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A COMPARISON OF COST EFFICIENCY OF PUBLICLY OWNED HOSPITALS: PRE AND POST THE UNIVERSAL HEALTH CARE

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ABSTRACT

The paper compares cost efficiency of regional and general hospitals before and after the implementation of the universal health care (UC) program. The UC program, fully implemented in the fiscal year 2002, generates greater demand for, better access to and narrow the disparity gap for health care; patients seek professional care sooner than the pre-UC era leading to more effective treatments at less cost. Hospitals faced with per capita funding have incentive to use available medical resources efficiently. The paper estimates two stochastic cost frontiers: one for a pre-UC sample (FY 2000-2001) and the other for a post-UC sample (FY 2002). Individual efficiency scores are used to create a pseudo data that removes inefficiency within its own group. The pseudo data for hospitals both pre and post-UC periods are used to estimate a new stochastic cost frontier and test whether hospital technologies remain the same after the implementation of the UC program. We find that post-UC cost efficiency, on average, is slightly better than the pre-UC average but the difference is not statistically significant at the 1% level. Furthermore, hospital technologies or the way in which hospitals manage their medical resources to provide care remain unchanged.

***Field**: Health Economics*

1. INTRODUCTION

Good health is an important aspect of a productive life, enabling people to contribute positively to the society they live in. Although an increasing proportion of Thai's GDP has been spent on health care over the past twenty years, approximately 18 million Thai citizens have no health insurance and another 37.3 million are covered by social security, medical welfare and health card programs (derived from Wibulpolprasert, *et al.*, 2002, p. 351 and total Thai population as of January 2002). These citizens receive care that may not meet acceptable standards for quality. Many Thai citizens continue to experience preventable and curable illnesses without adequate access to proper medical treatment, resulting in unnecessary deaths. As a result, Thai government fully implements the universal health care (UC) program in October 2001. This initiative intends to build healthier lifestyles that make people more immune to illness, leading to lower treatment cost and enhancing quality of life.

This paper compares cost efficiency of regional and general hospitals before and after the implementation of the universal health care (UC) program. It estimates two stochastic cost frontiers: one for a pre-UC sample (FY 2000-2001) and the other for a post-UC sample (FY 2002). Individual efficiency scores are used to create a pseudo data that removes inefficiency within its own group. The pseudo data for hospitals both pre and post-UC period are used to estimate a new stochastic cost frontier and compute cost efficiency scores for each hospital. These efficiency scores are then used to test the null hypothesis that hospital cost efficiency remains the same after the implementation of the UC program.

The paper is organized as follows. Section 2 provides background information on the health care systems in Thailand and effects of the universal health care program. Section 3 presents the theoretical underpinnings of the cost efficiency. Section 4 discusses the sample and presents our empirical results. Section 5 discusses potential implications of our efficiency results.

2. THE HEALTH CARE SYSTEMS IN THAILAND AND EFFECTS OF THE UNIVERSAL HEALTH CARE PROGRAM

The health services in Thailand are provided by the public sector as well as the private sector. Ministry of Public Health (MOPH) is the principal health agency in Thailand that is responsible for healthcare delivery services including promotion, support, control and coordination of all health activities. Other public sector agencies as well as non-profit and for-profit private organizations are active participants in Thai health care systems. Regional and general hospitals provide tertiary care, the most complex level of care, using specialized medical and health professionals.

The current health care systems in Thailand have a number of problems. First, medical resources are clustered in the Bangkok Metropolis Area (BMA) and are broadly different across regions outside BMA (Wibulpolprasert, *et al.*, 2002). Second, the health service systems are not efficient in terms of drug use, bed supply, and quality of care. Approximately one-third of total health care expenditure is for drug supplies, implying curative care rather than less expensive preventive care (Wibulpolprasert, *et al.*, 2002, p.327). Of the government budget for health care expenditure, curative care in hospitals accounts for approximately 60 to 66% and health promotion and disease prevention activities represent between 20 to 24% (Wibulpolprasert, *et al.*, 2002, p.333). Third, the four existing major publicly subsidized health insurance schemes, covering approximately 70% of the Thai population in 2001, have substantial different benefit packages across the schemes. Another 29% of Thais are without health insurance. These statistics highlight the problem with access to care.

The prevalence of these health care problems coupled with ever increasing total health care expenditures and a higher rate of premature deaths from inability to access to necessary care for preventable and curative illnesses implies that the health care in Thailand is in the state of crisis. As such, Thai government implements the UC program to change the ways Thai people seek health care from a passive to a proactive method. Specifically, the UC program promotes the use of primary care as a gatekeeper, standardizes the reimbursement mechanism under a cost containment system, provides patients with a flexible choice of primary care providers, and establishes a core benefit package that would minimize the differences in the current benefit packages across the publicly subsidized health insurance schemes (Health Insurance Office, 2002). The core benefit package includes curative care, medical rehabilitation, approved alternative care, high cost care as set by the designated committee, accident and emergency care, and preventive care (Health Insurance Office, 2002; Tancharoensathien, *et al.* 2001). Expenses beyond the core benefit package are patients' or their employers' responsibility.

The UC program replaces two of the four existing publicly subsidized insurance programs (Tangcharoensathien and Pitayarangsarit, 2003) and expands its coverage to include all Thai citizens who currently are not covered by any publicly subsidized health insurance schemes and are registered with the National Health Security Office to receive the core benefit package. With a few exceptions, registered beneficiaries pay a 30-baht co-payment for each episode of illness (Health Insurance Office, 2002). In effect, the UC program would provide Thai citizens equal access to health services that meet quality and efficiency standards.

Health care providers may participate in the UC program as contracting units for primary care, secondary care, and/or tertiary care. Both public and private health care facilities are eligible to participate in the program if they pass the primary standard evaluation. These facilities receive funding based on capitation rate per registered beneficiary. They also receive funding from other sources such as the 30-baht co-payment per episode of illness, reimbursements from other publicly subsidized insurance programs and private insurance, donations, sales of prescription drugs that are not on the approved list, out-of-pocket payments from inpatients staying in private rooms, and registered beneficiaries bypassing the referral procedure the UC program requires (mostly for outpatient care). A few studies focus on the financial implications of the UC program for health service facilities (Tancharoensathien, *et al.*, 2001; Tancharoensathien and Pitayarangsarit, 2003; Prakongsai, *et al.*, 2001; Banchuin, 2002). With the new funding method, health care facilities must control costs through better management of health care resources, and simultaneously improve the quality of services (Tancharoensathien, *et al.*, 2001; Tancharoensathien and Pitayarangsarit, 2003).

Although the capitation payment method is an effective way to contain costs, it could produce some undesirable effects. First, health care providers may attempt to reduce costs at the expense of quality (Tancharoensathien and Pitayarangsarit, 2003) by postponing treatments or using outpatient care instead of inpatient care (Tancharoensathien, *et al.*, 2001). However, evidence shows that the UC program has a positive effect on the development of the quality of laboratories, leading to a more effective and efficient use of resources and quality improvements, and that increased workloads are a result of increased access and increasing quality of services (Kadtu-in, *et al.*, 2003). Second, health care facilities may engage in selection bias such as refusing to provide care for complex, expensive cases (where possible), and transferring patients to other health care facilities (Tancharoensathien, *et al.*, 2001).

A few papers attempt to evaluate the success of the UC program based on case studies or surveys. These researchers focus on payment mechanism (Kongiamtrakun, 2002), collection of co-payment (Jongudomsuk, *et al.*, 2003), management of health resources (Patarakulvanich, 2003), and organization and information systems (Pengpara, *et al.*, 2003). To properly align with the capitation-based funding under the UC program, hospitals need effective manpower planning and management (Patarakulvanich, 2003; Pengpara, *et al.*, 2003), strategic plans that bridge the national policy and actions (Pengpara, *et al.*, 2003), and appropriate budget allocation and payment mechanisms (Pengpara, *et al.*, 2003; Kongiamtrakun, 2003). The current practice of co-payment collection follows the MOPH guidelines and achieves its objectives: (1) having Thai citizens participate in the national health systems reform, realize the value of services they receive, and (2) reducing unnecessary utilization of health care services (Jongudomsuk, *et al.*, 2003).

Using a large number of survey respondents in three low-income provinces in Thailand and the Probit regression method, Suraratdecha, *et al.* (2005) find that UC beneficiaries with a 30-baht co-payment do not utilize institutional health care excessively, compared to those with no co-payment and that the utilization of health care in general increases after the implementation of the UC program. The authors raise the issue of possible misclassification of beneficiaries between those with and without co-payments. In addition, the authors conclude that the disparity in health care utilization depends on patient preferences and their socio-economic status. A factor that might influence patient preferences is their perception that the UC program provides poor or inadequate medical treatment.

Elsewhere, a single health insurance plan has been implemented and studied in a variety of settings. For example, the United Kingdom has implemented the National Health Service for over 50 years and experienced a number of problems such as backlogs, lengthy waiting times, medical staff shortages, and customer/provider dissatisfaction (Umble and Umble, 2006). Smith (2002) highlights performance management activities used in British health care while Umble and Umble (2006) apply the buffer management to address these issues based on experience of three accident and emergency departments. Huang, *et al.* (2006) use Probit regression to analyze the effects of the Taiwanese Universal Healthcare System for a sample of appendectomy patients in 1996 to 2001. The authors conclude that the UC program effectively reduces barriers to access to care and the disparity in access between urban and rural patients. The monopsony power of the single-payer insurance market may in fact effectively allocate medical manpower and resources.

In the United States, discussion of a universal health care program as a means for cost containment occurs in the political and academic arena. Hackenschmidt (2006) discusses how the universal health care program in San Francisco creates a healthy community through improving preventive care, outpatient disease management, and appropriate utilization of emergency departments. Local universal access has ability to customize care for specific needs of its population. Similar effects are expected for the Massachusetts health care reform plan and many other states.

Existing studies for the effect of the universal health care program in Thailand as well as many other countries seem to suggest that, at least, the single-payer plan leads to better allocation of resources and access to care. Following this line of argument in the literature, this paper hypothesizes that post-UC program hospitals, on average, have higher cost efficiency than the pre-UC program hospitals. This hypothesis is tested using the methodology described below.

3. METHODOLOGY

Assume that each hospital minimizes its cost of providing health care services for given prices of inputs (e.g., medical personnel, medical supplies, capital) and consider a set of J

hospitals, $j = 1, 2, \ldots, J$. Each hospital provides M types of services, $m = 1, 2, \ldots, M$, using N inputs or resources, $n = 1, 2, \ldots, N$. Let y_{mj} be service m provided by hospital j. Let x_{nj} be input n used by hospital j and p_{nj} be the corresponding price. Let z_{ij} be characteristic i specific to hospital j, $i = 1, 2, \ldots, I$. These hospital-specific characteristics affect the service costs, regardless of the hospital's ability to utilize the available resources. The translog total cost function for hospital j (C_j) is expressed as follows.

$$\begin{aligned} lnC_j = \beta_0 + \sum_{m=1}^{M} \alpha_m ln\, y_{mj} + \frac{1}{2}\sum_{m=1}^{M}\sum_{m'=1}^{M} \alpha_{mm'} ln\, y_{mj} ln\, y_{m'j} + \sum_{n=1}^{N} \gamma_n ln\, p_{nj} \\ + \frac{1}{2}\sum_{n=1}^{N}\sum_{n'=1}^{N} \gamma_{nn'} ln\, p_{nj} ln\, p_{n'j} + \sum_{m=1}^{M}\sum_{n=1}^{N} \omega_{mn} ln\, y_{mj} ln\, p_{nj} + \sum_{i=1}^{I} \delta_i z_{ij} + \varepsilon_j, \\ j = 1, 2, \ldots, J, \end{aligned} \tag{1}$$

where $\varepsilon_j = u_j + v_j$ is a two-part error term comprised of the non-negative inefficiency component u_j and the random noise component v_j.

One of the properties of the cost function is the homogeneity of degree +1 in input prices, which requires that

$$\sum_{n=1}^{N} \gamma_n = 1; \quad \sum_{n'=1}^{N} \gamma_{nn'} = 0, n = 1, \ldots, N \text{ ; and } \sum_{n=1}^{N} \omega_{mn} = 0, m = 1, \ldots, M.$$

By imposing the linear homogeneity property and using p_{Nj} as a numeraire, the cost function in (1) becomes:

$$\begin{aligned} ln\left(\frac{C_j}{p_{Nj}}\right) = \beta_0 + \sum_{m=1}^{M} \alpha_m ln\, y_{mj} + \frac{1}{2}\sum_{m=1}^{M}\sum_{m'=1}^{M} \alpha_{mm'} ln\, y_{mj} ln\, y_{m'j} + \sum_{n=1}^{N-1} \gamma_n ln\left(\frac{p_{nj}}{p_{Nj}}\right) \\ + \frac{1}{2}\sum_{n=1}^{N-1}\sum_{n'=1}^{N-1} \gamma_{nn'} ln\left(\frac{p_{nj}}{p_{Nj}}\right) ln\left(\frac{p_{n'j}}{p_{Nj}}\right) + \sum_{m=1}^{M}\sum_{n=1}^{N-1} \omega_{mn} ln\, y_{mj} ln\left(\frac{p_{nj}}{p_{Nj}}\right) + \sum_{i=1}^{I} \delta_i z_{ij} + \varepsilon_j, \\ j = 1, 2, \ldots, J. \end{aligned} \tag{2}$$

We also impose the symmetry restriction, i.e., $\alpha_{mm'} = \alpha_{m'm} (m, m' = 1, \ldots, M)$ and $\gamma_{nn'} = \gamma_{n'n} (n, n' = 1, \ldots, N)$. We test the null hypothesis (H_0) that the log-linear function is an appropriate specification, i.e., $\alpha_{mm'} = 0, m, m' = 1, \ldots, M, \gamma_{nn'} = 0, n, n' = 1, \ldots N$ using the log-likelihood ratio test. A rejection of the null hypothesis indicates that the translog cost function is a more appropriate specification (H_a). The log-likelihood ratio ($\mathcal{L}$) is defined as: $\mathcal{L} = -2[\ln\mathcal{L}(H_0) - \ln\mathcal{L}(H_a)]$ follows a Chi-square distribution with degree of freedom equals to the difference in the number of parameters estimated under H_0 and H_a.

To estimate (2) as a stochastic cost frontier, we assume that v_j is identically and independently distributed as a normal random variable with zero mean and standard deviation σ_v (i.e., $v_j \sim iid\ N(0, \sigma_v^2)$), and that u_j and v_j are distributed independently of each other and of regressors. For the distribution of the inefficiency component u_j, this study assume that u_j is identically and independently distributed as a half-normal random variable with mean zero and standard deviation σ_u (i.e., $u_j \sim iid\ N^+(0, \sigma_u^2)$)[1]. The inefficiency component reflecting mismanagement of health care resources and raising total cost beyond the minimum possible cost, u_j, is computed using the algorithm described in Jondrow, *et al.* (1982). Essentially, the estimated u_j, $\hat{u}_j$, is computed as:

$$\hat{u}_j = E(u_j \mid \varepsilon_j) = \sigma_* \left[\frac{\phi(\varepsilon_j \lambda / \sigma)}{1 - \Phi(-\varepsilon_j \lambda / \sigma)} + \left(\frac{\varepsilon_j \lambda}{\sigma} \right) \right] \tag{3}$$

where $\sigma_*^2 = \frac{\sigma_u^2 \sigma_v^2}{\sigma^2}$, $\sigma^2 = \sigma_u^2 + \sigma_v^2$, $\lambda = \frac{\sigma_u}{\sigma_v}$. $\phi(\bullet)$ and $\Phi(\bullet)$ are the standard normal density and standard normal cumulative distribution functions, respectively. Note that λ is rough indication of the magnitude of inefficiency. As $\lambda \to 0$, the random component dominates the composed error term. As $\lambda \to +\infty$, the inefficiency component dominates the composed error term. (Kumbhakar and Lovel, 2000.)

The efficiency score for hospital j (Eff_j) is then computed as:

$$Eff_j = \exp(-\hat{u}_j). \tag{4}$$

This is equivalent to the ratio of minimum efficient cost to observed total cost. Eff_j is an index with a value between zero and one. When Eff_j is equal to one, i.e., the observed total cost is the same as the minimum efficient cost, hospital j is said to be cost efficient; it uses the available resources to the fullest extent. When Eff_j is less than one, say 0.8, the minimum efficient cost is 80% of the observed total cost. In this case, hospital j is cost inefficient. It could reduce its current cost by 20% while providing the same level of services at the given prices and quality of care if it could use the available resources efficiently. For further discussion of the stochastic cost frontier and its interpretation, see Greene (1993) and Kumbhakar and Lovell (2000).

As previously mentioned, we estimate equation (2) and compute individual cost efficiency, using equation (4), for pre-UC and post-UC samples separately. Our next step is to create a pseudo sample that removes within group inefficiency. This is accomplished by multiplying individual hospital's observed total cost by its respective efficiency score. We then re-estimate equation (2) for a pseudo sample that combines both pre-UC and post-UC observations. If hospitals have the same cost structure before and after the implementation of the UC program, no further inefficiency should be found after removing within group inefficiency. Otherwise, we compute cost inefficiency due to differences in cost structure between the two periods and compare their average efficiencies.

4. ANALYSIS OF PUBLICLY OWNED HOSPITALS IN THAILAND

4.1 Sample

The sample consists of 25 regional hospitals and 67 general hospitals in Thailand. We exclude hospitals in the Bangkok Metropolis Area since they operate in a very different environment. Both regional and general hospitals provide tertiary care for patients with similar case complexity, are staffed with medical personnel including medical specialists in all fields, and are under the MOPH. A regional hospital has at least 500 beds while the bed size for a general hospital ranges between 200 and 500. The pre-UC sample period covers the fiscal years 2000 and 2001. The post-UC sample period covers the fiscal year 2002. The main databases are financial and activity reports graciously provided by the Bureau of Planning and Technology, MOPH. Dr. Supasit Pannarunothai provides data on case mix variable. The remaining data are accessed from the websites of Health Resources (URL: *http://203.157.19.191/Pla1.1.html*) and of the National Statistical Office Thailand (URL: *http://www.nso.go.th/eng/indicators/economy/pi-e.htm*).

The annual financial report, based on a cash accounting basis, provides a breakdown of expenses by category. Total operating cost for each hospital is derived as the sum of salaries and wages, maintenance expenses, supplies, utilities, equipment and land expenses, and other expenses. The annual activity report provides information on output measures and hospital-specific characteristics.

This paper constructs two output measures: inpatient care and outpatient care. We use the number of inpatient discharges as a proxy for inpatient care. The outpatient care is measured as the number of outpatient visits including pre- and post-natal care, family planning, annual physical examination and immunization for various diseases such as polio, measles, and rubella.

The major input in health care service delivery is medical personnel, i.e., physicians, dentists, pharmacists, nurses and technicians. To construct the average salary for medical personnel, we need total wages and salaries and the number of full-time equivalent staff. The former is available from the financial report. The latter is not available at the hospital level. To overcome this problem, we assume that the number of medical personnel varies in proportion to the number of beds in a particular province and that the number of beds per each type of medical personnel is constant over the sample period. The latter assumption may slightly underestimate the number of beds per staff for large hospitals that limited hiring during the first year of the UC implementation. Using the number of beds per staff in 2000 and the reported number of beds in each hospital, we derive the number of medical personnel by category for individual hospitals. Total number of medical personnel for a hospital in a given year is the sum of the number of medical personnel in all five categories in that year. Average salary for medical personnel is therefore the ratio of total wages and salaries divided by total number of medical personnel.

Hospital-specific characteristics that may influence costs include hospital size, resource utilization, access, quality, and location. This paper uses number of beds (BED) to control for hospital size. Intensity of resource utilization depends on types and the severity of illness as proxy by a case-mix index (CM). CM is an index representing the average of standardized charges for DRG groups. A hospital treating relatively more complex patient cases requires more medical resources and therefore has higher CM. Access to care may be captured by number of outpatient visits per patient (V/P), occupancy rate (OCC), per capita income (INC) and population (POP). With the implementation of the UC program, citizens who previously have no health insurance are expected to seek medical care sooner. However, V/P may not necessarily increase since the number of patients may increase at a faster rate than the increase in number of visits. A high per capita income, on the other hand, increases access since patients have ability to pay for their care and perhaps increases costs through additional amenities requested during their in-hospital stays. In contrast, increase POP and/or occupancy rate may suggest less access due to increase demand for medical care while supply for care is limited. Quality of care is difficult to measure. The only available data include percentage of in-hospital deaths (DEATH_I), the percentage of patients being transferred to other hospitals (REF_OUT), the percentage of patients admitted from other hospitals (REF_IN), and hospital type dummy variable (TYPE, regional hospital = 1). Cost differences may be associated with hospital location. We attempt to capture this cost difference with regional dummies (Central, North, Northeast, and South). Based on the pair-wise correlations, this paper includes the following hospital specific characteristics: BED, CM, INC, TYPE and regional dummies. These variables are less correlated with one another and reduce multicollinearity that may exist in the estimation.

Table 1 presents descriptive statistics of the samples. The pre-UC sample includes 91 hospitals in FY2000 and 89 hospitals in FY2001. For FY2002, two general hospitals in the North report part year activities with full year financial data. The activities of these hospitals are pro-rated to make up for a full year. The UC sample includes 89 hospitals. Our samples exclude hospitals that we do not have complete data.

Table 1
Descriptive Statistics of the Samples

	Pre-UC Sample (N = 180)		*Post-UC Sample (N= 89)*	
Variable	*Mean*	*S.D.*	*Mean*	*S.D.*
Total costs (in constant FY 2000 million baht)	276.2	154.3	332.1	179.3
Outputs				
Number of outpatient visits	242317	110213	437151	182673
Number of inpatient discharges	27749	12884	26475	13151
Input price				
Average monthly wages for medical personnel (in constant FY 2000 baht)	18822.6	3159.5	21058.8	3160.1
Hospital specific characteristics				
Size: Number of beds	432.6	195.3	431.0	191.8
Utilization: Case mix index	0.84	0.125	0.90	0.14
Access: Monthly family income in 2000* (Baht)	10553.4	3469.8	11547.7	3874.0
Quality: Hospital type (1= Regional hospital)	0.27	0.45	0.27	0.45
Location: Regional dummies				
Central	0.37	0.48	0.35	0.48
North	0.22	0.41	0.22	0.42
South	0.21	0.41	0.21	0.41
Northeast	0.21	0.41	0.21	0.41

* Monthly family income and population for 2001 are not available. This paper applies the respective information for 2000 to 2001 data.

Overall, each sample comprises approximately a 27:73 mix of regional and general hospitals. These hospitals are evenly distributed across the nation with slightly more in the Central region. On average, total costs for the UC sample are higher than that for the pre-UC period. The high costs may be attributable to higher wages (due to annual salary and longevity increases), increase complexity of patients treated (significantly higher CM at the 1% level based on the ANOVA test), and the approximately 80% increase in outpatient care. In fact, the outpatient visits increase by 50%, the pregnancy care increases four times and the immunization increases by two-thirds while the population increases only 6%. This seems to indicate that the UC goals of providing access to care and of promoting preventive care are working. Average monthly income for the post-UC sample is higher than that for the pre-UC sample and is statistically significant at the 5% level. Although, the number of beds is stable between the two time periods with average occupancy rate of 85%, disparity in the distribution of beds exists.

4.2 Estimated Cost Frontiers and Efficiency Results

To empirically estimate the reduced-form cost function in (2), we use LIMDEP version 8.0 (Greene, 2002). The model includes two outputs, one input price, and seven hospital specific characteristics. Dummy variable for hospitals in central region is used as our reference. Since the full specification of the cost function has only one input price, the coefficients for the input price both the first and the second order terms and for the interactive terms between input price and output quantities disappear as a result of imposing homogeneity of degree +1 in input price. Therefore, the estimated reduced form of the cost function automatically satisfies the non-decreasing property of the cost function without further test. For each sample, we first estimate equation (2) and then restrict the coefficients for the second order terms of the output variables to zero to test for appropriate specification as described in Section 3. Our results show that the coefficients of the second order terms for the output variables are not significantly different from zero, supporting the log-linear cost specification.

Table 2 displays parameter estimates for the pre-UC and post-UC samples separately as well as the parameter estimates for the pseudo data after eliminating inefficiency within group. By and large, these parameter estimates are similar in terms of magnitude, sign, and level of significance. The first two column estimations are based on the frontier method which is comparable to the estimation in the third column because the data used to estimate parameters in the third column are efficient costs.

The coefficients for output variables are relatively stable across sample periods. Consistent with theory, they are positive and statistically significant at the 1% or 5% level. A one percent increase in outpatient visits raises total costs from 0.2% to 0.4%, ceteris paribus. The coefficients for the number of inpatient discharges are similar in magnitudes as for the number of outpatient visits. Ceteris paribus, total costs increase 0.2% to for every 1% increase in the number of inpatient discharges.

Although a bed increase raises total cost by mere 0.001%, it is statistically significant at the 1% level. This suggests that diseconomies of scale exist in the provision of health care. Coefficients for case mix index and income are positive and significant at the 1% level. We find evidence that higher access and more complex cases treated increase total cost. Patients who are very sick and/or able to afford their share of health care costs seek care from medical personnel. Income is a proxy for demand as well as access to care.

Table 2
Estimations of the Cost Frontiers

	Half-Normal		
Variable	*Pre-UC Coefficient*	*Post-UC Coefficient*	*Pseudo Sample Coefficient*
Constant	1.392 *	2.307 **	1.720 ***
Outputs:			
Log (outpatient visits)	0.367 ***	0.230 **	0.291 ***
Log(inpatient discharges)	0.199 **	0.248 **	0.236 ***
Hospital Specific Characteristics:			
Number of beds	0.001 ***	0.001 ***	0.001 ***
Income	0.000023 ***	0.000025 ***	0.000025 ***
Case mix index	0.803 ***	0.842 ***	0.825 ***
Hospital type (R = 1)	0.0061	0.0017	0.007 *
Regional dummies			
South	0.040	0.119 *	0.071 ***
Northeast	-0.104	-0.090	-0.100 ***
North	0.042	0.052	0.045 ***
Pre-UC			0.152 ***
λ	2.321 ***	2.071 ***	
σ	0.279 ***	0.270 ***	
Log likelihood	48.6	24.2	

'***', '**', and '*' denote respectively the 1%, 5%, and 10% level of significance. The pre-UC and the post-UC samples are estimated using a maximum likelihood estimation (MLE) method. The pseudo sample was estimated using OLS since no additional inefficiency beyond within group inefficiency and therefore OLS is MLE.

Coefficients for regional dummies provide mixed results in terms of significance. Hospitals in the Northeast experience lower costs, ceteris paribus, compared to hospitals in the Central region. This is consistent with the finding that the workload of medical personnel in this region is the highest (Patcharanarumol, et al., 2001). In other words, hospitals in the Northeast are extremely efficient in using limited medical resources to meet health care needs. This practice might be at the expense of quality care and may not be sustainable over time. Hospitals in the South and the North experience higher costs, compared to those in the central region. Contrary to general belief, regional hospitals do not incur higher costs compared to general hospitals.

Turning to cost efficiency, our results reveal that average pre-UC and post-UC cost efficiencies are 0.82 and 0.83, respectively. Relatively to its own group, these hospitals on average could potentially reduce their operating costs almost 20% had they manage their medical resources similar to best performers. These average efficiency scores are not statistically different at the 1% level, based on a battery of nonparametric tests. We further test the difference in efficiency scores before and after the implementation of the UC program by assuming that hospitals in both time periods process the same technology and estimating a common cost frontier for the combined sample. The average efficiency scores for the pre-UC and post-UC hospitals relative to the common frontier are, almost the same at 0.82. Similar to the separate frontier results, average efficiency scores are not statistically significant differences across time periods at the 1% level. Our evidence does not support the alternative hypothesis that the implementation of the UC program improves cost efficiency.

As mentioned in Section 3, we create frontier total costs using efficiency scores computed from separate frontiers (or within group efficiency we incorporate a pre-UC dummy if a hospital is from the pre-UC period) to eapture a possible shift in the frontier cost. to adjust total costs and re-estimate the total cost function using the combined adjusted data. The frontier estimation is the same as the OLS estimation. This indicates that hospitals pre and post the implementation of the UC program have similar cost structure or access to the same production technology, i.e. the management of medical resources after the inefficiency within group is eliminated. However, the coefficient of the pre-UC dummy is statistically significant at the 1% level. suggesting a slight downward shift in the frontier cost after the implementation of the UC program. There is no other difference in cost efficiency due to different cost structure between the two time periods.

5. CONCLUSIONS AND DISCUSSION

This paper estimates stochastic cost frontiers for regional and general hospitals operating during the two years prior to and the first full-year of nationwide implementation of the universal health care program. We use the separate frontier approach to compute within group inefficiency and the combined frontier approach to assess the potential efficiency differences pre and post the UC program.

Our analysis reveals that the UC program may be succeeding in making health care more accessible and that treating more complex cases with advanced and expensive medical procedures and/or patients with high income raise operating costs. Evidence also suggests that operating costs vary across regions. If hospitals in our sample manage their medical resources similar to the best performers, they could reduce operating costs by almost 20% on average. This figure should not be taken at the face value due to possible omitting variables such as accurate measures of quality, patients' risk scores, patients' satisfaction rates and readmission rates in our analysis similar to those discussed in Yaisawarng and Burgess (2006). Yet, the magnitude of cost inefficiency is substantial that warrants further research in determining a more accurate level of inefficiency. Cost inefficiency could be a major contribution to the growth of health care costs in Thailand.

Notes

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1. Alternative assumptions commonly used in the existing literature are truncated normal and exponential distributions. In general, efficiency scores and rankings are not sensitive to the distributional assumption (Rosko, 2001).
2. The number of inpatient days is positively correlated with the number of inpatient discharges with the pair-wise correlation of 0.9, suggesting that distributions of patients across hospitals are similar in the severity of illness levels.

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