HOSPITAL TECHINICAL EFFICIENCY:

COMPARISON OF FINANCIAL AND NON-FINANCIAL INPUT VARIABLES

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การประเมินประสิทธิภาพด้วยวิธี Data Envelopment Analysis (DEA) นั้นเป็นวิธีประเมินประสิทธิภาพของโรงพยาบาลที่ใช้อย่างแพร่หลายผลของการประเมินสามารถถูกเหนี่ยวนำด้วยตัวแปรที่เลือกใช้ในการวิเคราะห์มีตัวแปรสองกลุ่มที่ถูกใช้ในการวิเคราะห์กล่าวคือ กลุ่มที่ 1 เป็นตัวแปรทางด้านการเงินคือต้นทุนแรงงาน (labor cost) ต้นทุนที่ไม่เกี่ยวกับแรงงาน (non-labor cost)และต้นทุนของเงินทุน (capital cost) และตัวแปรกลุ่มที่ 2 เป็นตัวแปรที่ไม่เกี่ยวกับการเงินคือจำนวนแพทย์พยาบาลเจ้าหน้าที่และจำนวนเตียงผู้ป่วยการวิเคราะห์ด้วยวิธีDEAนี้ถูกใช้วัดประสิทธิภาพเชิงเทคนิคและเชิงขนาด (technical and scale efficiency) ในโรงพยาบาล 3 ระดับ (โรงพยาบาลศูนย์ โรงพยาบาลกลางและโรงพยาบาลชุมชน) ในประเทศไทยปี 2010 โดยใช้ตัวแปร 2 กลุ่มเพื่อวิเคราะห์แสดงผลลัพธ์เดียวกัน

ผลวิเคราะห์แสดงให้เห็นว่าผลการวิเคราะห์ประสิทธิภาพของโรงพยาบาลศูนย์ (regional hospital)ไม่ขึ้นอยู่กับตัวแปรที่เลือกในการวิเคราะห์สำหรับโรงพยาบาลกลาง (general hospital)ตัวแปรที่เลือกใช้ไม่มีผลเหนี่ยวนำต่อผลประสิทธิภาพเชิงเทคนิค (technical efficiency) แต่มีการเหนี่ยวนำต่อผลการวิเคราะห์ประสิทธิภาพเชิงขนาด (scale efficiency) ค่าของประสิทธิภาพเชิงขนาดโดยการคำนวณจาก 2 แบบจำลองที่มีตัวแปรต่างกันผลแสดงให้เห็นว่าโรงพยาบาลกลางเหล่านี้มีเงินมากพอแต่มีจำนวนบุคคลากรและจำนวนเตียงไม่เพียงพอซึ่งโรงพยาบาลสามารถเพิ่มขนาดได้โดยการจ้างบุคคลากรเพิ่มและเพิ่มจำนวนเตียงผู้ป่วยสำหรับโรงพยาบาลชุมชน(community hospital)ผลการวิเคราะห์วิธี DEA ให้ค่าที่ไม่คงที่และค่าของประสิทธิภาพที่วิเคราะห์ได้เปลี่ยนไปเมื่อเปลี่ยนแปลงตัวแปรในแบบจำลอง

สาขาวิชาเศรษฐศาสตร์สาธารณสุขและการจัดการบริการสุขภาพ ลายมือชื่อนิสิต..............................

ปีการศึกษา2554 ลายมือชื่อ อ. ที่ปรึกษาวิทยานิพนธ์หลัก..............................

ลายมือชื่อ อ. ที่ปรึกษาวิทยานิพนธ์ร่วม..............................

##5485604929: MAJOR HEALTH ECONOMICS AND HEALTH CARE MANAGEMENT
KEYWORDS: HOSPITAL EFFICIENCY / DATA ENVELOPMENT ANALYSIS(DEA) / INPUT VARIABLES

DI TIAN : HOSPITAL TECHNICAL EFFICIENCY: A COMPARISON OF FINANCIAL AND NON-FINANCIAL INPUT VARIABLES. ADVISOR: ASSOCIATE PROFESSOR SOTHITORN MALLIKAMAS, PH.D., CO-ADVISOR : PIRUS PRADITHAVANIJ, M.D. FACHE.,83 pp.

Data Envelopment Analysis is widely used in the field of hospital efficiency measurement. The result can be influenced by the choice of input variables. Two groups of input variables are applied in the analysis. Group 1 is consisted of financial variables: labor cost, non-labor cost and capital cost. Group 2 are non-financial variables including number of doctors, nurses, other personnel and beds. Input-orientated Data Envelopment Analysis is used to measurement the technical and scale efficiency of three level hospitals (regional, general and community hospital) in Thailand of 2010 with two different groups of input and the same output.

The result reveals that for regional hospital, the choice of input variables has no influence on the measurement of efficiency. For general hospital, the choice of input has no influence on the measurement of technical efficiency, but has special impact on the measurement of scale efficiency. The scale efficiency scores come from two models with different inputs of hospitals are different from each other. This reveals that general hospitals have had enough money but not enough labor and bed. They need to increase their scale by hiring more employees and opening more beds. For community hospital, the result of DEA is not steady and the scores change when different input variables is chosen.

Field of Study: Health Economics and Health Care Management Student's Signature ....

Academic Year : 2011 Advisor's Signature ....

Co-advisor's Signature ....

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LIST OF ABBREVIATION

AE	Allocative efficiency
AHA	American heart association
BBC	Banker-Charnes-Cooper model
CCR	Charnes-Cooper-Rhodes model
CMS	Center for measurement of science
CRS	Constant returns to scale
DEA	Data envelopment analysis
DMU	Decision making unit
FTE	Full time equivalent
MoPH	Ministry of Public Health
OE	Overall efficiency
SFA	Stochastic frontier analysis
TE	Technical efficiency
UC	Universal coverage
VRS	Variable returns to scale

CHAPTER Ⅰ

INTRODUCTION

Hospital efficiency is a hot spot all over the world. If hospital efficiency can be rightly measured, administration can be applied into appropriately way to decrease the health expenditure in unnecessary fields and improve their efficiency. This thesis is focused on a technical method for hospital efficiency measurement: data envelopment analysis (DEA).

1.1 Problem and significance

Improving the efficiency of health care is one of the most important management challenges currently because health expenditure increases fast and occupies a big portion of a country's gross national production all over the world. Managers and policy makers of health care need to respond to this kind of challenge with sound performance evaluation and decision making. Performance evaluation based on optimization technique and normative structure provides the benchmarks for hospitals evaluation on one hand, on the other hand, it contains information for lacking organizations and illustrates how to improve performance.

From the year of 1983, more and more parametric and non-parametric methods have been employed into the field of health care to measure and analyze the performance of health care service. It includes but not limits to hospitals, physician group practice, health maintenance organizations, nursing homes, and other health care delivery organizations. In these methods, the most widely used and accepted is data envelopment analysis (DEA) because it can easily be applied to the case with multiple inputs and outputs when information about factor or product price is not complete. The number of researches with this method keeps increasing because of availability of software which allowing easily application this technique to data. It can help health care managers to assess their organizations' relative performance, and identify top performance in the health care market. When further analysis followed, DEA can also identify ways to improve performance of the organization that are not one of the top performing organizations.

Measurement of the variables that describe the true nature of service production is an important prerequisite for performance measurement. In health care, due to the special characteristics of the services provided, it is often difficult to find appropriate variables and their measurement. This depends on the level of analysis and whether the measurement is carried out at level of hospital or department on some extent.

Although some researchers provide the ongoing identification of input and output variables for a robust hospital sector service production via DEA model contains case-mix adjusted admissions and outpatient visits as outputs and bed, service-mix, full time equivalents (FTEs) and other operational expenses as inputs, not all these variables are available in every country.

Defining and measuring the output at the hospital level varies considerably across providers by the volume and scope of services provides, and also by patient's severity. Lack of homogeneity in outputs produced and scale of operations may force one to conduct the performance analysis on those facilities considered peer-group organizations. What's more, even for a specific hospital, the different definitions of outputs can lead the results of efficiency evaluation go to different directions. For instance, there is a kind of definition that healthcare output is the quantity of health care services received by patients, adjusted to allow for the qualities of service provided. It can group into three types as activities, episodes of care and outcomes. All this three types can reflect some aspects of a hospital's output, but not all. Similarly, defining and measuring the inputs may pose difficulties as well. For example, difference may arise in whether pricing of input units or depreciation of capital assets should be taken into consideration. The representativeness of these input variables on hospitals' operational processes can also influence the result of DEA. From another side, the difference between the results with different inputs or outputs can reflect some true nature of service production.

Input variables can be categories as financial and non-financial variables. The former one contains variables measured by local currency, such as labor cost and capital cost. The latter one includes those measured by number, such as number of doctors and number of nurse. Input variables should represent the real input of a hospital. As usual, non-financial variables, such as number of doctors, number of nurse, number of other personnel and number of bed, can reflect the input of a hospital including labor and capital input. This kind of variables is simple, direct and easy available. In many previous researches about hospital efficiency, people prefer to choose them. However, financial variables contain more information about hospital inputs compared to non-financial variables. Financial variables take unit price of labor, capital cost and operating cost into consideration which may be different from hospital to hospital. Although in the system of public hospital in many countries, the unit price of labor can be the same from hospital to another which is decided by government, the capital input and operating cost are still different.

This thesis chooses Thai public hospital as the model. There have had many researches about public hospital efficiency measurement via DEA in Thailand already. There is a very widely quote paper which analyzes the efficiency of Thai provincial public hospitals during the introduction of universal health coverage using capitation by applying DEA and truncated regression. It provides the operating situation of hospitals in the special period of health reform. Therefore, DEA is a convenient tool for hospital efficiency measurement.

In the researches published in recent few years, most of the researches use only non-financial variables and some mix financial and non-financial together in their researches. These researches give the general information about the public hospital efficiency. What's more, because health personnel in public hospital are paid the same across region and by tenure in Thailand, the result of comparison between models with financial and non-financial variables can provide information about how the hospitals are operating.

1.2 Research questions

With the data of Thailand, this research aims at answering the question as following:

Primary research question

Whether the technical efficiency and scale efficiency scores change when applying into models with different groups of input variables: financial variables and non-financial variables.

Secondary research question

What phenomenon or characteristic of health service can be explained by the answer of primary research question?

1.3 Research objectives

The research objectives are corresponding to research questions as following:

Primary research objective

To analyze the difference of input variables (financial variables and non-financial variables) on hospital efficiency measurement via DEA.

Secondary research objective

To explain level of efficiency by using hospital characteristics.

1.4 Scope of study

This study analyzes data of Thailand public hospitals out of Bangkok in the year of 2010 excluding teaching hospitals from a hospital database because health system in Bangkok is different to the rest of the country. The competition from private hospitals in Bangkok is significantly higher than those in other provinces. What's more, teaching hospitals will not be taken into consideration as the reason that they normally operate in more efficiency way than other hospitals based on the advantages of better professionals and technology equipment.

Public hospitals will be divided into three groups as their levels: regional hospitals, general hospitals and community hospitals. The efficiency of each type of hospital will be analyzed separately in order to state the different respondent to two groups of input variables.

1.5 Possible benefit

Potential beneficiaries of this study may include: Ministry of Public Health, public hospitals, scholars involved in health policy, health administration and economic research. This study provides evidence on the effects of inputs on hospital efficiency in DEA. It reveals the influence on efficiency measurement profile in DEA approach when applying two groups of input variables into the model and tries to explain what is happening in the process of health service.

The result of this study can provide reference for policy makers in health care related sectors when evaluating the efficiency of certain hospital measured by DEA approach. What's more, it can reflect some characteristics of different types of hospital.

CHAPTER Ⅱ

LITERATURE REVIEW

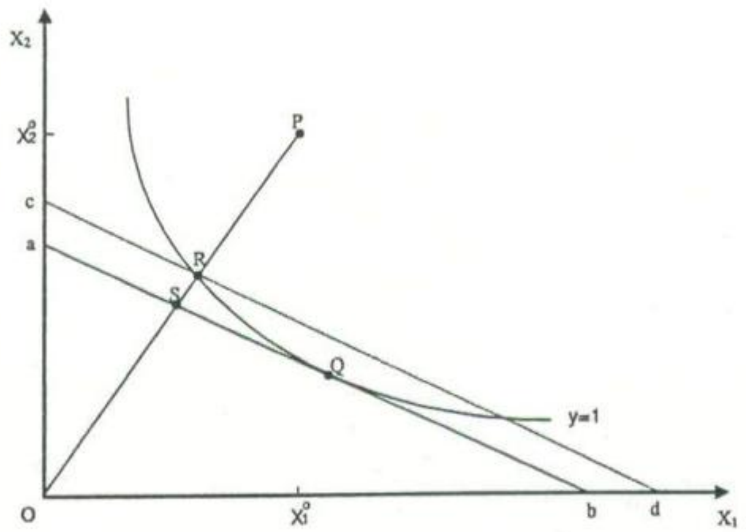
There have already had many researches about hospital efficiency measurement via DEA. This part analyze the definition of efficiency and hospital efficiency, measurement of hospital efficiency (including DEA and SFA), previous studies on hospital efficiency with DEA and studies about choosing input variables in order to find out what has been done and what has not.

2.1 Definition of efficiency and hospital efficiency

The definition of efficiency is the foundation of hospital efficiency measurement related research, especially for those applied with DEA method.

In particular and following the seminal work of Farrell (1957), technical efficiency has the meaning of producing the maximum amount of output from a given amount of input, or alternatively producing a given output with minimum quantities of input. The research points out it usually mean that its success in producing as large as possible an output from a given set of input in a firm. A simple example with a single output (y) being produced from two inputs, X1 and X2 is used to make a detailed explanation (Figure 2-1).

Figure 2-1 Farrell's measures of efficiency



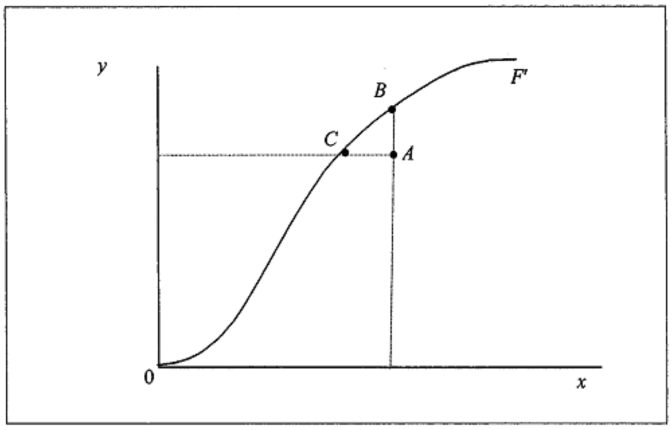
The production function shows the maximum output which produced from the input combinations and in general is $y = f(X_1, X_2)$. Assumptions are made here that the production function was linearly homogeneous and constant returns to scale.

In real cases, increasing or decreasing returns are possible.

The efficient unit isoquant y = 1 in Figure 2-1 shows the technically efficient input combinations used to produce a unit of output. Suppose that the actual observed input-output combination is at point P, with input-mix (X_1^0, X_2^0) and unit output y = 1. Production at P is technically inefficient since the firm can produce output y = 1 by employing the same input mix but using the input quantities at point R on the isoquant. Therefore, technical efficiency (TE) at point P is TE = OR / OP. If technical efficiency equals to 1, the firm is technically efficiency and operates on the efficiency isoquant and when TE is less than 1, the firm is technically in efficient and the more inefficient the unit, the smaller is technical efficiency. It should be noted that a firm may also be cost-minimizing. With given relative factor prices, shown in Figure 2-1 by the isocost line ab, the optimal input-mix to produce y =1 is at point Q. If the unit at P is technically efficient, that is, if operating at R, its cost is represented by the isocost line cd, which is above minimum cost ab. Thus, at its observed input mix, unit P needs to use input quantities that correspond to point S to deliver a unit of output at minimum cost. Therefore, allocative efficiency (AE) is AE = OS / OR. The overall cost of producing at point Q relative to P is the measure of overall (economic or productive) efficiency, OE, which is the product of technical and allocative efficiency, that is OE = OS / OP = OR / OP * OS / OR.

Coelli, Rao, O'Donnell and Battese (2005) contains the definition efficiency with more details. Although productivity and efficiency have similar meaning and are often used interchangeable, in fact, they are imprecisely the same thing. Productivity of a firm is the ratio of the output(s) that is produces to the input(s) that is used. In order to illustrate the distinction between productivity and efficiency, a simple production process in which a single input (x) is used to produce a single output (y) is introduced here.

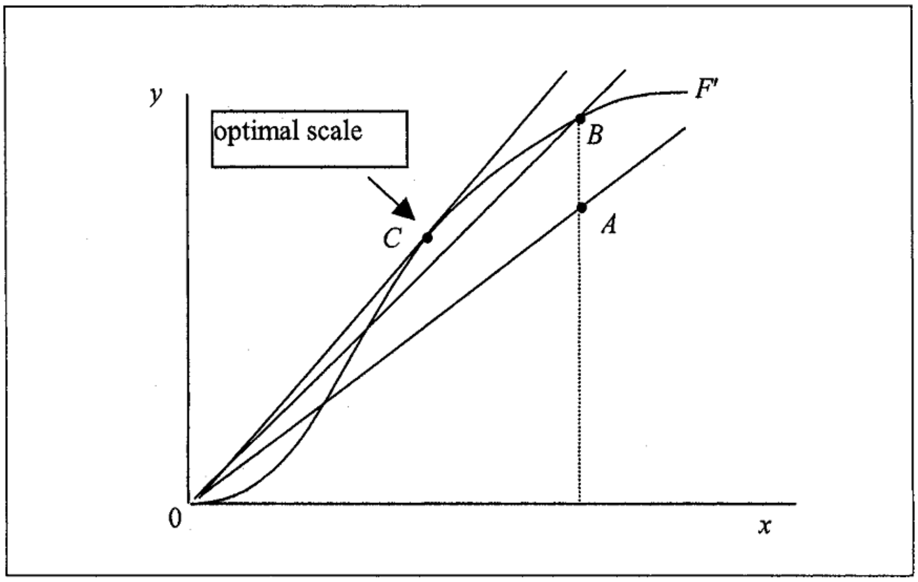
Figure 2-2 Production frontiers and technical efficiency



In Figure 2-2, the line OF' presents a production frontier that may be used to define the relationship between the input and the output. It represents the maximum output attainable from each input level. Hence it reflects the current state of technology in the industry. Firms in this industry operate either on that frontier, if they are technically efficient or beneath the frontier if they are not technically efficient. Point A represents an inefficient point whereas point B and C represent efficient point. A firm operating at point A is inefficient because it could increase output to the level associated with the point B without requiring more input. Or alternatively, it could produce the same level of output using less input by producing at point C on the frontier for example.

To illustrate the distinction between technical efficiency and productivity, Figure 2-3 is introduced in the following. In this figure, a ray through the origin point can measure productivity at a particular data point. The slope of this ray is y/x and hence provides a measure of productivity. If a firm operating at point A moves to the technically efficient point B, the slope of the ray would be greater, implying higher productivity at point B. However, by moving to the point C, the ray from the origin is at a tangent to the production frontier and hence defines the point of maximum possible productivity. The latter movement is an example of exploiting scale economies. The point C is the point of technically optical scale. Operation at any other point on the production frontier results in lower productivity.

Figure 2-3. Productivity, technical efficiency and scale economies



From this discussion it can be concluded that a firm may be technically efficient but may still be able to improve its productivity by exploiting scale economies. Changing the scale of operations of a firm can often be difficult to achieve quickly, technical efficiency and productivity can in some extent be given short-run and long-run interpretations. What's more, if information on prices is available, under an appropriate behavioral assumption, such as cost minimization or profit maximization, performance measures can be devised which incorporate this information. In such cases it's possible to consider allocative efficiency, in addition to technical efficiency. Allocative efficiency in input selection involves selecting that mix of inputs, such as labor and capital, which produces a given quantity of output at minimum cost. Allocative efficiency and technical efficiency combine to provide an overall economic efficiency measure.

Because of the unique characteristics of health care service, hospital efficiency seems to have a specific meaning. Magnussen (1996) has the opinion that a hospital is said to be technically efficient if an increase in an output requires a decrease in at least one other output, or an increase in at least one input. Alternatively, a reduction in any input must require an increase in at least one another input or decrease in at least one output. Hollingsworth, Dawson, and Manadiakis (1999) review 91 papers up to and including 1997 which relate to the measurement of productive performance of health care services, especially the conception and measurement of efficiency and productivity. The theoretical foundation of efficiency measurement comes after the concept of efficiency of Farrell's. Therefore, when a hospital is technically efficient, it is under the circumstance of operating on the production frontier. Allocative efficiency occurs when the input mix is that which minimizes cost given input prices, or alternatively, when the output mix is that which maximizes revenue given output prices. Technical and allocative efficiency comprise over efficiency. In short, there is no specific meaning of hospital efficiency. The conceptions of efficiency in hospital related references come from the general idea about technical efficiency which applied in other study fields.

2.2 Measurement of hospital efficiency

In order to measure efficiency, knowledge and information of the production function or the cost frontier is required. In practice, the frontier is formed by the most efficient among sampled firms. It is defined in terms of the firms which use the least input to produce a certain output or alternatively. There are two major characteristics that can be applied to distinguish alternative empirical approaches for constructing the frontier and measuring efficiency methods: whether it is parametric or not, and whether it is deterministic or stochastic. Parametric method assume that a specific functional form for the frontier, while non-parametric method does not. Deterministic method assumes that the distance of a unit from its frontier is a result of inefficiency whereas stochastic methods assume that is due to random error. The main methods are summarized in Table 2-1.

Table 2-1 Analytical methods of efficiency measurement

	Parametric	Non-parametric
Deterministic	● Parametric mathematical programming ● Deterministic (econometric) frontier analysis	● Data envelopment analysis (DEA)
Stochastic	● Stochastic (econometric) frontier analysis	● Stochastic data envelopment analysis

Data envelopment analysis (DEA) and stochastic frontier analysis (SFA) are the most prevalent two tools in the field of hospital efficiency measurement. Hollingsworth (2003) reviews 188 published papers up to 2002 on the topic of frontier efficiency measurement. The techniques used are mainly based on non-parametric data envelopment analysis. One fifth of these studies used two stage analysis (DEA followed by some form of regression) to identify determinants of efficiency and there is an increasing trend of using parametric techniques, such as stochastic frontier analysis. DEA and SFA take different approaches to establishing the location and shape of frontier and to determining where each decision making unit (DMU) is located in relation to the frontier.

DEA is a non-parametric technique which has an assumption that not all firms are efficient. It allows multiple inputs and outputs to be used in a linear programming model that develops a single score of efficiency for each observation used to measure technical efficiency, scale efficiency, allocative efficiency, congestion efficiency, technical change and total factor productivity change. DEA requires input and output quantities if production efficiency is examined and can be used with both cross-sectional and panel data. It does not account for noise due to its deterministic nature (deviation from the frontier is a result of inefficient operations). However, researchers are currently developing stochastic and other variants of DEA models that incorporate a random error component (Ozcan, 2007).

SFA is a parametric technique and it assumes that all firms are not efficient and account for noise. A general stochastic frontier model can be formulated as:

$$TC = TC(Y, W) + V + U$$

where TC = total cost

Y = output

W = input prices

V = random error assumed normally distributed with zero mean and variance

U = the inefficiency residual.

SFA can be used to conduct test of hypotheses. It can also be used to measure technical efficiency, scale economies, allocative efficiencies, technical change and total factor productivity change. However, SFA requires input and output quantities for empirical estimation of production function. It can also be used to analyze panel or cross-sectional data. It comes with certain shortcomings as well. For example, it requires specification of functional form and specification of a distributional form for the inefficiency term (U as mentioned in the above equation). With the use of price information as well as quantity information, additional measurement errors may be added to the results. The resulting inefficiency may be due to technical or allocative inefficiency or combination of both. These two sources of inefficiencies cannot be separated, which is prudent since such knowledge might illustrate the need for different policy action.

2.2.1 DEA and DEA model

DEA is a data oriented approach for evaluating the performance of a set of peer entities call decision making units (DMUs) which covert multiple inputs into multiple outputs. Since DEA in its present form was first introduced in 1978, researchers in a number of fields have quickly recognized that it is an excellent and easily used methodology for modeling operational processes for performance evaluation.

In an article which presents the inception of DEA, Farrell (1957) is motivated by the need for developing better methods and models for evaluating productivity. He argues that while attempts to solve the problem usually produced careful measurements of multiple inputs into any satisfactory overall measure of efficiency. Responding to these inadequacies of separate indices of labor productivity, capital productivity, etc., Farrell proposed an activity analysis approach that could more adequately deal with the problem. His measures are intended to be applicable to any productive organization. In the process, he extends the concept of productivity to the more general concept efficiency.

In their originating study, Charnes, Cooper and Rhodes (1978) describes DEA as a mathematical programming model applied to observational data provides a new way of obtaining empirical estimates of relations, such as the production function and/or efficient production possibility surfaces, that are cornerstones of modern economics. They initiate a DEA model based on the earlier work of Farrell and kept on improvement step by step and finally get a general model - Charnes-Cooper-Rhodes (CCR) model with both input-orientated and output-orientated versions, each in the form of a pair of dual linear programs.

Table 2-2 CCR DEA model

Input-oriented	
Envelopment model	Multiplier model
$\min \theta - \varepsilon(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+)$	$\max z = \sum_{r=1}^{s} \mu_r y_{ro}$
subject to	subject to
$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{io} \quad i = 1,2,\ldots,m;$	$\sum_{r=1}^{s} \mu_r y_{rj} - \sum_{i=1}^{m} \nu_i x_{ij} \leq 0$
$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{ro} \quad r = 1,2,\ldots,s;$	$\sum_{i=1}^{m} \nu_i x_{io} = 1$
$\lambda_j \geq 0 \quad j = 1,2,\ldots,n.$	$\mu_r, \nu_i \geq \varepsilon > 0$
Output-oriented	
Envelopment model	Multiplier model
$\max \phi + \varepsilon(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+)$	$\min q = \sum_{i=1}^{m} \nu_i x_{io}$
subject to	subject to
$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = x_{io} \quad i = 1,2,\ldots,m;$	$\sum_{i=1}^{m} \nu_i x_{ij} - \sum_{r=1}^{s} \mu_r y_{rj} \geq 0$
$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = \phi y_{ro} \quad r = 1,2,\ldots,s;$	$\sum_{r=1}^{s} \mu_r y_{ro} = 1$
$\lambda_j \geq 0 \quad j = 1,2,\ldots,n.$	$\mu_r, \nu_i \geq \varepsilon > 0$

If the constraint $\sum_{j=1}^{n} \lambda_j = 1$ is adjoined, they are known as Banker-Charnes-Cooper (BBC) models (Banker, Charnes, Cooper, 1984). This added constrain introduces an additional variable, μo , into the dual multiplier problems which make it possible to effect returns-to-scale evaluations, including increasing to scale, constant to scale and decreasing to scale. So the BBC model is also referred to as the variable returns to scale (VRS) model and distinguished from the CCR model which is referred to as the constant returns to scale (CCR) model.

An inefficient DMU can be made more efficient by projecting onto the frontier. In an input orientation, one improves efficiency through proportional reduction of inputs, whereas an output orientation requires proportional augmentation of outputs. However, it is necessary to distinguish between a boundary point and an efficient boundary point. Moreover, the efficiency of a boundary point can be dependent upon the model orientation.

The input-oriented model is one version of a CCR model which aims to minimize inputs while satisfying at least the given output levels. Another model is the output-orientated model that attempts to maximize output without requiring more of any of the observed input values.

However, the CCR model is built on the assumption of constant return to scale of activities as shown in Figure 2-4. This assumption can be modified to allow extended types of production possibility sets with different postulates for the production possibility sets. In fact, various extensions of the CCR model have been proposed since the beginning of DEA studies, among BBC model is representative. The BBC model has its production frontiers spanned by the convex hull of the existing DMUs. The frontiers have piecewise linear and convex characteristics which, as shown in Figure 2-5, leads to variable returns-to-scale characterizations with a) increasing return-to-scale occurring in the first solid line segment followed by b) decreasing return-to-scale in the second segment and c) constant return-to-scale occurring at the point where the transition from the first to the second segment is made (Cooper, Seiford, and Tone, 2006).

Figure 2-4 Production frontier of CCR model

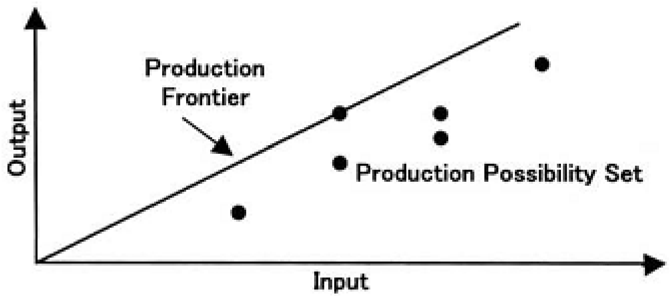
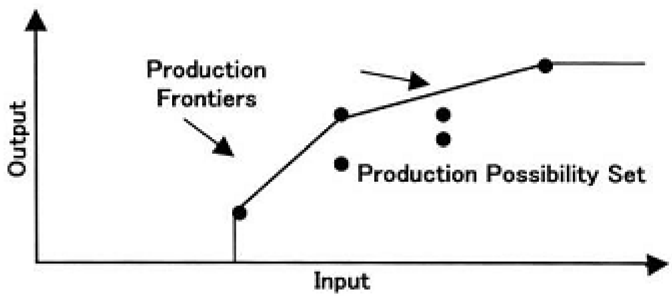


Figure 2-5 Production frontier of BCC model



2.2.2 SFA and SFA model

Coelli (1996) provides very clear explanation about SFA in the guide to the computer program for stochastic frontier production. The stochastic frontier production function is independently proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and van den Broeck (1977). The original specification involves a production function specified for cross-sectional data which has an error term that contain two components: one is to account for random effects and another to account for technical inefficiency. This model can be expressed in the following form:

$$Y_i = x_i\beta + (V_i - U_i) \qquad i = 1,2, \dots, N$$

where Y_i is the production (or the logarithm of the production) of the i-th firm;

X_i is a k x 1 vector of (transformations of the) input quantities of the i-th firm;

β is an vector of unknown parameters;

V_i are random variables which are assumed to be iid $N(0, \sigma_V^2)$ and independent of the U_i;

U_i are non-negative random variables which are assumed to account for technical inefficiency in production and are often assumed to be iid $|N(0, \sigma_U^2)|$.

This original specification has been altered and extended, including more general distributional assumptions for the U_i, the consideration of panel data and time-varying technical efficiencies, the extension of the methodology to cost functions and also to the estimation of systems of equations.

There are several models and each of them has special application. Two widely used models will be explained with details here: the Battese and Coelli (1992) Specification and the Battese and Coelli (1995) Specification. Both of these two specifications have been expressed in terms of a production function, with the U_i interpreted as technical inefficiency effects, which cause the firm to operate below the stochastic production frontier.

The Battese and Coelli (1992) Specification was designed for (unbalanced) panel data which has firm effects which are assumed to be distributed as truncated normal random variables, which are also permitted to vary systematically with time. The Battese and Coelli (1995) model propose a model which is equivalent to the Kumbhakar, Ghosh and McGukin (1991) specification, with the exceptions that allocative efficiency is imposed, the first-order profit maximizing conditions removed, and panel data is permitted.

SFA takes an indirect approach to measuring inefficiency (Smith and Street, 2005). Stochastic frontier models control for supposed influences on output, and content that unexplained variations in output are due to inefficiency. Different from standard econometric models, stochastic frontier models exact DMU-specific estimates of inefficiency from the unexplained part of the model.

2.2.3 Comparison of DEA and SFA

Bhat, Verma, and Reuben (2001) conclude some strengths and limitation of DEA. There are four characteristics that make DEA powerful. First of all, DEA can handle multiple inputs and multiple outputs. Secondly, it does not require an assumption of a function form relating input to outputs. What’s more, DMUs are directly compared against a peer or combination of peer. Finally, inputs and outputs can have different units. However, the same characteristics can also lead to problems. Firstly, DEA results are sampled specific. Secondly, since DEA is an extreme point technique, measurement error can cause significant problems. Thirdly, DEA is good at estimating relative efficiency but it converges very slowly to absolute efficiency. What’s more, DEA is a non-parametric technique, statistical hypothesis tests are difficult. Finally, since a standard formulation of DEA creates a separate linear program for each DMU, large problems can be computationally intensive. These limitations will possibly decrease the validity and reliability of the result.

Hollingsworth and Street (2006) also pointed out, although DEA is thought to be better than SFA in terms of flexibility, this advantage can be offset by how the technique interprets any distance from the frontier. First of all, DEA assumes correct model specification and that all data are observed without error while SFA allows for the possibility of modeling and measurement error. Even if these two techniques yield an identical frontier, SFA efficiency estimates are likely to be higher than those produced by DEA. Secondly, DEA uses a selective amount of data to estimate each DMU’s efficiency score by comparing it only to peers that produce a comparable mix of outputs. This comes after two implications. First, if any output is unique to a DMU, it will have no peers with which to make a comparison, irrespective of the fact that it may produce other common outputs. Second, when assigning an efficiency score to a DMU not lying on the frontier, only its peer are considered, which with limited information. In contrast, SFA appeals to the full sample information when estimating relative efficiency which will make it more robust in the presence of outlier observations and to the presence of atypical input / output combinations.

According to the word of Jacobs (2001), some trade-off exists between these methods. DEA has the disadvantages of assuming no statistical noise, but have the advantage of being non-parametric and requiring minimal assumptions about the production frontier. SFA models on the other hand have the attraction of allowing for statistical noise, but have the disadvantage of being parametric and requiring strong assumptions about the inefficiency term.

DEA and SFA have their own unique characteristics in efficiency measurement and both of them are widely applied to various DMUs. However, DEA became widely used especially in hospital, nursing room and pharmacy, where data about price is not always available and multi-output production is relevant, while price data is essential and only single output can be included in SFA approach. DEA needs fewer assumptions about the form of production technology than SFA, thus not requiring the imposition of any behavioral assumptions such as revenue maximization or cost minimization.

In this thesis, DEA is chosen as the main research method and there are some reasons. First of all, in the world scope, especially in Thailand, DEA is still the main approach in hospital efficiency measurement. The study about DEA has further influence in the following. Secondly, based on the availability and reliability of data, DEA is the best method for public hospital. The data about price is difficult to access in current situation.

2.3 Previous studies on hospital efficiency with DEA

DEA's greatest potential contribution to health care helps understand why some health care providers perform better or worse than others do. There are many variations in performance, such as a) the characteristics of the patients, b) the practice styles of physicians, c) the micro-processes of care, d) the managerial practices of the delivery systems, or e) other factors in the environment. The following general model has been used in this type of health care study:

DEA score = f(ownership, competitive pressure, regulatory pressure, demand pattern, wage rats, patient characteristics, physician or provider practice characteristics, organizational setting, managerial practices, patient illness characteristics, and other control variables)

The score depends on the selection of input and output various. In previous related cases, there are two main approaches of choosing input variables: financial and non-financial variables. Financial variables are those indicators that measured by local currency, such as labor cost, capital cost. Non-financial variables, on the contrary, are not measured by money, including number of (inpatient and outpatient) visits, number of beds. In some researches, two approaches were mixed up.

There was a detailed list including DEA related papers from 1986 to 2003 and it summarized the sample, inputs, outputs, explanatory variables (if applicable), analytical technique and main findings. (Worthington. A.C, 2004). In 22 selected DEA applications in health care, 6 researches applied pure financial variables, 11 applied pure non-financial and 5 applied mixed variables. The author found a problem that several inputs, most often capital, were typically not measured. For example, Kooreman (1994) justified the selective input approach of the basis that management typically had control over labor inputs, “but the use of capital inputs is largely beyond their ability to determine”. In common cases, capital had been proxied by the number of hospital bed, depreciation and interest expenses per bed or net plant assets. Most important, the theoretically appropriate capital input measure was the flow of capital services, not capital stock. On this basis, nearly all studies in health care overestimate the use of capital and then (incorrectly) suggest that reducing the level of capital could increase efficiency. What’s more, the author also emphasized variation within the sample may also arise in unmeasured inputs that are likely to have an even greater influence on hypothesized inefficiency or efficiency.

The similar phenomenon happened in the work of Afonso, A. and Fernandes S. (2008) in which summarized 10 papers to review some non-parametric applications measuring hospital efficiency. In the column of input variables, three approaches of choosing input variables existed – financial, non-financial and mixed variables.

Studies with only financial variables

DEA was applied to study 166 medium size community hospitals (between 21-60 beds) in the work of Patmasiriwat (2007) to get the relative efficiency of hospital cost management. Input variables were personnel costs and operating expenses and output variables were inpatient day, outpatient service provided, and the number transferred patient. The results found the average efficiency was 0.78 and 17 hospitals were on the cost frontier based on the variable return to scale assumption.

When Vitikainen, Street, and Linna (2009) aimed at examining the robustness of efficiency results due to choosing output and casemix measures, they applied total operating costs as their pure input data. They explained this choice as operating costs capture all the costs due to the hospital’s treatment activity including labor, material and depreciated capital costs. They cannot explore the contributions of specific inputs to technical efficiency, or substitution possibilities between inputs.

Studies with only non-financial variables

In the first chapter of thesis of Puenpatom (2006), he investigated the short-term impact on technical efficiency in larger public hospitals in the period when the new health insurance program was introduced in Thailand. It measured efficiency scores before and after universal coverage (UC) program using bootstrapping Data Envelopment Analysis. The conclusion was that mean technical efficiency scores of regional hospitals were 0.729 in 2000, 0.683 in 2001 and 0.845 in 2002. The scores of large general hospitals were 0.835 in 2000, 0.790 in 2001 and 0.821 in 2002. For small general hospitals, the scores were 0.898 in 2000, 0.875 in 2001 and 0.935 in 2002. In the part of choosing variables in DEA model, the inputs consisted of four categories of labor and one category of capital: full-time equivalent and differentiated by primary care physicians, ancillary professional care providers (dentists and pharmacists), nurses, other personnel and number of beds. When talking about why not take wages of labor into consideration, the author pointed out health personnel in public hospital was paid the same across region and by tenure. However, such as capital cost or operating cost of hospitals in different regions are probably different because of scope of services provided and patient severity. In this research, output variables were number of adjusted number of inpatient visits in acute surgical - general surgery and orthopedic surgery, adjusted number of inpatient visits in primary care – pediatrics, medical, and obstetrics and gynecology, adjusted number of inpatient visits in others – dental, ENT, ophthalmology, rehabilitation medicine and others, surgical outpatient visits, and non-surgical outpatient visits.

Studies with mixed variables

Through the work of Vivian Valdmanis, Lilani Kumanarayake and Jongkol Lertiendumrong (2004), in order to assess the capacity of Thai public hospitals to proportionately expand services to both the poor and the non-poor, researchers accomplished by measuring the production of services provided to the poor, relative to non-poor, patients. Data of 68 general hospitals were applied in DEA method and number of beds, number of doctors, number of nurses, number of other staffs, allowance, drug expense and other operating expense were chosen as input variables. Because authors were concentrated on congestion index approach and plant capacity approach, the results of DEA were not given in the paper. Although there is no comparison with other research, it stills showed a custom in DEA research that the choice of input variables is mainly decided by the accessible of data. It lacks convincible reason and the effect of this activity is vague.

Financial and non-financial variables are common widely applied preference when choosing input variables in DEA model. However, it lacks evidence and explanation about the criteria for how to choose and value them. The choice can have influence on the final DEA score and can reflect some special characteristics of hospitals.

2.4 Studies about choosing input variables for hospital

The preference of choosing input variables is different from one research to another. The reason behind is complex and the explanation is not very clear. In Ozcan's work, inputs of hospitals can be categorized in three major areas as capital investments, labor, and operating expenses (Ozcan, 2007).

a) Capital investment

Ozcan and Luke (1993) pointed out that one can estimate capital investments in a hospital using two indicators: (1) plant size, measured by number of operational beds, and (2) plant complexity, measured using number of diagnostic and specific services provided exclusively by the hospital. Tested using Virginia data, significant association was found between the two proxies and hospital assets, thus validating these measured for capital investment. Although same variables were used in defining the model, more commonly used names that correspond to current literature were chosen in the research. The author illustrated the details on the basis of AHA database in order to evaluate the available and value of inputs.

Number of *beds* was the first input mentioned. AHA database routinely provides operational beds in their annual reports, thus the measurement of this variable is readily available.

The second one is *service-mix*. AHA database currently identifies up to 80 services that are offered by a hospital and provides coding that indicates whether these services are offered by the hospital or through the hospital by others. The key to the coding is whether the services are offered by the hospital, thus appropriate investment is in place. If the service is not offered or offered by others for the hospital, then it can be coded as zero, otherwise code would be one indicating the service offering. By adding the number of services offered by the hospital, service-mix variable is created.

b) Labor

Labor is the second major category for hospital inputs. Operationalization of this variable would be different in USA and other countries, especially in those where socialized medicine is practiced and physicians are the part of the labor force for the hospitals. In the USA, however, physicians generally are not hospital employees with an exception of chiefs and department heads. Thus, in evaluating the performance, it is prudent to attribute the labor as non-medicine labor or their FTEs. The number of non-physician FTEs employed by a hospital would cover all nursing, diagnostic, therapy, clerks and technical personnel. It is also prudent to remind that some of the DEA studies used labor costs to measure this variable. Depending upon the location of the hospital and the availability of skill-mix, labor salaries may not accurately reflect this input variable. Thus, the labor costs would require regional or even state or city based adjustments. However, using FTEs overcomes this weakness. AHA database provides the total FTEs as well for various categories. Part time labor is converted to FTE by multiplying 1/2 of their numbers.

c) Operating expenses

Operating expenses for hospital can be obtained from CMS database. However, to eliminate double counting, labor expenses and expenses related to capital investments such as depreciation should be subtracted from this amount. Ozcan and Luke (1993) labeled this variable as supplies indicating all necessary non-labor resources in provision of patient care. The input variable of other operational expenses provides the account for medical supplies, utilities, etc, to provide the services to patients.

It needs to emphasize here that although the author gave these three categories of input variables, there are some weakness. And it also pointed 'it is also prudent to remind that some of the DEA studies used labor costs to measure this variable' because they believed that this variable was easily influenced by location, salary and other factors. Tone (2002) developed a new scheme for evaluating cost efficiency under different unit prices.

There are shortcomings and irrationality of the cost and allocative efficiencies. These shortcomings are caused by the structure of the supposed production possibility set P as defined by:

$$P = \{(x, y) | x \geq X\lambda, y \leq y\lambda, \lambda \geq 0\}.$$

P is defined only by using technical factors $X = (x_1, \dots, x_n) \in R^{mxn}$ and $Y = (y_1, \dots, y_n) \in R^{sxn}$, but has no concern with the unit input cost $C = (c_1, \dots, c_n)$.

Another cost-based production possibility set P_c is defined as:

$$P_c = \{(\bar{x}, y) | \bar{x} \geq \bar{X}\lambda, y \leq Y\lambda, \lambda \geq 0\}$$

where$\bar{X} = (\bar{x}_1, \dots, \bar{x}_n)$ with $\bar{x_j} = (c_{1j}x_{1j}, \dots, c_{mj}x_{mj})^T$.

Hence, it is assumed that matrices X and C are non-negative and all inputs are associated with cost. The elements of $\bar{x}_{ij} = \left(c_{ij}x_{ij}\right)(\forall i, j)$ are denominated in homogeneous units, viz. dollars, so that adding up the elements of x_{ij} has a meaning.

Based on this new production possibility set P_c, a new technical efficiency

$\theta^*$is obtained as the optimal solution of the following LP problem:

$$[\text{NTec}]\theta^* = \min\bar{\theta}$$

Subject to $\bar{\theta}\bar{x}_0 \geq \bar{X}\lambda$, $y_0 \leq Y\lambda$ and $\lambda \geq 0$.

The new cost efficiency γ^* is defined as $\gamma^* = e\bar{x}_0^*/e\bar{x}_0$ where $e \in R^m$ is a row vector with all elements being equal to 1, and $\bar{x}_0^*$ is the optimal solution of the LP giving below:

$$[\text{NCost}]\min e\bar{x}$$

subject to $\bar{x} \geq \bar{X}\lambda$, $y_0 \leq Y\lambda$, $\lambda \geq 0$.

New allocative efficiency is $\alpha^* = \gamma^*/\theta^*$. The new efficiency measures $\alpha^*, \gamma^*, \theta^*$ are all units invariant so long as X has a common unit of cost. This model can deal with the inclusion of non-cost input factors which means this model can extend to that with cost-related and non-related inputs.

In the traditional model, keeping the unit cost of DMU_0 fixed at c_0, the optimal input mix x^* that produces the output y_0 is found. But this model does not pay attention to possible choices of other unit costs. In the new model, optimal input mix $\bar{x}^*$ for producing y_0 (or more) is searching for here. It is assumed that, for a given output y_0, the optimal input mix can be found independently of the current unit cost c_0 of DMU_0. These points are the fundamental differences between the two models. Using the traditional one it cannot recognize the existence of other cheaper input mix.

Table 2-3 Comparison of traditional and new scheme

						Traditional efficiency		
						Tech.	Cost.	Alloc.
	x_1	c_1	x_2	c_2	Y	θ	γ	α
A	10	10	10	10	1	0.5	0.35	0.7
B	10	1	10	1	1	0.5	0.35	0.7
C	5	3	2	6	1	1	1	1
						New scheme efficiency		
						Tech.	Cost.	Alloc.
	x_1^*	e_1	x_2^*	e_2	y^*	θ^*	γ^*	α^*
A	100	1	100	1	1	0.1	0.1	1
B	10	1	10	1	1	1	1	1
C	15	1	12	1	1	0.8333	0.7407	0.8889

Table 2-3 was a simple example involving three DMUs A, B and C with each using two inputs (x_1, x_2) to product one output (y) along with input cost (c_1, c_2)

and the results were technical (θ), cost (γ) and allocative (α) efficiency scores.e (e_1, e_2) is a row vector with all elements being equal to 1 in the calculation of new cost efficiency.

For DUMs A and B, the traditional model gives the same score and DMU C is found to be the only efficient performer in this framework. However, the new scheme devised distinguishes DMU A from DMU B by according them different technical and cost efficiency scores. This is due to the difference in their unit costs.Moreover, DMU B is judged as technically, cost and allocative efficient with improvement in cost efficiency score from 0.35 to 1. However, the cost difference produces a drop in DMU A's cost efficiency score from 0.35 to 0.1. This drop in DMU A's performance can be explained by its higher cost structure. What's more, DMU C is no longer efficient in any of its technical, cost or allocative efficiency performance.
An empirical example was given in the following and they applied the new method to a set of hospital data. They obtain the new data set in the analysis by multiplying the number of doctors and nurses by their respective unit costs. The results gave more information.

The original data of hospitals are shown in Table 2-4 and the value of X^* in new data set (Table 2-5) comes from the number multiple cost.

Table 2-4 Date for hospitals

	Inputs				Outputs	
	Doctors		Nurse		Outpat. number	Inpat. number
DMU	Number	Cost	Number	Cost		
A	20	500	151	100	100	90
B	19	350	131	80	150	50
C	25	450	160	90	160	55
D	27	600	168	120	180	72
E	22	300	158	70	94	66
F	55	450	255	80	230	90
G	33	500	235	100	220	88
H	31	450	206	85	152	80
I	30	380	244	76	190	100
J	50	410	268	75	250	100
K	53	440	306	80	260	147
L	38	400	284	70	250	120
Average	33.6	435.8	213.8	85.5	186.3	88.2

Table 2-5 New data set and efficiencies

	Data				Efficiency			
	X*		Y		CCR	Tech	Cost	Alloc.
DMU	Doctor	Nurse	Inp.	Outp.				
A	10000	15100	100	90	1	0.994	0.959	0.965
B	6650	10480	150	50	1	1	1	1
C	11250	14400	160	55	0.883	0.784	0.724	0.923
D	16200	20160	180	72	1	0.663	0.624	0.941
E	6600	11060	94	66	0.763	1	1	1
F	24750	20400	230	90	0.835	0.831	0.634	0.764
G	16500	23500	220	88	0.902	0.695	0.693	0.997
H	13950	17510	152	80	0.796	0.757	0.726	0.959
I	11400	18544	190	100	0.960	0.968	0.953	0.984
J	20500	20100	250	100	0.871	0.924	0.776	0.841
K	23320	24480	260	147	0.955	0.995	0.863	0.867
L	15200	19880	250	120	0.958	1	1	1

It is found that hospital B is the best performer with all its efficiency scores being equal to one. Regarding to the cost-based measure, hospital E and L received full marks. Although E has the worst CCR score, its lowest unit costs push up the cost-based rank to the top. On the contrary, hospital D was rated worst with respect to cost-based measures, although it receives full efficiency marks in terms of its CCR score. This gap is explained through its high cost structure. Hospital D needs cost reduction to attain good cost-based scores.

Through the comparisons, there are two technical efficiency scores, θ and θ^*. The former is determined based only on purely technical input factors, while the latter is based on both input and cost factors. If, for a DMU, θ is low and θ^* is high, this suggests the need for input reduction. On the other hand, if θ is high and θ^* is low, the DMU needs an improvement in cost factors. Thus, both efficiency measures are utilized for characterizing the DMU and at the same time, suggest directions for improvement. This proposed new measures provided much more information than the traditional ones.

From the examples above, the efficiency scores with financial variables give more information about hospital's cost structure and can provide specific directions in the improvement of hospital efficiency.

2.5 Basic background about Thai health public hospitals

Because this research involves public hospitals in Thailand, some basic background should be reviewed here to know the characteristics of these public hospitals.

In all, there are over 700 community hospitals, 158 regional hospitals and general hospitals and 54 medical school hospitals and specialize hospitals out of Bangkok in the Thailand Health Profile Report 2007-2009.

Table 2-6 Health Facilities in Public Sector, 2009

Administrative level	Hospitals	Number
Bangkok Metropolis	Medical school hospitals	5
	General hospitals	26
	Specialized hospitals / institutions	13
	Public health centers / branches	68/76
Regional level and branches	Medical school hospitals	6
	Regional hospitals	25
	Specialized hospitals	48
Provincial level (75 provinces)	General hospitals, under MoPH	71
	Military hospital under the Ministry of Defense	59
	Hospital under the Royal Thai Police	1
878 districts	Community hospitals (Mar. 2009)	734
7,225 subdistricts	Health centers (2009)	9,768

Of these hospitals, there are 25 regional hospitals, 71 general hospitals and 734 community hospitals. These public hospitals are under the Ministry of Public Health (MoPH) and are operated as not-for-profit organizations. Community hospitals services are limited to only primary care, with less than 10 to 150 beds. They are mostly located in districts or minor-districts in rural areas. General hospitals have 200 to 500 beds and regional hospitals are usually equipped with over 500 beds. Both general hospitals and regional hospitals provide tertiary care and primary care services. Physicians in Thai public hospitals are employees of the hospital and as such are paid by the MoPH, according to budgetary structures, through the hospitals.

MoPH classifies hospitals by number of beds. The number of health personnel and bed are positively correlated with size of hospitals. Regional hospitals, which are the largest hospitals in Thai health care service, generated highest output while community hospitals provide the lowest amount of services. Larger hospitals are mostly located in the eastern and northeaster regions.

There are some special characteristics should be emphasized. First of all, although health personnel in public hospitals are paid the same across region and by tenure, in fact, in a specific hospital, personnels are paid according to their experience. Doctor is used an example here. The more experience a doctor is, the more he will get. The wage of a senior doctor is much higher than a junior one. However, although junior doctors are paid less, their efficiency can be higher than senior ones and they can provide more services. Therefore, the ratio of senior to junior personnel, or the structure of personnel as a more general description, has influence on hospital's cost and services they provide.

Secondly, Thais usually provide donations for good deeds to temples and hospitals. Although the major source of public hospital revenue is from the MoPH budget, part of the revenue is from donations of people residing in the province, which increases the hospitals' reserves. This additional financial reserve could help stabilize the hospital's financial status and loosen performance, but decrease in efficiency(Rajitkanok Puenpatom, 2006).

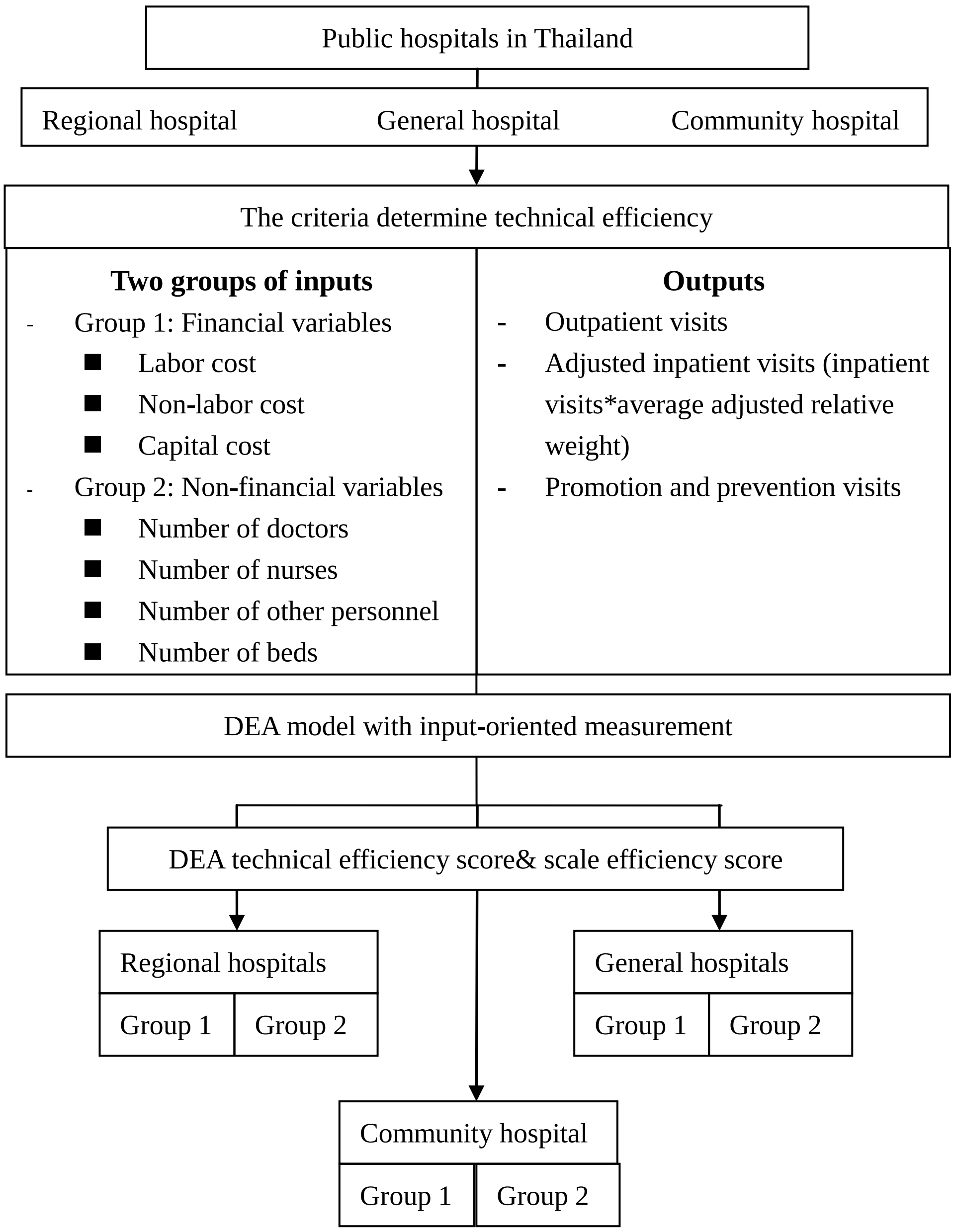
CHAPTER Ⅲ

RESEARCH METHODOLOGY

In this chapter, the research methods applied in this thesis will be illustrated and explained with details to give the general idea about what will be done.

3.1 Conceptual Framework

Figure 3-1 Conceptual framework



As shown in Figure 3-1, the study consists of two stages. The first stage is to measure the technical efficiency and scale efficiency of sampled hospitals with data envelopment analysis (DEA) using input-oriented measurement. The sampled hospitals are divided into three groups: general hospital, regional hospital and community hospital.The second stage will contain descriptive analysis, Wilcoxon signed rank test anddo the comparisonin both technical and scale efficiency scores for every type of hospital with different input variables with scattergrams.The null hypothesis of Wilcoxon signed rank test is the underlying efficiency distribution are identical. 5 percent level is used here to reject the hypothesis.

3.2 Study design

This is a study applying econometric techniques. A database of Thai hospitals will be used for data envelopment analysis (DEA) at the first step to get the result of technical and scale efficiency scores. Next, a series analysis will be done including descriptive analysis, Wilcoxon Signed Rank Test and comparison with scattergram.

3.3 Target and study population

The target population includes all public hospitals in Thailand. This study will choose the hospitals from the database based on four criteria.

First of all, all the hospitals included in this research should be public hospitals because government has better control over their inputs by constraint budgets and contraction. What’s more, the private hospital data is unavailable and unreliable. Secondly, hospitals in Bangkok will be excluded because health system in Bangkok is different to the rest of the country. The competition from private hospitals in Bangkok is significantly higher than those in other provinces. Influence of this factor is unknown right now on efficiency. Thirdly, teaching hospitals will not be taken into consideration as the reason that they normally operate in more efficiency way than other hospitals based on the advantages of better professionals and technology equipment. Finally, input and output variables of the hospital should be complete in order to minimize errors come from missing data.

Hospitals will be divided into three groups: regional hospital, general hospital and community hospital.

3.4 Type of data

All the data in this research are secondary data of Thai hospitals in the year of 2010.All the data are secondary data.

3.5 Data required

The quality of the results, to a big extent, relies on the choice of input and output variables. The challenges include identifying appropriate inputs and outputs, specifying the technical relationship among inputs, the representativeness of inputs and outputs and so on.

3.5.1 Input variables

There are many input categories.

a) Capital investment

Beds. The number of hospital beds for inpatient service is often used as a proxy for hospital size and capital investment. Some studies even disaggregated hospital beds into acute beds, intensive care unit (ICU) beds, long-term beds, and the number of bed, number of bed-day available based on different objectives and contexts of the studies.

Service-mix. The number of hospital services is a common variable for American-related researches because AHA publishes the data in its annual survey. However, in other countries, this kind of data is not available.

Capital cost. The amount of money for capital every year is the net gain between the capital investment and depreciation of plant assets. It can reflect the development in the infrastructure and high-tech equipment.

b) Labor

Labor can be measured by two approaches – labor costs or number of staffs. About two thirds of hospitals operating costs are due to payroll expenses and it’s a good proxy for labor. However, labor costs varied significantly by geographic region and the type of staff such as general labor, nursing staff, medical staff and other staff. There is a choice to used adjustment factor to control for the variation. If measured by number of staffs, labor is divided into clinical staff and non-clinical staff. Hospital clinical staffs consist of doctors, nurses and other medical personnel. Non-clinical staffs include technical, managerial and other staff.

c) Operating expense

This input category excludes labor expenses and expenses related to capital investments which indicate other inputs in provision of patient care.

In this research, two groups of inputs with financial variables and non-financial variables will be contained. Group 1 is consisted of three financial variables with labor cost, non-labor cost and capital cost. Group 2 contains four non-financial variables of number of doctors, number of nurses, number of other personnel and number of beds. The general information about input variables is shown in Table 3-1.

Table 3-1 Input variables, abbreviations, operational definitions and units

	Input variables	Abbr.	Operational definitions	Units
Group 1	Labor cost	LC	Include salary, permanent wages, other personnel expense, temporary wages and any compensation payment including OT expense	Million Baht
	Non-labor cost	NLC	Include drug and medical supplies cost, training expense, other allowance, total material, utility, device and instrument that worth less than 5000 baht, payment for referral case and other operating expense	Million Baht
	Capital cost	CC	Include depreciation and amortization	Million Baht
Group 2	Number of doctors	DOC	Doctors that in the final day of 2010 in a given hospital	Persons
	Number of nurses	NUR	Nurses that in the final day of 2010 in a given hospital	Persons
	Number of other personnel	OTH	Other personnel that in the final day of 2010 in a given hospital	Persons
	Number of beds	BED	Denotes the number of real beds providing services	Beds

3.5.2 Output variables

Three output variables are chosen here and they represent the three categories of services provided in hospitals: outpatient, inpatient and preventive and promotion services. In fact, more variables were taken into consideration in the design of research. However, other output variables are not available and these three are the most commonly and widely used variables. It can reflect the output of hospital service to a great extent. What's more, the inpatient visits is adjusted by average adjusted weight.

Table 3-2 Output variables, abbreviations, operational definitions and units

Output variables	Abbr.	Operational definitions	Units
Outpatient visits	OP	The number of visit in outpatient department	Visits
Adjusted inpatient visits	IP*	The number of visits in inpatient department adjusted with average weight (IP* is equal to number of inpatient multiply average adjusted weight)	Visits
Promotion and prevention visits	PP	Include maternal (antenatal and postpartum) and well child care, family planning, immunization, nutritional care, dental care, screening and confirmatory test for cervical cancer, breast cancer, thalassemia and thyroid and iodine deficiency and rehabilitative services	Visits

3.6 Source of data

All secondary data comes from Bureau of Health Administration and Health Insurance Group, both under Office of Permanent Secretary, Ministry of Public Health. The hospital sends these data monthly to Bureau of Health Administration and Health Insurance Group through web-based software application.

3.7 Analysis method

The first stage is DEA analysis uses input-orientated measurement. This study uses three multiply outputs and two groups of inputs, one group with three financial variables another one with four non-financial variables, being data for calculation using DEAP version 2.1: a data envelopment analysis (computer) program, designed by Tim Coelli to get technical efficiency scores. The second stage of the research will do some comparison test, including descriptive analysis, Wilcoxon Signed Rank Test and comparison with scattergram, for DEA efficiency scores within every type of hospital. The test is done by SPSS for Windows. The detail of DEA results are also analyzed by SPSS for Windows.

3.8 DEA model specification

There are input-oriented measurement and output-orientated measurement in DEA. Input-oriented measurement DEA assumes that the firm can change quantities of inputs, which quantities of outputs are fixed, to meet the most efficient point. In contrast, output-orientated measurement DEA assumes that quantities of outputs can change to match with the most efficiency point while quantities of inputs are fixed. In this research, input-orientated DEA will be used because in the comparison of the results coming from two different groups of input, the output is fixed. The objective of the work is to test whether the choice of inputs will influence the efficiency scores while outputs keep the same.

CHAPTER Ⅳ

RESULTS AND DISCUSSION

This chapter provides the results of DEA analysis with two groups of input vectors in the following parts:

1. Descriptive analysis of input mix and output mix of DEA;
2. The results of DEA efficiency scores;
3. Comparison between DEA efficiency scores with different input variables;

4.1 Descriptive analysis of the input mix and output mix of DEA

The descriptive analysis of input variables of DEA shows the general statistics of input and output variables, including numbers, mean, standard deviation, minimum, maximum and one-sample Kolmogorov-Smirnov test, as shown in Table 4-1, Table 4-2 and Table 4-3.

There are 801 hospitals in the database and they are divided into three levels. Overall, there are 24 regional hospitals, 66 general hospitals and 694 community hospitals in the year 2010. Each hospital is regards as a decision making unit (DMU). After viewing the database at the first step, all 24 regional hospitals are included in the analysis while some hospitals are excluded that there are only 65 general hospitals and 380 community hospitals left. The exclusion is based on two criteria. Firstly, because it is impossible for a hospital to have a value of input or output is 0, the hospitals that contain 0 value in its data set are eliminated from the database. Secondly, some hospitals have data missing in number of nurses or number of other personnel.

There are two groups of input vectors in this analysis. Group 1has three financial indicators: labor cost (LC), non-labor cost (NLC) and capital cost (CC) and Group 2 contains four non-financial indicators: number of doctors (DOC), number of nurses (NUR), number of other personnel (OTH) and number of beds (BED).

For financial variables, the average labor cost is 667 million baht of regional hospital, 294 million baht of general hospital and 52.79 million baht of community hospital. The average non-labor cost is 776 million baht of regional hospital, 252 million baht of general hospital, and 38.76 million baht of community hospital. The average capital cost is 72.9 million baht of regional hospital, 35.8 million baht of general hospital and 5.72 million baht of community hospital. Three types of hospital show a huge gap in their costs. Regional hospital has highest cost in labor cost, non-labor cost and capital cost and they are almost 3 times to the cost of general hospital. The gap between general hospital and community hospital is even bigger.

One-sample Kolmogorov-Smirnov test is a nonparametric test which proves the interesting data not being a normal distribution if p-value is less than 0.05. The LC, NLC and CC of regional hospital are normal distribution. For general hospital, LC and NLC are normal distribution. However, the CC is not. For community hospital, all three input variables are not normal distribution.

It needs to emphasize here that the CC of general hospital is not normal distribution. The value of capital cost of most of the general hospitals is several million baht. However, there are four hospitals have over hundred million baht which is ten times to most of other hospitals. And even 2 hospitals only have several million baht. That is why the distribution of capital cost is not normal. There are big gaps between general hospitals in capital cost.

Table 4-1 Descriptive statistics of input variables of DEA – Group 1

Level of hospital	Descriptive statistics	Input mix of DEA		
		LC	NLC	CC
Regional hospital	Number of included hospitals	24	24	24
	Number of excluded hospitals	0	0	0
	Mean	667	776	72.9
	Std. Deviation	194	391	34.5
	Minimum	404	270	31.7
	Maximum	1200	2160	153
	One-Sample K-S Test – Asymp. Sig. (2-tailed)	0.857	0.121	0.180
General hospital	Number of included hospitals	65	65	65
	Number of excluded hospitals	1	1	1
	Mean	294	252	35.8
	Std. Deviation	105.5	150.9	28
	Minimum	648	371	5.6
	Maximum	571	863	165
	One-Sample K-S Test – Asymp. Sig. (2-tailed)	0.762	0.086	0.005
Community hospital	Number of included hospitals	380	380	380
	Number of excluded hospitals	314	314	314

Mean	52.79	38.79	5.72
Std. Deviation	27.17	26.99	4.82
Minimum	1.53	5.53	0.28
Maximum	186	220	58.6
One-Sample K-S Test – Asymp. Sig. (2-tailed)	0.000	0.000	0.000

Note: K-S Test – Kolmogorov-Smirnov Test

The descriptive statistics of variables in Group 2 is shown in Table 4-2. The average number of doctor is 124.13 of regional hospital, 40.54 of general hospital and 6.52 of community hospital. The average number of nurse is 608.04 of regional hospital, 305.28 of general hospital and 53.06 of community hospital. The average number of other personnel is 206.67 of regional hospital, 109.05 of general hospital and 28.42 of community hospital. The average number of bed is 680.42 of regional hospital, 326.80 of general hospital and 43.46 of community hospital. Regional hospital, general hospital and community hospital have big difference in these variables. Regional hospital has the most capital and labor resource and general hospital has less but still times to that with community hospital.

One-sample Kolmogorov-Smirnov test shows that DOC, NUR, OTH and BED of regional hospital are normal distribution. For general hospital, all input variables are normal distribution. For community hospital, all four input variables are not with normal distribution.

Table 4-2 Descriptive statistics of input variables of DEA – Group 2

Level of hospital	Descriptive statistics	Input mix of DEA			
		DOC	NUR	OTH	BED
Regional hospital	Number of included hospitals	24	24	24	24
	Number of excluded hospitals	0	0	0	0
	Mean	124.13	608.04	206.67	682.42
	Std. Deviation	45.36	156.31	40.24	177.55
	Minimum	62	411	149	370
	Maximum	237	1011	276	1039
	One-Sample K-S Test – Asymp. Sig. (2-tailed)	0.908	0.911	0.698	0.814

General hospital	Number of included hospitals	65	65	65	65
	Number of excluded hospitals	1	1	1	1
	Mean	40.54	305.28	109.05	326.80
	Std. Deviation	18.47	92.20	28.91	96.06
	Minimum	10	55	54	150
	Maximum	107	490	174	543
	One-Sample K-S Test – Asymp. Sig. (2-tailed)	0.449	0.739	0.626	0.707
Community hospital	Number of included hospitals	380	380	380	380
	Number of excluded hospitals	314	314	314	314
	Mean	6.52	53.06	28.42	43.46
	Std. Deviation	4.96	22.14	10.34	25.48
	Minimum	1	12	8	10
	Maximum	32	156	64	150
	One-Sample K-S Test – Asymp. Sig. (2-tailed)	0.000	0.005	0.000	0.000

Descriptive statistics of output vector data of DEA shows the number, mean, standard deviation, minimum, maximum and one-sample Kolmogorov-Smirnov test of three indicators. The output variables keep constant when either Group 1 or Group 2 input vector is chosen. The multiple output variables are: out-patient visits (OP), adjusted in-patient visits (IP*) and promotion and prevention visits (PP). The value of adjusted in-patient visits is equal to in-patient visits multiply average adjusted relative weight.

The average visit of outpatient is 597272.25 of regional hospital, 290400.18 of general hospital and 108185.87 of community hospital. The average visit of inpatient is 77922.82 of regional hospital, 26495.35 of general hospital and 3110.99 of community hospital. The average visit of prevention and promotion is 143298.79 of regional hospital, 84511.85 of general hospital and 38067.09 of community hospital. The amount of services provided is different in these three types of hospital. Regional hospital provides most of the services in all hospitals and general hospital in the following.

One-sample Kolmogorov-Smirnov test is a nonparametric test which proves the interesting data not being a normal distribution if p-value is less than 0.05. The OP, IP* and PP of regional hospital are normal distribution. For general hospital, output variables are normal distribution. For community hospital, all three output variables are not normal distribution.

Table 4-3 Descriptive statistics of output mix of DEA

Level of hospital	Descriptive statistics	Output mix of DEA		
		OP	IP*	PP
Regional hospital	Number of included hospitals	24	24	24
	Number of excluded hospitals	0	0	0
	Mean	597272.25	75922.82	143298.79
	Std. Deviation	149054.96	32429.23	48124.11
	Minimum	325431	30730.35	62267
	Maximum	874147	155651.4	235580
	One-Sample K-S Test – Asymp. Sig. (2-tailed)	0.920	0.602	0.978
General hospital	Number of excluded hospitals	65	65	65
	Number of excluded hospitals	1	1	1
	Mean	290400.18	26495.35	84511.85
	Std. Deviation	121372.14	15562.73	53479.84
	Minimum	93782	2419.92	17015
	Maximum	665522	77156.64	270517
	One-Sample K-S Test – Asymp. Sig. (2-tailed)	0.351	0.119	0.179
Community hospital	Number of excluded hospitals	380	380	380
	Number of excluded hospitals	314	314	314
	Mean	108185.87	3110.99	38067.09

Std. Deviation	54389.39	2749.07	32088.24
Minimum	15174	154	436
Maximum	390143	27262.2	279846
One-Sample K-S Test – Asymp. Sig. (2-tailed)	0.004	0.000	0.000

In all, all the variables of community hospitals, including inputs and outputs, are not with normal distribution. What's more, considering 314 community hospitals are excluded because of missing data, the representative of left hospitals needs further discussion. A comparison between the two parts (included and excluded) is needed to be done here.

At first step, based on the first criteria of including hospital mentioned before, 3 data sets with value 0 are eliminated from total 694 community hospitals and 687 community hospitals are left. In these 687 hospitals, 380 with perfect data set and the descriptions are shown in Table 4-1 to Table 4-3 and the re-arrangement is done in Table 4-4. The imperfect data set of left 307 is also shown in Table 4-4 as a comparison. Independent Samples T test is applied to test the difference of means between included hospitals and excluded hospitals (Table C1).

Table 4-4 Descriptive statistics of included and excluded data set of community hospital and result of Independent Samples T Test

	Included hospitals		Excluded hospitals			
					Independent Samples T Test	
	Number	Mean	Number	Mean	T	Sig, (2-tailes)
LC	380	52.79	307	36.83	9.501	0.000
NLC	380	38.79	307	26.26	7.554	0.000
CC	380	5.72	307	4.15	5.494	0.000
DOC	380	6.52	303	4.83	5.413	0.000
NUR	380	53.06	0	-	-	-
OTH	380	28.42	281	22.07	8.754	0.000
BED	380	43.46	307	32.25	6.845	0.000
OP	380	108185.87	307	82290.39	7.221	0.000
IP*	380	3110.99	307	1982.32	6.902	0.000
PP	380	38067.09	307	26943.79	5.654	0.000

The descriptive statistics of these two groups of data set have some differences in the mean of both input and output variables as the p-values of independent samples t test are all less than 0.05. There are some special characteristics through the comparison. First of all, most of the missing data happens in the number of nurses. 307 community hospitals don't have the data of number of nurses. Secondly, the hospitals included have higher cost (including labor cost, non-labor cost and capital cost), more personnel, more beds and provide more services (including inpatient, outpatient and promotion and prevention services). The included hospitals are the hospital with bigger size. Therefore, the types of hospital in thesis are adjusted to regional hospital, general hospital and big community hospital.

4.2 The results of DEA efficiency scores

Input-orientated measurement model is used in the analysis. Two groups of input variables and one constant output vector are applied in the model. Technical efficiency scores and scale efficiency scores are reported for regional hospital, general hospital and big community hospital.

4.2.1 DEA scores with input variables of Group 1

For 24 regional hospitals, technical efficiency scores range from0.763 to 1.000 and the mean is 0.918. Scale efficiency scores range from 0.763 to 1.000 and the mean of scale efficiency is 0.949 (Table A1). There are 6 from 24 regional hospitals which have all efficiency scores equal to 1.000. The hospital has the lowest value in technical efficiency score (0.763) and scale efficiency score (0.763). In addition, the pattern of scale inefficiency of 23 hospitals is increasing return to scale (irs) and of 1 hospital is decreasing return to scale (drs).

For 65 general hospitals, technical efficiency scores are from 0.280 to 1.000 and the mean is 0.829.Scale efficiency scores are from 0.750 to 1.000 and the mean of them is 0.963 (Table A2). 16 hospitals' technical efficiency and scale efficiency scores are 1.000. The pattern of scale inefficiency of 27 hospitals is increasing return to scale and of 22 hospitals is decreasing return to scale (drs).

For 308 big community hospitals, technical efficiency scores range from 0.029 to 1.000 and the mean of them is 0.183. Scale efficiency scores range from 0.113 to 1.000 and the mean is 0.524 (Table A3). There is only 1 hospital with technical efficiency score and scale efficiency score equal to 1.000. The pattern of scale inefficiency of 30 hospitals is increasing return to scale and of 344 hospitals is decreasing return to scale. The scores classified by levels of three types of hospital are shown in Table 4-5.

Table 4-5 Technical efficiency scores and scale efficiency scores with Group 1 input variables classified by score levels

Scores	Regional hospitals		General hospitals		Community hospitals	
	TE	SE	TE	SE	TE	SE
Mean	0.918	0.949	0.829	0.963	0.183	0.524
1.000	6	6	15	15	1	1
0.999-0.950	2	9	4	37	1	15
0.949-0.900	9	5	4	6	0	5
0.899-0.850	3	3	5	1	0	7
0.849-0.800	2	1	9	3	1	18
0.799-	2	0	28	3	377	334
Total	24	24	65	65	380	380

TE – technical efficiency score

SE – scale efficiency score

4.2.2 DEA scores with input variables of Group 2

For 24 regional hospitals, technical efficiency scores are from 0.711 to 1.000 and the mean is 0.935. Scale efficiency are from 0.744 to 1.000 and the mean is 0.964 (Table B1). There are 12 from 24 regional hospitals which have all efficiency scores equal to 1.000. In addition, the pattern of scale inefficiency of 3 hospitals is increasing return to scale and 9 is decreasing return to scale.

The range of technical efficiency scores of 65 general hospitals is from 0.294 to 1.000 and the mean is 0.807. Scale efficiency scores range from 0.588 to 1.000 and the mean is 0.906 (Table B2). In all 65 general hospitals, 15 hospitals' technical efficiency and scale efficiency scores are 1.000. The pattern of scale inefficiency of 46 hospitals is increasing return to scale and of 4 hospitals is decreasing return to scale.

For 380 big community hospitals, the technical efficiency scores go from 0.157 to 1.000 and the mean is 0.666. Scale efficiency scores range from 0.246 to 1.000 and the mean is 0.899. 78 hospitals' technical efficiency score and scale efficiency scores are 1.000.The pattern of scale inefficiency of 250 hospitals is increasing return to scale and of 91 hospitals is decreasing return to scale. The scores of these three types of hospital are classified by score levels in Table 4-6.

Table 4-6 Technical efficiency scores and scale efficiency scores with Group 2 input variables classified by score levels

Scores	Regional hospital		General hospital		Community hospital	
	TE	SE	TE	SE	TE	SE
1.000	12	12	13	15	26	39
0.999-0.950	3	8	5	19	13	153
0.949-0.900	2	1	6	8	19	65
0.899-0.850	3	0	5	7	15	31
0.849-0.800	1	2	5	2	19	28
0.799-	3	1	31	14	288	64
Total	24	24	65	65	380	380

4.3 Comparison between DEA efficiency scores with different input variables

This part starts with the comparison between DEA efficiency scores with Group 1 and Group 2 input variables of regional hospital by applying Wilcoxon signed ranks test and general statistic distribution. Three types of hospital (regional, general and big community hospital) are discussed separately.

4.3.1 Comparison results of regional hospitals

Table 4-7 shows the result of Wilcoxon signed rank test of regional hospitals. The null hypothesis of Wilcoxon signed rank test is that the median difference between pairs of observations is zero. When comparing technical efficiency scores, Z value is -1.503 and p value is 0.133. When comparing scale efficiency scores, Z value is -1.067 and p value is 0.286. Both p-values are higher than 0.05. There is no significant difference between technical efficiency scores and scale efficiency scores with two models that with different input variables.

Figure 4-1 and Figure 4-2 show the distribution of technical efficiency and scale efficiency score of regional hospitals under two models with Group1 and Group2 input variables. The solid line is the tendency line of the points and the dotted line is the diagonal which means the scores are equal with Group 1 and Group 2 input variables.

Table 4-7 Result of Wilcoxon signed rank test of regional hospital

Ranks				
		N	Mean rank	Sum of ranks
Group2 & Group1 TE	Negative ranks	5	10.20	51.00
	Positive ranks	13	9.23	120.00
	Ties	6		
	Total	24		
Group2 & Group1 SE	Negative ranks	7	8.71	61.00
	Positive ranks	11	10.00	110.00
	Ties	6		
	Total	24		

Test statistics		
	Group2 TE-Group1 TE	Group2 SE-Group2 SE
Z	-1.503	-1.067
Asymp.Sig. (2-tailed)	0.133	0.286

In Figure 4-1, 6 points locate at (1.000, 1.000) which means the technical efficiency scores of these hospitals are 1.000 and they don't change when applied into two different models with two groups of input variables. However, there are 6 points at the top line of the figure which illustrate another situation. These hospitals have lower technical efficiency scores with Group1 input while the scores is 1.000 with Group2. The biggest gap comes at the point (0.862, 1.000). The left 12 points locate at the two side of the dotted line.

In the following it is the comparison of scale efficiency. In Figure 4-2, 6 points locate at (1.000, 1.000) and these DMUs are the same as in Figure 4-1. Both technical efficiency score and scale efficiency of these 6 hospitals are 1.000 no matter what input variables are chosen. Compared to Figure 4-1, more points concentrate at the right corner and most of the left points locate above the dotted line. This illustrates that many hospitals have higher scores with non-financial variables compared to with financial variables.

Figure 4-1 Scattergram of regional hospitals' technical efficiency scores for models using Group 1 input variables against Group 2 input variables

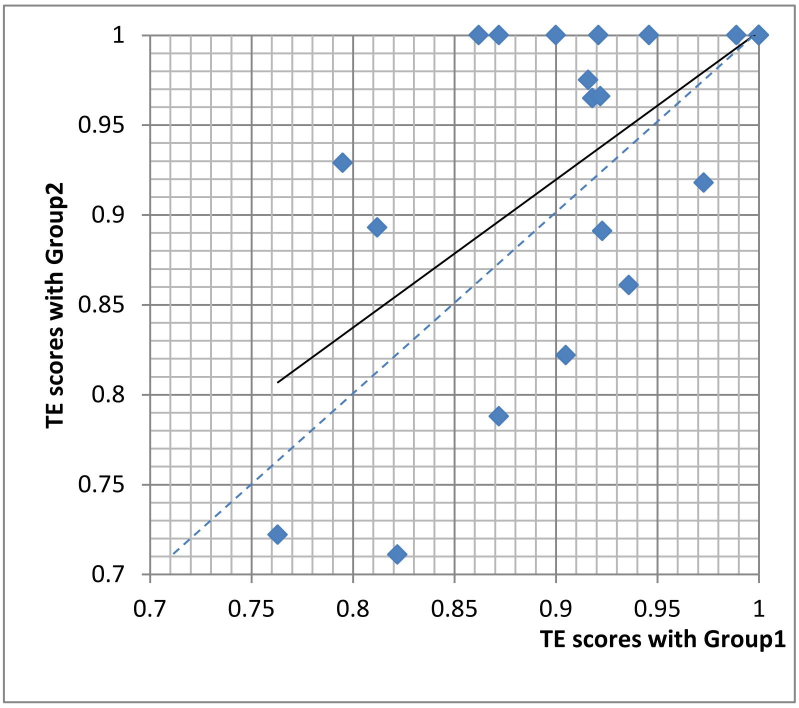
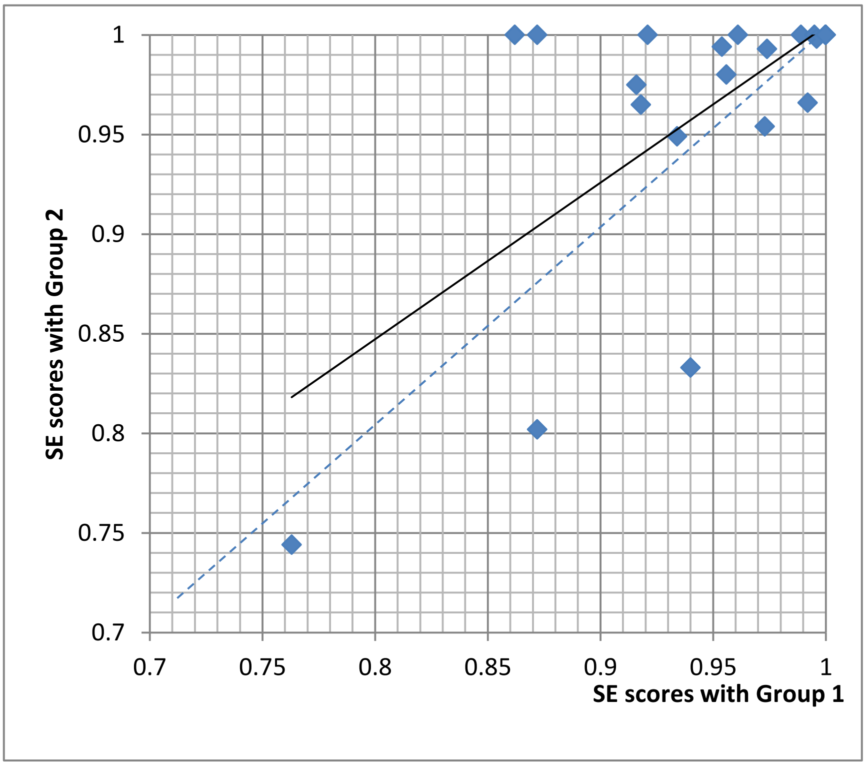


Figure 4-2 Scattergram of regional hospitals' scale efficiency scores for models using Group 1 input variables against Group 2 input variables



The result of Wilcoxon signed rank test is to test whether the observed differences are significant. The p-value of both technical efficiency score and scale efficiency score are higher than 0.05 which means no matter what group of input variables (financial or non-financial) is chosen, there is no median difference of the efficiency scores.

Although there is no influence on regional hospital, the choice of input variables can still have an effect on the choice of benchmark. It is easily to overestimate or underestimate a hospital's efficiency with different input variables, especially when the benchmark is chosen in the range of hospital efficiency score. However, because the technical efficiency and scale efficiency of regional hospital are very high (the lowest one is over 0.75 in this analysis) no matter with any group of input, this kind of influence will not be very big. In all, choice of input variables has limited influence on hospital efficiency measurement.

The scattergrams also provide some information. From the figures of technical efficiency and scale efficiency score, the "best" (fully efficient) and the "worst" hospitals can be uniquely identified no matter with any kind of input groups. However, 6 hospitals show fully efficiency with non-financial variables but not with financial variables. This shows that in the model with non-financial variables, their technical efficiency scores and scale efficiency scores are more likely to be 1.000 while the scores with financial variables are less than 1.000. There are 11 hospitals with higher technical efficiency scores with non-financial variables than with financial variables and 13 hospitals with higher scale efficiency scores.

The difference between the scores with financial variables and non-financial variables has a specific meaning in the explanation of hospital efficiency. As the output keeps the same in the calculation via DEA, it means there will be a financial input-mix and a non-financial input-mix according to each other to get the same efficiency score. If a hospital has higher efficiency score with financial inputs than with non-financial inputs, it means that the hospital has surplus in personnel or bed but better cost structure. Accordingly, if a hospital has higher efficiency score with non-financial input-mix, it illustrates that it has a better scheme in personnel and bed but worse cost structure.

For regional hospital, financial variables are more sensitive than non-financial because it can distinguish those hospitals with same or similar efficiency under model with non-financial variables. The result of regional hospitals maybe can be explained as they always receive donations from their patients which increase the hospitals' reserves. This additional financial reserve helps hospital's financial status keep stable and lose performance, but decrease in efficiency. Through the literature and reality of society, it really exists a custom that Thai people are willing to donate for "good" hospitals. But it lacks enough information and evidence to support that these regional hospitals have more donations than others and how they use the donations are unclear. Donation is only a potential explanation to the result of analysis.

4.3.2 Comparison results of general hospitals

The result of Wilcoxon signed ranks test between efficiency scores with Group 1 and Group 2 input variables of general hospitals is shown in Table 4-8. Z value of the comparison of technical efficiency scores is -1.328 and p value is 0.184 while Z value of the comparison of scale efficiency score -3.647 and p value is 0.000 which is lower than 0.05. There is no significant difference of technical efficiency scores while there is a significant difference of scale efficiency scores between two groups with different input variables.

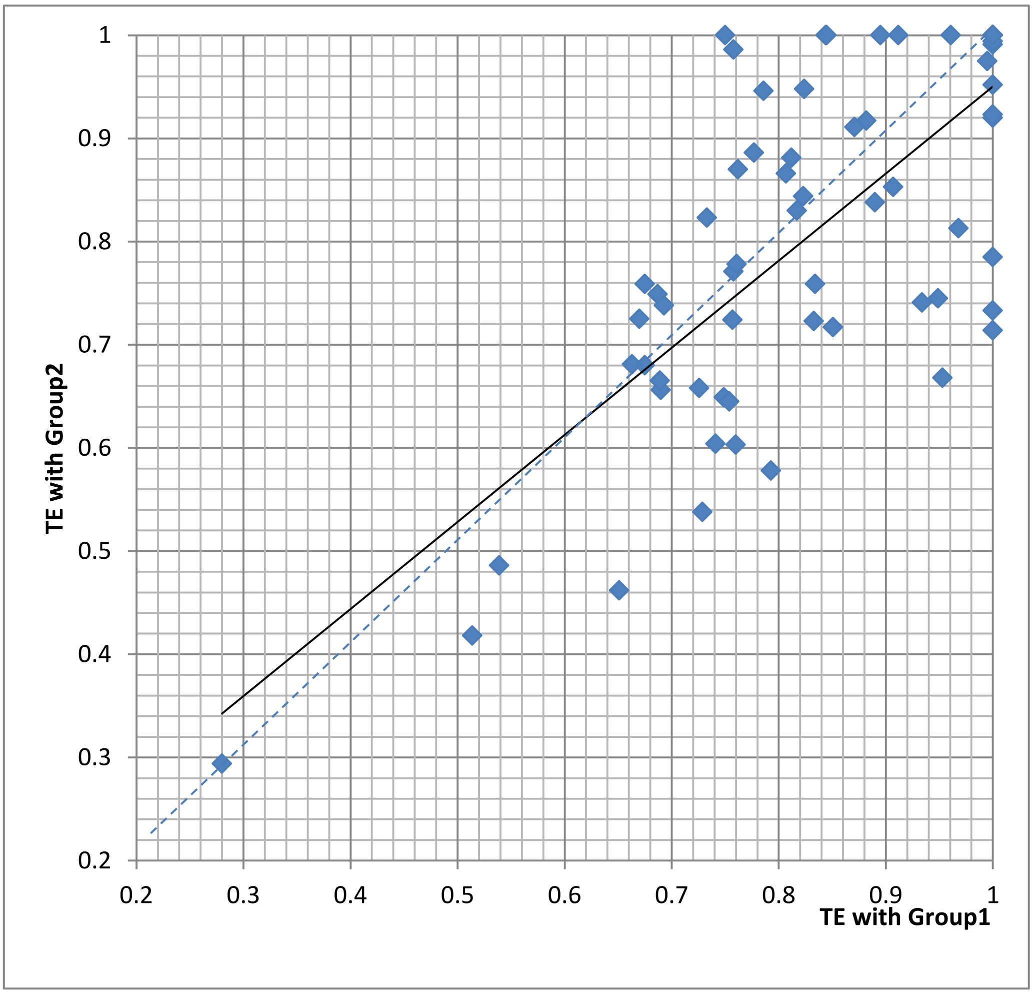
Table 4-8 Result of Wilcoxon signed rank test of general hospital

Ranks				
		N	Mean rank	Sum of ranks
Group2 & Group1 TE	Negative ranks	31	33.13	1027.00
	Positive ranks	27	25.33	684.00
	Ties	7		
	Total	65		
Group2 & Group1 SE	Negative ranks	42	31.58	1326.50
	Positive ranks	16	24.03	384.50
	Ties	7		
	Total	65		

Test statistics		
	Group2 TE-Group1 TE	Group2 SE-Group2 SE
Z	-1.328	-3.647
Asymp.Sig. (2-tailed)	0.184	0.000

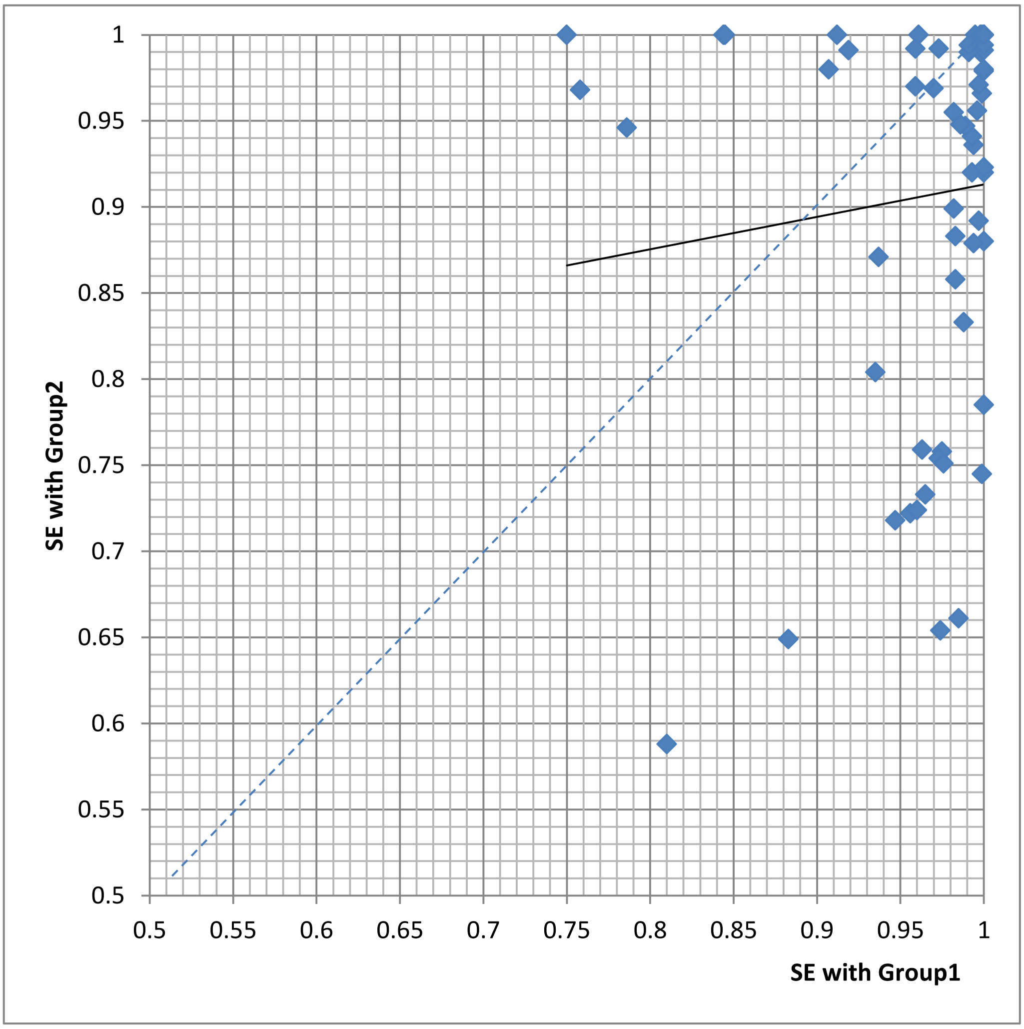
Figure 4-3 and Figure 4-4 show the distribution of technical efficiency and scale efficiency score of general hospitals. Shown as Figure 4-3, 7 of 65 points locate at (1.000, 1.000). Their technical efficiency scores are 1.000 and they don't change when applied into two different models with two groups of input variables. Two types of special points need to be emphasized here. One type is the point at the most right side which represent hospitals that have technical efficiency scores less than 1.000 with Group2 while the scores with Group1 is 1.000. There are 8 hospitals in this situation. Another type is the 6 points at the top line in the figure. These hospitals have technical efficiency scores less than 1.000 with Group1 while the score of Group2 is 1.000. Except from some extreme points ((0.28, 0.294), (0.514, 0.418) for example), other 34 hospitals locate almost average at the two sides of the dotted line. The tendency line and dotted line are close to each other.

Figure 4-3 Scattergram of general hospitals' technical efficiency scores for models using Group1 input variables against Group2 input variables



In comparison of scale efficiency, as shown in Figure 4-4, 7 points locate at (1.000, 1.000) and these DMUs are the same as in Figure 4-3. Both technical efficiency score and scale efficiency of these 7 hospitals are 1.000 no matter what input variables are chosen. Compared to Figure 4-3, 8 points locate at the most right side and 8 points at the top line. For general hospital, more points concentrate at the right side and below the dotted line. Scale efficiency scores under the model with Group 1 input variables are higher than those with Group 2. What's more, many points are very close to the most right side line. These hospitals' scale efficiency scores are nearly 1.000 with Group1 input variables but vary with Group2.

Figure 4-4 Scattergram of regional hospitals' scale efficiency scores for models using Group1 input variables against Group2 input variables



The Wilcoxon signed rank test provides the result that the choice of input variables has no significant influence on general hospital technical efficiency scores. But the influence on scale efficiency score is significant.

Through the figures, some hospitals' technical efficiency scores with non-financial variables are fully efficient while the scores with financial variables are less than 1.000. However, there are also some hospitals in the opposite direction which their technical efficiency scores are 1.000 with financial variables while are less than 1.000 with non-financial variables. In an overall view, the tendency line is very close to the dotted line and all the points locate average at the two side of the dotted line. For scale efficiency, many hospitals have scores as 1.000 or close to 1.000 with financial variables but lower scores with non-financial variables. These hospitals are almost perfect scale efficient with financial variables. But when measured by non-financial variables, the scores change a lot and range from 0.650 to 1.000.

At the beginning of this chapter, the descriptive analysis of general hospital's input variables mentions that the capital cost of general hospital is not normal distribution while other variables are with normal distribution. The DEA result with non-financial variables also shows in all 65 general hospitals, except from 15 fully efficient ones, the pattern of inefficiency of 4 hospitals is decreasing return to scale but of 46 hospitals is increasing return to scale. These hospitals can improve their scale efficiency by increasing their scale. This can explain why the points in scattergram distribute like that at some extent.

General hospitals have enough money and even some of them have surplus. That's why they have high efficiency score with financial variables. However, they don't have enough doctor, nurse, other personnel and bed which reflects on the efficiency scores that general hospitals are not efficient with non-financial variables. They are operating with insufficient labor and bed. Therefore, the scale of hospital plays the most important role in the efficiency measurement of general hospital.

4.3.3 Comparison results of big community hospitals

The result of Wilcoxon signed ranks test between efficiency scores with Group 1 and Group 2 input variables of big community hospitals is shown in Table 4-9. Z value of the comparison of technical efficiency scores is -16.860 and p value is 0.000 while Z value of the comparison of scale efficiency score -15.237 and p value is 0.000. These two p-value are both lower than 0.05. There is a significant difference of technical efficiency scores and scale efficiency scores between two groups with different input variables.

Table 4-9 Result of Wilcoxon signed rank test of big community hospital

Ranks				
		N	Mean rank	Sum of ranks
Group2 & Group1 TE	Negative ranks	3	23.50	70.50

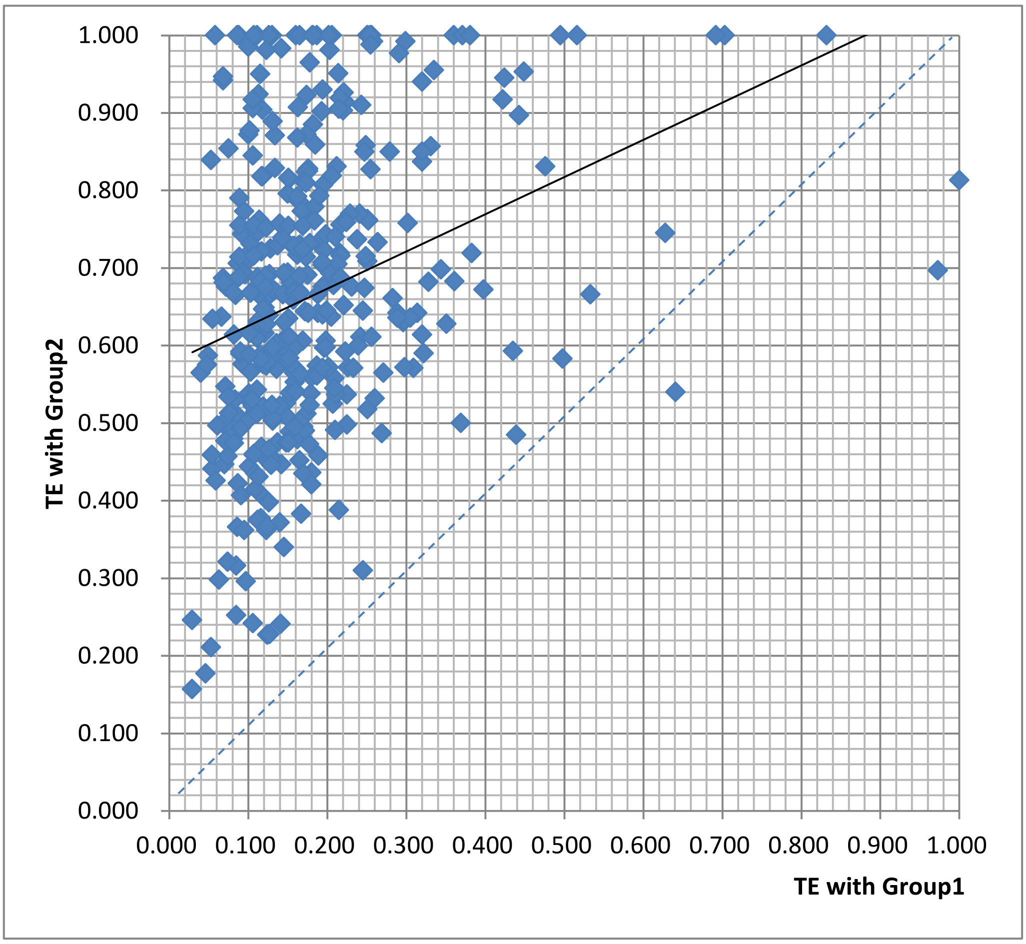
	Positive ranks	377	191.83	72319.50
	Ties	0		
	Total	380		
Group2 & Group1 SE	Negative ranks	55	64.52	3548.50
	Positive ranks	325	211.82	68841.50
	Ties	0		
	Total	380		

Test statistics

	Group2 TE-Group1 TE	Group2 SE-Group2 SE
Z	-16.860	-15.237
Asymp.Sig. (2-tailed)	0.000	0.000

Different from the figures of regional hospital and general hospital, the comparison of scores of big community hospitals is very interesting.

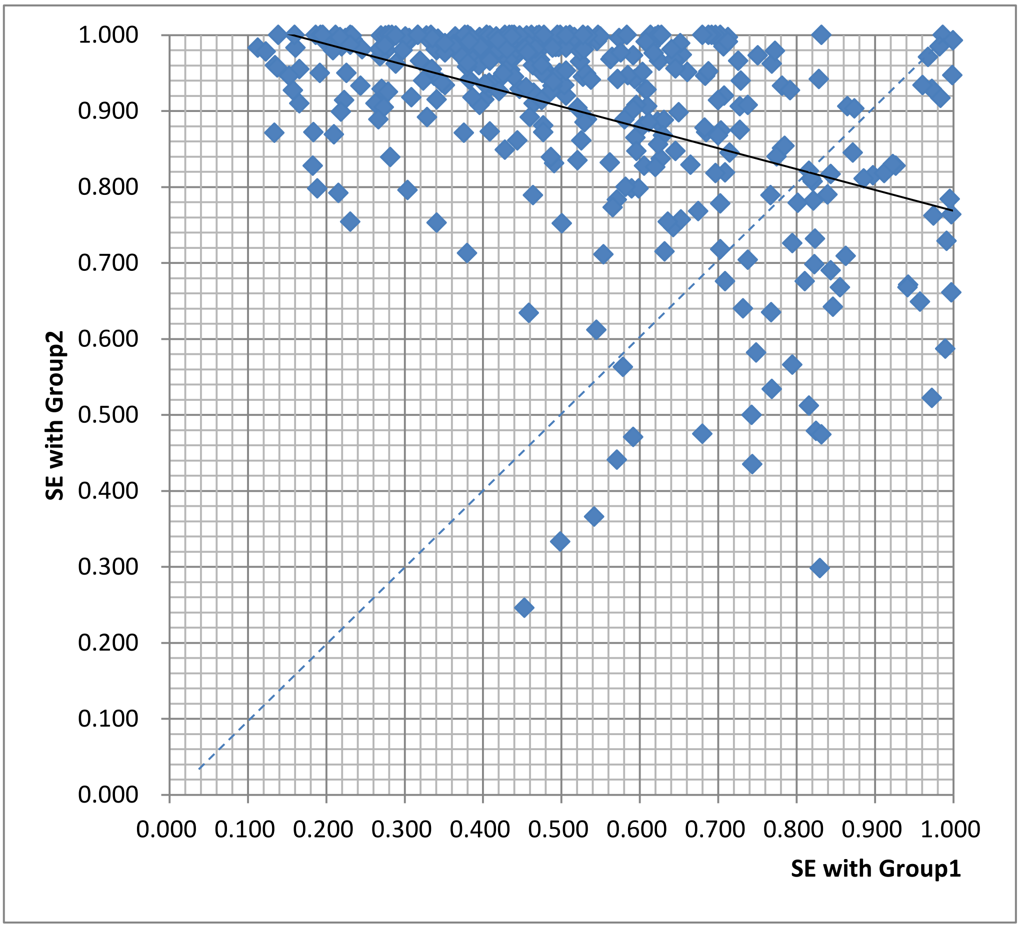
Figure 4-5 Scattergram of big community hospitals'technical efficiency scores for models using Group1 input variables against Group2 input variables



First of all, there is no point locate at (1.000, 1.000) or on the dotted line which means every hospital's technical efficiency score changes as applied into two models with financial variables and non-financial variables as inputs (Figure 4-5). 26 points locate at the top line. When technical efficiency scores are equal to 1.000 with non-financial variables, the scores with financial variables varies from 0.086 to 0.823. And there is only 1 point locates at the most right side. When technical efficiency score is equal to 1.000 with financial variables, its score with non-financial is 0.813.

What's more, taking all the points as a whole picture, the majority of these 380 points concentrate at left side. Their technical efficiency scores with financial variables are less than 0.400, while with non-financial variables range from 0.200 to 1.000. There are only 3 points locate below the dotted line. The majority of community hospital has higher technical efficiency score with non-financial variables.

Figure 4-6 Scattergram of big community hospitals' scale efficiency scores for models using Group1 input variables against Group2 input variables



In the comparison of scale efficiency scores with two groups of input variables, there is no point locates at (1.000, 1.000) or on dotted line. Through the figure, there are many points close to the line x= 1.000, only 1 point exactly on the line. And its score with non-financial variables is 0.993. There are 39 points on the line y=1.000 and their scores with financial variables range from 0.139 to 0.987. The majority of the points locate at upper area of the figure because they have high scale efficiency scores with non-financial variables which are more than 0.800. In fact, there are 257 hospitals' scale efficiency scores higher than 0.900 and among them 192 hospitals' scores are even more than 0.950. Most of the points are above the dotted line which means scale efficiency scores with non-financial variables are higher than those with financial variables. There is an unusual phenomenon here that doesn't happen in the analysis of regional and general hospital. The slope of tendency line in Figure 4-6 is negative.

Taking things together, the result of Wilcoxon signed rank test shows that the choice of input variables has significant influence on technical efficiency scores and technical efficiency scores for big community hospital. The technical and scale efficiency scores change when different input variables are chosen.

Through the figures, the majority of community hospitals have higher technical efficiency score and scale efficiency scores with non-financial variables. There are big gap between the scores with two groups of input variables. For technical efficiency score, the scores with non-financial variables can vary from 0.200 to 1.000 when the scores with financial variables keep steady in a small range of 0.100 to 0.300. The similar situation is also happened in technical efficiency scores. The scores with financial variables vary from 0.100 to 0.700 when their scores with non-financial variables keep in the range of 0.800 to 1.000.

It is difficult to get a reasonable explanation about the chaos of big community hospitals. In the descriptive analysis, the distribution of all input variables and output variables are not normal distribution. These are big differences among hospitals. And the distribution in the scattergram shows strange phenomenon. Therefore, with current situation, it needs more detailed information to re-group community hospitals. The included 308 community hospitals don't show any homology.

CHATPER Ⅴ

CONCLUSION AND RECOMMENDATION

In this part, conclusion will be generalized from previous chapters and recommendation on policy and further discussion will be provided.

5.1 General conclusion

The influence of the choice between financial variables and non-financial variables as input on the measurement of hospital efficiency via DEA is different according to different types of hospital. For regional hospital, the choice of input variables has no influence on hospital efficiency in both technical efficiency and scale efficiency. No matter what group of input variables, financial or non-financial, is chosen, the result is quite steady. For general hospital, there is no influence on technical efficiency but not on scale efficiency. And for big community hospital, there are significant differences on both technical efficiency and scale efficiency.

From the distributions of their efficiency scores, some special characteristics are concluded for three types of hospitals.

Regional hospitals have high efficiency scores and they are operating quite efficiently. And most of the hospitals have higher technical efficiency scores with non-financial variables, although this difference is not significant in statistic at 0.05 level. This phenomenon may be explained by an important characteristic of regional hospital that they receive donations from people and organizations to subsidize their budget. This makes their efficiency scores with non-financial variables are higher than with financial variables. Receiving donations stabilize the cost structure of hospital but decrease efficiency. But under current information and analysis, it is difficult to confirm and certify. There is no evidence to show that these regional hospitals receive more donations than others. Donation is only an explanation to the result in this analysis.

For general hospital, the significant difference in scale efficiency with two groups of input variables illustrates that general hospital has enough money but not enough labor and bed. They need to increase their scale to improve their efficiency.

For community hospital, DEA is not a suitable method to measure their efficiency under current database and information. Because of uncompleted database, only 308 of 694 hospitals can be applied into DEA program. Although the representativeness has been discussed, these 308 hospitals are those with bigger size, the variables of them still lack commonness. The efficiency scores change a lot when different input variables are chosen. What's more, it is very difficult to find anything valuable through their distribution of efficiency scores. With current database, the result of DEA is not reliable for community hospital.

5.2 Limitation

Considering that the result of DEA is influenced by many factors, the limitations of this study are as following.

First of all, there are only 24 regional hospitals in the calculation of efficiency score. The small number of observations may have effect on the result of DEA. If possible, panel data can be used to increase the number of observation.

Secondly, there are some missing data in the row database at the beginning. As discussed at the beginning of Chapter 4, 314 community hospitals are excluded because of missing data. Most of them lack the data of nurses. This can have big influence on the final result. And this is also why getting the result of community hospital is not possible.

Thirdly, in this research, only three financial variables, four non-financial variables and three output variables are involved in this research. Whether the result can broaden to other variables needs further discussion.

5.3 Recommendation

From the results of this study, some policy implication and recommendations can be derived.

First of all, the choice of input variables in DEA method has no influence on regional hospital's technical efficiency and scale efficiency measurement and on general hospital's technical efficiency. However, it can influence the result of general hospital's scale efficiency score. The influence on the measurement of community hospital is the biggest. With current database, the data about community hospital is incomplete and unreliable which leads to the unsuccessfully measurement of community hospital's efficiency. No matter financial variables or non-financial variables are chosen, the DEA result of community hospital is not reliable.

Secondly, if policy maker or hospital manager want to value the results come from DEA related researches, the result of regional hospital is quite reliable. The result on general hospital's technical efficiency is reliable, but not on scale efficiency. Whether the result of community hospital's efficiency measurement depends on how the researchers group the hospitals. If they just mix all the hospitals together, the result has no value because these community hospitals don't have any similarity.

Thirdly, the result of this study reflects that scale of hospital plays the most important role in the efficiency of general hospital. They need to improve their efficiency by increasing their scale. When allocating the budget, health policy maker should consider about increasing investment to help general hospitals by hiring more labor and increasing number of beds to increase the scale of general hospitals.

5.4 Recommendation for further study

More reliable data and information should be collected in order to do more detailed analysis on community hospitals. If the database is more completed and the data is more reliable, the result of this analysis may be changed. What's more, with further information, community hospitals can be grouped by some characteristics and they will show some similarities.

Including allocative efficiency to test whether there is an influence of choice of input variables is also a potential topic. Given measures of cost efficiency and technical efficiency, allocative efficiency can be calculated. Allocative efficiency can provide information about properly allocating the budget under constraint.

What's more, further study should collect data about donations of hospitals to test whether donation is an important factor of regional hospital efficiency. Under current analysis, it is only an assumption and possibility.

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APPENDIX

Appendix A Results of DEA with Group 1 input variables (financial variables)

Table A1 DEA scores of regional hospitals with Group 1 input variables

Hospital number (DMU)	CRSTEi	VRSTEi	SEi	Pattern of scale inefficiency
1	0.872	1.000	0.872	irs
2	0.989	1.000	0.989	irs
3	0.905	0.963	0.940	drs
4	0.872	1.000	0.872	irs
5	0.812	0.849	0.956	irs
6	0.862	1.000	0.862	irs
7	0.822	0.862	0.954	irs
8	0.763	1.000	0.763	irs
9	1.000	1.000	1.000	-
10	1.000	1.000	1.000	-
11	1.000	1.000	1.000	-
12	1.000	1.000	1.000	-
13	0.900	0.905	0.995	irs
14	0.918	1.000	0.918	irs
15	0.946	0.984	0.961	irs
16	0.795	0.852	0.934	irs
17	0.936	0.939	0.996	irs
18	0.916	1.000	0.916	irs
19	1.000	1.000	1.000	-
20	1.000	1.000	1.000	-
21	0.923	0.948	0.974	irs
22	0.922	0.930	0.992	irs
23	0.973	1.000	0.973	irs
24	0.921	1.000	0.921	irs
Mean	0.918	0.968	0.949	

`Note: CRSTE - technical efficiency from CRS DEA

VRSTE – technical efficiency from VRS DEA

SE – scale efficiency = CRSTE/VRSTE

Table A2 DEA scores of general hospitals with Group 1 input variables

Hospital number (DMU)	CRSTEi	VRSTEi	SEi	Pattern of scale inefficiency
1	0.844	1.000	0.844	drs
2	0.786	1.000	0.786	drs
3	0.824	0.896	0.919	drs
4	1.000	1.000	1.000	-
5	0.995	1.000	0.995	drs
6	0.687	0.687	0.999	-
7	0.953	0.978	0.975	irs
8	0.833	0.839	0.993	irs
9	0.851	0.890	0.956	irs
10	1.000	1.000	1.000	-
11	0.693	0.695	0.997	irs
12	0.690	0.737	0.935	irs
13	0.675	0.677	0.998	irs
14	0.689	0.703	0.983	irs
15	0.968	0.973	0.994	drs
16	0.762	0.763	0.999	irs
17	1.000	1.000	1.000	-
18	1.000	1.000	1.000	-
19	1.000	1.000	1.000	-
20	0.757	0.763	0.993	irs
21	0.912	1.000	0.912	drs
22	1.000	1.000	1.000	-
23	0.882	0.892	0.989	irs
24	0.823	0.835	0.986	irs
25	1.000	1.000	1.000	-
26	0.741	0.768	0.965	irs
27	0.758	1.000	0.758	drs
28	0.777	0.779	0.998	irs
29	0.758	0.765	0.991	drs
30	1.000	1.000	1.000	-
31	0.280	0.345	0.810	irs
32	1.000	1.000	1.000	-
33	0.949	0.950	0.999	irs

34	0.514	0.582	0.883	irs
35	1.000	1.000	1.000	-
36	0.934	0.940	0.994	drs
37	0.871	0.961	0.907	drs
38	0.729	0.770	0.947	irs
39	0.651	0.679	0.960	irs
40	0.663	0.675	0.982	irs
41	0.807	0.822	0.982	irs
42	0.539	0.553	0.974	irs
43	0.726	0.748	0.970	drs
44	0.670	0.672	0.997	irs
45	0.961	1.000	0.961	drs
46	1.000	1.000	1.000	-
47	0.733	0.783	0.937	irs
48	0.845	1.000	0.845	drs
49	0.812	0.834	0.973	drs
50	0.675	0.677	0.996	drs
51	0.760	0.781	0.973	irs
52	0.761	0.768	0.991	irs
53	0.749	0.767	0.976	irs
54	1.000	1.000	1.000	-
55	1.000	1.000	1.000	-
56	0.895	0.896	0.999	drs
57	1.000	1.000	1.000	-
58	0.750	1.000	0.750	drs
59	0.817	0.827	0.988	irs
60	0.907	0.946	0.959	drs
61	0.890	0.928	0.959	drs
62	0.834	0.866	0.963	drs
63	0.793	0.806	0.983	drs
64	0.754	0.766	0.985	drs
65	1.000	1.000	1.000	-
Mean	0.829	0.861	0.963	

Table A3 DEA scores of big community hospitals with Group 1 input variables

Hospital number (DMU)	CRSTEi	VRSTEi	SEi	Pattern of scale inefficiency
1	0.175	0.772	0.226	drs
2	0.092	0.578	0.158	drs
3	0.068	0.146	0.466	drs
4	0.089	0.159	0.563	drs
5	0.320	0.449	0.713	drs
6	0.256	0.632	0.405	drs
7	0.187	1.000	0.187	drs
8	0.212	0.432	0.491	drs
9	0.133	0.407	0.328	drs
10	0.361	0.512	0.706	drs
11	0.137	0.202	0.680	drs
12	0.118	0.226	0.521	drs
13	0.055	0.097	0.571	irs
14	0.184	0.369	0.499	drs
15	0.101	0.101	0.998	-
16	0.209	0.240	0.872	drs
17	0.162	0.308	0.524	drs
18	0.302	0.484	0.625	drs
19	0.106	0.148	0.715	irs
20	0.152	0.169	0.898	drs
21	0.703	1.000	0.703	drs
22	0.314	0.679	0.462	drs
23	0.149	0.243	0.616	drs
24	0.439	0.888	0.494	drs
25	0.383	0.832	0.459	drs
26	0.251	0.630	0.399	drs
27	0.208	0.367	0.565	drs
28	0.422	0.429	0.984	drs
29	0.116	0.151	0.768	irs
30	0.072	0.092	0.782	drs
31	0.136	0.174	0.782	drs
32	0.085	0.105	0.811	irs
33	0.533	0.815	0.654	drs
34	0.164	0.985	0.166	drs
35	0.223	1.000	0.223	drs
36	0.142	0.884	0.161	drs
37	0.162	0.856	0.189	drs
38	0.126	0.691	0.183	drs

39	0.124	0.283	0.438	drs
40	0.216	0.418	0.517	drs
41	0.145	0.382	0.380	drs
42	0.196	0.318	0.615	drs
43	0.320	0.491	0.652	drs
44	0.124	0.151	0.825	irs
45	0.118	0.118	0.998	-
46	0.131	0.268	0.487	drs
47	0.106	0.122	0.865	drs
48	0.231	0.326	0.709	drs
49	0.260	0.558	0.465	drs
50	0.100	0.147	0.685	drs
51	0.088	0.089	0.987	drs
52	0.245	0.290	0.847	drs
53	0.148	0.176	0.840	drs
54	0.150	0.233	0.644	drs
55	0.086	0.159	0.542	irs
56	0.148	0.278	0.533	drs
57	0.178	0.409	0.437	drs
58	0.128	0.275	0.465	drs
59	0.126	0.149	0.844	irs
60	0.189	0.245	0.769	drs
61	0.217	0.596	0.365	drs
62	0.068	0.082	0.829	irs
63	0.296	0.738	0.402	drs
64	0.177	0.223	0.792	drs
65	0.134	0.208	0.643	drs
66	0.107	0.278	0.383	drs
67	0.182	0.594	0.307	drs
68	0.157	0.318	0.493	drs
69	0.130	0.673	0.193	drs
70	0.196	0.541	0.363	drs
71	0.498	0.943	0.528	drs
72	0.172	0.700	0.246	drs
73	0.168	0.748	0.225	drs
74	0.101	0.610	0.166	drs
75	0.322	0.832	0.387	drs
76	0.198	0.602	0.329	drs
77	0.251	0.764	0.329	drs
78	0.101	0.144	0.704	drs
79	0.238	0.780	0.306	drs
80	0.174	0.943	0.184	drs

81	0.476	0.720	0.661	drs
82	0.127	0.274	0.464	drs
83	0.134	1.000	0.134	drs
84	0.258	0.651	0.396	drs
85	0.206	0.377	0.547	drs
86	0.194	0.407	0.477	drs
87	0.205	0.622	0.329	drs
88	0.155	0.453	0.341	drs
89	0.093	0.113	0.822	drs
90	0.243	0.926	0.263	drs
91	0.165	0.543	0.304	drs
92	0.424	1.000	0.424	drs
93	0.160	1.000	0.160	drs
94	0.118	0.199	0.594	drs
95	0.136	0.200	0.683	drs
96	0.344	0.844	0.408	drs
97	0.309	0.753	0.411	drs
98	0.249	0.734	0.340	drs
99	0.119	0.170	0.703	drs
100	0.185	0.365	0.506	drs
101	0.029	0.063	0.453	irs
102	0.283	0.541	0.439	drs
103	0.247	0.418	0.590	drs
104	0.221	0.945	0.234	drs
105	0.331	0.744	0.444	drs
106	0.398	0.563	0.707	drs
107	0.435	0.758	0.574	drs
108	0.166	0.167	0.992	drs
109	0.255	0.515	0.494	drs
110	0.114	0.413	0.277	drs
111	0.087	0.103	0.844	drs
112	0.181	0.259	0.697	drs
113	0.242	0.372	0.650	drs
114	0.096	0.158	0.608	drs
115	0.142	0.230	0.620	drs
116	0.159	0.262	0.609	drs
117	0.214	0.577	0.371	drs
118	0.111	0.799	0.139	drs
119	0.150	0.307	0.489	drs
120	0.066	0.588	0.113	drs
121	0.226	0.601	0.376	drs
122	0.225	0.580	0.387	drs

123	0.117	0.235	0.498	drs
124	0.220	0.508	0.434	drs
125	0.157	0.253	0.618	drs
126	0.070	0.095	0.738	irs
127	0.112	0.114	0.983	drs
128	0.090	0.147	0.610	drs
129	0.088	0.124	0.708	drs
130	0.154	0.481	0.320	drs
131	0.184	0.392	0.469	drs
132	0.113	0.835	0.135	drs
133	0.233	0.284	0.821	drs
134	0.150	0.252	0.596	drs
135	0.126	0.205	0.614	drs
136	0.074	0.129	0.579	irs
137	0.176	0.370	0.477	drs
138	0.153	0.508	0.301	drs
139	0.188	0.449	0.419	drs
140	0.128	0.472	0.271	drs
141	0.123	0.340	0.363	drs
142	0.106	0.249	0.425	drs
143	0.158	0.340	0.464	drs
144	0.176	0.519	0.338	drs
145	0.123	0.247	0.497	drs
146	0.142	0.325	0.437	drs
147	0.249	0.615	0.405	drs
148	0.217	0.633	0.343	drs
149	0.150	0.253	0.592	drs
150	0.251	0.929	0.270	drs
151	0.264	0.648	0.408	drs
152	0.153	0.192	0.795	drs
153	0.360	0.762	0.472	drs
154	0.081	0.130	0.623	drs
155	0.299	0.586	0.511	drs
156	0.170	0.280	0.606	drs
157	0.117	0.267	0.437	drs
158	0.097	0.133	0.728	drs
159	0.101	0.130	0.775	drs
160	0.251	0.504	0.499	drs
161	0.193	0.698	0.277	drs
162	0.371	0.868	0.428	drs
163	0.151	0.382	0.395	drs
164	0.203	0.316	0.641	drs

165	0.144	0.409	0.352	drs
166	0.109	0.191	0.571	drs
167	0.269	0.639	0.421	drs
168	0.194	0.669	0.289	drs
169	0.320	0.725	0.441	drs
170	0.298	0.498	0.599	drs
171	0.164	0.275	0.595	drs
172	0.172	0.285	0.604	drs
173	0.167	0.251	0.665	drs
174	0.165	0.234	0.703	drs
175	0.087	0.189	0.460	drs
176	0.084	0.680	0.123	drs
177	0.216	0.476	0.453	drs
178	0.195	0.407	0.478	drs
179	0.198	0.259	0.767	drs
180	0.114	0.287	0.396	drs
181	0.173	0.334	0.516	drs
182	0.213	0.605	0.352	drs
183	0.121	0.316	0.384	drs
184	0.165	0.717	0.231	drs
185	0.252	0.564	0.447	drs
186	0.122	0.194	0.631	drs
187	0.121	0.126	0.958	drs
188	0.121	0.207	0.584	drs
189	0.115	0.417	0.276	drs
190	0.122	0.560	0.219	drs
191	0.137	0.257	0.532	drs
192	0.241	0.589	0.409	drs
193	0.158	0.250	0.630	drs
194	0.117	0.200	0.585	drs
195	0.178	0.468	0.380	drs
196	0.188	0.427	0.441	drs
197	0.328	0.573	0.572	drs
198	0.175	0.365	0.479	drs
199	0.202	0.331	0.612	drs
200	0.115	0.158	0.728	drs
201	0.158	0.325	0.487	drs
202	0.074	0.122	0.608	drs
203	0.187	0.262	0.713	drs
204	0.169	0.241	0.700	drs
205	0.973	1.000	0.973	drs
206	0.180	0.203	0.886	irs

207	0.641	0.904	0.709	drs
208	0.053	0.105	0.499	irs
209	0.692	1.000	0.692	drs
210	0.082	0.100	0.816	irs
211	0.102	0.226	0.449	drs
212	0.151	0.277	0.546	drs
213	0.106	0.155	0.684	drs
214	0.170	0.526	0.324	drs
215	0.279	1.000	0.279	drs
216	0.210	0.444	0.473	drs
217	0.247	0.883	0.280	drs
218	0.100	0.453	0.220	drs
219	0.097	0.153	0.632	drs
220	0.148	0.293	0.504	drs
221	0.199	0.477	0.418	drs
222	0.162	0.231	0.700	drs
223	0.163	0.487	0.334	drs
224	0.289	0.634	0.456	drs
225	0.086	0.125	0.688	drs
226	0.029	0.039	0.749	irs
227	0.149	0.304	0.489	drs
228	0.134	0.551	0.244	drs
229	0.180	0.264	0.680	irs
230	0.251	0.570	0.440	drs
231	0.165	0.378	0.435	drs
232	0.495	1.000	0.495	drs
233	0.225	0.444	0.506	drs
234	0.254	0.532	0.478	drs
235	0.089	0.097	0.912	irs
236	0.194	0.342	0.566	drs
237	0.058	0.093	0.624	drs
238	0.215	0.515	0.417	drs
239	0.124	0.363	0.341	drs
240	0.140	0.187	0.751	drs
241	0.129	0.147	0.874	drs
242	0.151	0.317	0.476	drs
243	0.159	0.347	0.457	drs
244	0.107	0.123	0.863	drs
245	0.149	0.285	0.524	drs
246	0.239	0.488	0.489	drs
247	0.109	0.173	0.627	drs
248	0.119	0.237	0.501	drs

249	0.131	0.193	0.675	drs
250	0.207	0.477	0.433	drs
251	0.194	0.408	0.475	drs
252	0.223	0.491	0.455	drs
253	0.211	0.525	0.403	drs
254	0.107	0.246	0.434	drs
255	0.443	0.992	0.447	drs
256	0.204	0.474	0.430	drs
257	0.221	0.416	0.530	drs
258	0.271	0.492	0.550	drs
259	0.187	0.233	0.802	drs
260	0.160	0.305	0.526	drs
261	0.173	0.421	0.410	drs
262	0.335	1.000	0.335	drs
263	0.111	0.367	0.304	drs
264	0.074	0.136	0.545	drs
265	0.174	0.358	0.487	drs
266	0.449	0.888	0.506	drs
267	0.229	0.851	0.269	drs
268	0.111	0.475	0.233	drs
269	0.206	0.440	0.467	drs
270	0.103	0.306	0.336	drs
271	0.107	0.699	0.153	drs
272	0.255	0.665	0.383	drs
273	0.141	0.171	0.823	drs
274	0.107	0.503	0.212	drs
275	0.298	1.000	0.298	drs
276	0.173	0.631	0.274	drs
277	0.127	0.195	0.653	drs
278	0.123	0.168	0.732	drs
279	0.166	0.377	0.440	drs
280	1.000	1.000	1.000	-
281	0.078	0.080	0.975	drs
282	0.105	0.169	0.620	drs
283	0.198	0.404	0.490	drs
284	0.083	0.142	0.582	drs
285	0.126	0.265	0.475	drs
286	0.046	0.077	0.592	irs
287	0.190	0.466	0.409	drs
288	0.202	0.709	0.284	drs
289	0.162	0.750	0.216	drs
290	0.145	0.541	0.268	drs

291	0.131	0.225	0.581	drs
292	0.089	0.306	0.289	drs
293	0.115	0.598	0.192	drs
294	0.143	0.683	0.209	drs
295	0.123	0.289	0.426	drs
296	0.111	0.267	0.416	drs
297	0.160	0.301	0.532	drs
298	0.103	0.130	0.795	irs
299	0.152	0.445	0.341	drs
300	0.628	1.000	0.628	drs
301	0.063	0.076	0.830	irs
302	0.071	0.072	0.996	-
303	0.040	0.052	0.773	irs
304	0.055	0.120	0.459	irs
305	0.059	0.062	0.961	drs
306	0.054	0.073	0.738	drs
307	0.085	0.152	0.562	drs
308	0.256	0.673	0.381	drs
309	0.169	0.322	0.527	drs
310	0.118	0.183	0.646	drs
311	0.224	0.326	0.688	drs
312	0.179	0.193	0.927	drs
313	0.106	0.128	0.824	drs
314	0.090	0.290	0.309	drs
315	0.117	0.168	0.697	drs
316	0.053	0.187	0.282	drs
317	0.068	0.068	0.999	-
318	0.305	0.590	0.517	drs
319	0.112	0.408	0.275	drs
320	0.116	0.229	0.506	drs
321	0.178	0.245	0.726	drs
322	0.095	0.691	0.138	drs
323	0.129	0.315	0.408	drs
324	0.088	0.196	0.452	drs
325	0.123	0.232	0.529	drs
326	0.289	0.748	0.387	drs
327	0.095	0.097	0.973	irs
328	0.146	0.247	0.592	drs
329	0.194	0.363	0.534	drs
330	0.210	0.326	0.646	drs
331	0.071	0.087	0.819	irs
332	0.101	0.105	0.968	drs

333	0.091	0.099	0.923	irs
334	0.832	1.000	0.832	drs
335	0.091	0.174	0.521	drs
336	0.049	0.049	0.990	-
337	0.109	0.147	0.744	drs
338	0.351	0.815	0.431	drs
339	0.165	0.378	0.437	drs
340	0.516	0.978	0.528	drs
341	0.166	0.720	0.231	drs
342	0.102	0.164	0.624	drs
343	0.245	0.541	0.454	drs
344	0.176	0.291	0.604	drs
345	0.130	0.619	0.210	drs
346	0.320	0.439	0.729	drs
347	0.140	0.306	0.458	drs
348	0.215	0.361	0.596	drs
349	0.112	0.118	0.943	irs
350	0.061	0.153	0.400	drs
351	0.101	0.187	0.538	drs
352	0.076	0.390	0.196	drs
353	0.131	0.342	0.384	drs
354	0.159	0.389	0.409	drs
355	0.119	0.339	0.352	drs
356	0.381	1.000	0.381	drs
357	0.194	0.612	0.317	drs
358	0.209	0.498	0.419	drs
359	0.216	0.574	0.377	drs
360	0.140	0.712	0.196	drs
361	0.180	0.467	0.386	drs
362	0.048	0.218	0.218	drs
363	0.170	0.429	0.397	drs
364	0.189	0.495	0.383	drs
365	0.151	0.353	0.428	drs
366	0.152	0.331	0.457	drs
367	0.113	0.326	0.348	drs
368	0.124	0.463	0.267	drs
369	0.103	0.121	0.856	drs
370	0.291	0.505	0.576	drs
371	0.075	0.098	0.769	irs
372	0.069	0.124	0.554	irs
373	0.369	0.496	0.743	irs
374	0.082	0.099	0.832	drs

375	0.169	0.266	0.636	drs
376	0.174	0.754	0.231	drs
377	0.111	0.136	0.816	drs
378	0.081	0.085	0.942	irs
379	0.182	0.573	0.317	drs
380	0.075	0.096	0.785	drs
Mean	0.183	0.411	0.524	

Appendix B Results of DEA with Group 2 input variables (non-financial variables)

Table B1 DEA scores of regional hospitals with Group 2 input variables

Hospital number (DMU)	CRSTEi	VRSTEi	Sei	Pattern of scale inefficiency
1	1.000	1.000	1.000	-
2	1.000	1.000	1.000	-
3	0.822	0.931	0.833	drs
4	0.788	0.982	0.802	irs
5	0.893	0.912	0.980	irs
6	1.000	1.000	1.000	-
7	0.711	0.715	0.994	drs
8	0.722	0.970	0.744	irs
9	1.000	1.000	1.000	-
10	1.000	1.000	1.000	-
11	1.000	1.000	1.000	-
12	1.000	1.000	1.000	-
13	1.000	1.000	1.000	-
14	0.965	1.000	0.965	irs
15	1.000	1.000	1.000	-
16	0.929	0.979	0.949	irs
17	0.861	0.863	0.998	irs
18	0.975	1.000	0.975	irs
19	1.000	1.000	1.000	-
20	1.000	1.000	1.000	-
21	0.891	0.897	0.993	irs
22	0.966	1.000	0.966	drs

23	0.918	0.962	0.954	irs
24	1.000	1.000	1.000	-
Mean	0.935	0.967	0.964	

Table B2 DEA scores of general hospitals with Group 2 input variables

Hospital number (DMU)	CRSTEi	VRSTEi	SEi	Pattern of scale inefficiency
1	1.000	1.000	1.000	-
2	0.946	1.000	0.946	drs
3	0.948	0.957	0.991	irs
4	0.920	1.000	0.920	irs
5	0.975	0.975	1.000	-
6	0.749	0.775	0.966	irs
7	0.668	0.881	0.758	irs
8	0.723	0.785	0.920	irs
9	0.717	0.993	0.722	irs
10	0.714	0.729	0.979	irs
11	0.738	0.760	0.971	irs
12	0.656	0.816	0.804	irs
13	0.759	0.767	0.990	irs
14	0.665	0.775	0.858	irs
15	0.813	0.868	0.936	irs
16	0.870	0.878	0.992	irs
17	1.000	1.000	1.000	-
18	0.991	1.000	0.991	irs
19	1.000	1.000	1.000	-
20	0.724	0.771	0.941	irs
21	1.000	1.000	1.000	-
22	1.000	1.000	1.000	-
23	0.917	0.968	0.947	irs
24	0.844	0.890	0.948	irs
25	0.733	0.833	0.880	irs
26	0.604	0.825	0.733	irs
27	0.986	1.000	0.968	drs
28	0.886	0.887	1.000	-
29	0.771	0.779	0.990	irs

30	0.994	1.000	0.994	irs
31	0.294	0.501	0.588	irs
32	1.000	1.000	1.000	-
33	0.745	1.000	0.745	irs
34	0.418	0.644	0.649	irs
35	1.000	1.000	1.000	-
36	0.741	0.844	0.879	irs
37	0.911	0.929	0.980	irs
38	0.538	0.749	0.718	irs
39	0.462	0.637	0.724	irs
40	0.681	0.757	0.899	irs
41	0.866	0.906	0.955	irs
42	0.486	0.743	0.654	irs
43	0.658	0.679	0.969	irs
44	0.725	0.813	0.892	irs
45	1.000	1.000	1.000	-
46	0.923	1.000	0.923	irs
47	0.823	0.945	0.871	irs
48	1.000	1.000	1.000	-
49	0.881	0.889	0.992	irs
50	0.680	0.711	0.956	irs
51	0.603	0.800	0.754	irs
52	0.778	0.783	0.994	irs
53	0.649	0.865	0.751	irs
54	0.785	1.000	0.785	irs
55	1.000	1.000	1.000	-
56	1.000	1.000	1.000	-
57	0.952	0.971	0.980	drs
58	1.000	1.000	1.000	-
59	0.830	0.997	0.833	irs
60	0.853	0.879	0.970	drs
61	0.838	0.845	0.992	irs
62	0.759	1.000	0.759	irs
63	0.578	0.655	0.883	irs
64	0.645	0.975	0.661	irs
65	1.000	1.000	1.000	-

Mean	0.806	0.883	0.906

Table B3 DEA scores of big community hospitals with Group 2 input variables

Hospital number (DMU)	CRSTEi	VRSTEi	SEi	Pattern of scale inefficiency
1	0.769	0.810	0.950	drs
2	0.744	0.802	0.927	drs
3	0.687	0.697	0.985	irs
4	0.755	0.780	0.968	irs
5	0.614	0.616	0.997	drs
6	1.000	1.000	1.000	-
7	1.000	1.000	1.000	-
8	0.831	1.000	0.831	irs
9	0.671	0.671	0.999	irs
10	0.683	0.690	0.989	drs
11	0.475	1.000	0.475	irs
12	0.904	1.000	0.904	irs
13	0.441	1.000	0.441	irs
14	0.779	0.785	0.992	drs
15	0.444	0.581	0.764	irs
16	0.558	0.660	0.845	irs
17	0.479	0.497	0.965	irs
18	0.758	0.785	0.966	irs
19	0.845	1.000	0.845	irs
20	0.815	1.000	0.815	irs
21	1.000	1.000	1.000	-
22	0.642	0.643	1.000	-
23	0.604	0.605	0.997	irs
24	0.485	0.486	0.998	irs
25	0.719	0.724	0.993	drs
26	0.518	0.525	0.987	drs
27	0.678	0.698	0.971	irs
28	0.917	1.000	0.917	irs
29	0.377	0.593	0.635	irs
30	0.676	0.794	0.851	irs
31	0.603	0.647	0.933	irs
32	0.316	0.467	0.676	irs
33	0.666	0.684	0.974	irs
34	0.786	0.823	0.955	drs
35	0.914	1.000	0.914	drs
36	0.983	1.000	0.983	drs

37	0.717	0.899	0.798	drs
38	0.639	0.771	0.828	drs
39	0.452	0.453	0.997	irs
40	0.719	0.728	0.987	irs
41	0.340	0.477	0.713	irs
42	0.597	0.606	0.986	drs
43	0.837	0.846	0.989	irs
44	0.227	0.474	0.479	irs
45	0.661	1.000	0.661	irs
46	0.503	0.600	0.839	irs
47	0.906	1.000	0.906	irs
48	0.676	1.000	0.676	irs
49	0.532	0.585	0.910	irs
50	0.872	1.000	0.872	irs
51	1.000	1.000	1.000	-
52	0.310	0.482	0.642	irs
53	0.509	0.644	0.790	irs
54	0.694	0.717	0.968	irs
55	0.366	1.000	0.366	irs
56	0.526	0.591	0.889	irs
57	0.965	0.965	1.000	-
58	0.725	0.784	0.924	irs
59	0.398	0.577	0.690	irs
60	0.733	0.762	0.962	irs
61	0.756	0.757	0.998	irs
62	0.942	1.000	0.942	irs
63	0.630	0.688	0.915	drs
64	0.473	0.510	0.927	irs
65	0.452	0.605	0.747	irs
66	0.459	0.488	0.941	irs
67	0.885	0.890	0.993	irs
68	0.659	0.670	0.984	irs
69	1.000	1.000	1.000	-
70	0.723	0.732	0.988	irs
71	0.583	0.617	0.945	irs
72	0.644	0.657	0.981	drs
73	0.773	0.776	0.996	drs
74	0.711	0.782	0.910	drs
75	0.590	0.596	0.990	irs
76	0.743	0.745	0.997	irs
77	0.709	0.796	0.892	drs
78	0.538	0.615	0.874	irs

79	0.737	0.740	0.996	drs
80	0.872	1.000	0.872	drs
81	0.831	0.863	0.951	irs
82	0.692	0.720	0.960	irs
83	0.871	1.000	0.871	drs
84	0.992	0.995	0.997	irs
85	1.000	1.000	1.000	-
86	0.676	0.767	0.881	irs
87	0.637	0.639	0.996	irs
88	0.672	0.685	0.980	irs
89	0.576	0.736	0.782	irs
90	0.910	1.000	0.910	drs
91	0.730	0.735	0.993	irs
92	0.945	1.000	0.945	drs
93	1.000	1.000	1.000	-
94	0.818	0.869	0.942	irs
95	0.570	0.649	0.878	irs
96	0.698	0.750	0.930	drs
97	0.571	0.581	0.982	drs
98	0.715	0.728	0.981	drs
99	0.576	0.802	0.718	irs
100	0.859	0.934	0.920	irs
101	0.246	1.000	0.246	irs
102	0.661	0.683	0.969	drs
103	0.674	0.844	0.798	irs
104	0.926	0.932	0.994	drs
105	0.857	0.994	0.861	irs
106	0.672	0.682	0.985	irs
107	0.593	0.596	0.996	drs
108	0.729	1.000	0.729	irs
109	0.827	0.877	0.942	irs
110	0.762	0.764	0.997	irs
111	0.706	0.865	0.817	irs
112	1.000	1.000	1.000	-
113	0.611	0.680	0.898	irs
114	0.692	0.745	0.928	irs
115	0.594	0.595	0.998	irs
116	0.553	0.596	0.928	irs
117	0.951	0.976	0.974	drs
118	1.000	1.000	1.000	-
119	0.796	0.846	0.942	drs
120	0.637	0.648	0.983	drs

121	0.572	0.657	0.871	drs
122	0.498	0.514	0.967	drs
123	0.721	0.759	0.950	irs
124	0.903	0.923	0.979	drs
125	0.728	0.747	0.976	irs
126	0.447	0.636	0.704	irs
127	0.688	0.699	0.985	irs
128	0.589	0.650	0.906	irs
129	0.688	0.748	0.920	irs
130	0.681	0.705	0.966	drs
131	0.761	0.761	0.999	irs
132	0.924	0.963	0.960	drs
133	0.571	0.708	0.807	irs
134	0.507	0.558	0.908	irs
135	1.000	1.000	1.000	-
136	0.321	0.570	0.563	irs
137	0.828	0.949	0.872	irs
138	0.489	0.490	0.998	irs
139	0.642	0.648	0.990	drs
140	0.581	0.625	0.929	irs
141	0.574	0.583	0.985	irs
142	0.917	0.943	0.973	irs
143	0.728	0.923	0.789	irs
144	0.825	0.872	0.946	irs
145	0.981	0.997	0.984	irs
146	0.447	0.460	0.973	irs
147	0.858	0.858	1.000	-
148	0.716	0.720	0.995	drs
149	0.590	0.654	0.902	irs
150	0.763	0.764	0.999	drs
151	0.733	0.782	0.937	drs
152	0.539	0.742	0.726	irs
153	1.000	1.000	1.000	-
154	0.480	0.542	0.886	irs
155	0.992	0.992	1.000	-
156	0.495	0.598	0.828	irs
157	0.469	0.479	0.979	irs
158	0.296	0.327	0.906	irs
159	0.529	0.630	0.840	irs
160	1.000	1.000	1.000	-
161	0.902	0.921	0.980	drs
162	1.000	1.000	1.000	-

163	0.816	0.850	0.960	irs
164	0.981	1.000	0.981	irs
165	0.666	0.681	0.977	irs
166	0.515	0.658	0.783	irs
167	0.487	0.525	0.926	irs
168	0.640	0.665	0.962	irs
169	0.850	0.873	0.973	irs
170	0.632	0.793	0.798	irs
171	0.670	0.775	0.865	irs
172	0.490	0.557	0.880	irs
173	0.383	0.462	0.829	irs
174	0.452	0.580	0.778	irs
175	0.422	0.473	0.892	irs
176	0.665	0.680	0.978	drs
177	0.919	0.923	0.996	irs
178	0.807	0.844	0.956	drs
179	0.606	0.767	0.789	irs
180	0.410	0.451	0.908	irs
181	0.824	0.829	0.994	irs
182	0.705	0.755	0.934	drs
183	0.659	0.660	0.998	drs
184	1.000	1.000	1.000	-
185	0.761	0.819	0.929	irs
186	0.690	0.777	0.888	irs
187	0.649	1.000	0.649	irs
188	0.616	0.616	1.000	-
189	0.683	0.684	0.999	drs
190	0.674	0.750	0.899	drs
191	0.729	0.736	0.991	irs
192	0.770	0.771	0.999	drs
193	0.565	0.652	0.868	irs
194	0.618	0.652	0.947	irs
195	0.732	0.764	0.958	irs
196	0.666	0.680	0.979	irs
197	0.682	0.724	0.942	irs
198	0.691	0.700	0.987	drs
199	0.572	0.647	0.885	irs
200	0.587	0.671	0.875	irs
201	0.669	0.678	0.987	irs
202	0.506	0.510	0.991	irs
203	0.574	0.579	0.991	drs
204	0.606	0.663	0.914	irs

205	0.697	0.750	0.929	irs
206	0.436	0.537	0.811	irs
207	0.540	0.660	0.819	irs
208	0.211	0.632	0.333	irs
209	1.000	1.000	1.000	-
210	0.614	0.748	0.821	irs
211	0.877	0.890	0.986	drs
212	0.635	0.640	0.992	irs
213	0.522	0.552	0.946	irs
214	0.812	0.864	0.940	drs
215	0.850	0.918	0.925	drs
216	0.740	0.766	0.967	irs
217	0.850	0.850	1.000	-
218	0.985	1.000	0.985	drs
219	0.715	1.000	0.715	irs
220	0.475	0.508	0.934	irs
221	0.645	0.653	0.988	drs
222	0.868	1.000	0.868	irs
223	0.907	0.907	1.000	-
224	0.642	0.643	0.999	drs
225	1.000	1.000	1.000	-
226	0.157	0.270	0.582	irs
227	0.612	0.655	0.933	irs
228	0.829	0.889	0.933	drs
229	0.559	0.559	1.000	irs
230	1.000	1.000	1.000	-
231	0.689	0.722	0.954	irs
232	1.000	1.000	1.000	-
233	0.537	0.547	0.983	irs
234	1.000	1.000	1.000	-
235	0.714	0.873	0.818	irs
236	0.704	0.910	0.773	drs
237	1.000	1.000	1.000	-
238	0.905	0.906	0.998	drs
239	0.579	0.768	0.753	irs
240	0.522	0.537	0.973	irs
241	0.454	0.503	0.903	irs
242	0.475	0.500	0.950	irs
243	0.597	0.604	0.989	drs
244	0.460	0.650	0.709	irs
245	0.581	0.593	0.979	irs
246	0.600	0.610	0.983	irs

247	0.415	0.496	0.837	irs
248	0.521	0.693	0.752	irs
249	0.506	0.658	0.768	irs
250	0.525	0.543	0.967	irs
251	0.930	0.969	0.960	irs
252	0.592	0.636	0.931	irs
253	0.537	0.574	0.935	irs
254	1.000	1.000	1.000	-
255	0.897	0.898	0.999	irs
256	0.693	0.727	0.954	irs
257	0.652	0.737	0.885	irs
258	0.565	0.567	0.998	drs
259	0.561	0.720	0.779	irs
260	0.570	0.663	0.861	irs
261	0.714	0.733	0.974	irs
262	0.955	1.000	0.955	drs
263	0.543	0.683	0.796	irs
264	0.457	0.746	0.612	irs
265	0.512	0.553	0.926	irs
266	0.953	1.000	0.953	irs
267	0.770	0.793	0.972	drs
268	0.745	0.745	0.999	-
269	0.819	0.834	0.982	drs
270	0.731	0.734	0.996	drs
271	0.716	0.756	0.946	drs
272	0.988	1.000	0.988	drs
273	0.241	0.346	0.698	irs
274	0.755	0.755	1.000	-
275	0.572	0.584	0.980	drs
276	0.810	0.895	0.905	drs
277	0.228	0.301	0.757	irs
278	0.362	0.566	0.640	irs
279	0.563	0.595	0.945	drs
280	0.813	0.819	0.993	drs
281	0.489	0.642	0.762	irs
282	0.530	0.642	0.826	irs
283	0.598	0.638	0.938	irs
284	0.530	0.662	0.800	irs
285	0.466	0.509	0.914	irs
286	0.177	0.376	0.471	irs
287	0.793	0.908	0.873	irs
288	1.000	1.000	1.000	-

289	0.792	1.000	0.792	drs
290	0.693	0.706	0.981	irs
291	0.889	1.000	0.889	irs
292	0.790	0.791	0.999	irs
293	0.950	1.000	0.950	drs
294	0.739	0.754	0.980	drs
295	0.752	0.793	0.949	irs
296	0.610	0.625	0.976	irs
297	0.541	0.570	0.949	irs
298	0.566	1.000	0.566	irs
299	0.611	0.668	0.915	drs
300	0.745	0.745	1.000	-
301	0.298	1.000	0.298	irs
302	0.547	0.697	0.784	irs
303	0.565	0.577	0.979	irs
304	0.634	1.000	0.634	irs
305	0.426	0.573	0.934	irs
306	0.459	0.505	0.908	irs
307	0.252	0.303	0.832	irs
308	0.611	0.634	0.963	drs
309	0.724	0.731	0.991	drs
310	0.637	0.666	0.956	irs
311	0.759	0.797	0.952	irs
312	0.538	0.649	0.828	irs
313	0.242	0.331	0.732	irs
314	0.592	0.645	0.918	drs
315	0.818	1.000	0.818	irs
316	0.839	1.000	0.839	irs
317	0.947	1.000	0.947	irs
318	0.636	0.638	0.997	irs
319	0.631	0.640	0.986	drs
320	0.582	0.583	0.999	drs
321	0.523	0.541	0.966	irs
322	0.773	0.808	0.957	drs
323	0.446	0.460	0.969	irs
324	0.508	0.518	0.982	irs
325	0.627	0.639	0.981	irs
326	0.636	0.693	0.918	drs
327	0.362	0.693	0.522	irs
328	0.630	0.647	0.973	irs
329	0.707	0.708	0.999	drs
330	0.491	0.580	0.847	irs

331	0.477	0.588	0.811	irs
332	0.588	0.605	0.971	irs
333	0.494	0.595	0.830	irs
334	1.000	1.000	1.000	-
335	0.407	0.488	0.835	irs
336	0.587	1.000	0.587	irs
337	0.435	1.000	0.435	irs
338	0.628	0.640	0.981	irs
339	0.502	0.503	0.998	drs
340	1.000	1.000	1.000	-
341	0.667	0.884	0.754	drs
342	0.616	0.719	0.856	irs
343	0.645	0.657	0.982	drs
344	0.642	0.675	0.951	irs
345	0.523	0.602	0.869	drs
346	0.940	1.000	0.940	irs
347	0.372	0.381	0.977	irs
348	0.388	0.458	0.847	irs
349	0.375	0.559	0.671	irs
350	0.497	0.505	0.984	irs
351	0.505	0.537	0.941	irs
352	0.513	0.517	0.994	drs
353	0.598	0.605	0.988	irs
354	0.495	0.512	0.966	irs
355	0.647	0.654	0.989	irs
356	1.000	1.000	1.000	-
357	0.571	0.571	1.000	-
358	0.545	0.548	0.993	irs
359	0.688	0.688	1.000	-
360	0.757	0.757	1.000	-
361	0.421	0.423	0.995	irs
362	0.575	0.577	0.997	irs
363	0.435	0.442	0.984	irs
364	0.458	0.462	0.991	irs
365	0.754	0.889	0.849	drs
366	0.584	0.597	0.977	irs
367	0.431	0.460	0.937	irs
368	0.367	0.413	0.889	irs
369	0.668	1.000	0.668	irs
370	0.977	1.000	0.977	irs
371	0.534	1.000	0.534	irs
372	0.681	0.961	0.711	irs

373	0.500	1.000	0.500	irs
374	0.474	1.000	0.474	irs
375	0.754	1.000	0.754	irs
376	0.923	0.935	0.987	drs
377	0.512	1.000	0.512	irs
378	0.668	1.000	0.668	irs
379	1.000	1.000	1.000	-
380	0.854	1.000	0.854	irs
Mean	0.666	0.743	0.899	

Appendix C The result of independent samples test

Table C1 Result of Independent Samples T Test of included and excluded data set of community hospital

Variables		Levene's Test for Equality of Variances		T-test for equality of Means		
		F	Sig.	t	df	Sig. (2-tailed)
LC	Equal variances assumed	43.34	0.000	0.942	685	0.000
	Equal variances not assumed			9.501	637.737	0.000
NLC	Equal variances assumed	28.964	0.000	7.177	685	0.000
	Equal variances not assumed			7.554	631.882	0.000
CC	Equal variances assumed	21.122	0.000	5.160	685	0.000
	Equal variances not assumed			5.494	586.923	0.000
DOC	Equal variances assumed	34.218	0.000	5.159	681	0.000
	Equal variances not assumed			5.413	650.547	0.000
OTH	Equal variances	18.763	0.000	8.480	659	0.000

	assumed					
	Equal variances not assumed			9.754	654.119	0.000
BED	Equal variances assumed	96.570	0.000	6.582	685	0.000
	Equal variances not assumed			6.845	677.559	0.000
OP	Equal variances assumed	21.664	0.000	6.987	685	0.000
	Equal variances not assumed			7.221	677.559	0.000
IP	Equal variances assumed	42.034	0.000	6.499	685	0.000
	Equal variances not assumed			6.902	597.318	0.000
PP	Equal variances assumed	30.892	0.000	5.369	685	0.000
	Equal variances not assumed			5.654	630.021	0.000

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