ประสิทธิภาพทางเทคนิคของโรงพยาบาลโรงเรียนแพทย์ในประเทศไทย

นายกรภพ ภิรมย์ภักดี

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต

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TECHNICAL EFFICIENCY OF UNIVERSITY HOSPITALS IN THAILAND

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A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of Master of Science Program in Health Economics

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Thesis Title	Technical Efficiency of University Hospitals in Thailand
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กรภพ ภิรมย์ภักดี : ประสิทธิภาพทางเทคนิคของโรงพยาบาลโรงเรียนแพทย์ในประเทศไทย. (TECHNICAL EFFICIENCY OF UNIVERSITY HOSPITALS IN THAILAND)
อ. ที่ปรึกษาวิทยานิพนธ์หลัก : รศ.ดร. พงศา พรชัยวิเศษกุล,
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การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาประสิทธิภาพโรงพยาบาลโรงเรียนแพทย์และปัจจัยที่มีผลต่อประสิทธิภาพ โดยใช้เทคนิคการวิเคราะห์แบบDEA ตัวแทนปัจจัยการผลิตคือจำนวนของเตียง และจำนวนแพทย์ และตัวแทนผลผลิตคือ จำนวนครั้งของการเข้ารับการบริการของผู้ป่วยนอก จำนวนวันรับการรักษาของผู้ป่วยใน และจำนวนนักศึกษาแพทย์ปีที่6

จากการวิเคราะห์ข้อมูลของโรงพยาบาลโรงเรียนแพทย์ 5 แห่ง ตั้งแต่ปี พ.ศ.2544 ถึง พ.ศ.2550 จำนวนทั้งหมด 29 ข้อมูล ด้วยDEAพบว่า คะแนนประสิทธิภาพมีค่าตั้งแต่ 0.525 ถึง 1 โดยมีค่าเฉลี่ยประมาณ 0.887 ประมาณ 72.4 เปอร์เซ็นต์ของข้อมูล ประสบปัญหาไม่มีประสิทธิภาพทางขนาด และประมาณ 31.0เปอร์เซ็นต์ ไม่มีประสิทธิภาพทางเทคนิค ประมาณ 95.2เปอร์เซ็นต์ในกลุ่มที่ไม่มีประสิทธิภาพทางขนาดพบว่า เป็นไปในรูปแบบผลได้ต่อขนาดลดลง และยังพบว่าระบบประกันสุขภาพถ้วนหน้ามีแนวโน้มที่จะช่วยเพิ่มระดับประสิทธิภาพด้วย

ขั้นตอนต่อไปได้ทำการวิเคราะห์โดยเทคนิคสมการถดถอย พบว่าจำนวนของเตียงต่อจำนวนแพทย์ และจำนวนเภสัชกรต่อจำนวนแพทย์ มีความสัมพันธ์กับคะแนนประสิทธิภาพทางขนาดอย่างมีนัยสำคัญ โดยถ้าเพิ่มอัตราส่วนดังกล่าว 1หน่วย จะทำให้คะแนนลดลง 0.08 และเพิ่มขึ้น 1.18หน่วยตามลำดับ ส่วนคะแนนประสิทธิภาพทางเทคนิคพบว่า มีความสัมพันธ์กับ อัตราการครองเตียง จำนวนครั้งของการเข้ารับบริการของผู้ป่วยนอกต่อจำนวนแพทย์ และจำนวนนักศึกษาแพทย์ชั้นปีที่6ต่อจำนวนเตียง อย่างมีนัยสำคัญ โดยถ้าเพิ่มค่าตัวแปรดังกล่าว 1 หน่วยจะทำให้คะแนนเพิ่ม0.01 เพิ่ม2.98E-05 และลด0.69 หน่วยตามลำดับ นอกจากนี้ยังพบอีกว่าโรงพยาบาลโรงเรียนแพทย์ที่อยู่สังกัดกระทรวงศึกษาธิการ มีระดับคะแนนประสิทธิภาพทางเทคนิคที่สูงกว่าอย่างมีนัยสำคัญ ซึ่งสาเหตุดังกล่าวน่าจะเป็นผลมาจากความหลากหลายและขนาดของการบริการ ระบบการบริหาร และภาพลักษณ์ที่ต่างกัน

สำหรับการปรับประยุกต์ใช้กับการกำหนดนโยบาย การศึกษานี้ได้แสดงให้เห็นว่า โรงพยาบาลโรงเรียนแพทย์ส่วนใหญ่กำลังดำเนินงานในลักษณะรูปแบบผลได้ต่อขนาดลดลง ดังนั้นการลดขนาดของโรงพยาบาลลงเป็นสิ่งที่ควรกระทำเพื่อให้มีระดับประสิทธิภาพเชิงขนาดที่ดีที่สุด ณ จุดรูปแบบผลได้ต่อขนาดคงที่ การมุ่งเน้นไปที่การใช้เตียงผู้ป่วยในระดับกำลังการผลิตที่เต็มที่ หรือการลดจำนวนเตียง เป็นหนทางที่ควรกระทำเพื่อการยกระดับประสิทธิภาพทางเทคนิค

สาขาวิชา เศรษฐศาสตร์สาธารณสุข	ลายมือชื่อนิสิต KB
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KEYWORDS : TECHNICAL/EFFICIENCY/UNIVERSITY/HOSPITAL/THAILAND

KORNPOB BHIROMBHAKDI : TECHNICAL EFFICIENCY OF UNIVERSITY HOSPITALS IN THAILAND. ADVISOR : ASSOC. PROF. PONGSA PORNCHAIWISESKUL, Ph.D., CO-ADVISOR : ASSOC. PROF. JIRUTH SRIRATANABAN, M.D., Ph.D., **82**pp.

The objective of this study was to measure the university hospitals efficiency and identified the determinants of the efficiency. DEA technique specified with inputs (number of bed and number of physician) and outputs (OPD visits, IPD bed days and number of medical student year 6^{th}) was used in the first step.

29 data from 5 university hospitals since 2001 to 2007 were analyzed. The analysis found that efficiency scores were ranged from 0.525 to 1, average was about 0.887. 72.4% of decision making units(DMUs) were found inefficiency in scale, while about 31.0% were inefficiency in technique. Among the scale inefficiency hospitals, about 95.2% were operated with decreasing returns to scale pattern. Also found that, UC implementation tended to increase technical efficiency level.

Next step, regression analysis was done and the results showed that bed-physician ratio and pharmacist-physician ratio related to scale efficiency score significantly. Increasing in the ratios by 1 unit will make the score decreased by 0.08 and increased by 1.18 in sequences. For technical efficiency score was related to occupancy rate, out-patient visit-physician ratio and number of medical student year 6^{th}-bed ratio significantly. Increasing in the factors by 1 units will make the score increased 0.01, increased 2.98E-05 and decreased 0.69 in sequences. Moreover, the study also found that hospitals under ministry of education control had higher technical efficiency level than was not. The reasons for this finding might be because of economy of scope and scale, management system and image of hospital.

For policy makers, this study shows the evidence that most university hospitals were running in a decreasing return to scale pattern, so downsizing of the hospitals should be done to meet the most efficiency scale at constant return to scale pattern. Focusing on bed utilization at the maximal capacity or decreasing number of bed should be one solution to be considered because from the study shows that bed-physician ratio and occupancy rate highly significantly related to technical efficiency score.

Field of study : Health Economics.................Student's Signature: ....

Academic Year : 2008.....................................Advisor's Signature: ....

Co-advisor's Signature: ....

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CHAPTER I

INTRODUCTION

1.1 Problem and its significance

Since 2002, Thailand's government implemented a universal coverage scheme, or UC, for all Thai citizens. By following this policy directly many hospitals, especially public ones, which joined the scheme have been facing many problems, such as over demand, low quality complaints and financial crisis, etc.

The financial crisis is the most important problem which needs to be solved first. Because of the imbalanced budget allocation from the government to hospitals, they have been suffered by this problem more and more each year. Payment mechanism of universal coverage scheme is capitation. 1,659Baht/head/yr were paid in year 2006 while the general estimation by Dr. Jiruth Sriratanaban(in 2006) was about 2,000Baht/head/yr would be enough.

One example of the financial crisis occurred at one private hospital in Chiang Mai province, Thailand, which had joined the universal coverage scheme since January 2002 – private hospitals can decide to join or not to join the scheme with some conditions by themselves, withdrew itself from the scheme in August 2006 because the hospital claimed that it could not afford taking care of patients in universal coverage scheme with the amount of money paid by the government. And at that time, this was the 3^{rd} private hospital which had to withdraw itself from the scheme.

One of the best solutions for this financial problem is to do cost-minimization by using resources at the most efficient way. Because of the universal coverage scheme, many hospitals were restructured to meet the most efficient point. Some are now stable and can be able to sustain their activities while some are still not able to do so.

Many techniques have been used to evaluate the efficiency score of the businesses. Data Envelopment Analysis, or DEA, is the most popular technique which uses the concept of linear programming to evaluate the efficiency score of many businesses. Besides its powerful characteristics of non-parametric technique which can handle multiple inputs and outputs model, the efficiency score which comes from using the data envelopment analysis can not be checked by using statistical hypothesis testing and also can not be clarified of which factors make it inefficient and the strength of the factors affected the efficiency score. So the data envelopment analysis is a quick tool to estimate for the efficiency score while other techniques must be brought into use to find out more details of efficiency.

According to some studies before, the regression analysis, or RA, was the technique used together with the data envelopment analysis to provide more details of efficiency. The regression analysis is based on statistical testing and estimation, so the technique can provide more detail in each factor that influences the efficiency score.

Data envelopment analysis, together with regression analysis, can provide evidence of efficiency in businesses. Improving efficiency by using appropriate portion of inputs to produce outputs, called decision making units or DMUs, is one way to do cost-minimization done by following the result from this evaluation. For the future planning of policy, the policy makers can also aim at the right direction to improve the efficiency of using their resources in the right factors.

The health care system in Thailand can be classified into 5 levels of health facilities, according to their size and activities – self care level, primary health care level, primary care level, secondary level and tertiary care level. The most important hospitals in the system are teaching hospitals which provide tertiary care level in the systems and also have educational training of doctors and specialists. Teaching hospitals in Thailand at the present time, 2007, can be more subdivided, according to the government organization structure, to government-own hospitals and private teaching hospitals. There are two major owners of teaching hospitals in government-own structure. One owner is the ministry of public health, or MOPH, and another is ministry of education, or MOE. Some teaching hospitals can be owned by other ministries. MOPH teaching hospitals were reformed from regional hospitals which had never provided any education such as medical doctor training, MD, course before. After they have reformed, these hospitals provides medical training for clinical years only, 4^{th}-6^{th} year, and specialist training not for pre-clinical years, 1^{st}-3^{rd}. While MOE teaching hospitals, or called university hospitals, are considered as the most important hospitals which need to be sustained their activities because they provide education for both pre-clinical and clinical years of their own medical training course and for pre-clinical years of MOPH training course. Not only medical training, but also other health professional courses such as nurse and other technicians and specialists as well.

Because university hospitals have high reputation and trust from community so university hospitals have high intensity in those problems : over demand, high quality care expectation and, perhaps, financial crisis as well. Moreover, many cases which are treated in university hospitals are more severe than other hospitals which means that the hospitals must spend higher technology and cost to treat such the cases.

Because university hospitals have 3 main activities - service, education and research.

1. Service : university hospitals considered as tertiary care level in Thai health system which they have to provide 4 main aspects –
   - Curative care
   - Supportive care
   - Preventive care
   - Rehabilitation
2. Education : mainly the hospitals provide medical training both under-graduated level and specialist training. But in some hospitals may provide other courses such as nurse, technician, scientist, Thai traditional medicine for example in Siriraj Hospital, etc. More than that, some short-course, seminar, special activities training may be provided by some hospitals too, for example : elective courses in King Chulalongkorn Memorial Hospital and Thai massage training in Siriraj Hospital. According to prevention service, some hospitals do provide educational about disease to community in both direct and indirect ways such as printed-out handbill, hospital’s newspaper, community medicine and so on.
3. Research : medical field research mainly divided into 2 types of research, science research such as biochemistry, chemistry, immunology, etc. And clinical research such as bone marrow transparent study, drug efficacy study, screening test study, etc.

Also, government tertiary care level hospitals, especially university hospitals, have a lot of patients with high variation in many aspects. For example, low to high income patients but the proportion of low income is more than high income. Severity of case also ranges from low to very high but tends to have high severe cases more which included referred cases too. These make the university hospitals face with the financial problem more. Burdens of providing education and research which also consume resources from the hospitals while outcome from providing these are lower revenue while comparing with outcome from providing services.

So, this study focuses on evaluation of TE of university hospitals in Thailand to provide evidence of the TE score of the hospitals by using DEA and regression analysis.

1.2 Research questions

There are 2 major questions in this study:

1. What level are technical efficiency scores of university hospitals in Thailand?
2. How do some explanatory variables affect the technical efficiency scores?

1.3 Research objectives

1. General objective - To provide the evidence of TE in university hospitals in Thailand.
2. Specific objectives –
    - To evaluate TE of university hospitals in Thailand.
    - To evaluate SE of university hospitals in Thailand.
    - To identify the impact of some factors to TE score and SE score.

1.4 Scope of the study

Evaluation of technical efficiency of university hospitals in Thailand since 2002 until 2007, secondary panel data have been collected. 5 university hospitals have been selected as a sample group of this study.

1.5 Benefit of this study

By the result of this study, technical efficiency score were evaluated and let us know the hospital efficiency level of the university hospitals. Also by using regression analysis, the coefficiences of variables were estimated to represent the impact of variables to technical efficiency. The inefficient hospitals can cut their costs by reducing their waste inputs. More over, the best DMUs were identified, the inefficient hospitals can benchmark their units with the best DMUs. Further more, for future planning and policy implication, the policy makers can use the result as a guideline.

CHAPTER II

BACKGROUND OF HEALTH SYSTEM IN THAILAND

2.1 Health professional training in Thailand

1. Physician

   In 2005, there were 14 universities, 13 public and 1 private, which had medical training program. Number of medical training was slightly decreased each year. The latest number showed that new medical training was about 1,400 persons each year and number of graduated medical training was about 1,500 persons in year 2002.

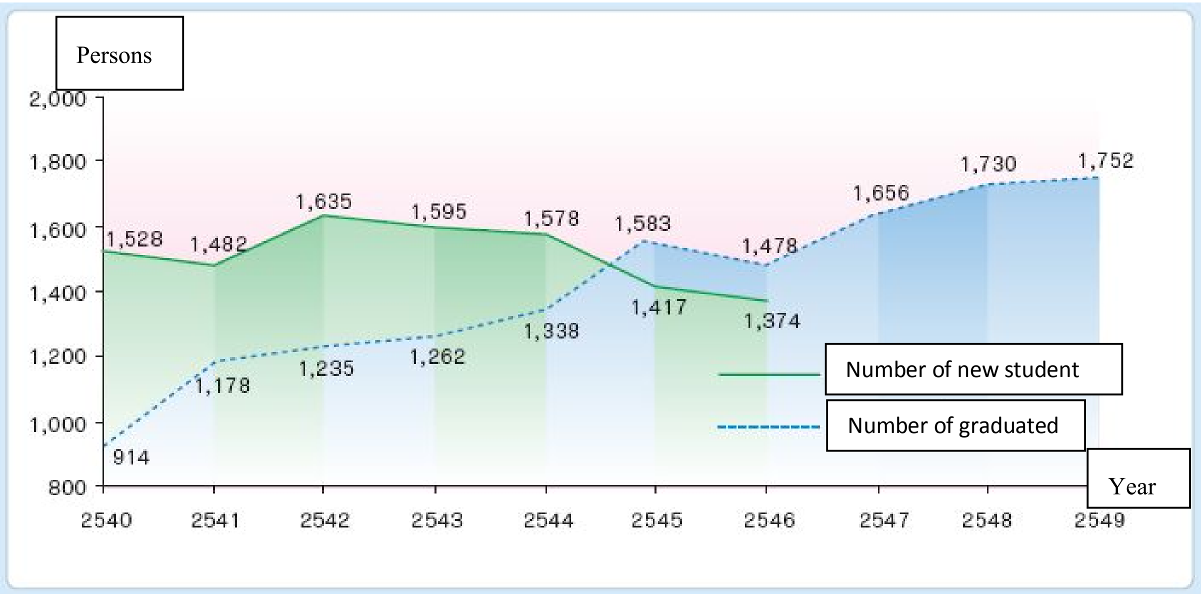

Figure 2.1-1 : Number new medical training and graduated from year 1997-2006

From Thailand Health Profile, 2005-2007

y-axis is year in Buddhist and x-axis is number of medical training(persons)

Continuous line represents number of new medical training and

Dot line represents number of graduated medical training

2. Dentist

There were 10 universities, 9 public and 1 private, which had dentist training program. Each year, 500 dentists were produced from those universities.

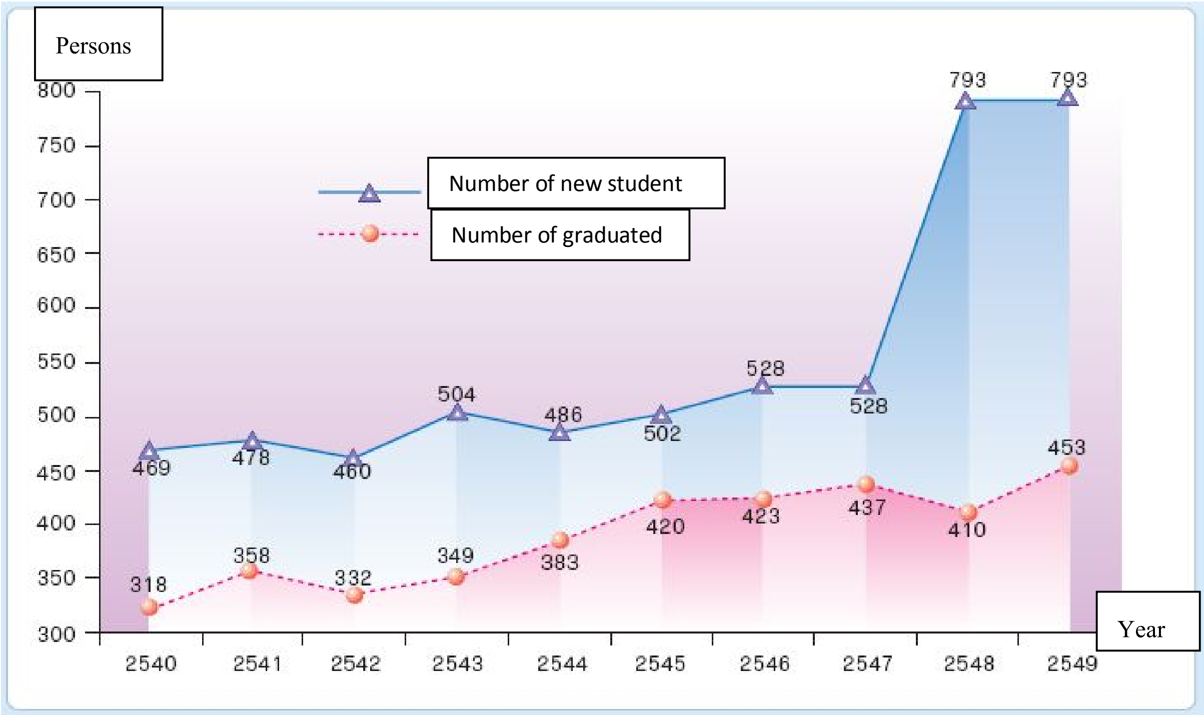

Figure 2.1-2 : Number new dentist training and graduated from year 1997-2006

From Thailand Health Profile, 2005-2007

y-axis is year in Buddhist and x-axis is number of dentist training(persons)

Continuous line represents number of new dentist training and

Dot line represents number of graduated dentist training

3. Pharmacist

14 universities, 11 public and 3 private, produced pharmacists each year about 220 persons.

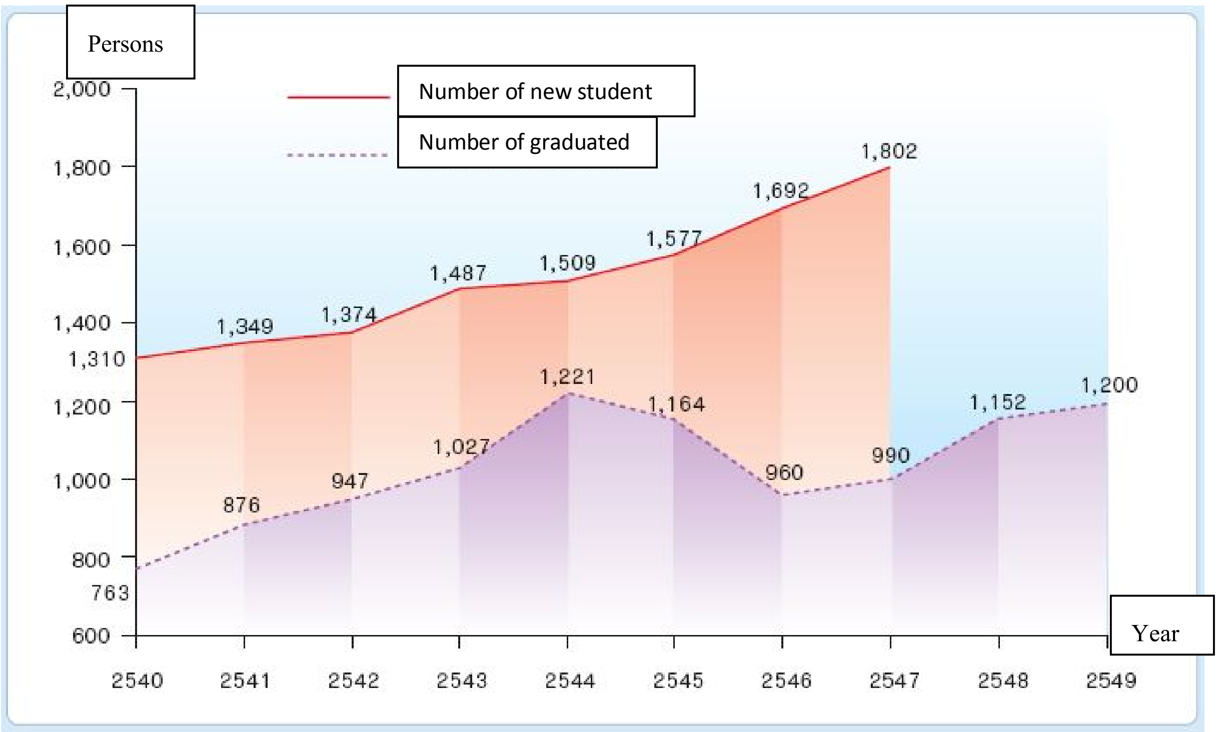

Figure 2.1-3 : Number new pharmacist training and graduated from year 1997-2006

From Thailand Health Profile, 2005-2007

y-axis is year in Buddhist and x-axis is number of pharmacist training(persons)

Continuous line represents number of new pharmacist training and

Dot line represents number of graduated pharmacist training

4. Registered nurse

Registered nurse was produced about 1,500 persons each year from 74 institutes, 64 public and 10 private.

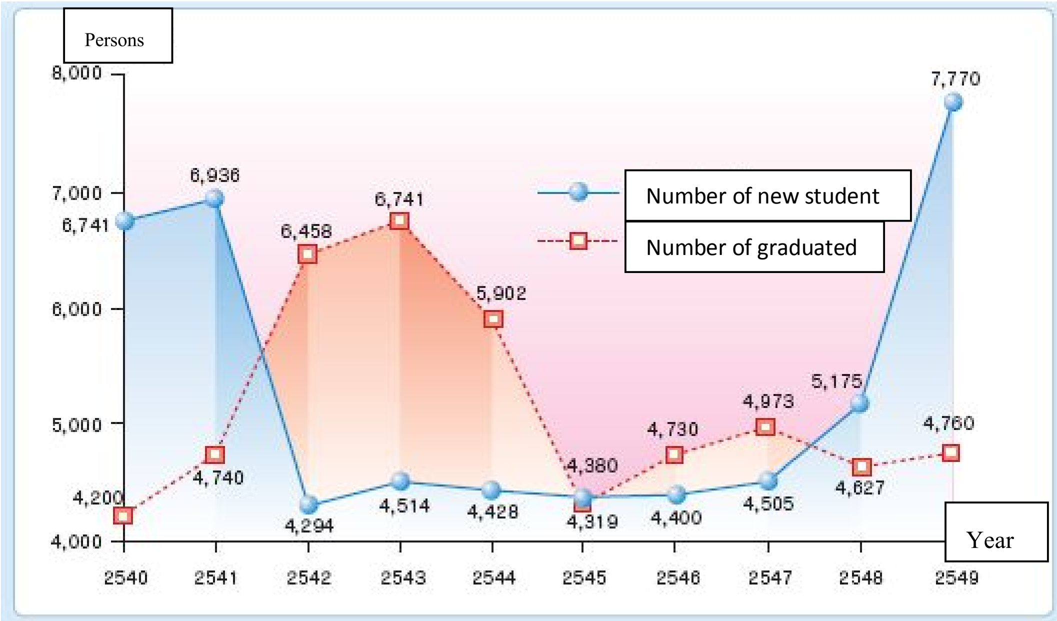

Figure 2.1-4 : Number new registered nurse training and graduated from year 1997-2006

From Thailand Health Profile, 2005-2007

y-axis is year in Buddhist and x-axis is number of registered nurse training(persons)

Continuous line represents number of new registered nurse training and

Dot line represents number of graduated registered nurse training

2.2 Health facilities in Thailand

1. Public health facilities

   Public health facilities, government owned, were a major role in the health system. Because people could access to the facilities easily and all over country, especially in the remote district. Public health facilities were composed of specialized hospitals, regional hospitals, general hospitals, community hospitals, health centers. The facilities were owned by many departments and institutes such as ministry of public health, ministry of education, ministry of defense, ministry of interior, etc., the major owner was ministry of public health. The facilities could be classified by level as follow :

   - Bangkok metropolitan level – There were 5 university hospitals, 26 general hospitals, 14 specialized hospitals and institutes and 68 health centers with 77 branches.
   - Regional level – 6 university hospitals, 25 regional hospitals and 47 specialized hospitals.
   - Provincial level – 70 general hospitals in every province and 59 hospitals owned by ministry of defense.
   - District level – 730 community hospitals and 214 health centers
   - Subdistrict level – 9,762 health centers in every subdistrict
   - Community level – 311 community health stations, 66,223 community health centers in remote area and 3,108 community health center in rural area.

Authority level	Health facility	Number
Bangkok	University hospital	5
	General hospital	26
	Disease-specific hospital & institution	14
	Health center	68
Regional	University hospital	6
	Regional hospital	25
	Disease-specific hospital & institution	47
Provincial	General hospital	70
	Hospital under ministry of defence	59
	Hospital under royal Thai police office	1
District	Community hospital	730
Sub-district	Health center	79618

Figure 2.2-1 : Public health facilities in 2007

From Thailand Health Profile, 2005-2007

2. Private health facilities

Private health facilities were very important especially in the rural areas which were good status in economic and people had enough purchasing power. Private health facilities were not only in Bangkok but also in other provinces all over country especially for drug stores and clinics. Private health facilities could be classified into 3 types as below :

- Drug store – There were 3 types of drug store. 8,801 Modern medication drug stores, 4,528 Modern medication without dangerous medication drug stores and 2,096 Thai traditional medication drug stores.
- Clinic – There were 16,800 clinics through out the country.
- Private hospital – There were 344 hospitals.

Health facility	Bangkok	Regional	Total
Drug store	4512	10913	15425
Clinic	3687	13113	16800
Private hospital	3603	12944	16547

Figure 2.2-2 : Private health facilities in 2006

From Thailand Health Profile, 2005-2007

2.3 Universal coverage scheme in Thailand

Before the year 2002, because of developing by parts, Thailand had had many types of health insurance with different objectives. Because of pay per service mechanism in payment, many health insurance schemes had been faced with financial crisis and efficiency crisis of the scheme. Also, many hospitals seemed to provide more services than necessary. While some schemes could sustain their financial status because they had used pay per head payment mechanism. Because of this, pay per head mechanism had been concerned as a standard payment mechanism which could sustain financial status of the scheme in a long period. More over, risk sharing had been not good enough so many schemes could not be sustained their activities in a long period.

The main objective of the UC scheme was to provide health insurance to every Thai citizens could access to necessary health services which considered as a basic "rights" of citizens and to organize social system to more equity level in sharing risk in budget due to health problems. Solidarity in the society would be higher. 3 main objectives were :

1. Universal coverage
2. Same standard in health services
3. Policy sustainability, Financial sustainability and Institutional sustainability

The universal coverage scheme was designed its system as follow :

4. Budget was come from tax. 30Bath co-payment would be paid per visit, excluded health promotion and prevention programs. Also, co-payment would not be paid in some conditions.
5. Primary care units which were located in every communities considered as a front line service and could be main contractors and unit for registration.
6. Financial system was to be cost containment system in a long period. Payment mechanism to health facilities was close end and performance related payment.
7. Sets of the same standard of benefits.
8. Quality assurance was brought into used to control standard of services.
9. Decentralization with provincial level management.
10. Purchaser provider split was to check, control, monitor and evaluate the system to higher efficient level.

CHAPTER III

LITERATURE REVIEW

3.1 Concept of efficiency measurement

Modern efficiency measurement begins with Farrell (1957) who drew upon the work of Debreu (1951) and Koopmans (1951) to define a simple measure of firm efficiency which could account for multiple inputs. He proposed that the productive efficiency of a firm composes of 2 aspects, technical efficiency or TE and allocative efficiency or AE.

The technical efficiency refers to the use of productive resources in the most technologically efficient manner. It implies the maximum possible output from a given set of inputs or, in reverse, minimum possible input from a given set of outputs. Then TE refers to the physical relationship between the resources used - capital, labor and equipment, and some health outcome. For the outcomes, may either be defined in terms of intermediate outputs or final health outcome.

The allocative efficiency reflects the ability of an organization to use these inputs in optimal proportions, given their respective prices and the available production technology. It is concerned with choosing between the different technically efficient combinations of inputs used to produce the maximum possible outputs or in reverse.

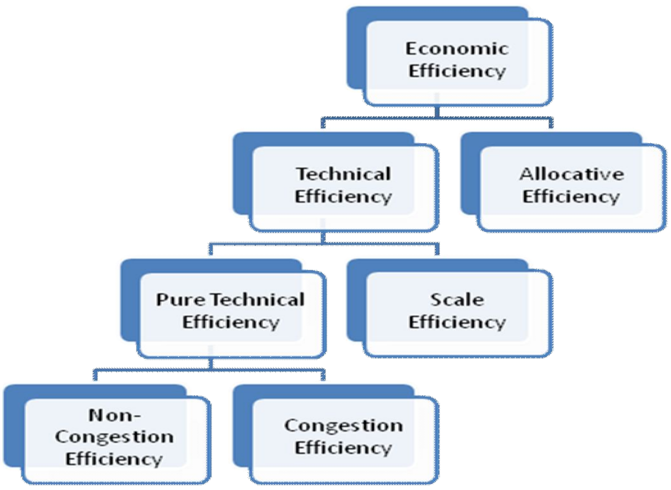

Figure 3.1-1 : Types of economic efficiency

Technical efficiency or technical efficiency under constant return to scale assumption (TECRS) can be decomposed into “pure” technical efficiency or technical efficiency under variable return to scale assumption (TEVRS) and scale efficiency (SE).

At the very first period of using the DEA measuring for technical efficiency score, there was an assumption of constant returns to scale, CRS. That’s mean the firm was assumed that it operated at the most efficient economy of scale.

Pure technical efficiency was developed after that, in 1984, variable returns to scale, VRS, assumption was proposed by Banker et al. Because in the real world, there are some constraints those make the firm can not operate at the optimal scale efficiency, SE. So, by this assumption SE of the firm is concerned.

Scale efficiency is the potential productivity gain from achieving optimal size of a firm. Scale efficiency pattern in economic is classified into 3 groups which are :

1. Increasing return to scale, IRS
2. Constant return to scale, CRS
3. Decreasing return to scale DRS

P(X)	= Y	
P(AX)	= BY	
	$A < B$	for increasing return to scale, IRS
	$A = B$	for constant return to scale, CRS
	$A > B$	for decreasing return to scale, DRS

From above, P(X) is represented for production function which has X as variable. By the function, X is used to produce Y. The next equation, X changes A time to AX which will make Y changed B time to BY. If the rate of changing of X, A, is lower than the rate of changing of Y, B, economic calls increasing return to scale, IRS. While constant return to scale, CRS, is called if they are equal and decreasing return to scale, DRS, if A is more than B.

The IRS and DRS are concerned as scale inefficiency pattern while the optimal scale efficiency pattern is CRS. And at this CRS, the unit cost will be the lowest too.

3.2 Technique for efficiency evaluation

There are 4 main methods those are used for technical efficiency estimation. Which are :

1. Least-squares econometric production models, LS
2. Total factor productivity indices, TFP
3. Data envelopment analysis, DEA
4. Stochastic frontiers, SF

Each technique has its own strength and weakness as shown in Table3.2-1 :

	LS	TFP	DEA	SF
Parametric?	Y	N	N	Y
Account for noise?	Y	N	N	Y
Assume all firms are efficient?	Y	Y	N	N
Assumption	*	Cost min, Revenue max	N	*
Method used to measure				
- Technical change	Y	Y	Y	Y
- Technical efficiency	N	N	Y	Y
- Scale efficiency	Y	N	Y	Y
- Allocative efficiency	N	N	Y	Y
- Congestive efficiency	N	N	Y	N
Prices needed?	*	Y	*	*
Type of data				
- Cross-sectional	Y	Y	Y	Y
- Panel data	Y	Y	Y	Y
- Time-series	Y	Y		

Table3.2-1 : Summary of the properties of the 4 methods

From Coelli, T., et al. 1998. "An Introduction to Efficiency and Productivity Analysis", Kluwer Academic Publishers.

Y = yes, N = No, * = depend on the model used

From many previous studies in healthcare efficiency, mainly DEA and SF were used and most were DEA.

3.3 What is DEA?

Data envelopment analysis, or DEA, involves the use of linear programming methods to construct a non-parametric piecewise surface, or frontier, over the data, so as to be able to calculate efficiencies relative to this surface. By using the technique, relative technical efficiency scores of decision-making units is defined among the samples. DEA can handle measuring efficiency of multiple inputs and outputs model. Efficiency measurement concepts of DEA is to measure the distance between the current position of the firm and the most efficiency position, which is on the frontier, according to the assumption, input-orientated or output-orientated. The more the distance is, the lower efficiency the firm is.

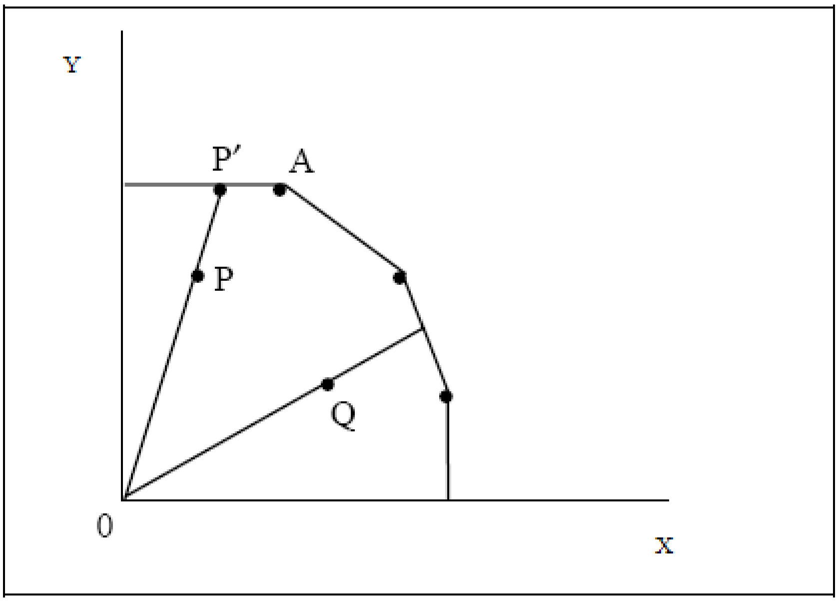

Figure 3.3-1 : The efficiency frontier

From the figure3.3-1 above, each point is a decision-making unit. While the piecewise line is a frontier which is lined between the most efficiency 4 points. P and Q are not on the line because they're not efficiency. So, a straight line OP is drawn and went further to intercept with the frontier for calculation of the efficiency score at the point P. A ratio between distance PP' divided by distance OP' is a representative for an inefficiency of the firm P. For technical efficiency score, it can be calculate from distance OP divided by distance OP' or 1 minus inefficiency score.

$$\text{Technical inefficiency score} = \frac{PP'}{OP'}$$

$$\text{Technical efficiency score} = 1 - \frac{PP'}{OP'}$$

$$= \frac{OP}{OP'}$$

3.4 Input and output – orientated DEA

Input-orientated measurement assumes that the firm is able to change quantities of inputs, while quantities of outputs are fixed, to meet up the most efficient point.

And in the reverse, output-orientated measurement assumes that quantities of outputs can be changed to match with the most efficiency point while quantities of inputs are fixed.

In healthcare researches, many studies used input-orientated assumption because :

1. Demand for healthcare is more inelastic than supply. The meaning is providers have more ability to change quantities of inputs to meet up the demand or output.

2. Implication from many studies aimed at cost minimization. So, measuring the technical efficiency score by the assumption can provide information for them to change quantities of inputs to meet up the same demand and gained higher efficient level.

3.5 DEA's assumption

At the very first period of using the DEA measuring for technical efficiency score, there was an assumption of constant returns to scale, CRS. That's mean the firm was assumed that it operated at the most efficient economy of scale.

P(X)	= Y	
P(AX)	= BY	
	A < B	for increasing return to scale, IRS
	A = B	for constant return to scale, CRS
	A > B	for decreasing return to scale, DRS

From above, P(X) is represented for production function which has X as variable. By the function, X is used to produce Y. The next equation, X changes A time to AX which will make Y changed B time to BY. If the rate of changing of X, A, is lower than the rate of changing of Y, B, economic calls increasing return to scale, IRS. While constant return to scale, CRS, is called if they are equal and decreasing return to scale, DRS, if A is more than B.

After that, in 1984, variable returns to scale, VRS, assumption was proposed by Banker et al. Because in the real world, there are some constraints those make the firm can not operate at the optimal scale efficiency, SE. So, by this assumption SE of the firm is concerned.

Standard input-orientated CRS and VRS assumptions were widely used in healthcare technical efficiency studies. But because of its weakness from non-parametric model, DEA can not be checked for noise error by doing any statistical hypothesis testing. And also for only DEA using, further details in relation between each factors to the efficiency can not be shown. Anyway, DEA is still popular for a quick used to determine any inefficiency inside the firm.
Another technique used together with DEA to provide more deeper details of efficiency is by using econometric regression analysis, but not SF. This technique uses the technical efficiency score from DEA evaluation as a dependent variable and define relevant independent variables to measure the relation to the score by looking at their coefficiences. The independent variables can be inputs, outputs or any factors those researchers consider as the important variables to the score.

3.6 Factors for university hospital's technical efficiency

Not many studies aimed mainly at an evaluation for a technical efficiency of university hospital, but they did to compare or did for the whole group of public or private hospitals which included non-teaching hospitals as well. In those studies, they chose service aspect in providing inpatient and outpatient only. May be because of its complexity of inputs and outputs from university hospitals makes an evaluation for the technical efficiency had been vey challenging and hard to define. But anyway, the concepts of defining factors are just to defining inputs and outputs.

Inputs : in economic inputs can be divided into 2 main groups, labor and capital.

1. Labor : many labor types work in hospitals from physician to janitor and guard.
2. Capital : such as bed, building, machine, equipment, ambulance car and any investment which can be considered as capital input according to the definition of capital in economic which means any inputs those once investment has more than 1 year-long in consuming the inputs. Worthington (2004) suggested that to measure capital inputs capital flow, not capital stock, should be measured.

Outputs : measuring output may be measured at intermediate level such as number of cases or at final outcome such as mortality rate.

Also each activity produces different outputs. The more usual case is to engage in some form of aggregation in order to ensure homogenous outcome. For example, output in treatment service is divided into inpatient, IPD, and outpatient, OPD. While in some studies may further subdivide IPD into emergency case OPD and non-emergency case IPD which they assume that emergency OPD and non-emergency are different outputs from OPD. Similarly to OPD, IPD may be divided more into surgical IPD and non-surgical.

Moreover, comparing the same output type in different hospitals such as cardiovascular disease, CVD, patient in hospital A and B. Because nature of illness has different severity in different individuals. The more severity, the more resources consumed. So, CVD patient in hospital A may be more severe than in B. So CVD treatment in A and B consume different amount of resources to get 1 output. That's mean there must be some weighted output technique used and also weighted cases such as CVD and diabetes mellitus, DM, consume different resources for treatment. DRG and case-mix or diagnosis-related groups, DRGs, are examples which are used widely.

The same as severity weighted output, quality weighted output must be concerned as well.

Because university hospitals have 3 main activities - service, education and research.

4. Service : university hospitals considered as tertiary care level in Thai health system which they have to provide 4 main aspects –

   - Curative care
   - Supportive care
   - Preventive care
   - Rehabilitation

5. Education : mainly the hospitals provide medical training both under-graduated level and specialist training. But in some hospitals may provide other courses such as nurse, technician, scientist, Thai traditional medicine for example in Siriraj Hospital, etc. More than that, some short-course, seminar, special activities training may be provided by some hospitals too, for example : elective courses in King Chulalongkorn Memorial Hospital and Thai massage training in Siriraj Hospital. According to prevention service, some hospitals do provide educational about disease to community in both direct and indirect ways such as printed-out handbill, hospital's newspaper, community medicine and so on.

6. Research : medical field research mainly divided into 2 types of research, science research such as biochemistry, chemistry, immunology, etc. And clinical research such as bone marrow transparent study, drug efficacy study, screening test study, etc.

Table A.3 in appendix section shows inputs and outputs according to each activity of university hospital.

It is very hard to define inputs separately to each activity because of shared inputs, so many studies used aggregated inputs according to their productivity. While output specification used the same concept of aggregation but because of nature of many variations in healthcare those make the same output consumes different amount of inputs but can have the same TE level as mentioned above about quality and severity. According to this concern, defining output has to be done carefully.

3.7 Weighted outputs

DRG is a system to classify hospital cases into one of approximately 500 groups expected to have similar hospital resource used. DRG has many types and each type has their own criterias in classifying the disease pattern and resource consumption. Concept of the DRG is, for example, treatment in disease A costs 10 baht used as a based disease, so DRG weight of the disease is 1. If disease B costs 40 baht for treatment, the disease B has DRG weight equals to 4. But using this concept to application with university hospitals in weighting inpatient output is still uncleared because not many studies mentioned about using DRG-weighted technique and no modeling in this application posted.

Assumption about no variation in outputs was taken into account in order to use unweighted outputs. Because hospitals which produce outputs at the same requirement and scope, further more the number of outputs is very large. That’s mean the distribution of both quality of cares and severity of diseases are normal distribution and the assumption can be taken.

One study from Grosskopf et al. 1993, claimed that there is no significant difference between using DRG-weighted and non-weighted outputs. But this may not true for small samples and long period. Because the distribution is not normal distribution, as mentioned above, and disease pattern may be change a long the time.

3.8 DEA model

CRS model – Assume there is data on K inputs and M outputs on each of N firms or DMU's. For the i-th DMU these are represented by the vectors x_i and y_i respectively. The K*N input matrix, X, and the M*N output matrix, Y, represent the data of all N DMU's. The purpose of DEA is to construct a non-parametric envelopment frontier over the data points such that all obvserved points lie on or below the production frontier. For the simple example of an industry where one output is produced using two inputs, it can be visualized as a number of intersecting planes forming a tight fitting cover over a scatter of points in three-dimensional space. The best way to introduce DEA is via the ratio form. For each DMU we would like to obtain a measure of the ratio of all outputs over all inputs, such as $u'y_i/v'x_i$ where u is an M*1 vector of output weights and v is a K*1 vector of input weights. To select optimal weights we specify the mathematical programming problem :

$$\max_{u,v} (u'y_i/v'x_i),$$

$$\text{st} \qquad u'y_j/v'x_j \le 1, \ \ j=1,2,\ldots,N,$$

$$u, v \ge 0.$$

This involves finding values for u and v, such that the efficiency measure of the i-th DMU is maximized, subject to the constraint that all efficiency measures must be less than or equal to one. One problem with this particular ratio formulation is that it has an infinite number of solutions. To avoid this one can impose the constraint $v'x_i = 1$, which provides :

$$
\begin{aligned}
&\max_{\mu,\nu} (\mu' y_i), \\
&\text{st} \quad \nu' x_i = 1, \\
&\qquad \mu' y_j - \nu' x_j \leq 0, \; j=1,2,...,N, \\
&\qquad \mu, \nu \geq 0,
\end{aligned}
$$

Where the notation change from u and v to μ and ν reflects the transformation. This form is known as the multiplier form of the linear programming problem. Using the duality in linear programming, one can derive and equivalent envelopment form of this problem :

$$
\begin{aligned}
&\min_{\theta,\lambda} \theta, \\
&\text{st} \quad -y_i + Y\lambda \geq 0, \\
&\qquad \theta x_i - X\lambda \geq 0, \\
&\qquad \lambda \geq 0,
\end{aligned}
$$

Where θ is a scalar and λ is a N*1 vector of constants. This envelopment form involves fewer constraints than the multiplier form (K+M < N+1), and hence is generally the preferred form to solve. The value of θ obtained will be the efficiency score for the i-th DMU. It will satisfy θ <= 1, with a value of 1 indicating a point on the frontier and hence a technically efficient DMU, according to the Farrell (1957) definition. Note that the linear programming problem must be solved N times, once for each DMU in the sample. A value of θ is then obtained for each DMU.

The piecewise linear form of the non-parametric frontier in DEA can cause a few difficulties in efficiency measurement. The problem arises because of the sections of the piecewise linear frontier which run parallel to the axes which do not occur in most parametric functions. Some authors have suggested the solution of a second-stage linear programming problem to move to an efficient frontier point by maximizing the sum of slacks required to move from and inefficient frontier point to an efficient frontier point. This second stage linear programming problem may be defined by :

$$\min_{\lambda, OS, IS} -(M1'OS + K1'IS),$$

$$\text{st} \qquad -y_i + Y\lambda - OS = 0,$$

$$\theta x_i - X\lambda - IS = 0,$$

$$\lambda \geq 0, OS \geq 0, IS \geq 0,$$

Where OS is an M*1 vector of output slacks, IS is a K*1 vector of input slacks, and M1 and K1 are M*1 and K*1 vectors of ones, respectively. Note that in this second-stage linear program, θ is not a variable, its value is taken from the first-stage results. Furthermore, note that this second-stage linear program must also be solved for each of the N DMU's involved.

There are two major problems associated with this second stage LP. The first and most obvious problem is that the sum of slacks is maximized rather than minimized. Hence it will identify not the nearest efficient point but the furthest efficient point. The second major problem associated with the above second-stage approach is that it is not invariant to units of measurement. The alteration of the units of measurement, say for a fertilizer input from kilograms to tones (while leaving other units of measurement unchanged), could result in the identification of different efficient boundary points and hence different slack and lambda measures.

As a result of this problem, many studies simply solve the first-stage linear program for the values of the Farrell radial TE measures (θ) for each DMU and ignore the slacks completely, or they report both the radial Farrell TE score (θ) and the residual slacks, which may be calculated as

$$OS = -y_i + Y\lambda \quad \text{and}$$

$$IS = \theta x_i - X\lambda.$$

However, this approach is not without problems either because these residual slacks may not always provide all slacks and hence may not always identify the nearest efficient point for each DMU.

VRS model - the CRS assumption is only appropriate when all DMU's are operating at an optimal scale. Imperfect competition, constraints on finance, etc. may cause a DMU to be not operating at optimal scale. Banker, Charnes and Cooper(1984) suggested an extension of the CRS DEA model to account for VRS situations. The use of the CRS specification when not all DMU's are operating at the optimal scale, will result in measures of TE which are confounded by SE. The use of the VRS specification will permit the calculation of TE devoid of these SE effects.

The CRS linear programming, LP, problem can be easily modified to account for VRS by adding the convexity constraint :

$$N1'\lambda = 1$$

To provide :

$$\begin{aligned} &\min_{\theta,\lambda} \theta, \\ \text{st} \quad & -y_i + Y\lambda \geq 0, \\ & \theta x_i - X\lambda \geq 0, \\ & N1'\lambda = 1 \\ & \lambda \geq 0, \end{aligned}$$

Where N1 is and N*1 vector of ones. This approach forms a convex hull of intersecting planes which envelope the data points more tightly than the CRS conical hull and thus provides technical efficiency scores which are greater than or equal to those obtained using the CRS model. The VRS specification has been the most commonly used specification in the 1990's.

<u>Calculation of SE</u> – many studies have decomposed the TE scores obtained from a CRS DEA into two components, one due to SE and one due to pure TE. So,

$$TE_{I,CRS} = TE_{I,VRS} \times SE_I$$

<u>Input orientations</u> –

$$\begin{array}{ll} \mathit{Min}\ \Phi & \\ \sum_j \lambda_j x_{jm} \le \Phi x_{j_0 m} & ;\ m = 1,2,\ldots,M \\ \sum_j \lambda_j y_{jn} \ge y_{j_0 n} & ;\ n = 1,2,\ldots.,N \\ \lambda_j \ge 0 & ;\ j = 1,2,\ldots.,J \end{array}$$

3.9 Regression analysis

Regression analysis or RA is based on econometrics model. Econometrics is the quantitative measurement and analysis of actual economic and business phenomena. It attempts to quantify economic reality and bridge the gap between the abstract world of economic theory and the real world of human activity. Econometrics allows us to examine data and to quantify the actions of firms, consumers, and governments. Econometrics has three major uses :

1. Describing economic reality
2. Testing hypotheses about economic theory
3. Forecasting future economic activity

The simplest use of econometrics is description. We can use econometrics to quantify economic activity because econometrics allows us to estimate numbers and put them in equations that previously contained only abstract symbols. This technique gives a much more specific and descriptive picture.

The second and perhaps most common use of econometrics is hypothesis testing, the evaluation of alternative theories with quantitative evidence. Much of economics involves building theoretical models and testing them against evidence, and hypothesis testing is vital to that scientific approach.

The third and most difficult use of econometrics is to forecast of predict what is likely to happen next in the future based on what has happened in the past. The accuracy of such forecasts depends in large measure on the degree to which the past is a good guide to the future. Business leaders and politicians tend to be especially interested in this use of econometrics because they need to make decisions about the future, and the penalty for being wrong is high. To the extent that econometrics can shed light on the impact of their policies, business and government leaders will be better equipped to make decisions.

Econometricians use regression analysis to make quantitative estimates of economic relationships that previously have been completely theoretical in nature.

Regression analysis is a statistical technique that attempts to explain movements in one variable, the dependent variable, as a function of movements in a set of other variables, called the independent or explanatory variables, through the quantification of a single equation.

The simplest single-equation linear regression model is :

$$y = c_0 + c_1*x$$

The equation stats that Y, the dependent variable, is a single-equation linear function of X, the independent variable. The model is a single-equation model because it's the only equation specified. The model is linear because if you were to plot the equation it would be a straight line rather than a courve.

The Cs are the coefficients that determine the coordinates of the straight line at any point. C_0 is the constant of intercept term; it indicates the value of Y when X equals zero. C_1 is the slope coefficient, and it indicates the amount that Y will change when X increases by one unit.

Besides the variation in the dependent variable that is caused by the independent variable, there is almost always variation that comes form other sources as well. This additional variation comes in part from omitted explanatory variables. However, even if these extra variables are added to the equation, there still is going to be some variation in Y that simply cannot be explained by the model. This variation probably comes from sources such as omitted influences, measurement error, incorrect functional form, or purely random and totally unpredictable occurrences. By random we mean something that has its value determined entirely by chance.

Econometricians admit the existence of such inherent unexplained variation ("error") by explicitly including a stochastic (or random) error term in their regression models. A stochastic error term is a term that is added to a regression equation to introduce all of the variation in Y that cannot be explained by the included Xs. It is, in effect, a symbol of the econometrician's ignorance or inability to model all the movements of the dependent variable.

The addition of a stochastic error term to the equation results in a typical regression equation :

$$y = c_0 + c_1{*}x + e$$

Our regression notation needs to be extended to include reference to the number of observations and to allow the possibility of more than one independent variable. If we include a specific reference to the observations, the single-equation linear regression model may be written as :

$$y_i = c_0 + c_1{*}x_i + e_i \qquad (i = 1, 2, 3, \ldots, n)$$

Where : y_i = the i-th observation of the dependent variable

x_i = the i-th observation of the independent variable

e_i = the i-th observation of the stochastic error term

c_0, c_1 = the regression coefficients

n = the number of observations

That is, the regression model is assumed to hold for each observation. The coefficients do not change from observation to observation, but the values of Y, X, and e do.

A second notational addition allows for more than one independent variable. Since more than one independent variable is likely to have an effect on the dependent variable, our notation should allow these additional explanatory Xs to be added. Then all variables can be expressed as determinants of Y in a multivariate linear regression model :

$$y_i = c_0 + c_1{*}x_{1i} + c_2{*}x_{2i} + c_3{*}x_{3i} + \ldots + e_i$$

Where : x_{1i} = the i-th observation of the first independent variable

x_{2i} = the i-th observation of the second independent variable

x_{3i} = the i-th observation of the third independent variable

And so on.

The meaning of the regression coefficient C_1 in this equation is the impact of a one unit increase in X_1 on the dependent variable Y, holding constant the other included independent variables. Similarly, C_2 gives the impact of a one-unit increase in X_2 on Y, holding the other Xs constant. These multivariate regression coefficients serve to isolate the impact on Y of a change in one variable from the impact on Y of changes in the other variables.

Once a specific equation has been decided upon, it must be quantified. This quantified version of the theoretical regression equation is called the estimated regression equation and is obtained from a sample of data for actual Xs and Ys.

$${}_ey_i = {}_ec_0 + {}_ec_1{*}x_i$$

where : e_i = estimated value of Y_i

${}_ec_0$ = estimated value of C_0

${}_ec_1$ = estimated value of C_1

The difference between the estimated value of the dependent variable $({}_eY_i)$ and the actual value of the dependent variable (Y_i) is defined as the residual (r_i) :

$$r_i = y_i - {}_e y_i$$

The residual is the difference between the observed Y and the estimated regression line, while the error term is the difference between the observed Y and the true regression equation. Note that the error term is a theoretical concept that can never be observed, but the residual is a real-world value that is calculated for each observation every time a regression is run.

The most widely used method of obtaining these estimates is Ordinary Least Squares (OLS). OLS has become so standard that its estimates are presented as a point of reference even when results from other estimation techniques are used. OLS is a regression estimation technique that calculates the estimated coefficients, ${}_eC$ so as to minimize the sum of the squared residuals, thus :

$$\text{OLS minimizes } \sum_{i=1}^{n} r_i^2 \text{ (i = 1, 2, 3, …, n)}$$

Although OLS is the most-used regression estimation technique, it's not the only one. Indeed, econometricians have developed what seems like zillions of different estimation techniques. There are at least three important reasons for using OLS to estimate regression models :

1. OLS is relatively easy to use.
2. The goal of minimizing $\sum_{i=1}^{n} r_i^2$ is quite appropriate from a theoretical point of view.
3. OLS estimates have a number of useful characteristics.

The Classical Assumption must be met in order for OLS estimators to be the best available.

1. The regression model is linear, is correctly specified, and has an additive error term.
2. The error term has a zero population mean.

3. All explanatory variables are uncorrelated with the error term.

4. Observations of the error term are uncorrelated with each other (no serial correlation).

5. The error term has a constant variance (no heteroskedasticity).

6. No explanatory variable is a perfect linear function of any other explanatory variable(s) (no perfect multicollinearity).

7. The error term is normally distributed (this assumption is optional but usually is invoked).

Steps in applied RA :

1. Review the literature and develop the theoretical model.

2. Specify the model : Select the independent variables and the functional form.

3. Hypothesize the expected signs of the coefficients.

4. Collect the data. Inspect and clean the data.

5. Estimate and evaluate the equation.

6. Documents the results.

3.10 Previous studies on hospital efficiency

Felix Masiye(2007) – Efficiency was measured using a DEA model. Vectors of hospital inputs and outputs, representing hospital expended resources and output profiles respectively, had been specified and measured. The data had been gathered from a sample of 30 hospitals throughout Zambia. The model estimated an efficiency score for each hospital. A decomposition of technical efficiency into scale and congestion was also provided. Results showed that overall Zambian hospitals were operating at 67% level of efficiency, implying that significant resources were being wasted. Only 40% of hospitals had been efficient in relative terms. The study further revealed that the size of hospitals was a major source of inefficiency. Input congestion was also found to be a source of hospital inefficiency. This study had had demonstrated that inefficiency of resource used in hospitals was significant. Policy attention was drawn to unsuitable hospital scale of operation and low productivity of some inputs as factors that reinforce each other to make Zambian hospitals technically inefficient at producing and delivering services. It was argued that such evidence of substantial inefficiency would undermine Zambia's prospects of achieving its health goals.

Eyob Zere et al.(2006) – All public sector hospitals (N=30) had been included in the study. Hospital capacity utilization ratios and the DEA technique had been used to assess technical efficiency. The DEA model had used three inputs and two outputs. Data for four financial years (1997/98 to 2000/2001) had been used for the analysis. To test for the robustness of the DEA technical efficiency scores the Jackknife analysis had been used. The findings suggested the presence of substantial degree of pure technical and scale inefficiency. The average technical efficiency level during the given period had been less than 75%. Less than half of the hospitals included in the study had been located on the technically efficient frontier. Increasing returns to scale is observed to be the predominant form of scale inefficiency. It was concluded that the existing level of pure technical and scale inefficiency of the district hospitals was considerable high and might negatively affect the government's initiatives to improve access to quality health care and scaling up of interventions that were necessary to achieve the health-related Millennium Development Goals. It was recommended that the inefficient hospitals learned from their efficient peers identified by the DEA model so as to improve the overall performance of the health system.

Vincenzo Rebba(2006) – This paper showed how both the choice of specific constraints on input and output weights (in accordance with health care policy-makers' preferences) and the consideration of exogenous variables outside the control of hospital management (and linked to past policy-makers' decisions) could affect the measurement of hospital technical efficiency using the DEA. Considering these issues, the DEA method was applied to measure the efficiency of 85 (public and private) hospitals in Veneto, a Northern region of Italy. The empirical analysis allowed us to verify the role of weight restrictions and of demand in measuring the efficiency of hospitals operating within a National Health Service (NHS). The study found that the imposition of a lower bound on the virtual weight of acute care discharges weighted by case-mix (in order to consider policy-maker objectives) reduced average hospital efficiency. Moreover, the results showed, in many cases, low efficiency scores were attributable to external factors, which were not fully controlled by the hospital management; especially for public hospitals low total efficiency scores could be mainly explained by past policy-makers' decisions on the size of the hospitals or their role within the regional health care service. Finally, non-profit private hospitals exhibited a higher total inefficiency while both non-profit and for-profit hospitals were characterized by higher levels of scale inefficiency than public ones.

Daniel Osei et al.(2005) – The DEA approach had been used to estimate the efficiency of 17 district hospitals and 17 health centres. This had been an exploratory study. Eight (47%) hospitals had been technically inefficient, with an average TE score of 61% and a standard deviation (STD) of 12%. Ten (59%) hospitals had been scale inefficient, manifesting an average SE of 81% (STD = 25%). Out of the 17 health centres, 3 (18%) had been technically inefficient, with a mean TE score of 49% (STD = 27%). Eight health centres (47%) had been scale inefficient, with an average SE score of 84% (STD = 16%). This pilot study had demonstrated to policy-makers the versatility of DEA in measuring inefficiencies among individual facilities and inputs. There was a need for the Planning and Budgeting Unit of the Ghana Health Services to continually monitor the productivity growth, allocative efficiency and technical efficiency of all its health facilities (hospitals and health centres) in the course of the implementation of health sector reforms.

Vivian Valdmanis et al.(2004) – assessed the capacity of Thai public hospitals to proportionately expand services to both the poor and the nonpoor. This was accomplished by measuring the production of services provided to poor, relative to nonpoor, patients and the plant capacity of individual public hospitals to care for the patient load. Input and output data for 68 hospitals had been collected using databases and questionnaire surveys. A distinction had been made between inpatient and outpatient services to both poor and nonpoor patients and the data had been assessed statistically. Congestion and capacity indiced to measure poor/nonpoor service trade-offs and capacity utilization had been estimated. The analysis had been undertaken by DEA. This study found that increases in the amount of services provided to poor patients had not reduced the amount of services to nonpoor patients. Overall, hospitals were producing services relatively close to their capacity given fixed inputs. Possible increases in capacity utilization amounted to 5 percent of capacity. Results suggested that some increased public hospital care could be accomplished by reallocation of resources to less highly utilized hospitals, given the budgetary constraints. However, further expansion and increase in access to health services would require plant investments. The study illustrated how DEA methodologies could be used in planning health services in data constrained settings.

Thomas T.H. Wan et al.(2002) – The variation in productivity and cost efficiency had been observed among 57 nursing units in a large tertiary care hospital. The inefficient units could achieve the same level of efficiency as the efficient units by altering their inputs (either nursing hours or patient costs). The optimization could be achieved through proper reallocations of nursing resources such as nursing hours or costs. However, the resource reallocation to achieve high efficiency should incorporate the nursing sensitive measures of quality in the analysis.

Shawna Grosskopf et al.(2001) – This study compared teaching and non-teaching hospitals in terms of their provision of patient services. The researchers proceeded by comparing the frontiers of the teaching and non-teaching hospitals using a DEA type approach, which the researchers applied to a sample of 236 teaching hospitals and 556 non-teaching hospitals operating in the US in 1994. The results suggested that only about 10% of the teaching hospitals could effectively "compete" with non-teaching hospitals based on the provision of patient services.

Tabolli S. et al. – This paper discussed the use of DEA for purpose of measuring efficiency in production and productive changes in the operative units of a University Hospital and a Dermatological Research Hospital in Rome. Hospital discharge abstracted data from 1999-01 had been used to calculate DRG weight and clinical severity (APR DRG) for each inpatient. Technical efficiency had been calculated for 9 dermatological operative units of a Dermatological Research Institute and 34 operative units of a University Hospital. Hospital beds, costs for health personnel, and other costs (drugs, medical supply) had been used as inputs. Two output measures had been separately employed in the analysis: the number of discharges adjusted by resource consumption (DRG weight) and clinical severity (APR-DRG). A comparison between similar operative units of the two institutions had been performed. Subsequently also the research activities (impact factor of publications per operative units) and teaching/training activities (hours of training implemented by each operative units) had been included as outputs. The study found that technical efficiency for dermatological operative units in the observed years range between 0.41 and 1 (maximum efficiency) with DRG as output and between 0.29 and 1 with APR DRG as outputs. The two approaches had yielded very similar results. The operative units which had appeared to be most efficient had been those attracting most complex ceases. The mean values for technical efficiency in the University Hospital including clinical severity, impact factor and teaching activity as outputs were respectively 0.70 (range 0.38-1) for 1999, 0.62(range 0.32-1) for 2000 and 0.71 (range 0.29-1) for 2001. Efficient operative units had changed over time: maximum efficiency had been reached by four operative units in 1999: cardiology, general surgery, plastic surgery, internal medicine; by one operative unit in 2000: geriatric medicine; and bye 2 operative units in 2001: cardiology, cardiosurgery. The advantage of DEA over other techniques was that each input and output could be measured in its natural physical unit without the need to apply a weighting system to collapse the different units in money or other single unit measure. The instrument was useful to identify differences in efficiency over time and between operative units. Input slacks provided for each unit useful information on costs or bed numbers that would be needed to be modified in order to have an efficiency improvement. The findings supported the conclusion that there was some room for efficiency improvement but the main challenge would be to reorganize the inpatient admission policy in the Dermatological Research Hospital to balance the different Dermatological operative units. Simply increasing the hospital volume could not be interpreted as a gain in technical efficiency. Improving appropriateness of care diverting minor dermatological cases towards outpatient care was a mandatory requirement of any health care system and was even more important in a National Health System. The impact of research and teaching activities on the efficiency of each operative unit were key issues and have to be included in the efficiency evaluation of a University Hospital. The comparison between operative units could be partially utilized for internal incentives by the hospital management where efficiency was an outcome.

Liam O'Neill(1998) – A perennial difficulty in measuring hospital efficiency, and one with important policy implications, was how to compare teaching versus non-teaching hospitals. This problem reflected a broader methodological concern in DEA, which was the comparison of specialist and non-specialist Decision-Making Units (DMUs). This paper presented a new performance measure in DEA, termed multifactor efficiency, which represents as average partial factor productivity index summed over all output-input ratios. The study applied this technique to measure the performance of 27 large, urban hospitals, including 13 teaching hospitals. These results had been reviewed and validated by a panel of health care experts, and multifactor efficiency had been shown to offer several benefits that enhance and complement existing performance measures in DEA.

3.11 Lessons from previous studies

1. Not much technical efficiency estimation had been done among university hospitals.
2. Estimation of efficiency in university hospitals were not easy to be done because of complexity of the organization.
3. Every study could pinpoint the area for efficiency improvement. For example, in Tabolli(2003)'s study shows that in order to have an efficiency improvement, bed numbers should be modified and some more room for efficiency improvement was to reorganize the inpatient admission policy. More example from Masiye(2007) shows that size of hospitals was a major source of inefficiency and also for input congestion as well.
4. DRG weighting technique had not been done much in the estimation. Some studies which used weighting technique showed some changes in results in the same way. And the changing was not significant.
5. Number of physician, registered nurse and bed were used as proxies for inputs in almost every study. While number of OPD visit and bed days were proxies for outputs in health care services. DRG-weight IPD cases was used as a proxy for inpatient service instead of bed days in some studies.
6. Many studies suggested to use DRG weighting technique. In some studies compared the results from with and without weighting found some insignificant changes in the same direction.
7. Some studies found significant difference efficiency due to different ownership such as government owned, not-for-profit private owned and for-profit private owned hospitals. While the others were not.

CHAPTER IV

METHODOLOGY

4.1 Hospital selection

5 University hospitals out of 14(35.7%) were selected as samples of this study. All were in central region of Thailand. 4 hospitals were owned by ministry of education and the rest 1 was not.

4.2 Type of data

Secondary panel data were collected since 2002-2007.

4.3 Data required

Because of limitation in this study due to lack of information and accessibility, some better proxies were changed into other proxies which can represent to service and education activities of university hospital, research activity data was unavailable. Moreover, just only important proxies which considered as real production factor were picked up, for example, janitor and guard were not picked up as labor inputs because the inputs do not relate in producing outputs in neither health care service, education nor research. So, available data which were required as proxies are below -

Aggregated inputs :

1. Number of physician, PHY – count for every physicians in the hospital in each year. Dentist also included in this group. (persons)
2. Number of nurse, Nurse – registered nurses in each year were included in this group. (persons)
3. Number of pharmacist, Phar – include every pharmacist in the hospital. (persons)
4. Number of bed, BED – count for every bed in the hospital. (beds)

Outputs :

5. Out-patient department visits, OPD – count for every visit in out-patient department for the whole year. Include dental clinic and extra-time clinic visits. (visits) – This OPD is a proxy for health care service activity in out-patient care service.
6. Inpatient cases, IPD – count for every case which were admitted in inpatient care services in each year. (cases) - This IPD is a proxy for health care service activity in in-patient care service.
7. Bed days, BD – count for the whole year consumption of bed in every inpatient care department. (days) - This BD is a proxy for health care service activity in in-patient care service.
8. Number of medical student year 6^{th} , MED – count for every medical student year 6^{th} in each academic year. (persons) - This MED is a proxy for education activity.
9. Mortality rate, Mor – each year mortality rate. (percentage) – This Mor is a proxy for quality in health care service.
10. Average length of stay, ALOS – each year average length of stay. (days) – This ALOS is a proxy for quality in health care service.
11. Occupancy rate, Occ – each year occupancy rate of the hospital. (percentage) – This Occ is a proxy for output in consumption of bed.

4.4 Source of data

Annual report of the hospital

4.5 Analysis technique

1. Data Envelopment Analysis, DEA
2. Regression Analysis, RA

4.6 Model specification

1. DEA specification

- Input - making specification simple as many studies did, total amount of inputs will be used as proxies by assumed that all inputs together produce outputs, any joint inputs will not be separated. All inputs can not be included in this study because of having not enough data. Only important inputs will be included while the others are assumed to be complementary inputs and no variation among hospitals.
    a) PHY – proxy for labor inputs which considered as the most important among labor input types.
    b) BED – proxy for capital inputs which considered as the most important among capital input types.
- Output – proxies for outputs of hospitals showed as follow,
    a) OPD – proxy for out-patient service.
    b) BD – proxy for in-patient service.
    c) MED – proxy for education service.

So in this study, Physician and number of bed were used as an input proxies and number of out-patient department visit, bed days and number of medical student year 6^{th} were outputs. The operational definition of technical efficiency was the ability of each decision making unit in using its physician and bed to produce out-patient care, in-patient care and education.

2. RA specification - to provide more details from efficiency score, RA will be used as mentioned. TE score and SE score from DEA evaluation will be used as dependent variables in RA to find out relation from independent variables to the TE and SE scores. Simple linear regression model and ordinary least square, OLS, estimation will be used.

- Relation between independent variables to SE score –

$$SE_j = c_0 + c_1 BP_j + c_2 NP_j + c_3 PP_j + e_j$$

Where: SE_j = SE score of the j-th observation

c_0 = constant

c_1 = coefficient of BP variable

c_2 = coefficient of NP variable

c_3 = coefficient of PP variable

BP_j = bed-physician ratio of the j-th observation = BED_j/PHY_j – This BP is a proxy for size determination of input combination between bed and physician. This was used in a form of ratio to eliminate variation of size among hospitals when is not used in a form of ratio.

NP_j = nurse-physician ratio of the j-th observation = $Nurse_j/PHY_j$ – This NP is a proxy for size determination of input combination between nurse and physician. This was used in a form of ratio to eliminate variation of size among hospitals when is not used in a form of ratio.

PP_j = pharmacist-physician ratio of the j-th observation = $Phar_j/PHY_j$ – This PP is a proxy for size determination of input combination between pharmacist and physician. This was used in a form of ratio to eliminate variation of size among hospitals when is not used in a form of ratio.

Hypothesis :

- BP has a negative relationship with SE. It is because this study hypothesized that university hospitals in Thailand tended to have excess bed and lack of physician. This proportion shows the combination of input between bed, as capital input, and physician, as labor input. Higher the ratio means higher in bed input while physician input is fixed, so there will have more excess bed and lack of physician input which considered as the operator of the bed input. So, the hospital will operate at scale inefficient point between combination of bed and physician. The excessive of bed makes the input cannot be used at the maximum capacity. While if physician or labor input is increased, bed is fixed, the ratio will lower and make SE higher. Or in reverse, increasing in physician while bed is fixed can reduce the ratio and affects to higher SE level because there is more physician input which can operate the bed input which is excess with higher capacity level.

- NP has a positive relationship with SE. It is because this study hypothesized that university hospitals in Thailand tended to lack in nurse and excessive of physician. This proportion shows the combination of input between nurse and physician. Nurse and physician are considered as complementary inputs which have to be used together to produce outputs. Higher the ratio means higher in nurse input while physician input is fixed, so there will have more nurse which can operate complementary with physician, the SE level should be higher because higher productivity in the complementary unit. Or in reverse, decreasing in physician while nurse is fixed can increase the ratio and affects to higher SE level.
- PP has a positive relationship with SE. It is because this study hypothesized that university hospitals in Thailand tended to use inproportion of pharmacist and physician. As can see in many big government hospitals in Thailand that there are a lot of people have to wait at drug room for a long time. Some patients which can not wait for such that long time, they will not wait for that treatment if they feel that the illness is not very severe after they have talked to physician. And for some patients which have to visit at more than one department to receive treatment more than one illness, some have to wait for a long time at drug room

before going to another treatment and sometimes it is too long so they will ignore next treatment or the department is closed because it is over office hour. This proportion shows the combination of input between pharmacist and physician. Pharmacist and physician are also considered as complementary inputs which have to be used together to produce outputs. Higher the ratio means higher in pharmacist input while physician input is fixed, so there will have more pharmacist which can operate complementary with physician, the SE level should be higher because higher productivity in the complementary unit. Or in reverse, decreasing in physician while pharmacist is fixed can increase the ratio and affects to higher SE level.

- Relation between independent variables to TE score –

$$TEVRS_j = c_0 + c_1 MOR_j + c_2 ALOS_j + c_3 OCC_j + c_4 OP_j + c_5 OI_j + c_6 MB_j + c_7 MOE_j + e_j$$

Where: $TEVRS_j$ = TE score under VRS assumption of the j-th observation

c_0 = constant

c_1 = coefficient of MOR variable

c_2 = coefficient of ALOS variable

c_3 = coefficient of Occ variable

c_4 = coefficient of OP variable

c_5 = coefficient of OI variable

c_6 = coefficient of MB variable

c_7 = coefficient of MOE variable

MOR_j = mortality rate of the j-th observation – proxy for quality of health care especially for severity case.

$ALOS_j$ = average length of stay of the j-th observation – proxy for quality of health care especially for in-patient care.

OCC_j = occupancy rate of the j-th observation – proxy for level of bed consumption.

OP_j = out-patient visit-physician ratio of the j-th observation = OPD/PHY – proxy for determining effect of providing out-patient care to technical efficiency level. This was used in a form of ratio to eliminate variation of size among hospitals when is not used in a form of ratio.

OI_j = out-patient visit-inpatient case ratio of the j-th observation = OPD/IPD – proxy for determining proportion between providing out-patient care and in-patient care.

MB_j = number of medical student year 6^{th} –bed ratio of the j-th observation = MED/BED – proxy for determining proportion between providing education compared to size of the hospital.

MOE_j = dummy variable for ministry of education owned hospital

Hypothesis :

- MOR has a positive relationship with TEVRS. This was hypothesized that lower mortality rate means higher consumption in resources which especially for high severity cases, the consumption will very much while output is just one cured case or death. So, lower mortality rate also tends to consume much resources and make lower technical efficiency level when compared with other hospitals which have higher rate.
- ALOS has a positive relationship with TEVRS. This was hypothesized that lower average length of stay means higher consumption in resources and also increases in turn over rate of bed consumption. Higher consumption in resources makes the same effect as mortality rate while increasing in turn over rate of bed affects to increase in output which also brings higher technical efficiency level when compared to other hospitals because increasing in output, input is fixed, makes technical efficiency level increased.

- Occ has a positive relationship with TEVRS. This was hypothesized that higher occupancy rate means increasing bed consumption and reaches at higher level of productivity by using bed. So, that means output is increased while input is fixed also yield to higher technical efficiency level too.
- OP has a positive relationship with TEVRS. This was simply hypothesized by increasing in this ratio means increasing in output or decreasing in input, that makes higher technical efficiency level when compared to other hospitals which are not.
- OI has a positive relationship with TEVRS. This was hypothesized by comparing between increasing in one out-patient visit and one in-patient case. Increasing in one out-patient visit, which can be assumed as one cured case for out-patient care, consumes lower resources than increasing in one in-patient case. So, when resources or inputs are fixed, increasing in this ratio by increases in out-patient case or decreases in-patient case will make higher technical efficiency than other hospitals which are not.
- MB has a negative relationship with TEVRS. This was hypothesized that medical training consumes more resources when compared to health care provision. One medical student trained in this analysis is quite the same as one output in health care provision because this analysis didn't use weighted technique which can consider the whole real value of one medical student trained in tangible, intangible, future and social value and so on. So, that means in this analysis one medical student trained consumes a lot of resources which will make lower technical efficiency level. This proxy was used in a form of ratio over number of bed to eliminate variation of size among hospitals.
- MOE has a positive relationship with TEVRS. This was hypothesized by visiting in a real place when had gone to collect

data. It was very obvious that hospital which is not under MOE had more inputs especially for labor inputs than in the other group while outputs seemed to be lower also. By that observation, hospitals under MOE seemed to have higher technical efficiency level than the other group.

CHAPTER V

RESULT AND DISCUSSION

5.1 General descriptive statistics

Data were collected from 5 hospitals from year 2001 to 2007. Some data in some years can't be collected due to the hospitals didn't collect those data. So, total are 29 data(n=29).

Hospitals	5
Data2001	3
Data2002	4
Data2003	5
Data2004	5
Data2005	5
Data2006	5
Data2007	2
N	29

Table 5.1-1 : Number of hospitals and data separated by year

Overall descriptive statistics was shown as follows.

	OPD	*BD*	*MED*	*PHY*	*BED*	*Nurse*	*Phar*
Mean	1,248,979.07	342,088.40	145.72	570.59	1,366.52	1,311.76	53.38
Standard Error	107,571.03	29,246.31	11.30	62.38	115.25	143.40	4.89
Minimum	276,298.00	101,053.00	55.00	74.00	358.00	293.00	22.00
Maximum	2,584,665.00	607,471.00	225.00	1,236.00	2,368.00	2,694.00	118.00
N	29.00	29.00	29.00	29.00	29.00	29.00	29.00

Table 5.1-2 : Total descriptive statistics of data

OPD	=	Number of out-patient department visit (visits)
BD	=	Total bed days (days)
MED	=	Number of medical student year 6^{th} (persons)
PHY	=	Number of physician (persons)
BED	=	Number of bed (beds)
Nurse	=	Number of registered nurse (persons)
Phar	=	Number of pharmacist (persons)

Group descriptive statistics were presented below.

Year2001	*OPD*	*BD*	*MED*	*PHY*	*BED*	*Nurse*	*Phar*
Mean	1,088,507.67	294,909.30	130.00	537.00	1,332.67	1,113.33	34.33
Standard Error	116,529.66	47,896.38	35.68	185.00	196.96	257.40	2.96
Minimum	855,922.00	235,855.00	60.00	351.00	941.00	658.00	30.00
Maximum	1,217,662.00	389,755.91	177.00	907.00	1,565.00	1,549.00	40.00
N	3.00	3.00	3.00	3.00	3.00	3.00	3.00

Table 5.1-3 : Group descriptive statistics of data in year 2001

Year2002	*OPD*	*BD*	*MED*	*PHY*	*BED*	*Nurse*	*Phar*
Mean	1,301,290.50	389,959.99	163.00	625.50	1,549.75	1,488.50	45.00
Standard Error	234,325.15	74,613.97	36.49	163.34	298.37	414.40	7.43
Minimum	880,471.00	249,092.00	66.00	354.00	869.00	645.00	30.00
Maximum	1,972,119.00	587,243.00	225.00	1,015.00	2,324.00	2,598.00	65.00
N	4.00	4.00	4.00	4.00	4.00	4.00	4.00

Table 5.1-4 : Group descriptive statistics of data in year 2002

Year2003	*OPD*	*BD*	*MED*	*PHY*	*BED*	*Nurse*	*Phar*
Mean	1,098,193.20	341,981.00	142.40	540.80	1,324.20	1,200.40	47.20
Standard Error	282,334.25	85,507.89	31.37	173.83	333.99	358.75	8.94
Minimum	276,298.00	101,053.00	64.00	74.00	358.00	293.00	23.00
Maximum	2,032,064.00	607,471.00	210.00	1,057.00	2,368.00	2,358.00	70.00
N	5.00	5.00	5.00	5.00	5.00	5.00	5.00

Table 5.1-5 : Group descriptive statistics of data in year 2003

Year2004	OPD	BD	MED	PHY	BED	Nurse	Phar
Mean	1,183,594.20	339,352.70	146.80	529.00	1,321.80	1,205.00	49.60
Standard Error	295,458.04	81,191.78	31.56	164.85	329.46	371.96	10.17
Minimum	384,741.00	113,212.00	55.00	84.00	400.00	297.00	22.00
Maximum	2,208,103.00	595,855.00	222.00	1,001.00	2,363.00	2,443.00	76.00
N	5.00	5.00	5.00	5.00	5.00	5.00	5.00

Table 5.1-6 : Group descriptive statistics of data in year 2004

Year2005	OPD	BD	MED	PHY	BED	Nurse	Phar
Mean	1,219,953.20	329,788.07	146.40	555.00	1,320.20	1,278.60	57.40
Standard Error	284,080.39	80,211.52	29.33	183.59	321.23	404.74	14.89
Minimum	492,382.00	120,705.00	60.00	74.00	423.00	328.00	22.00
Maximum	2,219,259.00	584,814.00	217.00	1,135.00	2,340.00	2,644.00	105.00
N	5.00	5.00	5.00	5.00	5.00	5.00	5.00

Table 5.1-7 : Group descriptive statistics of data in year 2005

Year2006	OPD	BD	MED	PHY	BED	Nurse	Phar
Mean	1,260,411.20	319,891.00	142.80	599.60	1,302.20	1,265.40	59.80
Standard Error	289,675.86	76,801.95	30.83	188.96	309.36	408.29	14.04
Minimum	532,306.00	123,430.00	57.00	160.00	423.00	334.00	30.00
Maximum	2,288,071.00	568,288.00	221.00	1,236.00	2,268.00	2,681.00	107.00
Count	5.00	5.00	5.00	5.00	5.00	5.00	5.00

Table 5.1-8 : Group descriptive statistics of data in year 2006

Year2007	OPD	BD	MED	PHY	BED	Nurse	Phar
Mean	1,969,474.50	410,466.00	146.00	656.00	1,545.00	2,000.00	97.50
Standard Error	615,190.50	174,348.00	33.00	157.00	653.00	694.00	20.50
Minimum	1,354,284.00	236,118.00	113.00	499.00	892.00	1,306.00	77.00
Maximum	2,584,665.00	584,814.00	179.00	813.00	2,198.00	2,694.00	118.00
N	2.00	2.00	2.00	2.00	2.00	2.00	2.00

Table 5.1-9 : Group descriptive statistics of data in year 2007

	OPD	BD	MED	PHY	BED	Nurse	Phar
Year2001	1,088,507.67	294,909.30	130	537	1,332.67	1,113.33	34.33
Year2002	1,301,290.50	389,959.99	163	625.5	1,549.75	1,488.50	45
Year2003	1,098,193.20	341,981.00	142.4	540.8	1,324.20	1,200.40	47.2
Year2004	1,183,594.20	339,352.70	146.8	529	1,321.80	1,205.00	49.6
Year2005	1,219,953.20	329,788.07	146.4	555	1,320.20	1,278.60	57.4
Year2006	1,260,411.20	319,891.00	142.8	599.6	1,302.20	1,265.40	59.8
Year2007	1,969,474.50	410,466.00	146	656	1,545.00	2,000.00	97.5
N	29.00	29.00	29.00	29.00	29.00	29.00	29.00

Table 5.1-10 : Compare means of variables by year

5.2 Technical efficiency result from DEA

In this study, Physician and number of bed were used as an input proxies and number of out-patient department visit, bed days and number of medical student year 6^{th} were outputs. So, for this study, the operational definition of technical efficiency was the ability of each decision making unit in using its physician and bed to produce out-patient care, in-patient care and education.

TE and SE score results

The CRS DEA model estimated the score of 29DMUs from year 2001-2007. The result showed that average of the TECRS score was about 88.7% while the minimum was 52.5% and the maximum was 100%

There were 8 DMUs(27.6%) get 100% score, 9(31.0%) were in the range of 90%-100%, 6(20.7%) were about 80%-90% and the rest, 6(20.7%) were lower than 70% score.

The result from VRS DEA model estimation indicated 97.4% was an average score of TEVRS. Minimum was 69.8% and maximum was 100%

20DMUs(69.0%) got 100% score, 6(20.7%) were in 90%-100%, 2(6.9%) in 80%-90% and just only 1(3.4%) got score in range 60%-70%

The SE score showed average was 91.1% while minimum was 75.2% and maximum was 100%.

27.6% of DMUs were 100% score, 34.5% in the next range 90%-100%, 17.2% were around 80%-90% and the rest 20.7% were lower than 70%

From the result, most of DMUs – 79.3% in TECRS, 96.6% in TEVRS and 79.3% in SE - were considered as high efficiency level, more than 80% in score.

The technical efficiency scores were calculated by DEA technique and presented below.

Hospital	YEAR	TECRS	TEVRS	SE	
A	2001	0.525	0.698	0.752149	drs
	2002	0.695	0.968	0.717975	drs
	2003	0.692	0.96	0.720833	drs
	2004	0.697	1	0.697	drs
	2005	0.688	0.955	0.720419	drs
	2006	0.643	0.876	0.734018	drs
B	2001	0.87	0.886	0.981941	drs
	2002	0.934	1	0.934	drs
	2003	1	1	1	-
	2004	0.973	1	0.973	drs
	2005	0.954	0.97	0.983505	drs
	2006	0.926	0.943	0.981972	drs
C	2002	0.869	1	0.869	drs
	2003	0.881	1	0.881	drs
	2004	0.866	1	0.866	drs
	2005	0.86	1	0.86	drs
	2006	0.861	1	0.861	drs
	2007	0.919	1	0.919	drs
D	2001	0.965	1	0.965	drs
	2002	1	1	1	-
	2003	0.953	1	0.953	drs
	2004	1	1	1	-
	2005	0.976	0.984	0.99187	drs
	2006	1	1	1	-
	2007	1	1	1	-
E	2003	0.985	1	0.985	irs
	2004	1	1	1	-
	2005	1	1	1	-
	2006	1	1	1	-
Mean		0.887	0.974	0.911	
Min		0.525	0.698	0.752	
Max		1	1	1	

Table 5.2-1 : Technical efficiency scores of data

TECRS = Technical efficiency score on CRS assumption

TECRS = Technical efficiency score on VRS assumption or pure technical efficiency score

SE = Scale efficiency score

TECRS							
Score	2001	2002	2003	2004	2005	2006	2007
100%	0	1	1	2	1	2	1
<=90%-100%<	1	1	2	1	2	1	1
<=80%-90%<	1	1	1	1	1	1	0
<=70%-80%<	0	0	0	0	0	0	0
<=60%-70%<	0	1	1	1	1	1	0
<60%	1	0	0	0	0	0	0

Table 5.2-2 : TECRS score classified by year and score level

TEVRS							
Score	2001	2002	2003	2004	2005	2006	2007
100%	1	3	4	5	2	3	2
<=90%-100%<	0	1	1	0	3	2	0
<=80%-90%<	1	0	0	0	0	0	0
<=70%-80%<	0	0	0	0	0	0	0
<=60%-70%<	1	0	0	0	0	0	0
<60%	0	0	0	0	0	0	0

Table 5.2-3 : TEVRS score classified by year and score level

SE							
Score	2001	2002	2003	2004	2005	2006	2007
100%	0	1	1	2	1	2	1
<=90%-100%<	2	1	2	1	2	1	1
<=80%-90%<	0	1	1	1	1	1	0
<=70%-80%<	1	1	1	0	1	1	0
<=60%-70%<	0	0	0	1	0	0	0
<60%	0	0	0	0	0	0	0

Table 5.2-4 : SE score classified by year and score level

Score	TECRS	TEVRS	SE
100%	8	20	8
<=90%-100%<	9	6	10
<=80%-90%<	6	2	5
<=70%-80%<	0	0	5
<=60%-70%<	5	1	1
<60%	1	0	0

Table 5.2-5 : Technical efficiency score classified by type of score and score level

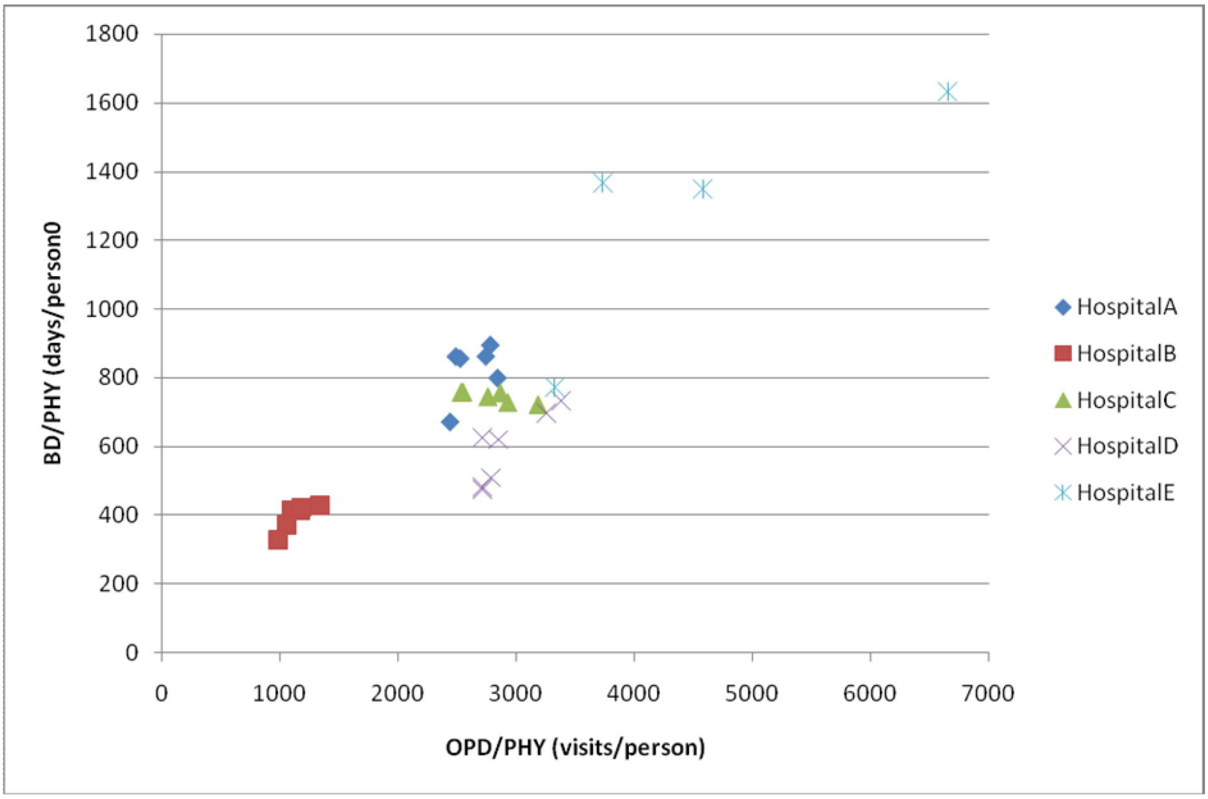

Figure 5.2-1 : Relationship between BD-PHY ratio on y-axis and OPD-PHY ratio on x-axis

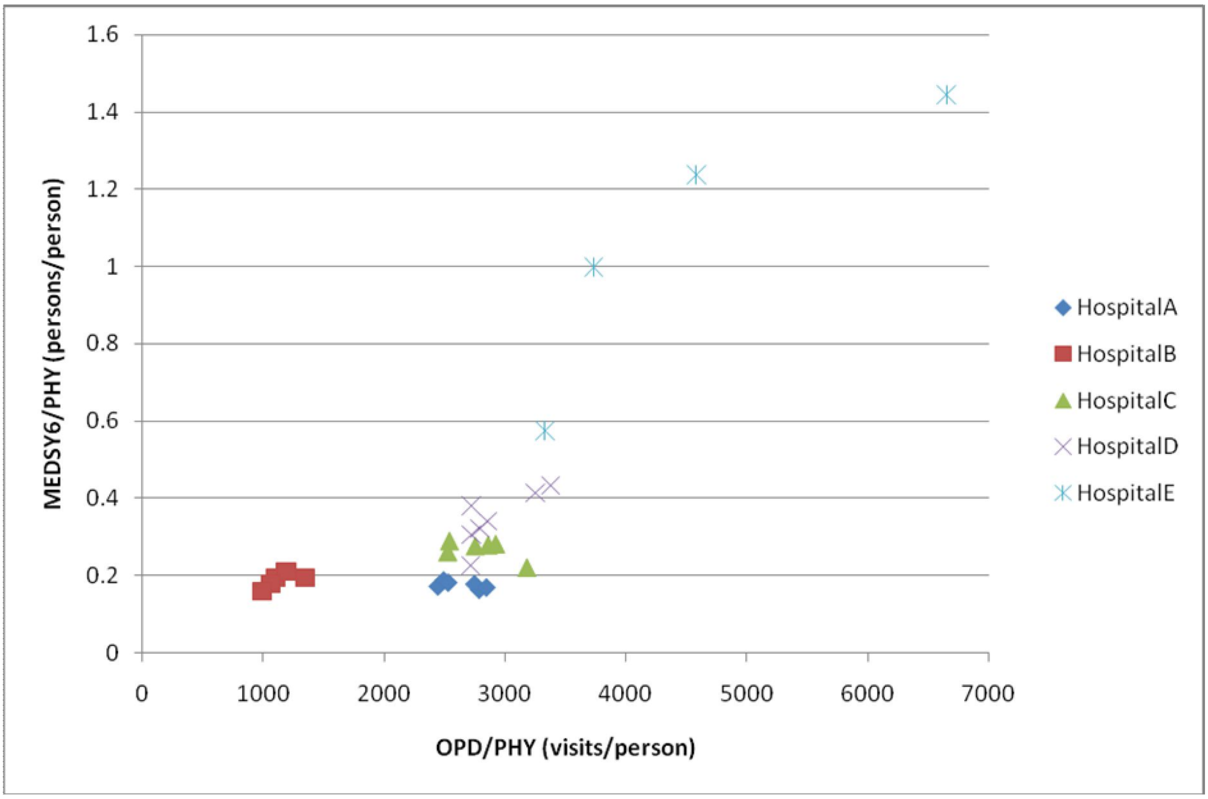

Figure 5.2-2 : Relationship between MED-PHY ratio on y-axis and OPD-PHY ratio on x-axis

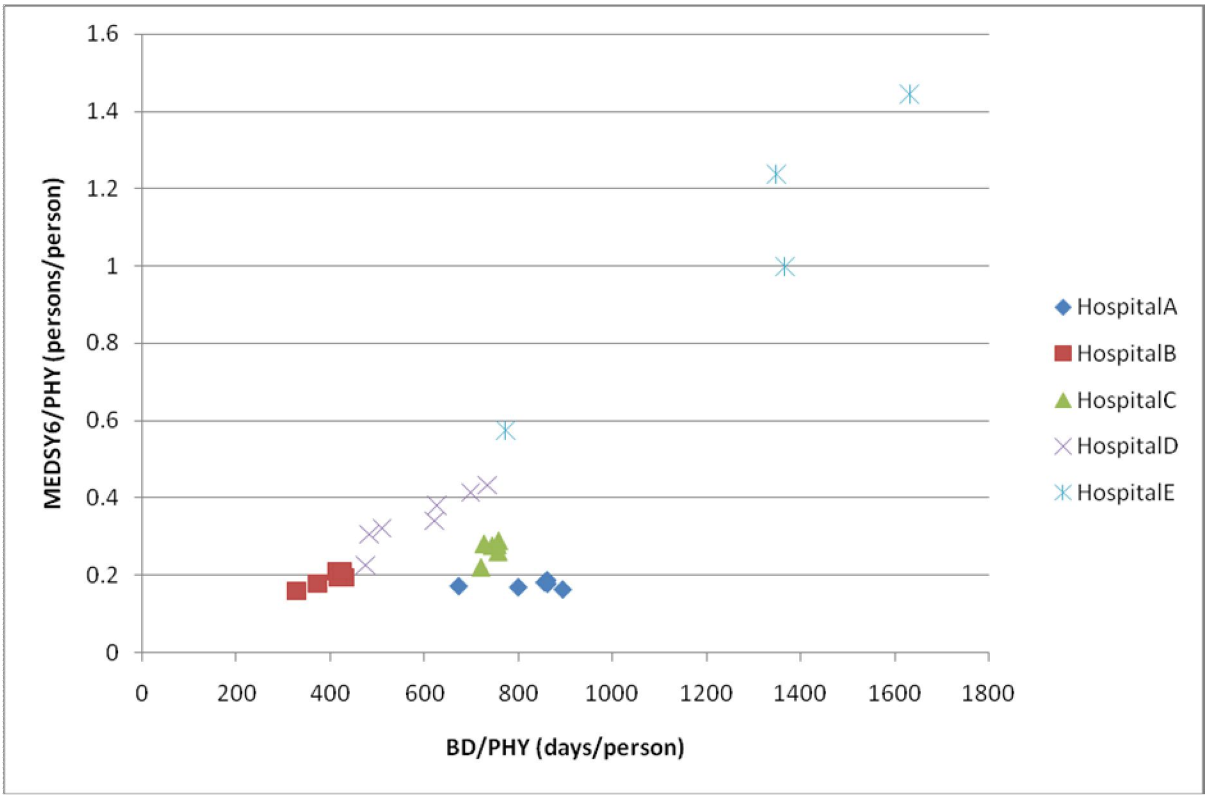

Figure 5.2-3 : Relationship between MED-PHY ratio on y-axis and BD-PHY ratio on x-axis

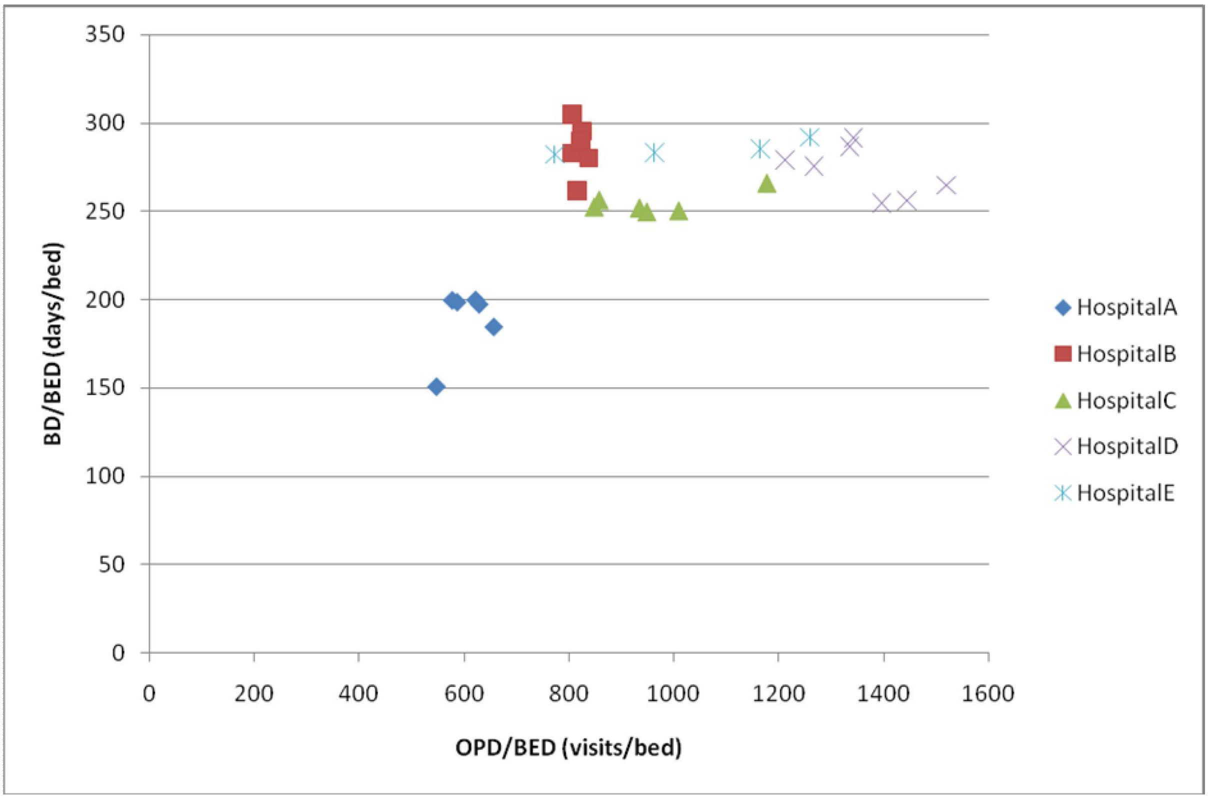

Figure 5.2-4 : Relationship between BD-BED ratio on y-axis and OPD-BED ratio on x-axis

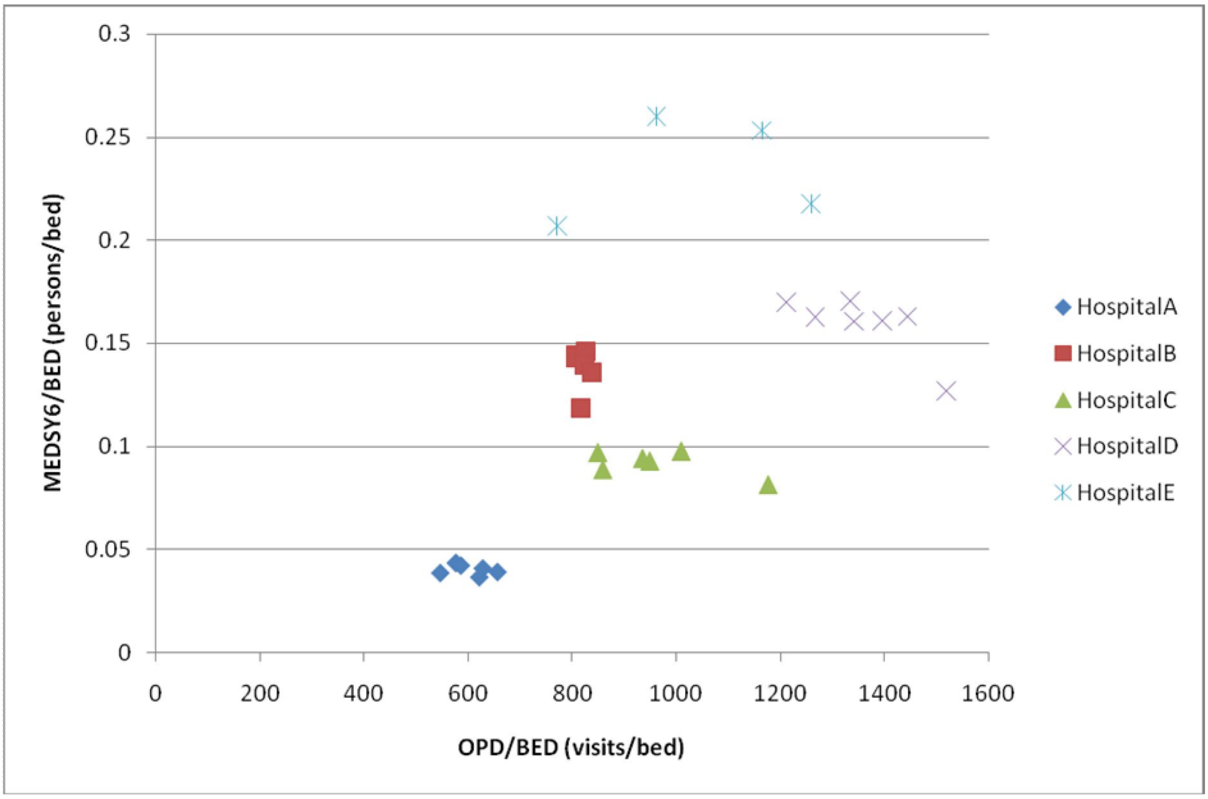

Figure 5.2-5 : Relationship between MED-BED ratio on y-axis and OPD-BED ratio on x-axis

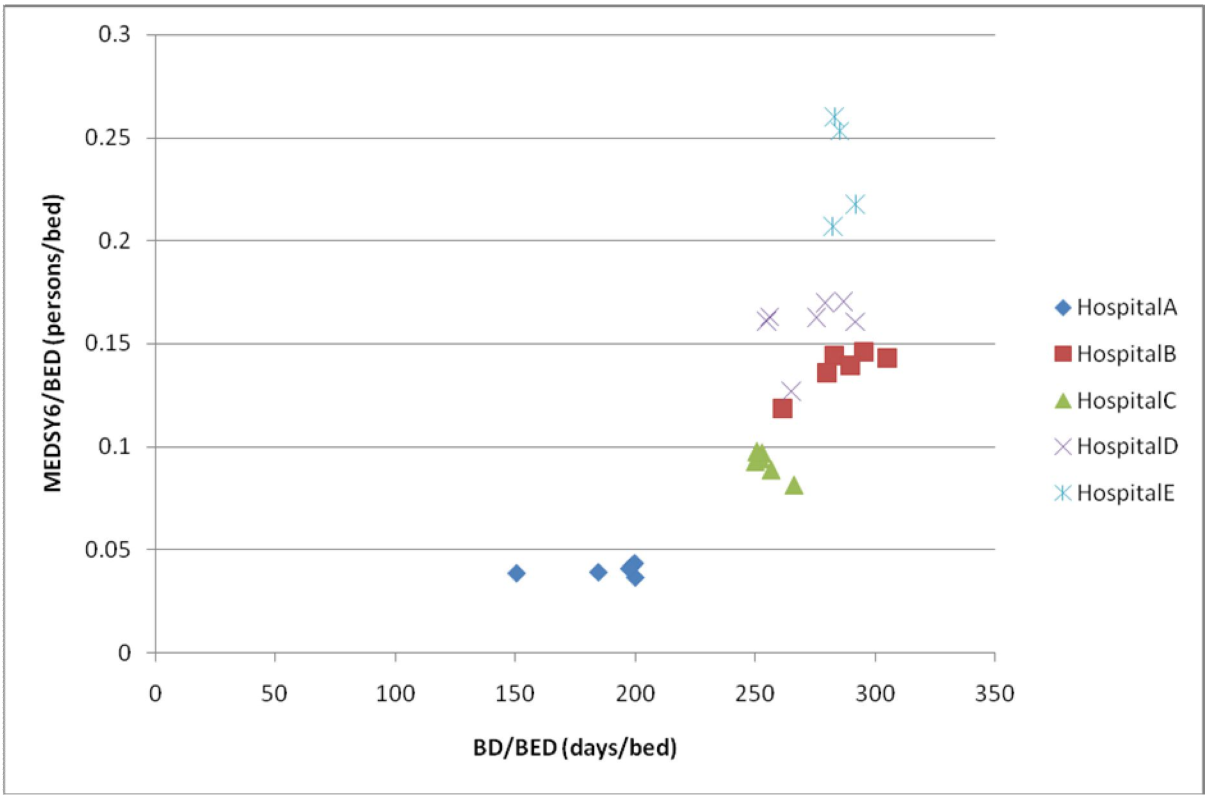

Figure 5.2-6 : Relationship between MED-BED ratio on y-axis and BD-BED ratio on x-axis

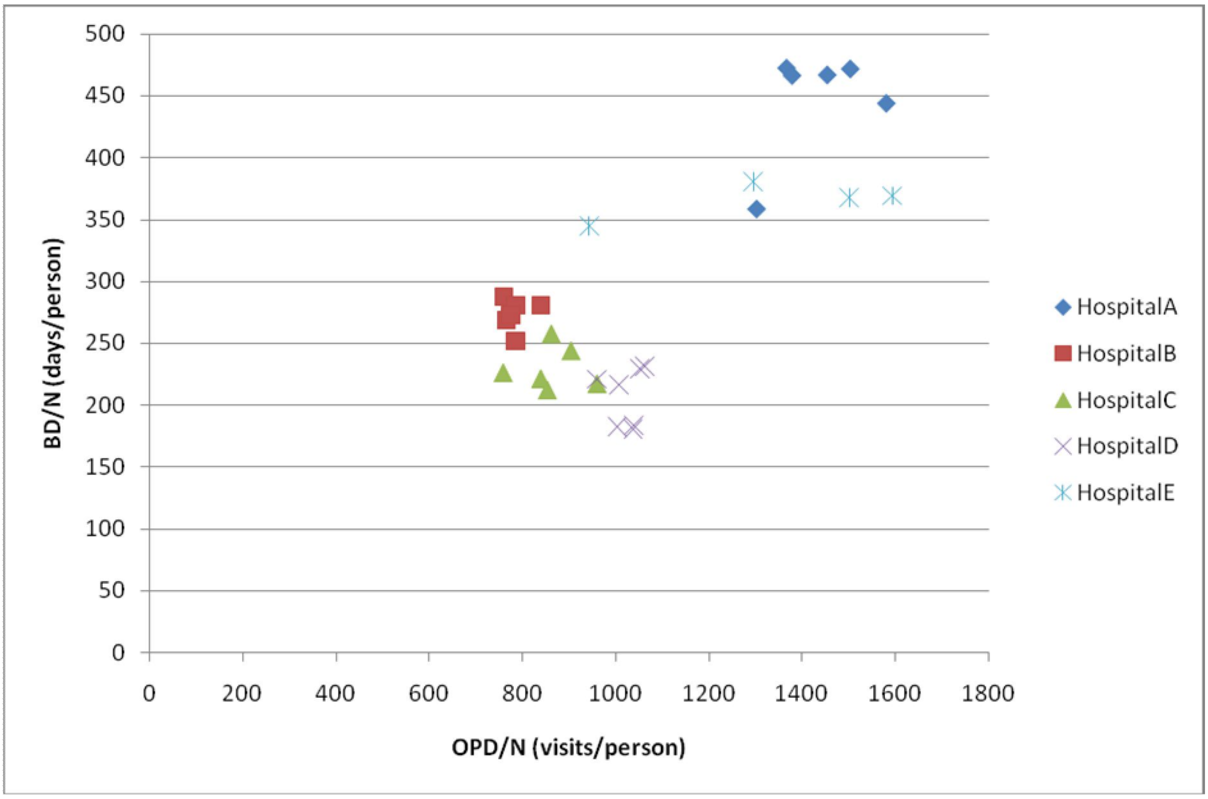

Figure 5.2-7 : Relationship between BD-Nurse ratio on y-axis and OPD-Nurse ratio on x-axis

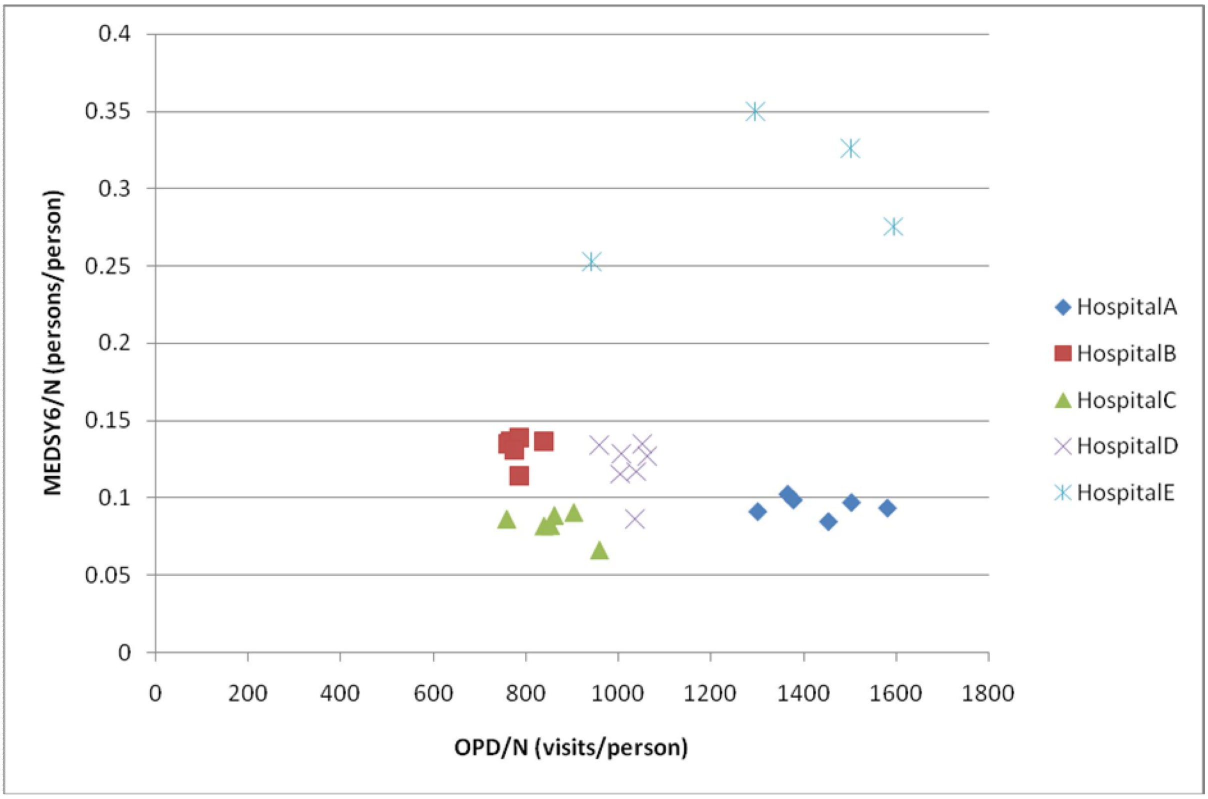

Figure 5.2-8 : Relationship between MED-Nurse ratio on y-axis and OPD-Nurse ratio on x-axis

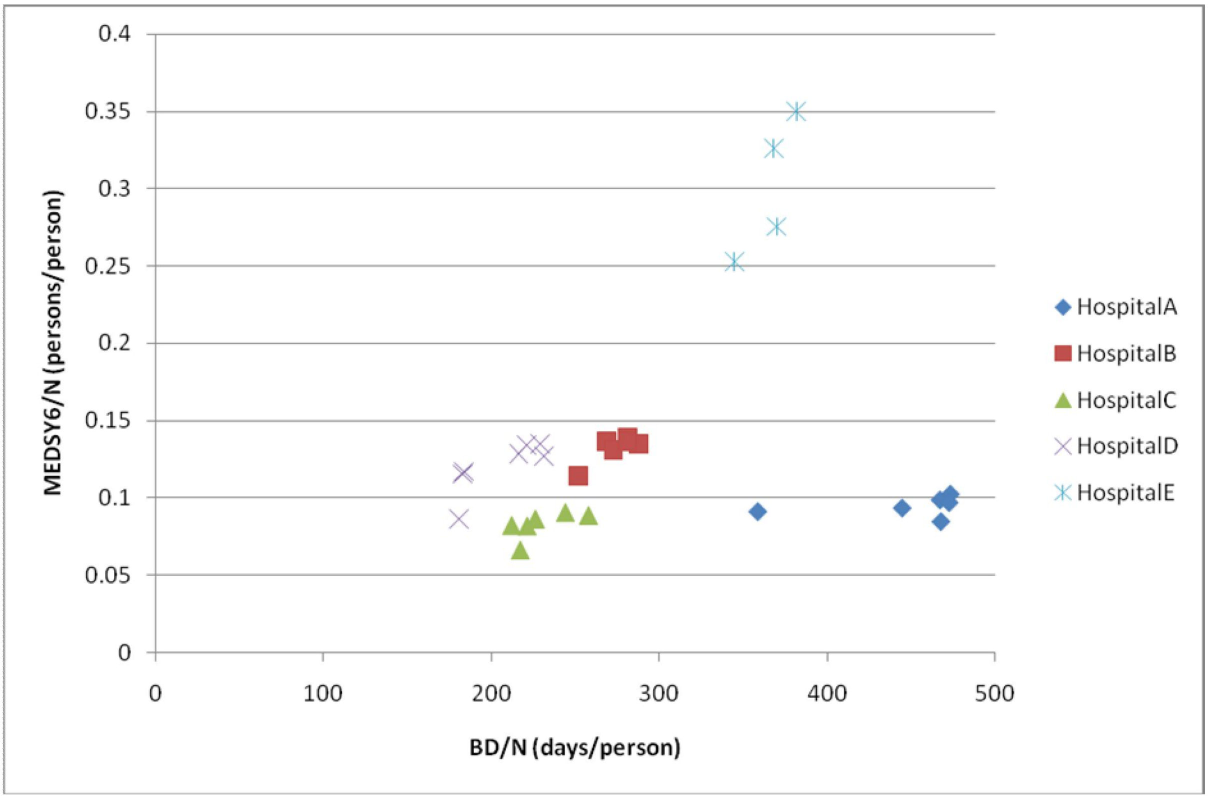

Figure 5.2-9 : Relationship between MED-Nurse ratio on y-axis and BD-Nurse ratio on x-axis

Hospital E was the newest and smallest university hospitals in this group which seemed to operate at the best efficient level. The reasons for this might be :

1. Due to Hospital E was the newest in this group, so the hospital had been increased in inputs until in the recent years which the hospital could operate at constant return to scale pattern.
2. Hospital E could use their resources at high capacity might be because scope of the hospital was not as much as the bigger hospitals in every activities – services, education and research. For example, scope of services in bigger hospitals might focus on tertiary care more than smaller hospitals, especially for tertiary care level hospitals which have a lot of severe cases transferred from lower level hospitals tend to go to bigger than smaller which makes more burden to bigger hospitals in providing treatment to the cases those consume many resources. And in this study, DRG weighting technique had not been done to weight for the severity, so one case of severe and non-severe were assumed as the same output of one case. So, Hospital E could be efficient more than others because of these. Moreover, in education and research activities, bigger hospitals consumes resources to do the

activities in percentage higher than smaller one which tends to pay more attention to provide treatment services more. Further more, in bigger hospitals, many campaigns and programs such as health promotion programs, educational programs which educate people in communities near to the hospitals are organized more frequently than in smaller hospitals. So, organizing these activities have to consume some resources which produce outputs those can not be counted as number of service nor number of educational training and also do not earn revenue.

3. Management system
4. Hospital E was the only hospital in this group which located in an industrial area which there is no big government hospital in. So, location of the hospital could be one important factor which affected to the efficiency level. For example, patients in that area had to visit only Hospital E, so the hospital could produce maximum services according to resources which the hospital had.

Scale inefficiency

More DMUs were confronted with scale inefficiency than pure technical inefficiency.

Also, scale efficiency estimation could indicate for the stage of DMUs whether it was in increasing return to scale(IRS), constant return to scale(CRS) or decreasing return to scale(DRS).

YEAR	DRS	CRS	IRS	N
2001	3	0	0	3
2002	3	1	0	4
2003	3	1	1	5
2004	3	2	0	5
2005	4	1	0	5
2006	3	2	0	5
2007	1	1	0	2
Total	20	8	1	29

Table 5.2-6 : Classify types of return to scale by year

Most hospitals(72.4%) were not running at CRS. While almost all of them(20 from 21 = 95.2%) were operated in DRS and the rest 1 of 21 was operated in IRS. 8 out of 29(27.6%) were running at CRS. All of them also had 100% in TECRS score.

This suggests that downscaling hospitals exhibiting decreasing returns to scale and shifting resources towards those facing increasing returns to scale would generally yield efficiency gains.

In the case of those exhibiting decreasing returns to scale which had a TEVRS score of 1, this result implies that even if they perform efficiently with their inputs, maintaining their current capacity casts the hospital into a region of considerable technical inefficiency from a CRS benchmark.

Economics suggests that scale efficiency, which results from finding the minimum average cost level of operation, is not really a short run phenomenon. In other words, changing the staffing profile and capital stock of a hospital cannot be done within a short period of time. Improving scale efficiency will require 'right-sizing' hospitals in line with their output profile. This would require careful planning.

Input saving

Efficiency score ranging from 52.5%-100% were observed in TECRS. This implies that if the inefficient hospitals were to operate as efficient as their peers on the best-practice frontier, the health system could have reaped efficiency gains amounting to 47.5% of the total resources used in running the hospitals.

Impact of UC

Due to lacking of data and other better data as proxies for estimation of impact of UC to efficiency level. In this study, comparing average of the 2 different periods of UC – before and after – without using statistical testing was done to see the impact. This result shows that UC tended to increase TECRS score which is a combination of pure technical efficiency and scale efficiency. While effects to TEVRS or pure technical efficiency and SE or scale efficiency were not still concludable.

This finding suggested that UC might affect in increasing technical efficiency level. The reason of the finding might be because when UC implemented, people could access to health care services at lower price, so demand in health care services would be higher and hospitals or suppliers in health care services could use their resources with higher capacity level and gain higher technical efficiency level when compared to period before UC implemented.

	Before UC			After UC			Difference		
Hospital	TECRS	TEVRS	SE	TECRS	TEVRS	SE	TECRS	TEVRS	SE
A	0.525	0.698	0.752	0.741	3.887	0.954	0.216	3.189	0.202
B	0.870	0.886	0.982	0.957	0.982	0.974	0.087	0.096	-0.008
D	0.965	1.000	0.965	0.988	0.997	0.991	0.023	-0.003	0.026

Table 5.2-7 : Averages of efficiency score classified by period of UC

Table 5.2-7 shows averages of efficiency score classified by period of UC and also difference between before and after. Year2001 considered as before UC period and Year2002-2007 considered as after UC period. Geometric mean was used in calculating averages of the score. Differences of average score is calculated by using after UC period score minus before UC period.

5.3 Regression analysis

Observations	29
R Square	0.83
Adjusted R Square	0.81
F	40.72
Significance F	0.00

					95%CI	
	Coef.	*SE*	*t Stat*	*P-value*	*Lower*	*Upper*
Intercept	0.98	0.03	31.84	0.00	0.92	1.05
BP	-0.08	0.01	-10.26	0.00	-0.10	-0.07
NP	0.01	0.02	0.61	0.55	-0.02	0.04
PP	1.18	0.20	5.98	0.00	0.77	1.59

Table 5.3-1 : Regression analysis result for SE and other variables

BP = Bed-physician ratio (beds/person)

NP = Registered nurse-physician ratio (persons/person)

PP = Pharmacist-physician ratio (persons/person)

According to the results of regression analysis, this study used ratios of bed-physician(BP), nurse-physician(NP) and pharmacist-physician(PP) to capture the effects of portion of inputs to the SE score.

The result shows that bed-physician ratio(BP) and pharmacist-physician ratio(PP) were significant at 0.01 level($p<0.01$) to SE score while nurse-physician ratio(NP) were not significant at 0.05 level($p>0.05$).

Coefficients of all variables show the same result as in hypothesizes. NP and PP relate to SE score positively and BP has negative relationship.

BP's coefficient is -0.08[-0.10,-0.07] – point estimation is -0.08 and range estimation of 95%CI is between -0.10 to -0.07 - means that if the bed-physician ratio increases by 1 unit, the SE score will be decreased by 0.08 unit in average or decreased between 0.07 to 0.10 with probability of 95%. Increasing bed or decreasing physician individually will make the ratio increased. While changing both bed and physician also can make the ratio increased as well.

NP's coefficient is 0.01[-0.02,0.04] means that if the nurse-physician ratio increases by 1 unit, the SE score will be increased by 0.01 unit.

PP’s coefficient is 1.18[0.77,1.59] means that if the pharmacist-physician ratio increases by 1 unit, the SE score will be increased by 1.18 unit.

From t-stats show that BP(|t|=10.26) is more significant than PP(|t|=5.98).

This implies that :

1. Choosing between decreasing BP ratio or increasing PP ratio to increase the SE score, changing BP ratio is more significant than PP ratio(|t| of BP is more than PP) so changing BP ratio can affect to increasing in SE score more probability than PP.
2. The magnitude changed of SE score affected by changing BP is less than PP ratio(Coef. Of BP is less than PP). But in the practical way, pattern of returns to scale of the firms has to be considered in choosing the combination too. IRS firms have to increase their inputs, while DRS firms have to decrease.
3. In the real situation, concerning price of inputs in weighting or allocative efficiency has to be done in calculation for the right combination.

Observations	29
R Square	0.74
Adjusted R Square	0.65
F	8.57
Significance F	0.00

					95%CI	
	Coef.	*SE*	*t Stat*	*P-value*	*Lower*	*Upper*
Intercept	0.33	0.14	2.26	0.03	0.03	0.63
Mor	-0.01	0.04	-0.21	0.84	-0.09	0.07
ALOS	0.01	0.01	0.90	0.38	-0.02	0.04
Occ	0.01	0.00	4.53	0.00	0.00	0.01
OP	2.98E-05	1.23E-05	2.42	0.02	4.18E-06	5.53E-05
OI	-2.85E-03	1.45E-03	-1.96	0.06	-5.87E-03	1.67E-04
MB	-0.69	0.30	-2.31	0.03	-1.31	-0.07
MOE	0.20	0.04	4.87	0.00	0.11	0.28

Table 5.3-2 : Regression analysis result for TEVRS and other variables

Mor = Mortality rate (percentage)

ALOS = Average length of stay (days)

Occ = Occupacy rate (percentage)

OP = Out-patient visit-physician ratio (visits/person)

OI = Out-patient visit-inpatient case ratio (visits/case)

MB = Medical student year 6^{th} –bed ratio (persons/bed)

MOE = Dummy variable for ministry of education-owned hospitals (D=1)

This regression analysis chose TEVRS score as an dependent variable while some proxies were chosen to be determinants for other variations of the hospitals to the score.

Mor is a representative proxy for quality of the hospitals Lower Mor means higher quality which has tentation to provide excessive and complexity of health care.

ALOS is also one proxy for inputs consumption. High ALOS means more inputs consumed, both labor and capital inputs.

Occ is chosen to represent consumption of beds. Higher Occ means more utilization of beds.

OP is chosen to be a representative of ratio between output and input. More OP means more outputs produced while constant inputs consumed.

OI is a representative for structure of health care between OPD and IPD.

MB is a representative for structure of educational provided and size of hospitals.

The result shows that Occ and MOE variables are significant at 0.01 level($p<0.01$) while OP and MB are significant at 0.05 level($p<0.05$). OI is significant at 0.10 level($p<0.10$) and the rests are not significant.

Almost all of variables' coefficients are followed as hypothesizes. Just only Mor and OI which are not.

Mortality rate's coefficient is -0.01[-0.09,0.07] means that if the mortality rate is increased by 1 unit, the TEVRS score will be decreased 0.01 unit.

ALOS's coefficient is 0.01[-0.02,0.04] means that if the ALOS is increased by 1 unit, the TEVRS score will be increased 0.01 unit.

Occ's coefficient is 0.01[0.00,0.01] means that if the Occ is increased by 1 unit, the TEVRS score will be increased 0.01 unit.

OP's coefficient is 2.98E-05[4.18E-06,5.53E-05] means that if the OP is increased by 1 unit, the TEVRS score will be increased by2.98E-05 unit.

OI's coefficient is -2.85E-03[-5.87E-03,1.67E-04] means that if the OI is increased by 1 unit, the TEVRS score will be decreased by 2.85E-03 unit.

MB's coefficient is -0.69[-1.31,-0.07] means that if the MB is increased by 1 unit, the TEVRS score will be decreased by 0.69 unit.

MOE's coefficient is 0.20[0.11,0.28] means that if the hospital is owned by MOE, the TEVRS score will be increased by 0.20 unit.

From t-stats show that significance of MOE > Occ > OP > MB > OI(|t| is high means more significant).

This implies that :

1. Hospitals under MOE controlled had some mechanisms which can make the hospitals operated with higher technical efficiency than the hospital that was not. The mechanisms may be
    - Image of hospital which can attract more patients.
    - Management system
    - Level of technology
    - Economy of scale and scope

2. Occupancy rate shows a positive relationship with technical efficiency score than OP and MB, cause higher occupancy rate means higher consumption of beds which considered as one important capital input. This finding is similar to other studies. For example, Chang(1998), in their study the occupancy rate has a positive and significant impact on efficiency. A high occupancy rate results in a high efficiency. Nyman and Bricker(1989) found that if we assume that nursing homes tend to staff for close 100% occupancy rate, then the degree to which the firm's actual occupancy rate is less than this target occupancy rate will have effect on the firm's staffing hours per patient day. As a result, higher occupancy rates would tend to be associated with higher efficiency scores.
3. Out-patient-physician ratio positively relates to technical efficiency score due to higher of this ratio means increasing in out- patient visit or decreasing in physician consumption which also means increasing in output and decreasing in input those can yield to increasing in technical efficiency. Changing in input combination also has to concern about pattern of scale efficiency – DRS, IRS or CRS
4. Medical student year 6^{th}-bed ratio has negative sign in it's coefficient which means more medical student year 6^{th}, while the bed as a representative of hospital's size is fixed, the technical efficiency score will be decreased. Increasing in medical student produced which considered as output in educational aspect of the university hospitals didn't show the positive relation ship due to medical student is a human capital which needs a lot of input consumption so the fraction of input consumption of producing one medical student year 6^{th} is more than other fractions. In fact, producing medical student year 6^{th} is more valuable than this simple evaluation can count for, especially for intangible value of the output. Because this is a long term development of human capital which will have more and more value with appreciation rate over the time. For the whole society perspective, this output has very much value.
5. Out-patient visit-inpatient case ratio shows negative sign with 0.10 level of significant. That means increasing the ratio tends to affect to lower the technical efficiency level. So, comparing between increasing in one out-patient visit and one in-patient case, increasing in one out-patient visit, which can be assumed as one

cured case for out-patient care, consumes more resources than increasing in one in-patient case. So, when resources or inputs are fixed, increasing in this ratio by increases in out-patient case or decreases in-patient case will make lower technical efficiency than other hospitals which are not.

Policy implication

For policy makers, this study shows the evidence that most university hospitals were running in a decreasing return to scale pattern, so downsizing of the hospitals should be done to meet the most efficiency scale at constant return to scale pattern. Focusing on bed utilization at the maximal capacity or decreasing number of bed should be one solution to be considered because from the study shows that bed-physician ratio and occupancy rate highly significantly related to technical efficiency score.

CHAPTER VI

CONCLUSION AND RECOMMENDATION

6.1 Conclusion and recommendation

Thailand's government has been implemented the universal coverage scheme since 2002. And because of this scheme, many hospitals have been facing a lot of problems especially financial crisis. University hospitals which considered as the most important group of hospital in health care system because this group of hospital has very important activities of providing education and research, besides providing health care. And because of those main activities of providing education and research which have to invest a lot, so this group of hospital seemed to face the problem with more severity than other groups.

One of the best solution for the problem is to operate hospitals by using resources efficiently. Data envelopment analysis together with regression analysis were mostly used together in measuring efficiency level of a business in recent years. University hospital's technical efficiency measurement was not been done much either. So, that came to the research questions of this study :

1. What level are technical efficiency scores of university hospitals in Thailand?
2. How do some explanatory variables affect the technical efficiency scores?

So, the objective of this study was to use DEA together with RA to investigate in the evidence of technical efficiency level in university hospitals in Thailand. And the specific objectives were :

1. To evaluate technical efficiency score of university hospitals in Thailand.
2. To evaluate scale efficiency score of university hospitals in Thailand.
3. To identify the impact of some factors to TE score and SE score.

This study was analyzed by using data from 5 university hospitals from year 2001-2007 and total were 29 data or decision making units, DMUs. In DEA, physician and number of bed were used as an input proxies and number of out-patient department visit, bed days and number of medical student year 6^{th} were outputs. So for this study, the operational definition of technical efficiency was the ability of each decision making unit in using its physician and bed to produce out-patient care, in-patient care and education. Results show that :

Evaluate technical efficiency score of university hospitals in Thailand

The CRS DEA model estimated the score of 29DMUs from year 2001-2007. The result showed that average of the TECRS score was about 88.7% while the minimum was 52.5% and the maximum was 100%. While the result from VRS DEA model estimation indicated 97.4% was an average score of TEVRS. Minimum was 69.8% and maximum was 100%.

Evaluate scale efficiency score of university hospitals in Thailand

SE score showed average was 91.1% while minimum was 75.2% and maximum was 100%. This study also reveals that the cause of inefficiency of the university hospitals is mostly because of scale inefficiency. Decreasing return to scale, DRS, shows predominantly pattern of scale inefficiency among the group, 20 out of all(69.0%) and 20 out of 21(95.2%) which are scale inefficiency. For the DRS pattern, portion of increasing of inputs increases outputs in lower portion than inputs increased, so unit costs is increased and lower technical efficiency level. So, reaching the better level of technical efficiency, reduced inputs or increasing outputs while other variables are fixed has to be done.

Identify the impact of some factors to SE score

The result from regression analysis of scale efficiency score shows that bed-physician ratio(BP) and pharmacist-physician ratio(PP) were significant to SE score while nurse-physician ratio(NP) was not significant.

BP's coefficient is -0.08[-0.10,-0.07] – point estimation is -0.08 and range estimation of 95%CI is between -0.10 to -0.07 - means that if the bed-physician ratio increases by 1 unit, the SE score will be decreased by 0.08 unit in average or decreased between 0.07 to 0.10 with probability of 95%. Increasing bed or decreasing physician individually will make the ratio increased. While changing both bed and physician also can make the ratio increased as well.

PP's coefficient is 1.18[0.77,1.59] means that if the pharmacist-physician ratio increases by 1 unit, the SE score will be increased by 1.18 unit.

Identify the impact of some factors to TE score

And the result from regression analysis of TEVRS score shows that MOE, Occ, OP, MB and OI are significant while Mor and ALOS are not.

Occ's coefficient is 0.01[0.00,0.01] means that if the Occ is increased by 1 unit, the TEVRS score will be increased 0.01 unit.

OP's coefficient is 2.98E-05[4.18E-06,5.53E-05] means that if the OP is increased by 1 unit, the TEVRS score will be increased by2.98E-05 unit.

OI's coefficient is -2.85E-03[-5.87E-03,1.67E-04] means that if the OI is increased by 1 unit, the TEVRS score will be decreased by 2.85E-03 unit.

MB's coefficient is -0.69[-1.31,-0.07] means that if the MB is increased by 1 unit, the TEVRS score will be decreased by 0.69 unit.

MOE's coefficient is 0.20[0.11,0.28] means that if the hospital is owned by MOE, the TEVRS score will be increased by 0.20 unit.

Input saving

The results of this study indicate that some of the university hospitals in Thailand operated at technical efficiency levels below the frontier. About 60.0% of university hospitals are able to improve their technical efficiency level both in pure technical or scale efficiency. In year 2006, one out of 5(20.0%) has TECRS score about 64.3%, lower than 80.0%, which needs to be improved and can save input consumption up to about 35.7%.

Reducing inputs is not easy to be done, but one way to increase to technical efficiency level is to use inputs in higher capacity level such as using beds with higher occupancy rate.

For changing amount of outputs, especially for health care demand, this is beyond the control of the hospitals as mentioned earlier that demand for health care is quite inelastic. But there are some mechanisms to increase health care demand such as promotion. Other outputs such as preventive care, education, research, etc. also able to be done to increase amount of outputs and consume inputs at their higher capacity level.

Input saving can be done by down sizing of the hospitals and reallocate some waste inputs to other hospitals which can yield more efficiency level. Or, without down sizing, increase in output can be done. By doing so can reduce inequities too.

Impact of UC

For the impact of UC implementation to technical efficiency score, the result shows that UC tended to increase TECRS score which is a combination of pure technical efficiency and scale efficiency. While effects to TEVRS or pure technical efficiency and SE or scale efficiency were not still concludable. This suggested that UC might affect in increasing technical efficiency level. The reason of the finding might be because when UC implemented, people could access to health care services at lower price, so demand in health care services would be higher and hospitals or suppliers in health care services could use their resources with higher capacity level and gain higher technical efficiency level when compared to period before UC implemented.

Suggestion from the results

About the determinants of technical efficiency which are estimated in regression analysis suggested that :

- According to DRS predominant pattern of scale inefficiency, decreasing in number of beds, while other variables especially for number of physicians are fixed, can increase scale efficiency level significantly more than the others. For mechanism of decreasing in number of beds such as resold can benefit to hospitals more than earning in scale efficiency. Also, revenue eared by the decreasing can be used in other efficient ways, more free space for utilization and lower maintenance cost. More over, decreasing in number of physicians, while other variables especially for number of pharmacists are fixed, can also increase scale efficiency level. So, the right portion in changing number of beds and physicians which can affect to BP ratio has to be done to yield total gain of scale efficiency level. Cost and price need to be concerned in changing inputs

- University hospitals under MOE shows significantly to higher technical efficiency level. The mechanism underlines this finding should be clarified more.
- Occupancy rate shows the same result as previous studies in significantly positively relates to technical efficiency level. Also, together with downsizing by reducing number of beds can also increase in occupancy rate and increase in scale efficiency level.
- From PP and OP ratio, decreasing in physicians also can affect in increasing both technical and scale efficiency.
- Increasing medical training can affect to lower efficiency level. But in a long term, human capital is high in value and capacity, so the human capital can produce high value of outputs with high capacity and may be yield higher efficiency level to the hospitals and also to the society.
- Increasing in inpatient cases tends to increase technical efficiency level better than increasing in outpatient visits. Also, increasing in inpatient cases can affect to increase in consumption of beds and occupancy rate to increase. The finding is significant at 0.10 but not at 0.05, so further study has to be done in the future.
- Quality of health care has to be concerned as a determinant in technical efficiency evaluation. In this study, mortality rate is used as a proxy for quality of care, but show insignificant. So, other better proxies for quality of care have to be picked up in future studies.

Policy implication

This study is expected to help hospital management level in future policy implication and planning. Knowledge of the causes in hospital inefficiency can bring to the right direction of improvement. Benchmarking with the most efficiency DMUs can be used as one mechanism for such the improvement.

For policy makers, this study shows the evidence that most university hospitals were running in a decreasing return to scale pattern, so downsizing of the hospitals should be done to meet the most efficiency scale at constant return to scale pattern. Focusing on bed utilization at the maximal capacity or decreasing number of bed should be one solution to be considered because from the study shows that bed-physician ratio and occupancy rate highly significantly related to technical efficiency score. Note that changing combination of inputs has to be concerned about allocative efficiency by using input's price and also scale pattern has to be concerned too.

6.2 Limitation of this study

Some limitations of this analysis were :

- Lack of information. This made the study could not be done in more details and also the results might not be good enough to present the real behavior of the population.
- Complexity of activities of university hospitals which makes the study was hard to specify inputs and outputs. This made identifying proxies and explanatory variables were very hard when compared with other groups of hospital.
- Quality adjustment in outputs had not been done in this study due to lacking of data. So, this made the study had to assume each hospital produced same quality of outputs while in the real is not.

6.3 Suggestion for further study

Sample size

For further study, bigger sample size and more university hospitals recruited in the study should be done to capture the real behavior of the population.

DEA specification

In DEA, some more important inputs should be included in the model and separated input type should be concerned. Price of input for estimation of allocative efficiency measurement should be concerned. Some important investments in capital inputs such as buildings, facilities, technologies, etc. For example, investment in waste water treatment system, water recycled system, solid waste separation and treatment system, information technology system, etc., these investments also consume many resources in development at first and their outcomes will be shown once the systems have been stable. Value of the outcomes are far more than improvement in hospital's efficiency but also improvement in environment and society. And some other investments in development such as human resource development investment and research investment should be included in the studies because these investments will bring to the better output and efficiency score.

Also for outputs, separated output should be done or aggregated outputs with weighting technique such as DRG for severity weighting in patient cases will bring the better result than aggregated outputs without weighting in this study. Quality adjustment of outputs may be used together with weighting technique. The most important outputs of university hospitals, more important than providing health services in curative care, supportive care, preventive care and rehabilitation, are specialist training and research which consume a lot of resources and these activities' return is not revenue in money term and can not be evaluated directly, but the outcome from the activities are high in value. So, in the future studies, these important outputs should be included if possible. Further more, some community contributions such as campaigns or programs, for example free obesity screening in a special occasion or some health promotion programs, should be concerned to be selected as a proxy as well because these activities have been done a lot in almost every big hospital such as university hospitals. And same as specialist training and research, these activities do not earn revenue and can not be evaluated directly.

Regression analysis specification

For RA, some better functional form should be developed and also better determinants as well.

Impact of UC measurement

For estimation the impact of UC implementation, more data and other better proxies and methods with statistical testing should be done.

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APPENDIX

A.1 Data for DEA

Hospital	Year	OPD	BD	MED	PHY	BED
A	2001	855922	235855	60	351	1565
	2002	880471	304958	66	354	1526
	2003	893804	302888	64	354	1524
	2004	942808	303250	55	339	1516
	2005	929843	292212	60	339	1479
	2006	963534	270971	57	339	1467
B	2001	1217662	389755.9	177	907	1492
	2002	1192826	418547	213	1015	1480
	2003	1161445	438876	206	1057	1440
	2004	1187170	424652.5	210	1001	1439
	2005	1199741	421721.4	203	1135	1457
	2006	1215024	405776	197	1236	1450
C	2002	1972119	587243	225	776	2324
	2003	2032064	607471	210	804	2368
	2004	2208103	595855	222	802	2363
	2005	2219259	584814	217	776	2340
	2006	2288071	568288	221	783	2268
	2007	2584665	584814	179	813	2198
D	2001	1191939	259117	153	353	941
	2002	1159746	249092	148	357	869
	2003	1127355	259617	158	415	931
	2004	1195149	259794	143	419	891
	2005	1258541	229488	145	451	902
	2006	1303121	230990	147	480	903
	2007	1354284	236118	113	499	892
E	2003	276298	101053	74	74	358
	2004	384741	113212	104	84	400
	2005	492382	120705	107	74	423
	2006	532306	123430	92	160	423

A.2 Data for RA

Hospital	Year	BP	NP	PP	SE
A	2001	4.458689	1.874644	0.08547	0.752149
	2002	4.310734	1.822034	0.084746	0.717975
	2003	4.305085	1.833333	0.084746	0.720833
	2004	4.471976	1.914454	0.088496	0.697
	2005	4.362832	1.825959	0.088496	0.720419
	2006	4.327434	1.79941	0.088496	0.734018
B	2001	1.644983	1.707828	0.044101	0.981941
	2002	1.458128	1.535961	0.04532	0.934
	2003	1.362346	1.443709	0.050142	1
	2004	1.437562	1.51049	0.057942	0.973
	2005	1.2837	1.363877	0.052863	0.983505
	2006	1.173139	1.170712	0.045307	0.981972
C	2002	2.994845	3.347938	0.083763	0.869
	2003	2.945274	2.932836	0.087065	0.881
	2004	2.946384	3.046135	0.094763	0.866
	2005	3.015464	3.407216	0.135309	0.86
	2006	2.896552	3.42401	0.136654	0.861
	2007	2.703567	3.313653	0.145141	0.919
D	2001	2.665722	3.209632	0.093484	0.965
	2002	2.434174	3.226891	0.109244	1
	2003	2.243373	2.833735	0.144578	0.953
	2004	2.126492	2.682578	0.147971	1
	2005	2	2.780488	0.155211	0.99187
	2006	1.88125	2.614583	0.15	1
	2007	1.787575	2.617234	0.154309	1
E	2003	4.837838	3.959459	0.310811	0.985
	2004	4.761905	3.535714	0.261905	1
	2005	5.716216	4.432432	0.297297	1
	2006	2.64375	2.0875	0.2125	1

Hospital	Year	Mor	ALOS	Occ	OP	IB	MB	MOE	TEVRS
A	2001	3.32	9.19	59.5	2438.524	16.73866	0.038339	0	0.698
	2002	4.16	11.87	86.67	2487.206	17.07536	0.04325	0	0.968
	2003	4.23	11.64	85.55	2524.87	17.30906	0.041995	0	0.96
	2004	3.84	11.27	86.49	2781.145	18.031	0.03628	0	1
	2005	4	11.48	86.08	2742.9	17.48546	0.040568	0	0.955
	2006	3.69	11.51	80.69	2842.283	16.36469	0.038855	0	0.876
B	2001	3.51	8	71.57	1342.516	33.46783	0.118633	1	0.886
	2002	3.108	9	77.48	1175.198	32.34189	0.143919	1	1
	2003	3.106	9	83.5	1098.813	35.20903	0.143056	1	1
	2004	3.056	9	80.85	1185.984	33.62682	0.145935	1	1
	2005	2.996	8.96	79.3	1057.041	33.0906	0.139327	1	0.97
	2006	3.162	8.89	76.67	983.0291	31.84828	0.135862	1	0.943
C	2002	2.653772	6.665566	69.23	2541.39	37.90921	0.096816	1	1
	2003	2.691164	6.971447	70.28	2527.443	36.79772	0.088682	1	1
	2004	2.564324	6.441676	68.9	2753.246	39.14515	0.093948	1	1
	2005	2.49787	6.150693	72.89	2859.87	40.63291	0.092735	1	1
	2006	3.223657	7.889602	68.65	2922.185	31.75926	0.097443	1	1
	2007	3.020737	7.504543	72.89	3179.17	35.45405	0.081438	1	1
D	2001	2.41	6.42	75.65	3376.598	41.42827	0.162593	1	1
	2002	2.3	6.54	77.70	3248.588	41.79287	0.170311	1	1
	2003	2.22	6.72	75.65	2716.518	39.12782	0.16971	1	1
	2004	2.36	6.72	77.64	2852.384	41.00337	0.160494	1	1
	2005	2.46	6.81	80.16	2790.557	40.68736	0.160754	1	0.984
	2006	2.44	6.98	85.72	2714.835	39.4928	0.162791	1	1
	2007	2.32	6.96	90.85	2713.996	40.39462	0.126682	1	1
E	2003	1.7	4.146104	74.93	3733.757	68.08101	0.206704	1	1
	2004	1.52	3.600547	79.77	4580.25	78.6075	0.26	1	1
	2005	1.44	3.2844	81.95	6653.811	86.8818	0.252955	1	1
	2006	2.04	3.61255	80.15	3326.913	80.77305	0.217494	1	1

A.3 Inputs and outputs of university hospital

Service	IPD	Input	Labor	Physician(GP,Specialist,Residence),Nurse,Pharmacist, Technician,Scientist,Other officers
			Capital	Equipment,Machine,Area,Facilities,Other investment
		Output	Intermediate	No. of cases,No. of visits
			Final	Mortality rate,Complication rate,Satisfaction
	OPD	Input	Labor	Physician,Nurse,Pharmacist,Technician,Scientist, Other officers
			Capital	No. of beds,Equipment and machine,Area,Facilities, Other investment
		Output	Intermediate	Occupacy rate,Total no. of bed days,No. of cases
			Final	Average length of stay(ALOS),Nosocomial infection rate,Mortality rate,Complication rate,Satisfaction
Education		Input	Labor	Physician,Nurse,Pharmacist,Technician,Scientist, Other officers
			Capital	Equipment and Machine,Lab devices,Area,Dormitory, Facilities,Other investment
		Output		No. of students,No. of training courses, newspaper,No. of articles,Satisfaction
Research		Input	Labor	Physician,Nurse,Pharmacist,Technician,Scientist, Other officers
			Capital	Equipment and Machine,Lab devices,Area,Facilities, Other investment
		Output	Intermediate	No. of projects
			Final	No. of research articles,No. of citated papers

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