cost function frontier also includes a time trend.

2.4.4 Determinants of inefficiency effects

A number of firm-specific and environmental variables are included in equation (4), the model for cost inefficiency. To study the impact of ownership on inefficiency, a binary variable for investor owned nursing homes (for-profit) and the other nursing homes is used. The other nursing homes category includes non-profit nursing homes, governmental facilities and church-related nursing homes. Also included is an indicator for whether the nursing home is part of a larger multi-facility system, and a time trend. The latter should capture changes in inefficiency over time.

The efficiency of nursing homes belonging to a multi-facility system may differ from that of free-standing nursing homes. So, multi-facility membership is entered as a binary variable to capture its effect on inefficiency. Medicare and Medicaid patients are often viewed as two separate

populations of residents, with different lengths of stay and often different acuity levels. The percentages of Medicare patients and Medicaid patients out of total admissions are also included in the inefficiency effects to investigate whether having a larger fraction of Medicare or Medicaid patients encourages a facility to be more or less cost efficient.

The staffing level rating is included as a determinant of inefficiency. According to Donabedian [4], structure denotes the characteristics of the settings in which care occurs. This includes the characteristics of human resources such as number and qualifications of personnel, and the staffing rating fits well with this notion. Also, as noted earlier, because it reflects the level of nursing inputs, it is not included as product descriptor in the cost function. On a more practical level, following Greene [21], when I attempted to include the staffing rating in the cost function, the resulting model estimates made little sense, e.g., the estimated value of σ_u jumped to greater than 1 and all variables in the inefficiency equation became insignificant, whereas the estimates were reasonable with the inclusion of the staffing rating in the model for inefficiency. Thus, the staffing rating belongs more appropriately in the inefficiency model rather than in the cost function. Finally, a time trend is also included to capture variation in inefficiency over time. Descriptive statistics on the variables are provided in Table 1.

2.5. Results

2.5.1 Model specification

This study assumes a hybrid translog function for the stochastic cost frontier together with a truncated-normal, time-varying inefficiency effects model. This choice is based on the results of three likelihood ratio tests. The first likelihood ratio tests the appropriateness of using truncated normal distribution against half-normal for inefficiency term assuming that the later distribution is nested in the former. The hypothesis that the distribution of the error term is half-normal is rejected

by the data (χ^2 = 16.81 (p <0.01)) for the year 2013. The estimated mean cost inefficiencies from the two models (half-normal and truncated normal) are highly correlated (r = 0.9408). Similar results found for the rest of the years (not shown, but available upon request). The second test hypothesizes that the hybrid translog function in equation (3) can be approximated by a Cobb-Douglas form. This hypothesis is firmly rejected by the data (χ^2 = 37.57 (p<0.01)). The third test hypothesizes that the inefficiency effects model is not needed, and this too is firmly rejected by the data (χ^2 = 20.09 (p<0.01)). Thus, the hybrid translog function with an inefficiency effects model is the preferred model for this sample of nursing homes.

2.5.2 Results from cost function estimation

Table 2 reports parameters for the estimated cost function. The table shows that some of the estimated coefficients of the input prices are counter intuitive or statistically insignificant at the 5% level. This results from multicollinearity due to the presence of the squared and interaction terms for these variables. Once the parameters of the squared and interaction terms are set to zero, the translog converts to the Cobb-Douglas (C-D) model. The coefficients of the input prices and output variables are statistically significant and have expected signs. The mean cost inefficiency increases slightly from 0.115 to 0.129 when the C-D model is adopted and the estimated cost inefficiencies from the two models (translog and C-D) are highly correlated (r = 0.946).

The coefficients on the output variables have the expected signs. Having more discharges in a year raises costs. Similarly, having more inpatient days in a year also raises costs. The calculated case-mix index, measured in minutes, is also positive and significant, indicating that residents with higher resource requirements also raise costs.

The rating for quality measures, a key variable of interest, is negatively related to costs and statistically significant. The associated cost elasticity for the quality measures is -.039, indicating

that a 10% increase (improvement) in rating on the quality measures decreases nursing home costs by .39%. Similarly, the calculated marginal effect of the rating for quality measures at the mean is -$10,101. This implies that an improvement in quality measures by a score of 10 points (1 star) would decrease annual total costs by $101,010 in the average nursing home. One interpretation is that better patient outcomes from improved quality require fewer resources, which ultimately decreases costs. The second dimension of quality, the health inspection rating, has no impact on costs. Finally, the positive and significant time trend suggests there is an upward shift in nursing home costs over the 2009-2013 period.

2.5.3 Results from inefficiency effects estimation

Table 3 shows parameter estimates for the model of determinants of inefficiency. Consistent with prior studies [34, 35], having a greater percentage of Medicaid admissions reduced inefficiency, whereas having a greater percentage of Medicare admissions increased inefficiency. The staffing rating is positively and significantly related to inefficiency. The magnitude of the effects of changes in structure quality measures upon inefficiency is obtained by calculating marginal effect. Following Wang [36], I calculate the marginal effect of the quality rating on the unconditional mean of inefficiency. The marginal effect of the staffing (structure) rating is .003254.

The inefficiency effects model also suggests that for-profit nursing homes are more cost efficient than the other nursing homes. Nursing homes affiliated with multi-facility systems are less efficient than their free-standing counterparts. One interpretation is that homes which are members of chains have another top layer of management adding to their expenses, thereby reducing efficiency.

2.5.4 Effects of quality adjustment on efficiency/efficiency rankings of nursing homes

This section considers the impact of quality adjustment, i.e., the inclusion of quality ratings in the analysis, on cost efficiency and rankings of nursing homes based on their cost efficiency. Table 5 illustrates the rankings of the twenty most cost efficient nursing homes in 2013 when quality variables are ignored, and the rankings of these same 20 nursing homes when estimates of efficiency are adjusted for quality. Similarly, Fig 1 plots the ranks of the twenty most efficient nursing homes against their respective ranks after adjusting for quality. Most of these 20 nursing homes experienced a substantial change in rank after adjusting for quality ratings in the analysis. For example, the nursing homes that rank 7th, 8th and 9th in efficiency when quality is ignored fall to 14th, 11th and 17th in the rankings, respectively, once quality is incorporated into the analysis. This clearly illustrates how misleading an efficiency ranking of nursing homes can be if it is based solely on measures of health services and not adjusted for quality of care. Similar results are found for the rankings of nursing homes in other years, as well as for the overall multi-year ranking (not shown, but available upon request). This shows that quality adjustment is crucial for the reliable measurement of relative cost efficiencies of nursing homes.

In order to further analysis the impact of quality adjustment on cost efficiency, I compare the estimated mean cost inefficiencies with and without quality adjustment in the cost frontier. The quality adjustment, however, has no effect on the mean cost inefficiency. The estimated mean cost inefficiency changes from 0.1146 to 0.1147 after adjusting quality in the cost frontier. The estimated inefficiencies under the two specifications are highly correlated with Spearman rank correlation coefficient = 0.98 ($P > 0.01$). Although correlations are very strong, the inclusion of quality in the cost frontier can have a significant impact on the estimate of individual nursing home inefficiency. For example, the estimated highest cost inefficiency changes from 0.645 to 0.651

after adjusting quality for the year 2013. Similarly, the estimated lowest cost inefficiency changes from 0.0142 to 0.0140.

2.6 Discussion

Three main findings emerge from this analysis. First, different measures of quality have different relationships with cost and cost efficiency. In particular, the five-star rating for quality measures is inversely related to costs, but has no effect on the estimated mean cost inefficiency. This implies higher quality nursing homes, according to this measure, incur lower total annual health care costs. A higher score reflects a less frequent occurrence of negative patient ailments, such as pressure sores, urinary tract infections, physical restraints, moderate to severe pain, and other problems that can occur in nursing homes. At the same time, another measure of quality, a facility's rating based on its health inspection, is found to be unrelated to cost. The rating also has no effect on the estimated mean cost inefficiency. It also indicates that different dimensions of quality relate to costs differently, most likely because they entail different resource requirements.

Second, staffing level per resident, which is a structural measure of quality, is found to be negatively associated with cost efficiency. This finding, together with the first one, suggests that to improve both quality and cost efficiency, nursing homes should focus on improving the processes and procedures used in caring for patients, instead of simply raising staffing ratios.

Finally, given a sample of nursing homes, their relative rankings in terms of cost efficiency (e.g., 1st, 2nd, 3rd, and so on) depend critically on whether the efficiency estimates have adjusted for care quality. In this sample of California nursing homes, not adjusting for quality leads to a misleading efficiency ranking of facilities, one that is very different than when there is a proper adjustment for care quality. This suggests that quality adjustment is essential for both the reliable measurement of cost efficiency and correct ranking of nursing homes.

A number of caveats to this analysis should be noted. First, the sample studied is limited to California nursing homes that participated in Medicaid or Medicare over the 2009-2013 period, and those nursing homes may not be representative of nursing homes elsewhere. Second, the case-mix index is calculated using methods developed by Thoms and Schlesinger and used by Cohen and Spector [33]. A more comprehensive case-mix index based on the Resource Utilization Group (RUGs) would have been desirable. However, the RUGs were updated from RUGs-III to RUGs-IV during the observed time period, which make it difficult to compare over the period of the data analyzed here.

Table 1 Variables and descriptive statistics (per nursing home, 2009 - 2013)		
Variables	Mean	Standard Deviation
Cost function variables		
Total annual healthcare expenditure ($)	8,188,830	4,295,660
Case-mix index (minutes)	179.4566	43.42507
Inpatient days	31,627.19	15,803.44
Number of discharges	323.3306	282.6714
Annual FTE wage of registered nurse ($)	69,880.24	14,741.48
Annual FTE wage of management ($)	104,855.1	27,176.66
Annual FTE wage of licensed practical nurse ($)	53,007.87	8,046.173
Annual FTE wage of nurse aides ($)	26,249.18	4,807.206
Price of capital ($)	5,712.92	3,347.922
Average score for quality measure ratings	31.7132	13.18235
Average score of health inspection ratings	27.59584	12.62452
Inefficiency- effect variables		
Average score of staffing ratings	31.16659	11.42766
Medicaid admissions as a percentage of total admissions	63.60261	24.41657
Medicare admissions as a percentage of total admissions	15.7445	13.6492
Investor-owned (for-profit) nursing homes	.8849976	.3190626
Member of multi-facility system	.5229531	.499532

Note. FTE = full time equivalent.

Table 2 Parameter estimates for the SFA cost frontier model (n=4177, 2009-2013)

Variable	Coefficient	Z	P > |Z|
Ln(Number of discharges)	.3778971**	7.21	0.000
Ln(Inpatient days)	1.062402**	19.44	0.000
Ln(Case-mix index)	.0574563**	10.12	0.000
Ln(Rating for quality measures)	-.039119**	-9.75	0.000
Ln(Rating for health inspection)	-.0039607	-1.03	0.305
Ln(Price of management)	.2527213	1.05	0.293
Ln(Price of Licensed Practical Nurse)	-.4426105	-0.81	0.419
Ln(Price of Nurse Aides)	.7077089	1.69	0.091
Ln(Price of Capital)	.1217248	1.64	0.101
Ln(Number of discharges squared)	.0675607**	12.35	0.000
Ln(Capital Squared)	.0509408**	11.78	0.000
Ln(Price of Management-squared)	-.0305912	-0.54	0.588
Ln(Price of Licensed Practical Nurse-squared)	.8048612**	5.24	0.000
Ln(Price of Nurse Aides-squared)	.7335202**	4.84	0.000
Ln(Price of capital*price of management)	-.0991738**	-3.03	0.002
Ln(Price of Capital*price of Licensed Practical Nurse)	-.0618413	-0.92	0.358
Ln(Price of capital*price of Nursing Aides)	-.2935602**	-5.25	0.000
Ln(Price of management*price of Licensed Practical Nurse)	.2513252	1.48	0.138
Ln(Price of management*price of Nursing Aides)	-.3749854**	-2.40	0.017
Ln(Price of Licensed Practical Nurse*price of Nursing Aid)	-1.364154**	-4.99	0.000
Ln(Inpatient days*price of capital)	-.0008549	-0.12	0.903
Ln(Inpatient days*price of management)	-.0426622	-1.56	0.118
Ln(Inpatient days*price of Licensed Practical Nurse)	-.0266212	-0.45	0.650
Ln(Inpatient days*price of Nurse Aides)	-.0127675	-0.27	0.784
Ln(Number of discharge*price of capital)	.0016037	0.41	0.678
Ln(Number of discharges*price of management)	.0019239	0.14	0.890

Ln(Number of discharges*price of Licensed Practical Nurse)	.0499345	1.79	0.073
Ln(Number of discharges*price of Nurse Aides)	.0162064	0.65	0.518
Ln(Number of inpatient days*discharge)	-.108057**	-8.09	0.000
Time Trend	.0270394**	16.09	0.000
Constant	-5.82**	-12.10	0.000
Wald	57953.18		
Log likelihood	2404.9611		
σ_u	.651147		
σ_v	.0902814		
λ	7.212418		

** Significant at a 5% level. * Significant at a 10% level. Dependent variable: log (total expense/wage rate). Price of Registered Nurse used for normalization of prices and costs

Table 3 Parameter estimates of the SFA inefficiency-effects variables (2009-2013)

| Variables	Coefficient	Z	p> |Z|
Medicaid admissions percentage	-.0147284**	-2.94	0.003
Medicare admissions percentage	.0109238**	2.48	0.013
Staffing ratings	.0831645**	2.99	0.003
For-profit (investor owned) nursing home	-1.735509 **	-3.13	0.002
Member of multi-facilities system	.2640827*	1.77	0.076
Time Trend	-.0835848	-1.52	0.129
Constant	-4.062502	-2.54	0.011

** Significant at a 5% level. * Significant at a 10% level.

Table 4 Ranking of the 20 most efficient nursing homes for FY 2013

Nursing homes (Identification number)	Ranking without quality adjustment	Ranking with quality adjustment
05E119	1	1
56190	2	3
56238	3	4
55364	4	2
555019	5	5
56317	6	7
555371	7	14
56253	8	11
55525	9	17
555787	10	13
56435	11	10
55557	12	16
555755	13	15
555690	14	18
555799	15	12
55259	16	20
555635	17	22
56405	18	9
55181	19	24
555854	20	23

Fig. 1 Effects of adjusting for quality on the rankings of the 20 most efficient nursing homes without quality adjustment
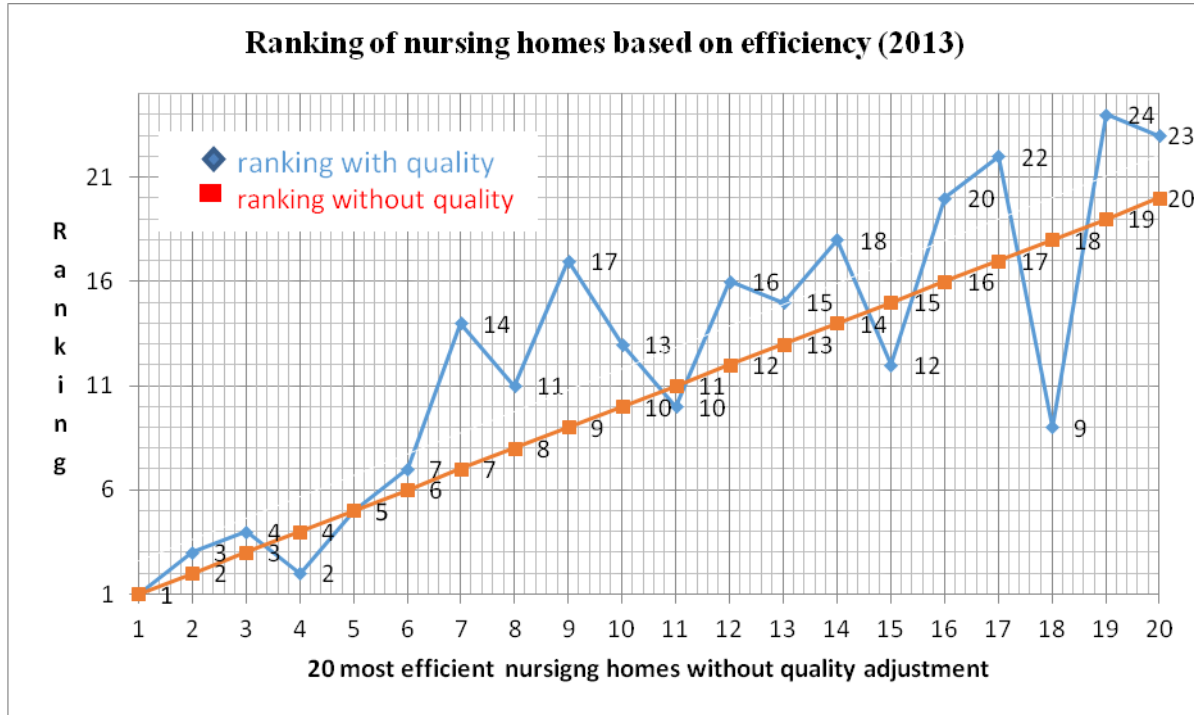
CHAPTER 3 TECHNICAL EFFICIENCY OF NURSING HOMES: DO FIVE-STAR QUALITY RATINGS MATTER?

3.1 Introduction

The association between quality and quantity of health care is crucial and most feel that a tradeoff exists between the two when resources are constrained [37]. It may be possible, however, that a better way of resource utilization such as an improved care process can enhance quality of care which in turn reduces the cost of care [38]. Technical efficiency is one possible way to assess the economic performance of a health care provider. It measures the ability of a firm to produce the given output with minimum inputs or the maximum output with the given inputs.

Literature shows that there is potential for efficiency gain in long-term care including nursing homes, and various factors affect their performance. Given the unprecedented growth of old-age population and higher cost of nursing homes, finding factors that drive the economic performance of these health care providers is a relevant concern for decision makers. Nursing homes in USA seem less efficient compared with those in Europe with means efficiency scores 0.765 and 0.821 [39]. Studies show that for-profit nursing homes, in general, are more efficient than non-profit [38, 7, and 10]. Similarly, competition among health care providers forces nursing homes to improve resource utilization making them more efficient [19, 16]. Payer mix also may affect the economic performance of a nursing home. Most studies, for example, show that a high proportion of low reimbursement payer recipients such as those of Medicaid motivates a nursing home to be efficient [38, 34, 35]. Size of nursing homes and chain affiliation, however, have mixed effects on efficiency of nursing homes [7, 16, and 40].

The importance of quality of care in a nursing home cannot be overstated. Defining and measuring the quality of care in a nursing home, however, is a challenge. Donabedian developed a conceptual model called the SPO framework. Variable S implies structure which refers to the

characteristics of the settings in which care is delivered such as hospital buildings, staff, and equipment. Similarly, P refers to process which denotes the transactions between the patients and the providers throughout the health care delivery. O implies outcomes referring to a change in the patient's health status that can be attributed to the earlier health care [4]. Some of the factors excluded from this framework are the external environment's influences such as the social, legal, and political context in which the health care providers function [41].

Nursing homes may respond to the pressure to increase efficiency by reducing the quality of care, so the two should be analyzed simultaneously. Literature, however, offers mixed findings on the association between efficiency and quality of care in long-term care. Laine and colleagues [42] show that there exists a clear association between technical efficiency and the prevalence-type of quality indicators e.g., prevalence of urinary tract infections, anxiety in long-term care from Finland. Garavaglia and colleagues [18] study the association of care quality with efficiency of nursing homes in Italy. Their finding shows that quality of care is positively associated with efficiency when nursing homes can implement a labor cost containment strategy. Dellis and Ozcan [19] examine the relationship between quality of care and the efficiency of U.S. nursing homes and find mostly favorable quality outcomes for efficient nursing homes. From the study of nursing homes in California, Dulal [38] find that the quality measures and health inspection ratings, two of the three five-star quality ratings of nursing homes, do not affect the mean cost efficiency of nursing homes. These ratings, however, affect the estimate of efficiency of particular nursing homes. Rosko and colleagues [14] find that the cost efficiency of nursing homes in Pennsylvania is not associated with process or outcome measures of quality, but is affected by managerial and environmental factors.

The literature above shows most studies have incorporated only limited dimensions of quality in the technical efficiency estimates, and the association between the efficiency and quality of care is inconclusive. Findings have shown that failure to control for variation in the type or amount of care required by patients can lead to a biased estimate of efficiency of health care organization [20, 21]. This is the first study to investigate the relationship of technical efficiency with five-star quality ratings of nursing homes. The star ratings incorporate multi dimensions of care quality and should improve the precision of estimates.

3.2 Research design and method

3.2.1 Data

The observational unit in this study is a nursing home facility from California. Data covering 2009 through 2013 from two sources are used: (1) CMS's Online Survey, Certification and Reporting or Certification And Survey Provider Enhanced Reports (OSCAR/CASPER); (2) the Nursing Home Compare website maintained by CMS. The Nursing Home Compare website has facility-level data on the five-star quality ratings for each nursing home in each year.

The final analytic dataset is a balanced panel dataset of 338 nursing homes spanning 2009-2013. The final sample is the result of merging data from the two sources mentioned above, and cleaning of the data. During the data cleaning process, nursing homes with zero hours of registered nurse (RN) and with the ratings values greater than 50 are dropped from the sample. The rating values 10, 20, 30, 40, and 50 are assigned as 1, 2, 3, 4 and 5 stars respectively by CMS. So, a rating value greater than 50 implies either a wrong data entry or insufficient data.

3.2.1.1 Five-star quality ratings

Since December 2008, CMS has published a set of quality ratings for each nursing home that participates in Medicare or Medicaid or both. These ratings are in the form of "star" ratings

which are available at the *Nursing Home Compare* website maintained by CMS [26]. A one-star rating indicates the worst performance of a nursing home whereas a five-star is the best. The rating system has four types of star-ratings available: health inspection rating, quality measures rating, staffing rating, and the overall rating. The overall rating is based on a nursing home's performance in the first three ratings mentioned above.

3.2.1.1.1 Health inspection rating

The health inspection rating incorporates information of the number, score and severity of deficiencies identified during the most recent annual health inspection surveys, and complaint surveys. These surveys are conducted by a team of state surveyors, and provide a comprehensive assessment of the facility's performance in areas such as medication management, skin care, resident needs, environment, and kitchen/food services.

3.2.1.1.2 Staffing rating

The staffing rating contains information of the number of hours of care provided each day on average to each resident. The rating is calculated based on a registered nurse (RN) hours per resident day, and the total nursing hours per resident day. Total nursing hours is the sum of registered nurse (RN), licensed practical nurse (LPN), and nurse aide (NA) hours. Both of these staffing hours are equally weighted and adjusted for differences in the levels of residential care need in each nursing home.

3.2.1.1.3 Quality measures rating

This rating provides information about how well a nursing home is caring for its resident's physical and clinical needs. Up until June 2012, the rating was based on 10 different physical and clinical measures for nursing home residents. From July 2012 until January 2015, CMS used 9

different measures to calculate the rating. Out of 9 quality measures, 7 pertain to long-stay residents and 2 to short stay residents (Appendix A).

3.2.1.2 Case-mix index

Case-mix index is one of the widely used approaches to capture the heterogeneity in resource requirement in health care. This study calculates the index at the facility-level as the number of minutes of nursing staffs required in taking care of the average resident. It follows the management minutes system used by Cohen and Spector [33] (Appendix B).

3.2.2 Technical efficiency

One of the widely used approaches in evaluating performance of a health care organization is to estimate its technical efficiency. Technical efficiency is a measure of the effectiveness of using minimum input quantities to produce a certain output or alternatively, producing maximum amount of output from a given amount of inputs [43]. A firm is considered technically more efficient if it can produce the same output with fewer inputs than another firm or alternatively more output with the same inputs.

3.2.3 Data envelopment analysis

Data envelopment analysis, a non-parametric approach, is the most popular method of estimating technical efficiency in health care [39]. The method uses linear programming methods to construct a 'best-practice frontier' from the available data. The efficiency measures are then calculated relative to this frontier [25]. The diagram below (Fig 2), for example, illustrates a production technology with two inputs and one output. The units A, C, D are on the isoquant (frontier) Q, and produce the same output with different combinations of the inputs. The efficiency scores are estimated taking this frontier as the reference. The production units A, C, D that lie on the frontier are efficient units and have an efficiency score of 1.0. The unit B that lies above the

frontier is inefficient as it uses more inputs for the same output compared with the other units. The efficiency of this unit is calculated by the ratio: OB′/ OB. This implies the production unit B could produce the output Q with BB′ fewer inputs.
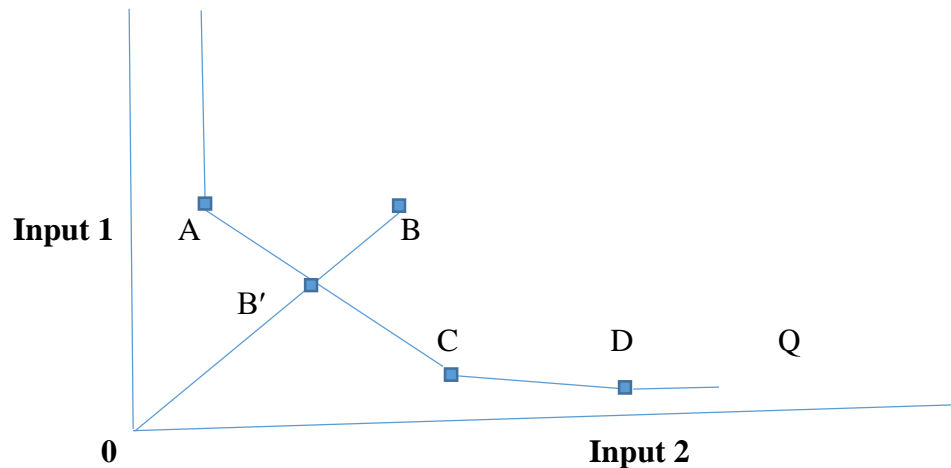
Fig 2 Efficiency measures with data envelopment analysis. Best practice frontier (Q) and production units (A, B, C, D).

3.2.4 Model specification

Following the literature [34], the study employs two-stage data envelopment analysis (DEA).

3.2.4.1 Stage 1: Input-oriented variable returns to scale model

I use an input-oriented variable returns to scale (VRS) linear programming method to estimate technical efficiency of nursing homes in the first-stage of the two-stage DEA approach. The input-oriented model is chosen because a manager in a nursing home can alter the input combinations, but usually does not have a control over the number of residents (output). Similarly, the constant returns to scale assumption is only appropriate when all the production units (nursing homes) are operating at an optimal scale. Government regulation, imperfect market structure,

finance constraints, however, may cause a firm to be operating at a level below the optimum [25]. The choice of the input-oriented VRS model is also supported by literature [44, 45].

According to Banker et al. [46], nursing home efficiency can be obtained by solving the following linear programming problem:

$$\text{Max} \quad \frac{\sum_{r=1}^{S} u_r y_{r\mathbf{0}} - u_{\mathbf{0}}}{\sum_{i=1}^{m} v_i x_{i\mathbf{0}}}$$

$$\text{s.t.} \quad \frac{\sum_{i=1}^{S} u_r y_{rj} - u_{\mathbf{0}}}{\sum_{i=1}^{m} v_i x_{ij}} \leq 1 \quad j = 1, \dots, n \quad u_r, v_i \geq 0, r = 1, \dots, s, i = 1, \dots, m \qquad (1)$$

where y_{rj} is the amount of output r for nursing home j; x_{ij} is the amount of input i in the jth nursing home; u_r is the weight given to output r; v_i is the weight given to input I; n is the number of nursing homes in the sample; and $u_{\mathbf{0}}$ is unconstrained in sign.

The study uses a set of inputs, outputs, and product descriptors in the first stage. The input variables include: full-time equivalent hours of management (MGT); full-time equivalent hours of registered nurses (RN); full-time equivalent hours of licensed practical nurse (LVN); full-time equivalent hours of nurse aides (NA); the average number of bed per nursing home. These are annual full-time equivalent working hours. Annual inpatient days and annual number of discharges are two output variables. Following the SPO framework and practices in literature [36, 2], quality measures ratings and health inspection ratings are treated as outcome measures of quality and are included as product descriptors (output). The case mix index, expressed in minutes, is also used as a product descriptor and included as an output. The technical efficiencies are estimated through Window analysis using a DEA-Solver Pro5.0. A DEA window analysis applies the concept of moving average to find efficiency trends of decision making units (DMU) over time.

3.2.4.2 Stage 2: Tobit regression

The impacts of firm-specific and environmental variables on technical efficiency are estimated using Tobit regression at the second stage. First of all, the efficiency scores obtained from the stage first above are transformed as: Transformed DEA score = 1 / (DEA score) – 1. Now the transformed score becomes inefficiency score and has no upper bound. It can be expressed as:

Tobit regression dependent variable: y_{it} = > 0, if DEA score < 1

0, if DEA score = 1.

So, y_{it} now is left-censored continuous variable and Tobit regression is left-censored at 0 [47]. Now a standard Tobit model with panel-level random effects:

$$y_{it} = x_{it}\beta + v_i + \varepsilon_{it} \tag{2}$$

for i = 1, ….……..., n panels, t = 1, ……………, n_i. The random effects v_i are iid N $(0, \sigma_u^2)$, and ε_{it} are iid N $(0, \sigma_\varepsilon^2)$ independently of v_i.

A number of determinants of technical inefficiency are included in the Tobit regression. To investigate the impacts of ownership on technical efficiency, a binary variable for investor owned (for-profit) versus the other nursing homes is used. Similarly, multi-facility membership is included as a binary variable. Fractions of Medicare and Medicaid patients are also included to capture their effects on inefficiency. Ratings on staffing level is considered as a structural form of quality and hence included as another determinant of inefficiency. Finally, a time trend included should capture changes in inefficiency over the study period.

To address the issues of possible sampling errors and serial correlation of efficiency scores, the study follows a bootstrap procedure proposed by Simar and Wilson [48]. The STATA software package is used for the bootstrap and Tobit regression models. Descriptive statistics of all the variables are included in Table 5.

3.3 Results

This section includes results from the two stages of DEA analysis.

3.3.1 Results from the first-stage DEA

Table 5 Descriptive statistics of the variables per nursing home (N=338, 2009-2013)

Variables	Mean	Standard deviation	Minimum	Maximum
Variables in the first- stage of DEA				
Inpatient days	31177.05	15488.76	1433	109198
Case-mix index (minutes)	177.75	39.78	10	364.57
Number of discharges	335.52	277.77	0	2238
Number of beds (average per year)	98.71	48.28	19	305
Annual FTE hours of management	1.29	.84	0	12.57
Annual FTE hours of registered nurse	6.81	5.28	.006	43.13
Annual FTE hours of licensed practical nurse	11.74	7.7	0	63.14
Annual FTE hours of nurse aide	37	18.12	4.78	125.69
Average score of quality measures ratings	31.28	13.07	10	50
Average score of health inspection ratings	28.22	13.02	10	50
Variables in the second-stage DEA				
Average score of staffing ratings	32.62	11.04	10	50
Medicaid admission as a percent of total admissions	60.85	24.82	0	100
Medicare admission as a percent of total admissions	16.02	13.75	0	100
Fraction of for-profit nursing homes	0.87	.33	0	1
Member of multi-facility	0.56	0.49	0	1

Note. *FTE* full time equivalent

The average technical efficiency of all the nursing homes without adjusting for quality is

0.92. This implies these nursing homes, on average, could provide the service (produce the given

output) with 8% less input resources. The mean technical efficiency score after including quality in the model is 0.93. As mentioned earlier, I have included quality measures and health inspection ratings as product descriptors for quality adjustment. This implies these quality ratings have no effect on the estimate of mean technical efficiency.

The association between technical efficiency and care quality

Although quality ratings have no effect on the estimate of mean technical efficiency, these quality variables change the efficiency score of particular nursing homes. For example, one of the lower efficiency scores with a value of 0.95 changes to 1.0 after quality adjustment. This is more obvious through an analysis of the impact of quality on the ranking of nursing homes based on their efficiency score. Table 6 shows the rankings of twenty nursing homes from the sample based on the efficiency score with and without quality adjustments for the year 2010. All the nursing homes with efficiency score 1.0 are ranked as 1st, the nursing home with the second highest score as the 2nd and so on. Many of these nursing homes experienced a considerable change in rank after inclusion of quality in the model. For example, the nursing home (Id 55612) that ranks 9th when quality is ignored moves to the 1st rank after the quality adjustment. Similarly, the ranking of the nursing home (Id 555442) changes from 19th to 15th after quality adjustment. Figure 3 also illustrates these changes in ranking of nursing homes after quality adjustment. This clearly shows how misleading an efficiency-based ranking of nursing homes can be if it is based solely on various aspects of health care not adjusted for quality.

3.3.2 Results from the second – stage DEA

Table 7 shows the results from the Tobit regression at the second-stage DEA analysis. Fractions of Medicaid and Medicare admissions have no effect on efficiency. Staffing rating, a structural form of quality, is positively associated with inefficiency. This implies a nursing home

with higher staff per resident does not necessarily have a better care process (technical efficiency). The negative association between for-profit nursing homes and inefficiency scores shows that a for-profit nursing home is more efficient than its counterpart. Using the delta-method, the average marginal effect of for-profit nursing homes on technical inefficiency is estimated to be -.04. This implies that a for-profit nursing home is 4% (on average) more efficient than its nonprofit counterpart. Similarly, the average marginal effect of staffing rating is .0005. Finally, the negative coefficient of the time trend indicates that these nursing homes are becoming more efficient during the study period.

3.4 Discussion

The study has two main findings. First, quality measures impact the estimate of technical efficiency of nursing homes. For example, the inclusion of quality measures rating and health inspection rating alter the efficiency score of particular nursing homes. Furthermore, the result has also shown that the relative ranking of nursing homes in terms of technical efficiency depend upon whether the efficiency estimated are adjusted for quality of care. These imply that quality of care is critical and should not be overlooked while evaluating performance of a nursing home. These quality ratings, however, have no substantial effect on the estimate of mean technical efficiency of a given sample of nursing homes. The proper weight assigned for quality measures may improve the precision of estimate of the impacts on technical efficiency [17].

Second, the staffing rating, used as an input measure of quality, is negatively associated with the mean technical efficiency. This implies that a higher staff/resident ratio does not necessarily lead to a better care process in nursing homes. This indicates a possibility of improving care process and quality of care through a reallocation of a part of resource from nursing staff

towards care process. It involves finding the right inputs mix, more training, and monitoring the care process.

Consistent with many other findings [38, 34, 35], the study shows that for-profit nursing homes are more efficient than non-profit nursing homes. The result also shows that nursing homes are, on average, becoming more efficient over time. For a future study, it is worth investigating changes in quality of care in nursing homes after the launch of five-star quality ratings system by the CMS. Also, finding the effectiveness of these star-ratings to residents and their family in choosing a nursing home is crucial.

There are a number of limitations of this study. The sample used is limited to nursing homes from California that participated in Medicaid or Medicare over the period 2009-2013. Following Cohen and Spector [33], the case-mix index is calculated based on the minutes of staffs required in caring the average resident. A more comprehensive case-mix index such as the one based on the Resource Utilization Group (RUGs) can capture the heterogeneity of resource requirements more precisely. Similarly, the study includes the star ratings of measures of quality in the model without weight assignment to these ratings. Proper weight assignment to these quality measures may improve the precision of the findings.

Table 6 Ranking of nursing homes based on efficiency scores for FY 2010

Nursing homes (Identification number)	Ranking without quality	Ranking with quality
555257	1	1
55129	2	1
555842	3	1
555418	4	1
555326	5	2
555570	6	3
55968	7	4
555767	8	1
55612	9	1
55242	10	1
55806	11	1
555180	12	8
555487	13	1
55308	14	10
555355	15	12
55335	16	7
555476	17	13
555566	18	14
555442	19	15
555806	20	1

Table 7 Random-effect Tobit regression (bootstrap replications 100)

Variables	Coefficients	Z
Medicaid admissions percentage	-.0002	-1.45
Medicare admissions percentage	-.003	-0.89
Staffing ratings	.0005*	2.44
For-profit nursing home	-0.04*	-4.24
Member of multi-facilities system	.002	0.36
Time trend	-.008*	-5.30
Constant	.134*	7.94

Dependent variable: Technical inefficiency. * Significant at a 5% level.

Fig 3 Effects of quality adjustment on efficiency-based ranking of nursing homes

Ranking of nursing homes based on efficiency 2010
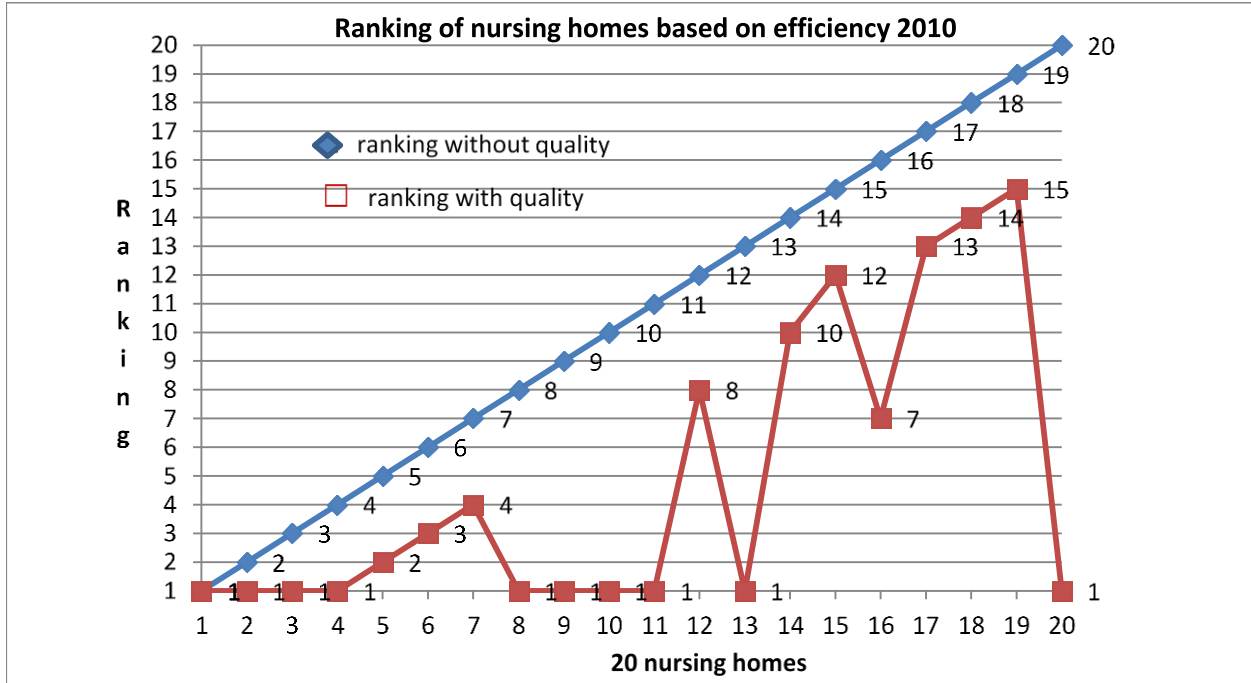
CHAPTER 4 SUMMARY AND CONCLUSIONS

The dissertation has sought to examine the measurement, impacts, and associations of nursing home quality. This is important because measuring and finding the associations of the various dimensions of quality can help decision makers in finding ways to improve quality without substantially raising cost or even with a reduction in cost. The first essay of the dissertation investigates the relationship among cost, five-star quality ratings, and cost efficiency of nursing homes from California. It uses stochastic frontier approach with inefficiency effects for panel data. Using the cost frontier, the first model of the approach, the study investigates various determinants of cost and also studies how various outcome measures of quality influence the cost structure of nursing homes. The inefficiency effect model, the second model of the approach, is used to study the impacts of various environmental variables including structural form of quality i.e., staff rating on cost efficiency.

The second paper employs two stage data envelopment analysis for evaluating the impacts of five-star quality ratings on technical efficiency of nursing homes. In the first stage, it applies an input oriented variable returns to scale to investigate the impacts of outcome measures of quality i.e., quality measures ratings and health inspection ratings on efficiency. In the second stage, Tobit regression model is used to study the impact of various environmental variables including staffing ratings on technical efficiency. Both these studies are confined to a state level sample of nursing homes and the case-mix index used captures limited heterogeneity of resource requirements. A future study using the country level sample of nursing homes and a more comprehensive case-mix index such as the one from RUGs can improve generality and precision of the findings.

Essay 1 seeks to answer the question of possibility of tradeoff between cost reduction and quality improvement. The paper finds that relationship between cost and quality depends upon the

form/type of quality under consideration. In other words, different forms of quality are linked with cost differently. For example, quality measures ratings is negatively associated with cost whereas the health inspection rating has no association with cost. The staffing rating, however, is positively linked with cost inefficiency. This implies there is no tradeoff between outcomes forms of quality and cost. A nursing home, however, may face a tradeoff of improving quality by raising staff/resident ratio versus becoming cost efficient by decreasing the ratio. The study addresses the query of possibility of quality improvement without raising cost substantially or with a reduction in cost. The study indicates a possibility of achieving that if a nursing focuses on improving care process rather than simply raising the number of staffs per resident. The findings also show that the quality adjustment impacts the efficiency estimate of particular nursing homes and alter the efficiency-based ranking of nursing homes.

Essay 2 seeks to answer the question of the impacts of quality adjustment on the care process i.e., technical efficiency of nursing homes. Results show that the quality adjustment does impact the efficiency estimate of individual nursing homes. This is illustrated by changes in the efficiency-based ranking of nursing homes after quality adjustment. The paper also addresses the query of the association of a higher staff/resident ratio with the improved care process. The results, however, show that a higher staff/resident ratio does not always lead to a better care process or higher technical efficiency. The study also answers the question of possibility of achieving improved care process without requiring additional inputs. The finding shows that this may be possible if a part of resources from nursing staff is reallocated toward improving care process through more training and monitoring the process.

All of such studies have limitations. Limitations of this study are related to the sample size, case-mix index, private duty staff, and weight assignment of the quality. The study uses the sample

of California nursing homes that participate in Medicaid or Medicare. This sample may not be the representative of the nursing homes elsewhere. The case-mix index used in the study is less comprehensive than the one from RUGs. So, the index may not have captured the heterogeneity of resources requirement as desired. Also, the study includes two star ratings of nursing homes as product descriptors, but has not assigned proper weightage to these quality ratings. The research also does not include the cost associated with private duty staff.

This is the first dissertation to investigate the association of five-star quality ratings of nursing homes with their cost, and cost efficiency. It is also the first to study the relationship between these star ratings and technical efficiency. Future research in this area should address the importance of different types of quality ratings to the residents and their family. Futures studies should also focus on methods for helping the stakeholders of nursing homes in understanding these ratings including their limitations, and utilizing them in decision makings.

One of the policy implications of the findings is related to payment policy. The results show that an improvement in outcome measure of quality such as quality measures rating can reduce the cost of care. This implies a payment policy based on these star ratings i.e., quality measures and health inspection may provide an incentive for a nursing home to improve these aspects of quality which in turn should reduce the cost. Finding also shows that a higher staff/resident does not necessarily provide a better care quality. This implies a nursing home manager should focus on improving care delivery through more training and monitoring instead of simply relying on the number of staff per resident.

APPENDIX A MEASURES OF QUALITY FOR LONG-STAY AND SHORT-STAY RESIDENTS

Quality measures for *long-stay* residents are:

1. Percent of residents whose need for help with daily activities has increased.

2. Percent of high risk residents with pressure sores.

3. Percent of residents who had a bladder inserted and left in the bladder.

4. Percent of residents who were physically restrained.

5. Percent of residents with a urinary tract infection.

6. Percent of residents who self-report moderate to severe pain.

7. Percent of residents experiencing one or more falls with major injury.

Quality measures for *short-stay* residents are:

1. Percent of residents with pressure ulcers (sores) that are new and worsened.

2. Percent of residents who self-report moderate to severe pain.

APPENDIX B CASE-MIX INDEX CALCULATION

Following Cohen and Spector [33], the case mix index of a nursing home is measured at the facility-level as the number of minutes of staff time required for the care of the average resident. More specifically, using weights based on the management minutes system developed by Thoms and Schlesinger, the case-mix index is calculated as:

A(20)+B(18)+C(30)+D(30)+E(20)+F(48)+G(90)+H(90)+I(45)+J(32)+K(20)+L(50)+M(36)

where A = percentage of patients needing full assistance bathing,

B = percentage of patients needing partial assistance bathing,

C = percentage of patients needing full assistance dressing,

D = percentage of patients needing partial assistance dressing,

E = percentage of patients catheterized,

F = percentage of patients incontinent,

G = percentage of patients needing parental feeding,

H = percentage of patients needing tube feeding,

I = percentage of needing assistance eating,

J = percentage of patients non-ambulatory,

K = percentage of patients with pressure sores,

L = percentage of patients receiving bowl/bladder retraining, and

M = percentage of patients receiving special skin care.

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ABSTRACT

**THE COST AND TECHNICAL EFFICIENCY OF NURSING HOMES:
DO FIVE – STAR QUALITY RATINGS MATTER?**

by

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August 2016

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Degree: Doctor of Philosophy

Chapter 2 examines the determinants of nursing home costs and cost efficiency, and investigates how various measures of nursing home care quality influence both of these. It applies a one-step stochastic frontier approach to a large panel of California nursing homes surveyed between 2009 and 2013. Quality is measured by three different ratings available on the *Nursing Home Compare* website: rating on quality measures, rating on the health inspection, and rating on staffing levels. Results show that the rating on quality measures, an outcome-based measure of quality, is inversely related to costs but unrelated to mean cost efficiency. In other words, a better rating on quality measures is associated with lower nursing home costs. The health inspection rating is not associated with either costs or mean cost efficiency. The rating for staffing levels, a structural measure of quality, is negatively associated with cost efficiency. These findings reveal that different measures of quality have different relationships with costs and cost efficiency. The findings suggest that better quality outcomes in nursing homes may be achievable with fewer resources and/or improved care procedures, which in turn should reduce nursing home costs.

Chapter 3 investigates the relationships between three recently launched five-star quality ratings and technical efficiency of nursing homes. It employs an input-oriented two-stage data

envelopment analysis in a sample of 338 nursing homes in California from 2009 through 2013. Results show that the quality measures rating and health inspection rating, used as product descriptors, do not affect mean technical efficiency of nursing homes. These ratings, however, affect efficiency of particular nursing homes and hence alter the ranking of nursing homes based on efficiency scores. The staffing rating, used as a structural quality, is negatively associated with mean technical efficiency. The different dimensions of quality have different impacts on technical efficiency and that a higher staff /resident ratio does not necessarily lead to an improved care process. It implies that a reallocation of a part of resources from nursing staffs towards monitoring care process/procedure may lead to better resource utilization and higher care quality.

AUTOBIOGRAPHICAL STATEMENT
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Education:

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