International Journal of Statistical Sciences ISSN 1683-5603
Vol. 22(1), 2022, pp 99-113

Efficiency of California Hospitals

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[Received July 25, 2021; Accepted March 3, 2022]

Abstract

This study estimates the cost efficiencies in California hospitals from 1995 to 2005 by using a stochastic cost frontier model. In addition, we also investigate the factors affecting the cost efficiencies of these hospitals. Our results reveal that the cost of California hospitals is on average about 10% above the cost frontier that represents the minimum possible cost. Consequently, the state of California lost on average $3.28 billion a year. Further, we note that inefficiency increases over time, decreases as the severity of inpatients increases, and is lower for psychiatric, big, and DSH reporting hospitals.

Keywords: Cost efficiency, Stochastic cost frontier model.

AMS Subject Classification: 91G70; 91B70.

1. Introduction

Around the middle of the last century researchers introduced the concept of efficiency, but by the second half of the century they estimated productive, cost, and profit efficiencies in almost all sectors of the economy, e.g., manufacturing, agriculture, service, health, education among others. The most popular method to estimate efficiency during the last thirty-five years has been the stochastic frontier model. In the economic context production is assumed to take place at the frontier, i.e., for a given technology maximize the output for a given set of inputs or using the duality theory this is equivalent to minimizing the costs or maximizing the profits. When estimating a production function (or its dual, a cost or a profit function) researchers assume that production is at the frontier except for economic shocks, captured by a stochastic error term.

Although a hospital is not a factory, however, it must operate efficiently to minimize costs. Numerous researchers around the world have estimated efficiency of hospitals. Rosko (1999) noted that technical, allocative, scale, scope, and cost inefficiencies are all examples of a hospital inefficiencies. When a hospital maximizes outputs for a given level of inputs or services, or when it minimizes inputs for a given level and choice of outputs, it is technically efficient. When a hospital allocates and uses the least expensive combination of inputs in producing its outputs, or when hospital resources are dedicated to producing outputs that are societal goals, it is said to be allocating efficiency. Scale efficiency results when the scale of a hospital's operations is optimum, and any changes in size will make the hospital less efficient. When a hospital decreases its average cost by generating many outputs, this is known as scope efficiency.

Studies related to hospital efficiency usually also discuss the cause of efficiency differentiation among hospitals. Guerrini et al. (2018) investigate the factors that influence efficiency in an Italian regional health system, as well as the impact of ownership on hospital efficiency. Their results indicate that private hospitals outperform public hospitals. This is due to their access to more capital. Private hospitals are often able to hire the best medical professionals, and they can better handle their human resources by openly negotiating physician salaries and providing more money than public administrations.

Using a sample of 27 Portuguese public hospitals, Ferreira et al. (2018) analyses the scale efficiency and the optimal scale for clinical staff. The ideal scale was 274 doctors and 475 nurses. By using a meta-regression analysis on hospital ownership, Bel and Esteve (2020) examined if private organizations can outperform public ones when it comes to providing public services. Their study reveals that there is evidence in favor of public hospitals, and that public sector might be able to deliver public health services at a lower cost than the private sector. Nundoochan (2020) used the Mauritius' hospitals data from 2001 to 2017 and estimated the technical efficiency by using stochastic frontier analysis. He used three different production functions, i.e., Cobb Douglas, Translog, and Multioutput functions, and found that mean technical efficiency scores were 0.83, 0.84, and 0.89 respectively. He further noted that the most significant factors in hospital development are nurses and beds. Additionally, Alwaked et. Al. (2020) investigated the efficiency of 29 Jordanian public hospitals from 2006 to 2015. Their results reveal that the efficiency of these hospitals ranged from 11.7% to 94.4%, with average an efficiency of 54.5% only.

Li and Rosenman (2001) used the US hospitals data from 1988 to 1993 and investigated the effect of growing cost on the efficiency. Their study concludes that the harsher the illnesses and the greater number of beds used by the hospitals, the more inefficient is the hospital. Moreover, the greater the number of Medicare patient days the more cost efficient is the hospital. Choi et al. (2017) used stochastic frontier analysis and data envelopment analysis methods to estimate the efficiency of 1,471 US hospitals and noticed a U-shaped size effect when hospitals were grouped by size.

The hospital sector in the state of California expanded during the late 1990s and early 2020s. This expansion came in the form of rising total assets, total operating cost, and total paid hours. Data reveals that hospitals' assets increased from $33.96 billion in 1995 to $54.02 billion in 2005. In the same direction, total annual operating costs increased on average by $2.01 billion per year for eleven years and the total paid hours increased by $77.76 million hours during the period of this study. On the other hand, the number of hospitals decreased from 495 in 1995 to 441 in 2005. In addition, the available beds decreased on average by 823 beds every year, for eleven years. These facts raise the question: Are the hospitals in California becoming more efficient?

This study investigates the possibility that the expansion of hospitals' assets and operating cost in California State have an influence on the cost efficiency of those hospitals. Towards this goal, we estimate the cost efficiency of California hospitals for the period 1995 to 2005 by using a stochastic cost frontier model. We also analyse the following hypothesis: Are big hospitals more cost efficient than small hospitals? Are public hospitals less cost efficient than private ones? And are specialty hospitals less cost efficient than general hospitals?

This study is organized as follows. Section 2 discusses the data and the variables used in this study. Sections 3 and 4 discusses the methodology used and the results. Finally, Section 5 concludes this study.

2. Data

The data used in this study is from 1995 to 2005 and is provided by the Healthcare Quality & Analysis Division of the California Health and Human Services Agency. The number of hospitals differs across years. There were 495 hospitals in 1995 and 382 in 2005. Our plan is to estimate the efficiency using balanced panel data, these differences and the presence of missing values and negative unexplained values reduce the observations from 5700 to 3256. i.e., 296 hospitals for eleven years.

Our variables are classified in four categories. First the cost, represented by total operating expenses. Second input price variables, these are salaries and wages that represent the price of labor and the price of capital represented by depreciation expenses plus the interest expenses. The third type are the output variables. These are represented by total discharges, and total outpatient visits. The first one measures the total number of inpatients discharges from the hospital each year. The second one measures the number of days the patient stayed in the hospital as inpatient. The last one measures the number of patients that come to hospital as outpatients.

The fourth type of variables are the efficiency variables. They are as follow; first, the ownership and the legal organization of a hospital license, which can be categorized into five categories, i.e., District hospitals; County/City; Investor; Non-Profit; and State hospitals. Second, the type of care provided at the hospital is also classified in one of four categories: General - hospitals which provide general care; Children's - hospitals which primarily treat children; Psychiatric - hospitals which emphasize psychiatric care; and specialty hospitals, such as chemical dependency recovery hospitals and rehabilitation hospitals. Third, based on licensed number of beds we classify hospitals into the following seven categories: 1-49 beds, 50-99 beds, 100-149 beds, 150-199 beds, 200-299 beds, 300-499 beds, and 500+beds.

3. Methodology

The stochastic frontier model was initially introduced by Aigner et al. (1977) and by Meeusen and van Den Broeck (1977) and have attracted a great deal of attention in the literature since then. A comprehensive review of stochastic models can be found in Coelli et al. (2005) and Kumbhakar and Lovell (2000). A production frontier refers to the maximum output attainable for a given technology and set of inputs, while a cost frontier refers to the minimum cost to produce a given level of output.

For the i_{th} firm the stochastic frontier model can be written as

$$y_i = f(x_i, \beta) + \epsilon_i \qquad i = 1, 2, \dots \dots n \tag{1}$$

y_i is the output, xi a vector of inputs, $f(.)$ is the production function, β is a set of parameters and ϵ_i is the stochastic error term. They assume that ϵ_i is composed of two components, i.e.

$$\epsilon_i = v_i + u_i \quad , u_i \geq 0$$

v_i and u_i are independent, v_i are assumed to be normally distributed with mean zero and variance σ_v^2, and u_i is a one-sided error term representing technical inefficiency. Aigner et al. (1977) showed that the average technical inefficiency can be estimated by the mean of the distribution of u_i, but the issue of obtaining the inefficiency of each firm was still unsolved. Jondrow et al. (1982) resolved this problem and proposed to estimate the mean, or mode of the conditional distribution of u_i given ϵ_i, which can be used as a point estimate of u_i. Few years later, Battese and Coelli (1988) argued that since the production function is generally defined as logarithmic of the production the technical efficiency of the i_{th} firm should be defined as $E[exp(-u_i)/\epsilon_i]$. They also extended Jondrow et al. (1982) results for the case of a cross sectional time series model, i.e. let y_{it} denote the output of the i_{th} unit at time t, then the stochastic frontier model can be written as

$$y_{it} = f(x_{it}, \beta)e^{\epsilon_{it}}$$

$$\epsilon_{it} = v_{it} + u_{it} \quad , u_{it} \geq 0 \tag{2}$$

Where, i = 1, 2, ..m denotes the units and t=1 2, ..T denotes the time trend, x_{it} denotes vector of inputs for unit i at time t, β is a set of parameters to be estimated, and ϵ_{it} is the stochastic error term. The unobservable components of ϵ_{it}, v_{it} and u_{it} are assumed to be independent of one another, v_{it} is distributed as normal with mean zero and variance σ_v^2 and u_{it} the one-sided error term represents technical inefficiency. Following Battese and Coelli (1995), we assume that u_{it} are obtained by the truncation at zero of the normal distribution with mean δZ_{it} and variance σ_u^2. Z_{it} denotes a (g*1) vector of variables suspected of contributing to cost inefficiency in hospitals, and δ is a (1*g) vector of unknown parameters. Thus, the technical inefficiency component u_{it} in (2) are specified as

$$u_{it} = \delta Z_{it} + w_{it} \tag{3}$$

where w_{it} is truncated normal random variables with mean zero and variance σ_u^2. Thus, u_{it} are distributed as $N^{+}(\delta Z_{it},\ \sigma_u^2)$.

For the cross sectional- time series model, we follow Battese and Coelli (1988) and estimate technical efficiency as

$$TE_{it} = E[exp(-u_{it})/\epsilon_{it}] \tag{4}$$

To estimate TE_{it} first, we specify the functional form $f(x_{it}, \beta)$ and the most common functional form used in the literature is the translog function. The Translog cost frontier specification for this study is as follow:

$$\begin{aligned}\ln TC_{it} = {} & \alpha_0 + \sum_{j=1}^{J} \alpha_j \ln y_{j_{it}} + \sum_{k=1}^{K} \beta_K \ln p_{k_{it}} + 0.5 \sum_{j=1}^{J}\sum_{l=1}^{J} \tau_{jl} \ln y_{j_{it}} \ln y_{l_{it}} \\ & + 0.5 \sum_{k=1}^{K}\sum_{m=1}^{K} \gamma_{km} \ln p_{K_{it}} \ln p_{m_{it}} + \sum_{j=1}^{J}\sum_{k=1}^{K} \rho_{jk} \ln y_{j_{it}} \ln p_{k_{it}} + \vartheta T_{it} + \varphi T_{it}^2 \\ & + \sum_{j=1}^{J} \theta_j T_{it} \ln y_{j_{it}} + \sum_{k=1}^{K} \eta_k T_{it} \ln p_{k_{it}} + v_{it} \\ & + u_{it}\end{aligned} \tag{5}$$

$$u_{it} = Z_{it}.\delta + w_{it} \tag{6}$$

$y_{j_{it}}$: is the output j of hospital i at time t, $p_{k_{it}}$: is the price of input k of hospital i at time t, TC is the total cost, and the remaining variables are defined earlier.

4. Results

There are two ways to count the inpatients as outputs in equation (5). The first one is the number of discharges for admitted inpatients. The second one counts the number of days admitted inpatient stayed in the hospital. In this study, we used the first one as an independent variable. We also tried the second one and it produces similar results. The variables used in equation (5) and (6) are defined in Table 1. In equation (6), time and eight other variables are used.

Table 1: Variables used in the model

Variables	Description
lnDs	Logarithm of discharge output (inpatients output)
lnVs	Logarithm of Visitors output (outpatient output)
lnpl	Logarithm of price of labor
lnpk	Logarithm of price of capital
T	Time trend
TypeOfContrl	A dummy variable that has the value of one if the type of control is governmental and zero otherwise
General	A dummy variable that has the value of one if the type of care is general and zero otherwise
Specialty	A dummy variable that has the value of one if the type of care is specialty and zero otherwise
Dsh	A dummy variable that has the value of one if the hospital reported as DSH hospital and zero otherwise
Big	A dummy variable that has the value of one if the hospital has more than 200 beds zero other wise
lnAvBD	Logarithmic of number of available beds in the hospital
lnSeverity	Logarithmic of the average number of days the patients stay at hospital
lnUnObed	Logarithmic of the number of unoccupied beds in the hospital

Equations (5) and (6) are estimated jointly by using FRONTIER 4.1 software developed by Coelli (1996) which uses Maximum likelihood method. In Table 2, we report parameter estimates of these equations. We note that the estimate of gamma is 0.99 and highly significant. This is an indication that the use of stochastic frontier model is appropriate. It suggests that the cost efficiency effect contributes to around 99% of the explanation of the variance of the residual term. This result provides strong evidence that operating cost inefficiencies are important to explain the behavior of the cost frontier of hospitals in California. In addition, this shows that inefficiency is an important factor, and decision makers must give more attention to reasons that causes inefficiencies. Most of the parameter estimates of equation (5) in Table 2 are statistically significant.

Table 2: Parameter Estimates of Stochastic Cost Frontier

Variables	Equation (5) Estimator	t-statistics	Variables	Equation (6) Estimators	t-statistics
Intercept	-0.8499	-1.4455	T	0.0145	1.2772
(lnDs)	-0.3767	-4.3932	TypeOfContrl	1.2105	12.5335
(lnVs)	0.2945	5.8428	General	1.6394	15.1463
(lnpl)	0.9970	7.1889	Specialty	4.0453	23.7224
(lnpk)	0.2853	5.5586	Dsh	-0.0259	-0.4151
H(lnVs)^2	0.0211	4.5890	Big	-0.5479	-4.1215
H(lnDs)^2	-0.0095	-1.0453	lnAvBD	0.0742	0.8892
(lnDs)(lnVs)	-0.0072	-1.6482	lnSeverity	-0.4962	-5.2253
H(lnpl)^2	0.0248	1.3759	lnUnObed	0.0357	0.4263
H(lnpk)^2	0.0338	18.0174			
(lnpl)(lnpk)	-0.0411	-6.9117			
(lnDs)(lnpl)	0.0428	4.2143			
(lnDs)(lnpk)	-0.0053	-1.1648			
(lnVs)(lnpl)	-0.0307	-5.1631			
(lnVs)(lnpk)	0.0026	0.7299			
T	-0.0727	-5.3342			
T(lnDs)	-0.0058	-4.8715			
T(lnVs)	0.0036	3.7373			
T(lnpl)	0.0021	1.2509			
T(lnpk)	0.0036	3.8889			
Intercept	-5.1512	-6.4471			
Sigma-squar	0.5285	41.4221			
Gamma	0.9912	3310.5551			

The inefficiency term (in equation 6) is a function of nine variables suspected of causing inefficiencies. From Table 2, we observe that the cost inefficiency decreases as the severity of inpatient increases, since this will force the patient to stay in the hospital for more days. It is lower for big and DSH reporting hospitals. The cost inefficiency increases by raising the unoccupied beds and is higher for general and specialty hospitals compared to Psychiatric hospitals. It is interesting to note that parameter estimate for time was positive but not significant.

In Table 3, we report the yearly average cost efficiencies of Californian hospitals from 1995 to 2005. We find limited variation in the average cost efficiencies over time during this period. The results indicates that Californian hospitals on average are 89.5% cost efficient. It implies that those hospitals on average carry on a cost about 10% above the cost frontier that represent the minimum possible cost. The highest average cost efficiency across Californian hospitals was encountered in 1996 and the lowest one was in 2004. The efficiencies in Table 3 are higher than the average cost efficiency of Catalonian hospitals in Spain which was 58.3% (Wagstaff and Lopez, 1996). It is higher than the average cost efficiency of the Japanese municipal hospitals, with cost efficiency around 43.8% (Fujii and Ohta, 1999) and it is higher than the average cost efficiency of Washington State hospitals with average cost efficiency around 67% (Li and Rosenman, 2001).

Table 3: Yearly Cost Efficiencies from 1995 to 2005

Year	efficiency	Rank
1995	0.8972	2
1996	0.8999	1
1997	0.897	3
1998	0.8957	6
1999	0.8955	7
2000	0.8968	4
2001	0.8965	5
2002	0.8908	9
2003	0.8884	10
2004	0.8875	11
2005	0.8947	8
Averages	0.8945	-

Figure1 displays the distribution of cost efficiency of all the hospitals, and it shows a wide variation in the magnitude of their efficiencies. The efficiency was 100 % in 2001, while it was minimum, 35% in 1996. We note that there are 14 hospitals that have efficiency between 25% and 50% and 214 hospitals with cost efficiency between 50% and 75%.

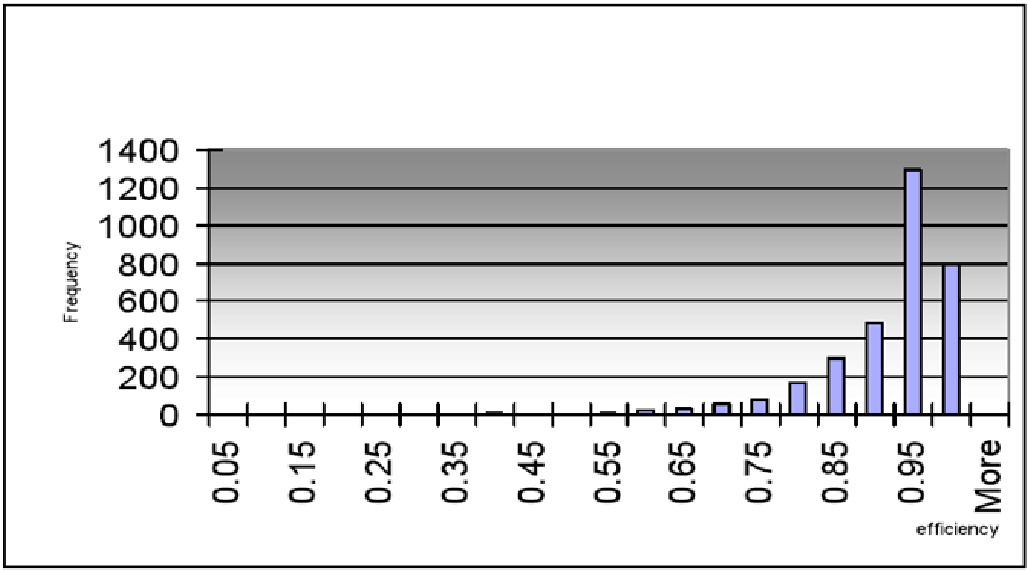

Figure 1. The Distribution of Efficiency Across Hospitals During the Period (1995-2000)

Table 4: Mean Cost Efficiencies by Size of Hospitals, Type of Control and Type of Services

Type	Variable	# Of Hospitals	Mean efficiency
Size*	Size1	20	0.8988
	Size2	61	0.9137
	Size3	36	0.9069
	Size4	37	0.8835
	Size5	51	0.9060
	Size6	54	0.8737
	Size7	37	0.8953
Type of Control	Non-Profit	180	0.8995
	District	43	0.9283
	City/County	17	0.8921
	Investor	56	0.8672
Type of Care	General	263	0.9016
	Specialty	13	0.8238
	Psychiatric	20	0.8863
DSH	DSH	80	0.9034

The average cost efficiencies by certain categories of hospitals are reported in Table 4. In general, the estimates of mean cost efficiency for most categories of hospital do not differ dramatically from the average cost efficiency for all the 296 hospitals that represent the sample of study. However, the most impressive but most expected differences are observed for the specialty care type of hospitals. These hospitals are 7% less cost efficient than the rest of the sample. These findings support the results of Li and Rosenman (2001). This may be because specialty hospitals deal with the complicated cases that need high tech capital and highly specialized labor.

We observe that size 6 hospitals are less efficient than the others. In addition, the district control hospitals are 3% more efficient than other hospitals. The investor control hospitals are 3% less cost efficient than the rest of the sample. On the contrary, the psychiatric care type hospitals were 1% less cost efficient than the average of other hospitals.

Our findings of the higher cost efficiency for district hospitals and lower cost efficiency for investor hospitals seems to be counter intuitive, specially, if compared with Wagstaff and Lopez (1996) results. They noted that five publicly owned hospitals were the most inefficient. This may be due to the fact that hospitals in California are highly regulated and competitive. This places a high pressure on non-private hospitals to be even more cost efficient than investor hospitals. No differences were found between the cost efficiency of hospitals with different sizes. The only difference that was reported earlier for size 6 hospitals was very minimal. This suggests that size does not matter in the cost efficiency of hospitals in California state during the period 1995 to 2005.

The average cost efficiencies of all the possible cross categories' averages are presented in Table 5. The efficiencies ranged from 73.4% to 97%. The biggest cross category was for general non-profit control hospitals, which contains 164 hospitals. In contrast, there were no hospitals for 11 cross categories. The cross categories for specialty size 5 hospitals are 17% less cost efficient than the average cost efficiency in our sample of study. Similarly, the following cross categories are at least 5% less cost efficient than the average: specialty care size 4 hospitals; specialty care size 5 hospitals, specialty care non-profit hospitals and specialty DSH reporting hospitals. In contrary, the cross category for psychiatric care size 7 hospitals is 7% more than the average cost efficiency. Likewise, the following hospitals are at least 5% more efficient than the average cost efficiency in the sample: city/county size 4 hospitals; psychiatric care size 7 hospitals; specialty care size 7 hospitals and psychiatric DSH hospitals.

Table 5: Mean Cost Efficiencies by Size of Hospitals, Type of Control, Type of Services and DSH Reporting

Variable	Mean		Variable	Mean	
	Obs.	efficiency		Obs.	efficiency
Size1*non-profit	15	0.9019	Size6*non-profit	25	0.8969
Size1*District	-	-	Size6*District	7	0.9180
Size1*City/County	5	0.9010	Size6*City/County	3	0.8617
Size1*Investor	-	-	Size6*Investor	19	0.8526
Size1*General	20	0.9017	Size6*General	31	0.8929
Size1*specialty-	-	-	Size6*specialty	8	0.8604
Size1*psychiatric	-	-	Size6*psychiatric	15	0.8713
Size1*DSH	10	0.9172	Size6*DSH	7	0.9055
Size2*non-profit	49	0.9169	Size7*non-profit	14	0.8835
Size2*District	6	0.9491	Size7*District	18	0.9276
Size2*City/County	3	0.8976	Size7*City/County	-	-
Size2*Investor	3	0.8949	Size7*Investor	5	0.8534
Size2*General	60	0.9184	Size7*General	35	0.8970
Size2*specialty1	1	0.8991	Size7*specialty	1	0.9690
Size2*psychiatric	-	-	Size7*psychiatric	1	0.9703
Size2*DSH	15	0.9198	Size7*DSH	7	0.9055
Size3*non-profit	27	0.9166	non-profit*General	164	0.9084
Size3*District	2	0.9154	non-profit*specialty	8	0.8291
Size3*City/County	4	0.8731	non-profit*psychiatric	8	0.9331
Size3*Investor	3	0.9184	non-profit*DSH	36	0.9042
Size3*General	36	0.9119	District*General	43	0.9281
Size3*specialty-	-	-	District*specialty	-	-
Size3*psychiatric	-	-	District*psychiatric	-	-
Size3*DSH	11	0.9085	District*DSH	10	0.9314
Size4*non-profit	25	0.8944	City/County*General	16	0.8907
Size4*District	2	0.9200	City/County*specialty	1	0.8991
Size4*City/County	1	0.9607	City/County*psychiatric	-	-
Size4*Investor	9	0.8660	City/County*DSH	16	0.8898
Size4*General	35	0.8906	investor* psychiatric	12	0.8606
Size4*specialty1	1	0.8381	investor*specialty	4	0.8814
Size4*psychiatric	1	0.9453	investor*psychiatric	12	0.8606
Size4*DSH14	14	0.8858	investor*DSH	18	0.9174
Size5*non-profit	25	0.9087	General*DSH	75	0.9110
Size5*District	8	0.9275	specialty*DSH	3	0.7931
Size5*City/County	1	0.9147	psychiatric*DSH	2	0.9553
Size5*Investor	17	0.9099			
Size5*General	46	0.9184			
Size5*specialty2	2	0.7339			
Size5*psychiatric	3	0.9354			
Size5*DSH	14	0.8961			

The cost inefficiency of Californian hospitals imposes a huge cost in the California state. And this may not be clear when we look at the average efficiency during the period of study that did not change much from 90 %. In Table 6, we present the average efficiency for all the hospitals under the study at each year in the first column. In the second column we calculate the annual total cost for the Californian hospitals. In the third column we sum the annual total minimum possible cost for all the hospitals under the study. Column four shows that the cost loss start by $ 2.2 billion in 1995, then doubled to reach a $4.6 billion in 2005. That amount of money or even a part of it is valuable and can be reinvested to improve the life of many people in the state of California.

Table 6: Monetary Loss due to Cost Inefficiency from 1995 to 2005

year	Average efficiency	Actual cost (A)	Minimum Cost (B)	Cost lost (A-B)
1995	0.8972	$21,848,138,881	$19,602,150,204	$2,245,988,677
1996	0.8999	$22,245,720,796	$20,018,924,144	$2,226,796,652
1997	0.897	$23,071,594,318	$20,695,220,103	$2,376,374,215
1998	0.8957	$24,638,908,303	$22,069,070,167	$2,569,838,136
1999	0.8955	$26,067,159,604	$23,343,141,425	$2,724,018,179
2000	0.8968	$28,101,154,436	$25,201,115,298	$2,900,039,138
2001	0.8965	$30,367,021,778	$27,224,035,024	$3,142,986,754
2002	0.8908	$32,848,002,229	$29,261,000,386	$3,587,001,843
2003	0.8884	$36,645,310,908	$32,555,694,211	$4,089,616,697
2004	0.8875	$39,951,621,982	$35,457,064,509	$4,494,557,473
2005	0.8947	$43,299,239,709	$38,739,829,768	$4,559,409,941

5. Conclusions

The hospital sector in the state of California expanded during the last decades. This expansion came in the form of rising total assets, total operating cost, and total paid hours. Available data shows that hospitals' assets increased from $ 33.955 billion in 1995 to $ 54.022 billion in 2005. However, the number of hospitals decreased from 495 hospitals in 1995 to 441 hospitals in 2005.

Our study reveals that the efficiencies of Californian hospitals ranged between 35% and 100% cost efficient. The average cost efficiency of about 90% implies that hospitals on average are 10% above the cost frontier that represent the minimum possible cost. This is higher than the cost efficiency estimated by the previous studies. Moreover, the efficiencies in Californian hospitals varies by size of the hospital, type of control, and type of care. Our results indicate that district control hospitals have higher than average cost efficiency, but specialty type of care hospitals, and investor type of control hospitals have less than average Cost efficiency. These differences become clear when we looked at the cross categories hospitals' average cost efficiencies. Efficiencies here ranged between 73% and 97%. The cross categories for specialty size 5 hospitals are 17% less cost efficient than the average cost efficiency in the sample of study. However, the cross category psychiatric care size 7 hospitals are 7% more efficient than the average cost efficiency.

References

[1] Aigner, D., Lovell, C. K., and Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. Journal of Econometrics, 6(1), 21–37.

[2] Alwaked, A. A., Al-qalawi, U. R., and Azaizeh, S. Y. (2020) Efficiency of Jordanian public hospitals (2006–2015). Journal of Public Affairs, e2383.

[3] Battese, G. E., and Coelli, T. J. (1988). Prediction of Firm Level Technical Efficiencies with a Generalized Frontier Production Function and Panel Data, Journal of Econometrics, 38, 387-399

[4] Battese, G. E., and Coelli, T. J. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data, Empirical economics, 20(2), 325-332.

[5] Bel, G., and Esteve, M. (2020). Is private production of hospital services cheaper than public production? A meta-regression of public versus private costs and efficiency for hospitals, International Public Management Journal,

[6] Choi, J. H., Fortsch, S. M., Park, I., and Jung, I. (2017). Efficiency of US hospitals between 2001 and 2011, Managerial and Decision Economics, 38(8), 1071-1081.

[7] Coelli, T. J. (1996). A guide to Frontier version 4.1: a computer program for stochastic frontier production and cost function estimation, CEPA Woeking Paper 96/07. Armidale: Center for Efficiency and Productivity Analysis, University of New England.

[8] Coelli, T. J, Rao D. S. P, O'Donnell, C. J, and. Battese, G. E. (2005). An Introduction to Efficiency and Productivity Analysis. New York: Springer

[9] Ferreira, D. C., Nunes, A. M., and Marques, R. C. (2018). Doctors, nurses, and the optimal scale size in the Portuguese public hospitals, Health Policy, 122(10), 1093-1100.

[10] Fujii, A., and Ohta, M. (1999). Stochastic cost frontier and cost inefficiency of Japanese hospitals: a panel data analysis, Applied Economics Letters, 6(8), 527-532.

[11] Guerrini, A., Romano, G., Campedelli, B., Moggi, S., and Leardini, C. (2018). Public vs. private in hospital efficiency: Exploring determinants in a competitive environment., International Journal of Public Administration, 41(3), 181-189.

[12] Jondrow, J., Lovell, C. K., Materov, I. S., and Schmidt, P. (1982). On the estimation of technical inefficiency in the stochastic frontier production function model, Journal of Econometrics, 19(2-3), 233-238.

[13] Kumbhakar, S. C., and Lovell, C. K. (2000). Stochastic Frontier Analysis, Cambridge: Cambridge University Press.

[14] Li, T., and Rosenman, R. (2001). Cost inefficiency in Washington hospitals: a stochastic frontier approach using panel data, Health Care Management Science, 4(2), 73-81.

[15] Meeusen, W., and van Den Broeck, J. (1977). Efficiency estimation from Cobb–Douglas production functions with composed error, International Economic Review, 18, 435–444.

[16] Nundoochan, A. (2020). Improving public hospital efficiency and fiscal space implications: the case of Mauritius, International Journal for Equity in Health, 19(1), 1-16.

[17] Rosko, M. D. (1999). Impact of internal and external environmental pressures on hospital inefficiency, Health Care Management Science, 2(2), 63-74.

[18] Wagstaff, A., and Lopez, G. (1996). Hospital costs in Catalonia: a stochastic frontier analysis, Applied Economics Letters, 3(7), 471-474.