TECHNICAL AND SCALE EFFICIENCY OF HEALTH CENTERS IN BANGKOK METROPOLITAN AREA

Miss. Cheeranun Chinarksorn

A Thesis Submitted in Partial Fulfillment of the Requirements

for the Degree of Master of Science Program in Health Economics and Health Care Management

Faculty of Economics

Chulalongkorn University

Academic Year 2010

ประสิทธิภาพทางเทคนิคและประสิทธิภาพขนาดของศูนย์บริการสาธารณสุข
ในเขตกรุงเทพมหานคร

นางสาวจีรนันท์ ชินอักษร

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต

สาขาวิชาเศรษฐศาสตร์สาธารณสุขและการจัดการบริการสุขภาพ

คณะเศรษฐศาสตร์ จุฬาลงกรณ์มหาวิทยาลัย

ปีการศึกษา 2553

Thesis Title	**TECHNICAL AND SCALE EFFICIENCY OF HEALTH CENTERS IN BANGKOK METROPOLITAN AREA**
By	**Miss Cheeranun Chinarksorn**
Field of Study	**Health Economics and Health Care Management**
Thesis Advisor	**Associate Professor Pongsa Pornchaiwiseskul,Ph.D.**

Accepted by the Faculty of Economics, Chulalongkorn University in Partial Fulfillment of the Requirements for the Master's Degree

……………………………………………….. Dean of the Faculty of Economics

(Professor Teerana Bhongmakapat, Ph.D.)

THESIS COMMITTEE

……………………………………………….. Chairman

(Assistant Professor Phitsanes Jessadachatr, Ph.D.)

……………………………………….……. Thesis Advisor

(Associate Professor Pongsa Pornchaiwiseskul, Ph.D.)

……………………………………………….. Examiner

(Associate Professor Siripen Supakankunti, Ph.D.)

……………………………………………….. External Examiner

(Porntep Siriwanarangsun, M.D., Ph.D.)

นางสาวจีรนันท์ ชินอักษร : ประสิทธิภาพทางเทคนิคและประสิทธิภาพขนาดของศูนย์บริการสาธารณสุขในเขตกรุงเทพมหานคร. (TECHNICAL AND SCALE EFFICIENCY OF HEALTH CENTERS IN BANGKOK METROPOLITAN AREA) อ. ที่ปรึกษาวิทยานิพนธ์หลัก : รศ.ดร.พงศา พรชัยวิเศษกุล, 64 หน้า.

การศึกษานี้มีวัตถุประสงค์เพื่อวัดประสิทธิภาพทางเทคนิคและประสิทธิภาพขนาดของศูนย์บริการสาธารณสุขในเขตกรุงเทพมหานครทั้งหมด 68 ศูนย์ ในปี 2552 และ 2553 การศึกษาวิเคราะห์ระดับประสิทธิภาพทางเทคนิคและประสิทธิภาพขนาดโดยใช้แบบจะลอง DEA และวิเคาระห์ปัจจัยกำหนดประสิทธิภาพโดยอาศัยแบบจำลอง OLS

ผลการวัดระดับประสิทธิภาพทางเทคนิคพบว่า ค่าเฉลี่ยของประสิทธิภาพทางเทคนิคเภายใต้ข้อสมมติ constant return to scale เท่ากับ 0.8866 ในขณะที่ค่าเฉลี่ยของประสิทธิภาพทางเทคนิคภายใต้ข้อสมมติ variable return to scale เท่ากับ 0.9268 และค่าเฉลี่ยประสิทธิภาพขนาดเท่ากับ 0.9553 55 จาก 136 หน่วยประเมิณที่มีประสิทธิภาพรวมสูงสุด หรือ 40.44% 86 จาก 136 หน่วยประเมิณที่มีค่าประสิทธิภาพทางเทคนิคที่แท้จริงสูงสุดหรือคิดเป็น 61.76% 58 จาก 136 หน่วยประเมิณที่มีค่าประสิทธิภาพขนาดสูงสุดหรือคิดเป็น 42.65% การศึกษาปัจจัยกำหนดประสิทธิภาพทางเทคนิคพบว่า อัตราส่วนระหว่างแพทย์กับเจ้าหน้าที่อื่นๆ, อัตราส่วนระหว่างพยาบาลต่อเจ้าหน้าที่อื่นๆ,อัตราส่วนจำนวนครั้งของการให้บริการวางแผนครอบครัวต่อพยาบาล, และ อัตราส่วนจำนวนครั้งของการรักษาผู้ป่วยทั่วไปต่อแพทย์ มีผลด้านบวกต่อประสิทธิภาพทางเทคนิค ขณะที่อัตราส่วนทันตแพทย์ต่อเจ้าหน้าที่อื่นๆมีผลด้านลบต่อประสิทธิภาพทางเทคนิค สำหรับประสิทธิภาพขนาดพบว่าจำนวนแพทย์มีผลด้านบวกต่อประสิทธิภาพขนาด ข้อมูลที่ได้สามารถนำมาประยุกต์ใช้ในการกำหนดนโยบาย โดยหน่วยประเมินที่ไม่มีประสิทธิภาพขนาดส่วนใหญ่เป็นแบบผลตอบแทนที่เพิ่มขึ้น ดังนั้นการเพิ่มขนาดของศูนย์บริการสาธารณสุขเป็นสิ่งที่ควรกระทำเพื่อเพิ่มประสิทธิภาพขนาดให้ดียิ่งขึ้น การเพิ่มจำนวนแพทย์เป็นหนึ่งในวิธีแก้ปัญหาเพราะจากการศึกษาพบว่าอัตราส่วนแพทย์ต่อเจ้าหน้าที่อื่นๆและจำนวนแพทย์มีผลด้านบวกต่อค่าคะแนนประสิทธิภาพ

สาขาวิชา เศรษฐศาสตร์สาธารณสุขและการจัดการบริการสุขภาพ ลายมือชื่อนิสิต...

ปีการศึกษา 2553 ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก.....................

5385720929 : MAJOR HEALTH ECONOMICS AND HEALTH CARE MANAGEMENT

KEYWORDS : HEALTH CENTERS/ TECHNICAL EFFICIENCY / DEA / BANGKOK METROPOLITAN AREA

CHEERANUN CHINARKSORN : TECHNICAL AND SCALE EFFICIENCY IN BANGKOK METROPOLITAN AREA. ADVISOR : ASSOC. PROF. PONGSA PORNCHAIWISESKUL, Ph.D., 64 pp.

This study aims to measure the technical and scale efficiency of 68 health centers in Bangkok Metropolitan Area from 2009 - 2010 as 136 decision making units (DMUs). Data envelopment analysis (DEA) method is used to analyze technical and scale efficiency and ordinary least square regression is used to analyze the determinants of efficiency.

DEA results showed the average technical efficiency under constant return to scale assumption (TEcrs) was 0.8866, the average technical efficiency under variable return to scale assumption (TEvrs) was 0.9268, and the average scale efficiency was 0.9553. There were 55 efficient DMUs from 136 DMUs for overall technical efficiency scores that 40.44% of DMUs were overall technical efficiency. There were 86 efficient DMUs from 136 DMUs that 61.76% of DMUs were pure technical efficiency (TEvrs) and there were 58 efficient DMUs from 136 DMUs that 42.65% of DMUs were scale efficiency. For the OLS regression, it found that the ratio of doctor to other staff, the ratio of nurse to other staff, the ratio of general patient visits to doctor, the ratio of family planning to nurse had a positive impact on pure technical efficiency (TEvrs) scores. The ratio of dentist to other staff had a negative impact on pure technical efficiency (TEvrs) scores. For scale efficiency scores, the result revealed the number of doctor had a positive relationship with scale efficiency (SE) scores. All above information could be used for policy makers in health sector of BMA to improve inefficient health centers in proper direction such as most of the pattern of scale inefficiency were increasing return to scale which can be improved through up-sizing. Focusing on increasing number of doctors should be one solution to be considered because from the study showed that the ratio of doctor to other staffs and number of doctors significantly related to efficiency scores.

Field of Study : Health Economics and Health Care Management	Student's Signature ....
Academic Year : 2010	Advisor's Signature ....

ACKNOWLEDGEMENTS

I would like to thanks and appreciation to my thesis advisor, Assoc. Prof. Pongsa Pornchaiwiseskul, Ph.D. for his guidance ,feedbacks, and great encouragement throughout the entire thesis process.

I would like to thanks my thesis committee, Asst Prof. Phisanes Jessadachatr, Ph.D., Assoc Prof. Siripen Supakankunti, Ph.D., and Doctor Porntep Siriwanarangsun for their supports, comments, and revisions for my thesis.

I also thanks to all my teachers, Faculty of Economics, Centre for Health Economics and staffs for their kindness, and helpfulness.

I would like to thanks to Bangkok Metropolitan administration (BMA) for their permission and support data collection.

Finally, I would like to thanks my parents for their love, support and encouragement during this program.

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

BMA	Bangkok Metropolitan Administration
CRS	Constant return to scale
DEA	Data envelopment analysis
DMUs	Decision making units
DRS	Decreasing return to scale
IRS	Increasing return to scale
OLS	Ordinary least square
S.D.	Standard deviation
SE	Scale efficiency
TEcrs	Technical efficiency under constant return to scale assumption
TEvrs	Technical efficiency under variable return to scale assumption
VRS	Variable return to scale

CHAPTER I

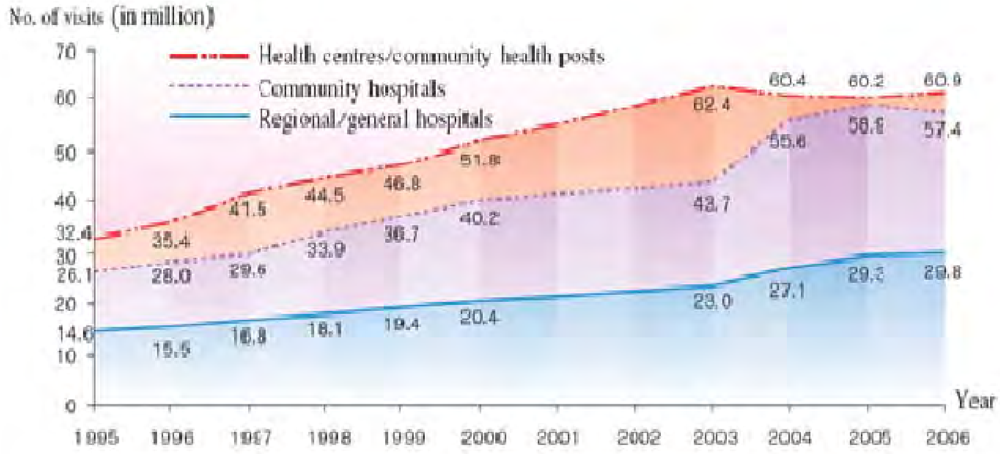
INTRODUCTION

1.1 Problem and its significant:

Thailand implemented the universal coverage scheme for all Thai citizens in 2002. The policy of this scheme is to contact primary health care units to provide services. PHC units are the first contact point for the beneficiaries to receive health services, and the beneficiaries are not allowed to go directly to secondary or tertiary care without referral from the primary health care unit.

Health care demand increases more and more in all levels of health care providers. Statistics indicated that health centers and community hospitals were the most popular source of health care especially in primary health care services (Bureau of health service system development, MOPH)

Figure 1.1 Number of OPD visits from year 1995 - 2006



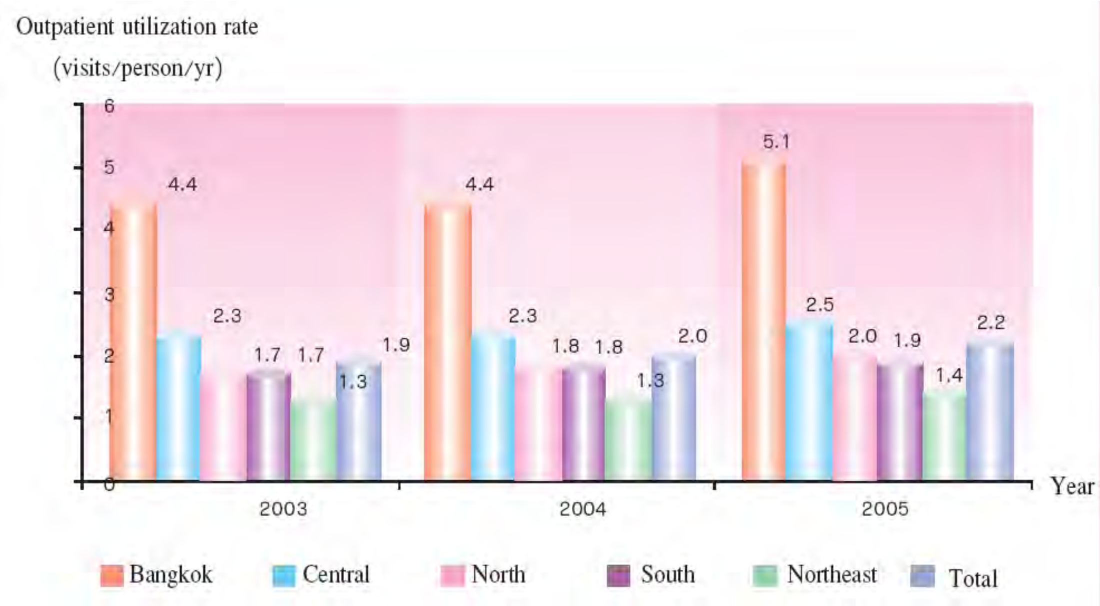
SOURCE: Bureau of health service system development, (2008)

Thai health system has been expanded to provide health care services at all levels from primary to tertiary level.

In Bangkok, there were 5 medical school hospitals, 26 general hospitals, 14 specialized hospitals and institutions, and 68 health centers (Thailand health profile, 2008)

Throughout the country, beyond Bangkok, there are 6 medical school hospitals, 25 regional hospitals, 47 specialized hospitals, 70 general hospitals, 730 community hospitals, 9762 health centers in every sub-district. In community level, there are 311 community health stations, 66223 community health centers in remote are, and 3108 community health centers in rural are 2008 (Thailand health profile, 2008).

Figure 1.2 Outpatient utilization rate in each region of Thailand

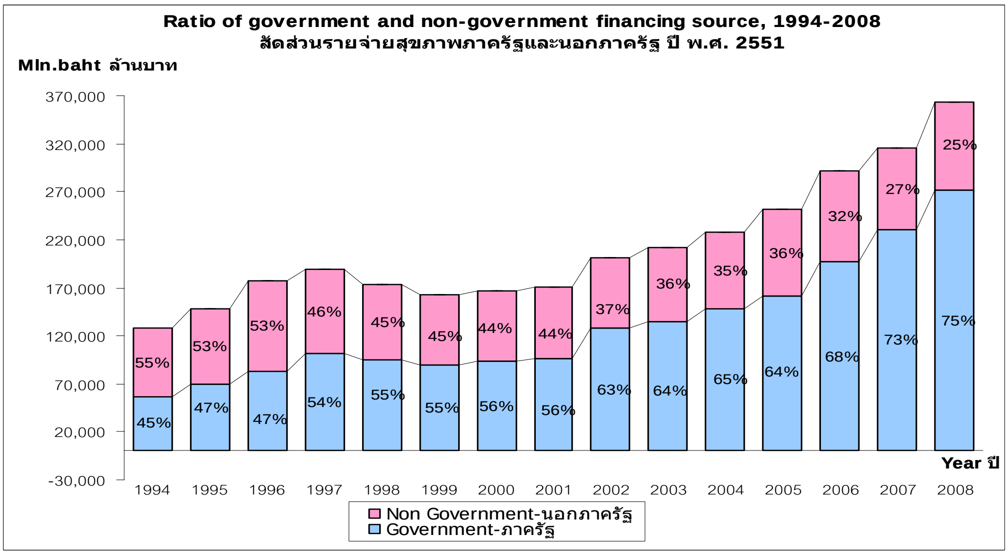


SOURCE: Thailand Health Profile, (2008)

The rate of out-patient service utilities was highest in Bangkok (Thailand health profile, 2008). Out-patient visits in health center in Bangkok were increase every year from 1,179,064 visits in 2001 to 1,481,661 visits in 2008 (source: Public Health System Development Division, Health Department: Bangkok Metropolitan Administration).

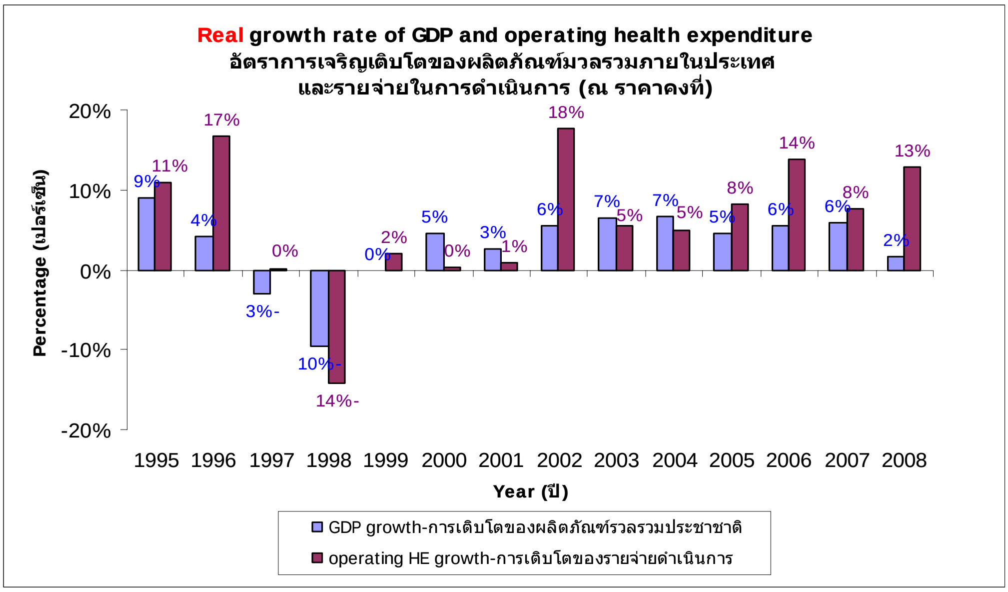
Moreover, Thailand's health expenditure increased dramatically after implemented UCS and still increases in every year (Thailand national health account).

Figure 1.3 The ratio of government and non-government financing source, 1994-2008



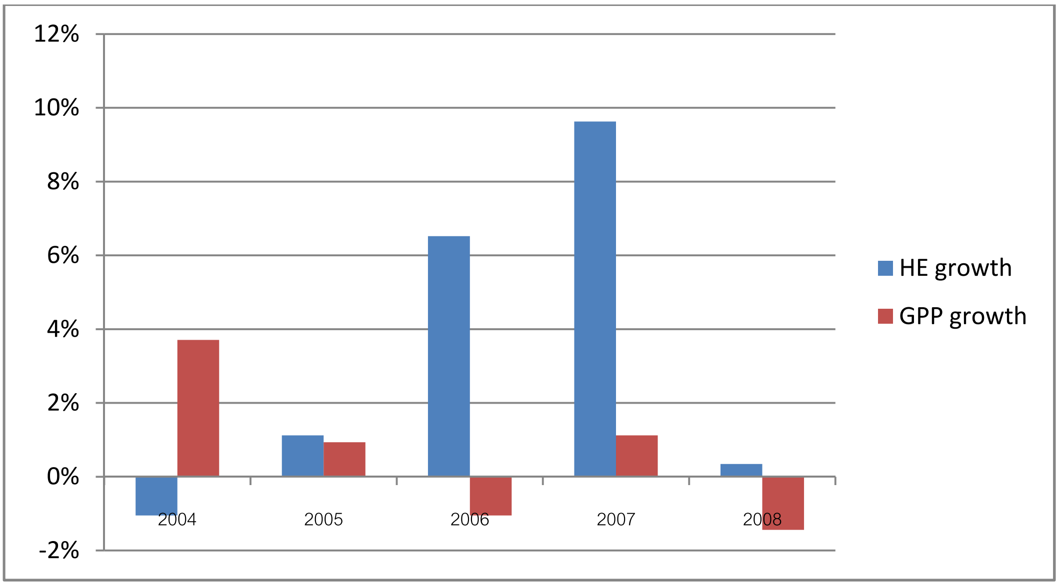
SOURCE: Thailand Health Profile, (2008)

Figure 1.4 Real growth rate of GDP and operating health expenditure



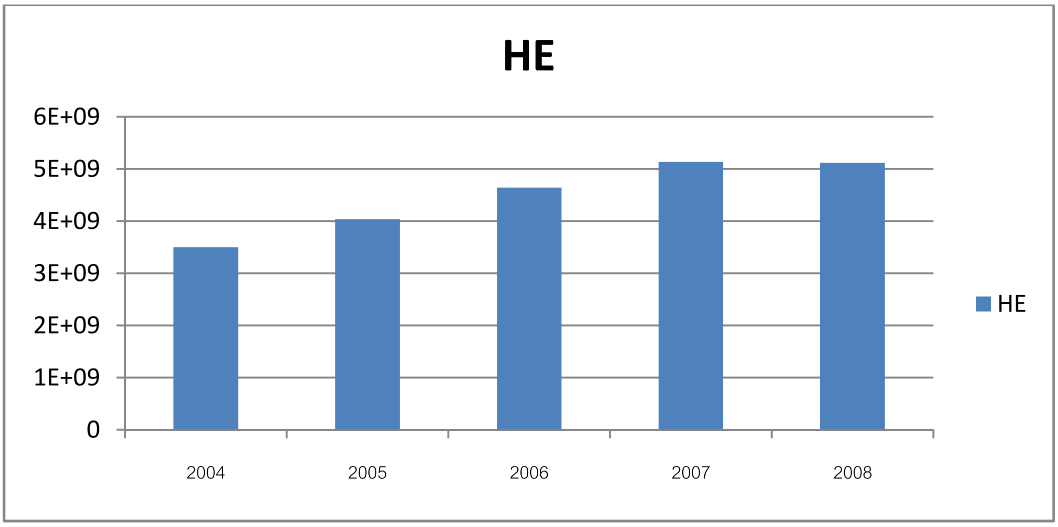
SOURCE: Thailand Health Profile, (2008)

Figure 1.5 Growth rate of GPP and health expenditure in Bangkok



SOURCE: The Bangkok Metropolitan Administration, (2009)

Figure 1.6 Health expenditure in Bangkok, 2004-2008



SOURCE: The Bangkok Metropolitan Administration, (2009)

Health expenditure in Bangkok increased every year from 3,498,561,600 baht in 2004to 5,117,383,100 baht in 2008 and trended to increase in the future.

If health care demand still increases while the budget to health care providers does not increase in the same rate, the financial problem in health care providers will increase in the future. One of best solution for this problem is to using resources at the most efficient way.

Data envelopment analysis with regression analysis can provide evidence of efficiency and factor that influences the efficiency score. Decision making units (DMUs) are the units using appropriate portion of inputs to produce outputs to compare efficiency (Bhirombhakdi, 2008)

In the previous study in Thailand, there are some studies of technical efficiency of university hospitals, regional hospital, public provincial hospitals, medium-size community hospitals. But in health centre has never studied before in Thailand. Therefore, I am interested in studying technical efficiency of health centers in Bangkok Metropolitan Area, Thailand by using DEA and regression analysis.

1.2 Health centers under BMA, Bangkok

Health Centers are under the Department of Health, Bangkok Metropolitan Administration. There are 68 of the Health Centers that provide services promotion, prevention treatment, rehabilitation, and curative care.

Essential elements of PHC:

- Education concerning prevailing health problems and the methods of preventing and controlling them.
- Promotion of food supply and proper nutrition.
- Maternal and child health care, including family planning.
- Adequacy of safe water supply and basic sanitation.
- Immunization against major infectious diseases.
- Prevention and control of locally endemic diseases.
- Appropriate treatment of common diseases and injuries.
- Dental health/ oral hygiene
- mental health
- Prevention and control HIV/AIDS
- Prevention and control of accidents and non-communicable diseases.

Health Bangkok Plan 2010-2013

Goal: Bangkokians will be healthier.

Indicator: 1. Decreased rates of preventable diseases (heart disease, hypertention, diabetes and cancer) and epidemic/contagious disease in Bangkok (diarrheas, haemorrhagic fever, tuberculosis, AIDS)

2. Increased rates of people participation for promoting community health.

Strategies

1. **Support the people for their healthy life by reducing risk factors toward preventable illnesses, and have activities for creating good health.** Encouraging people for promoting their health in educational places, hospitals, health centers, and communities to prevent and control of communicable and non-communicable diseases, and epidemic diseases but chronic diseases that is TU, HIV/AIDS, diabetes, hypertension.
2. **Promote mental and emotional health of people.** Operate the public health works by the mobile medical service unit, home visit, including nurse care and rehabilitation the health of the elderly, building the social protection system by religious principle, giving consultations on mental health on people.

3. **Develop the community capacity for health promotion and disease prevention and control.**
   Support the volunteers and expanding the group network and health centers in the communities to build voluntary mind. Developing to increase the volunteer capacity for public health, community leaders, youth leaders. Constructing people networks in monitoring and prevention of health problems, fortification of the system monitoring contagious diseases and epidemic in community, campaign and propagation of knowledge to control and prevent diseases in community.
4. **Promote organizing informal education activities in order to Bangkok is the lifetime learning source.**
   Promoting social behaviors to consume hygienic food, inspect contaminated substance in food, monitor, prevent and use of legal measures in eliminating micro-organism residues in meat, develop and prepare sanitation standard for food-producing places.
5. **Promote sport and exercise for people health.**
6. **Accelerate development of health service unit to provide holistic service with equivalent quality comparable with the international standard.**
   Building potential of doctors, nurses and health personnel, develop of health care to meet the international standards, support medical material, equipment and supply, study for research development of medical innovation and technology, and develop medical emergency service quality and mobile medical services.
7. **Promote child and youth health to meet the standard criteria.**
   To prevent and redress narcotic problems and HIV/AIDS, monitor risk behavior on vice and narcotic of children and youth in the educational institutions and community, also provide vaccination, prevention of obesity and malnutrition.
8. **Treat and rehabilitate physical and mental health of resident in the political unrest affected area.**
   Provide check-up/treatment of people injures from the political unrest physically and mentally.

1.3 Research question

General question

What are technical efficiency and scale efficiency of health centers in Bangkok Metropolitan Area in Thailand?

Specific question

What are the technical efficiency scores of health centers in Bangkok Metropolitan Area in Thailand?

What are the scale efficiency scores of health centers in Bangkok Metropolitan Area in Thailand?

What are factors determining the efficiency scores of health centers in Bangkok Metropolitan Area in Thailand?

1.4 Research objective

General objective:

To measure the technical efficiency and scale efficiency of health centers in Bangkok Metropolitan Area in Thailand.

Specific objective:

To evaluate technical efficiency of health centers in Bangkok Metropolitan Area in Thailand.

To evaluate scale efficiency of health centers in Bangkok Metropolitan Area in Thailand.

To analyze the factors affecting efficiency of health centers in Bangkok Metropolitan Area in Thailand.

1.5 Scope of study

This is study using the secondary source of cross-sectional data of year 2009-2010. The study will cover the 68 health centers in Bangkok Metropolitan Area, Thailand.

1.6 Possible benefits

This study will offer the technical efficiency of health centers in Bangkok Metropolitan Area in Thailand. We will know the efficiency profile of the whole picture, the individual health centers in Bangkok Metropolitan Area, the best practice of health centers and inefficiency health centers. Moreover, it also offers the factors effecting on the efficiency of health centers in Bangkok Metropolitan Area.

The policy makers can use this information to improve the inefficiency health centers under BMA to be more efficiency. The health center administrators use this information to improve their health centers to be more efficiency in the right direction.

CHAPTER II

LITERATURE REVIEW

Farrell (1957) was the first person to develop a deterministic frontier analysis by using non-parametric method to define a simple measure efficiency which could account for multiple inputs. He divided the production efficiency to two components, technical efficiency or TE and allocative efficiency or AE.

Technical efficiency reflects the ability to produce maximal possible of outputs from a given sets of inputs or minimum possible of inputs from a given sets of outputs. Allocative efficiency reflects the ability to use inputs in optimal proportion, given their prices.

The initial DEA model was developed by Charnes, Cooper, and Rhodes (CCR model) (1978), build on the framework of Farrell (1957). CCR model is referred to CRS (constant return to scale) model. Banker, Charnes, and Cooper (1984) developed BBC model that is referred to as the VRS (variable return to scale) model.

Technical efficiency (TEcrs) under constant return to scale assumption can be released into pure technical efficiency under variable return to scale assumption (TEvrs) and scale efficiency (SE)

$$TEcrs = TEvrs * SE$$

Technical efficiency depicts the capability of production units to transform their inputs into outputs. A firm is perceived as efficient if it produces the maximum possible output, given its available inputs or, equivalently, if it utilizes a minimum level of inputs to produce a given amount of outputs.

Scale efficiency is the potential productivity gain from achieving optimal size of a firm. To compare efficiency on the variable return to scale frontier to efficiency on constant return to scale will find SE.

$$SE = TEcrs / TEvrs$$

Scale efficiency is classified into 3 groups.

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

The optimal scale efficiency pattern is constant return to scale. Increasing return to scale and decreasing return to scale are the scale inefficiency due to being too small firm (in IRS) or too large firm (in DRS). Increasing returns are said to exist when a proportional increase in inputs causes outputs to increase by a greater proportion, whereas decreasing returns is the situation in which an increase in inputs causes output to increase by a smaller proportion.

Input-oriented measurement assumes that quantities of inputs can be changed while quantities of outputs are fixed.

Output-oriented measurement assumes that firm can maximize quantities of outputs while quantities of inputs are fixed.

Osei et al (2005) recommended that input-oriented measurement was used for hospital analysis and output-oriented measurement was used for health center analysis. The management of health centers has no control over inputs, especially it's staffing. However, given their primary health care orientation, with a strong bias towards health promotion and disease prevention, they can influence a great number of people seeking, for example, antenatal care, family planning services, birthing services, immunizations and health education, through their public health outreach work among communities.

2.1 Technical efficiency definition

Pareto-Koopmans Definition: Full (100%) efficiency is attained by any DMU (decision making unit) if and only if none of its inputs or outputs can be improved without worsening some of its other inputs or outputs.

In most management or social science applications the theoretically possible levels of efficiency will not be known. The preceding definition is therefore replaced by emphasizing its uses with only the information that is empirically available as in the following definition:

Definition (Relative Efficiency): A DMU is to be rated as fully (100%) efficient on the basis of available evidence if and only if the performances of other DMUs does not show that some of its inputs or outputs can be improved without worsening some of its other inputs or outputs.

Technical efficiency is producing maximum outputs from a given set of inputs or minimum amount of inputs from a given set of outputs (Hollingsworth et al , 1998).

There are 4 methods that are used for technical efficiency measurement.

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

Table 2.1 Summary of the properties of the 4 methods

	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		

SOURCE: Coelli, (1998)
NOTE: Y = Yes, N = No, * = depend on the model used

From many previous studies in health sectors, efficiency were mainly used DEA and SF, and the most use were DEA.

DEA is more appropriate than SF in not for profit sectors (Coelli, 1998). As judged by Hollingworth et al. (1998), on balance, DEA is probably the most appropriate technique currently available for measuring efficiency in health services. The DEA method admits multiple inputs and multiple outputs that are appropriate for health care services which are not assumption, production function, and distribution of error.

Strengths and weaknesses of DEA (Osei et al, 2005)

Strengths of DEA

Many studies chose to employ DEA approach to estimate technical efficiency of individual hospitals and health centers because of its unique strengthens:

1. It can handle multiple input and multiple output models.
2. It does not require an assumption of a functional form relating inputs to output.
3. Health facilities are directly compared against a peer or combination of peers.
4. Inputs and outputs can be very different units

Weaknesses of DEA

1. It attributes any deviation from the "best practice frontier" to inefficiency, while some could be due to statistical noise, e.g. epidemics or measurement errors.
2. DEA is nonparametric technique, statistical tests of hypotheses concerning the inefficiency and the structure of the production function is difficult.

There are many application of DEA method in health sector. Many studies used input factors including capital and labor resources and output factors including outpatient visits, inpatient days, and some special factors such as graduate students.

In economics inputs can be divided to 2 groups, labor and capital. Bhirombhakdi (2008), Charunwatthana (2007) used number of beds to be a capital input factor. They used number of physicians, nurses, dentists, and other personnel are proxies of labor input factors. Phuong (2009) used number of room as a proxy of capital input factor and medical staffs as proxies of labor input factors.

Outputs may be measured at intermediate level or final outcome. For example, outputs in treatment services are OPD and IPD. Some studies were divided IPD into surgical IPD and non-surgical IPD.

The choice of inputs and outputs in DEA approach has very important implication for the results obtained (Bahurmoz, 1998). To validate variations in TE score, TE scores were regression against explanatory and control variables (Phoung, 2009). If TE scores are used in a two-stage regression analysis to explain efficiency, OLS is required. There are three important reasons to use OLS

1. OLS is easy to use.
2. The goal of minimizing sum square of residual is appropriate to use for reducing error.

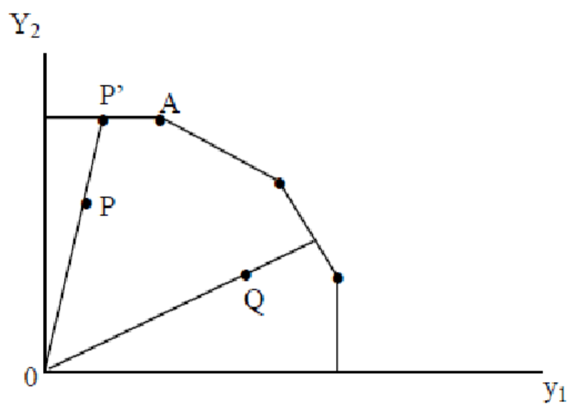
3. OLS estimates have a number of useful characteristics.

Standard multiple regression assumes a normal and homoscedastic distribution of the disturbance and the dependent variables. However, in case of limited dependent variables, the expected error will not equal zero. Therefore, the standard regression will lead to a biased estimate. The distribution of TE score is never normal distribution. 1/TE score helps to normalized distribution of TE (Chilingerian, 1995).

2.2 Data envelopment analysis: DEA

Data envelopment analysis is a non-parametric technique based on linear programming. It establishes an efficiency frontier by solving the series of mathematical programming problems to find the most efficient production units and measure the relative efficiency of each decision making unit (DMU). Efficiency measurement concept is to measure the distance between the current position of a firm and the most efficiency position (on the frontier). The more distance is, the lower efficiency the firm is. A positive efficiency ratio of less than 1 are defined as inefficient compare to an efficiency ratio of 1. The efficiency ratio of 1 represent the best practice units when compare with the others in their subset.

Figure 2.1 An output-orientation with 2 outputs



SOUCE: Coilli, (1998)

Each point of the above is a decision making unit. The line is the efficiency frontier that is lined from the most efficiency 4 points (the maximum combination of outputs that can be produced for a given set of inputs). P and Q are not on the line. Therefore, they are inefficiency.

TE score = OP/OP'

Technical inefficiency score = 1 – OP/OP'

= PP'/OP'

This initial DEA model assumes constant returns to scale (CRS). Later on, Banker et al. proposed a DEA model that assumes the existence of variable returns to scale (VRS), which is applicable when returns to scale exist.

Constant Returns to Scale (CRS) model

The constant returns to scale model assumes a production process in which the optimal mix of inputs and outputs is independent of the scale of operation. The following CRS model measures overall technical efficiency for each of the sample health centre. The objective function is to maximize the efficiency score h_0 for health centre j_0, subject to the constraints that no health centre will be more than 100% efficient and the coefficient values are positive and non-zero, when the same set of *u* and *v* coefficients (weights) are applied to all other health centers being compared.

$$\text{Max } h_0 = \sum_{r=1}^{s} u_r y_{rj_0}$$

$$\text{Subject to } \sum_{i=1}^{m} v_i x_{ij_0} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \leq 0 \quad j = 1, \ldots, n$$

$$u_r, v_i \geq 0$$

Variable Returns to Scale (VRS) model

The variable returns to scale (VRS) model was estimated to facilitate the estimation of scale efficiency. It assumed that changes in inputs would lead to disproportionate changes in outputs. A percentage increase in input can yield less than a percentage change in output signifying diseconomies of scale, or more than a percentage increase of output implying existence of economies of scale. The scale efficiency (SE) is the ratio of constant returns to scale technical efficiency (TE_{CRS}) to variable returns to scale technical efficiency (TE_{VRS}).

$$SE = (TE_{CRS})/(TE_{VRS})$$

Scale efficiency is classified into 3 groups.

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

From the VRS model, it is possible to analyze whether a health centre's production indicates increasing return to scale, constant return to scale, or decreasing return to scale by the sign of the variable z_{jo}. Increasing returns to scale exists if the value of z_{jo} is greater than zero ($z_{jo} > 0$), constant returns to scale if the value of z_{jo} is equal to zero ($z_{jo} = 0$), and decreasing returns to scale if the value of z_{jo} is less than zero ($z_{jo} < 0$). Thus, we can analogize the existence of efficiencies of scale similar, confirm the most productive scale size (minimum efficient scale) of a health centre and estimate the number of health centers operating at the efficient scale.

$$Max\ h_0 = \sum_{r=1}^{s} u_r y_{rj_0} + z_{j0}$$

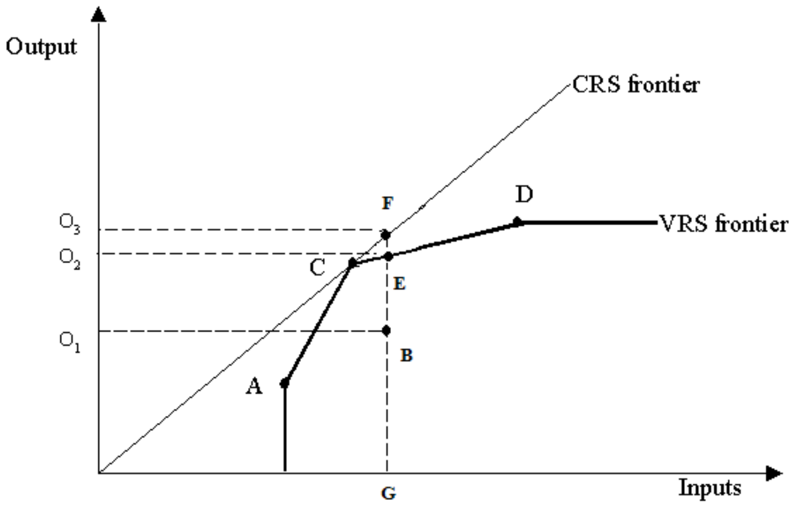
$$\text{Subject to} \quad \sum_{i=1}^{m} v_i x_{ij_0} + z_{j0} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} + z_{j0} \leq 0 \quad j = 1, \ldots, n$$

$$u_r, v_i \geq 0$$

This study concentrated on the VRS model. This is so because the VRS model isolates the pure technical efficiency component and scale efficiency which related to the size or structure of the decision making unit (DMU). Health centers that are overall efficient exhibit constant returns to scale. The size of a Health centre may sometimes be a cause for inefficiency. A health centre may be too large for the volume of activities that it is conducting; and therefore may experience inefficiencies of scale. On the other hand, a health centre may be too small for its level of operation, and thus experience efficiencies of scale. Inefficiency due to congestion refers to too many inputs (staff, funds, drugs, etc) leading to decreased output or what is commonly known as inefficiencies of scale which to some extend are realistic assumption for a developing country where political and other irrational reasons affect the establishment of facilities such health centers, schools etc.

Figure 2.2 An output-orientation with single input and single output



SOUCE: Coilli, (1998)

Four data points (A, B, C, and D) are used to estimate the efficient frontier and the level of capacity utilization under both scale assumptions. With constant returns to scale, the frontier is defined by point C for all points along the frontier, with all other points falling below the frontier (hence indicating capacity underutilization). With variable returns to scale, the frontier is defined by points A, C and D, and only point B lies below the frontier. The capacity output corresponding to variable returns to scale is lower than the capacity output corresponding to constant returns to scale.

$TE_{CRS}(B) = GB/GF$

$TE_{VRS}(B) = GB/GE$

$SE(B) = GE/GF = TE_{CRS}/TE_{VRS}$

Input and output orientation:

Input Orientated measurement

Input orientated measurement assumes that the firm is able to change quantities of input, while quantities of outputs are fixes, to meet the most efficient point.

In the hospital analysis the input orientation assumed that these facilities had limited control over the volume of their outputs. There was no linkage between staff earnings and output; thus, there was no incentive for inducing demand for health services. Otherwise, hospital management has got greater control over the use of inputs. Thus, an input-oriented DEA model was used for hospital analysis (Osei et al, 2005).

Output orientated measurement

Output oriented measurement assumes that quantities of outputs can be changed to match with the most efficient point while quantities of inputs are fixed.

Output orientation was assumed for health centers. The management of health centers has no control over inputs, especially it's staffing. However, given their primary health care orientation, with a strong bias towards health promotion and disease prevention, they can influence a great number of people seeking, for example, antenatal and postnatal care, family planning services, birthing services, immunizations and health education, through their public health outreach work among communities. Thus, the output-oriented DEA model was used for the health center analysis (Osei et al, 2005).

2.3 Analysis of factors effecting technical efficiency scores

Budget factors, Phoung (2009) found that free drug was related to technical efficiency in community health centers. Charunwatthana (2007) mentioned about the universal coverage scheme has a negative relation to technical efficiency.

Internal and external factors, Larger size hospitals tend to be efficient than smaller hospitals. The internal factors included age of hospitals, size of hospitals, technology, and management of human resources and the external factors included community demographic situation and competitive environment (Pavananunt, 2004)effect to technical efficiency.

Charunwatthana (2007) found that number of beds was related to technical efficiency in public hospitals (large hospitals are more efficient than small hospitals).

Input output mix factor, Bhirombhakdi (2008) found that bed-physician ratio and pharmacist-physician ratio related to scale efficiency score significantly. Technical efficiency score related to occupancy rate, outpatient visit-physician ratio, and number of medical student year 6^{th}-bed ratio. Charunwatthana (2007) beds-physician ratio, other personnel-physician ratio, nurses-physician ratio, trained interns-physician staff ratio, and trained interns-physician staff ratio were related to pure technical efficiency scores. In-patient visits adjusted with relative weight of DRG per physician was related to scale efficiency scores.

Location, Location difference includes differences in socio-economic status, demographic characteristics. Charunwatthana (2007) found that geographic location was related to technical efficiency in public hospitals.

Specialization, hospital offering a large number of service types faces higher cost. The management of hospitals with a more complex service is likely to face difficulties to organize the production efficiently (Chang, 1998). Hospital had different levels of specialization in patient services, and more specialized hospitals were more likely to be efficient.

2.4 Previous studies on technical efficiency in PHC

Kirigia, Sambo, and Scheel (2001) applied DEA approach to investigate TE of 155 public clinics in Kwazulu-Natal province of South Africa. Two inputs were nurses and general staffs and eight outputs were number of antenatal, number of births, number of child health, number of dental care visits, number of family planning, number of psychiatry visits, number of sexual transmitted diseases visits, number of tuberculosis visits. 30% of clinics were found to be technical inefficiency, 16% had on efficiency scores of 50% or less. They provided the amount of input reductions or output increases to achieve technical efficiency.

Renner et al.(2005) used output-oriented DEA model to evaluate TE and SE among 37 peripheral health units in Sierra Leone. The input variables used technical staff, sub-ordinate staff, materials and supplies, capital inputs. Six outputs were antenatal care, babies delivered, growth monitoring visits, family planning visits, under5' immunized+ pregnant women immunized, health education. Results showed that 22 (59%) of the 37 PHUs were found to be technical inefficiency. 24 (65%) PHUs were found to be scale inefficiency. The existing high level of technical and scale inefficiency, scaling up of the interventions to achieve both global and regional targets such as the MDG. They strongly recommended that Sierra Leone and other countries should institutionalize health facility efficiency monitoring at the Ministry of Health headquarter and at each health district headquarter.

Osei et al.(2005) used DEA to estimate the technical efficiency of 17 district hospitals and 17 health centers. The health centers were estimated with a total of 6 variables: 4 outputs and 2 inputs. The four outputs were the number of child deliveries, the number of fully immunized children under the age of 5 years, the number of other maternal (i.e. antenatal care, postnatal care and family planning services) and childcare (nutritional/child growth monitoring) visits, and the number of outpatient curative visits. The two inputs were the number of technical staff (this included medical assistants, nurses and paramedical staff), and the number of support or subordinate staff (including cleaners, drivers, gardeners, watchmen and others). 8(47%) hospitals had been technical efficiency with average TE scores of 61%. 10(59%) hospitals were found scale inefficiency. 3(18%) health centers had been technical inefficient and 8 (47%) had been scale inefficient. This study had demonstrated to policy makers the versatility of DEA in measuring inefficiency among individual facilities and inputs. There was a need for planning and budgeting unit of Ghana Health Services to continually monitor the productivity growth, allocative efficiency and technical efficiency of all its health facilities (hospitals and health centers) in the course of the implementation of health sector reforms.

Corredorra, and Kimberly (2006) applied DEA methodology to estimate relative clinic efficiency among 353 addiction treatment clinics in Maryland and were found that 111 clinics were on the efficient frontier. Their study found that number of patient treated is positively associated to clinic efficiency. While state funding, patient social network, and travel distance to the clinic have no impact on clinical efficiency.

Kontodimopoulos et al. (2007) studied The effect of environmental factors on technical and scale efficiency of primary health care providers in Greece. The sample comprised of 194 units (103 NHS and 91 IKA). Efficiency was measured with Data Envelopment Analysis (DEA) using three inputs, -medical staff, nursing/paramedical staff, administrative/other staff - and two outputs, which were the aggregated numbers of scheduled/emergency patient visits and imaging/laboratory diagnostic tests. Facilities were categorized as small, medium and large (<15,000, 15,000–30,000 and >30,000 respectively) to reflect catchment population and as urban/semi-urban or remote/island to reflect location. In a second stage analysis, technical and scale efficiency scores were regressed against facility type (NHS or IKA), size and location using multivariate Tobit regression. They found that technical efficiency, IKA performed better than the NHS, smaller units better than medium-sized and larger ones, and remote/island units better than urban centers. As for scale efficiency results were reversed in respect to facility size and location. Specifically, larger units performed better, and urban units showed higher scale efficiency than remote ones. 75% of facilities appeared to be functioning under increasing returns to scale. Tobit regression models showed that facility type, size and location were significant explanatory variables of technical and scale efficiency.

Akazili et al.(2008) applied DEA method to measure the extent of TE of public health centers in Ghana. This study used DEA to calculate The TE of 89 randomly sampled health centers. Inputs in health centre were number of non clinical staff including laborers, number of clinical staff, number of beds and cots, expenditure on drugs and supplies. Outputs were general outpatient visits, number of antenatal care visits, number of deliveries, number of children immunized, number of family planning visits. The results showed that 65% of health centers were technical inefficiency and were using resources that they did not actually need. The results broadly point to grave inefficiency in the health care delivery system of public health centers and significant amounts of resources could be saved if measures were put in place to curb the waste.

Phoung (2009). measured the technical efficiency of 495 community health centers in rural Red river delta region in Vietnam by using DEA approach. There were five input factors; number of room, number of doctors, total of obstetric assistants and midwifes, number of assistant physicians, and number of nurses. Output factors included number of pregnancy visits, number of maternal and child health care visits, number of other patient visits. The results indicate that the level of technical efficiency in health center is rather low. Regarding the determination of technical efficiency, it is found that staff salary and free-in charge drugs has a positive impact on technical efficiency. Health center in Hanoi has lower technical efficiency than others under constant return to scale assumption.

2.5 Previous studies in Thailand

Pavananunt (2004) studied of technical efficiency of 662 public community hospitals in Thailand. The results showed average efficiency score was 0.55 and there was a wide variation of technical efficiency scores; in addition, larger size hospitals tend to be efficient than smaller hospitals. There were the external factors and the internal factors that effect to TE. The internal factors included age of hospitals, size of hospitals, and management of human resources and the external factors included community demographic situation and competitive environment.

Pamasiriwat (2007) applied DEA model to measure 166 medium-size community hospitals under MOPH in Thailand about the relative efficiency of hospital cost management, based on cost and performance statistic of hospitals for fiscal year 2005. The results found the average efficiency was 78% and 17 hospitals were on the cost frontier based on the variable return to scale assumption. The researcher suggested investigating qualitative study from hospital manager to deep understand the real situation.

Charunwatthana (2007) used DEA model to measure 805 public hospitals in Thailand. The results showed that the large hospitals were more efficient than small ones and the most public hospitals were operating very close to their optimal size. He found that number of beds, occupancy rate, geographic location, and service complexity were associated with technical efficiency.

Bhirombhakdi (2008) measured hospital efficiency in 5 university hospitals in Thailand by using DEA. The results found that efficiency scores were ranged from 0.525 to 1 and 72.4% of DMUs were found inefficiency in scale, while 31% were inefficiency in technique. Among the scale inefficiency, 95.2% of hospitals were operated with decreasing return to scale pattern. He found that bed-physician ratio and pharmacist-physician ratio related to scale efficiency score significantly. Technical efficiency score related to occupancy rate, outpatient visit-physician ratio, and number of medical student year 6^{th}-bed ratio.

Thianjaruwatthana (2009) used Output-orientated Data Envelopment Analysis to measure the technical efficiency of 25 regional hospitals in Thailand. The results revealed that there were 31 efficient DMUs from 50 DMUs for overall technical efficiency scores. There were 36 efficient DMUs from 50 DMUs for pure technical efficiency scores. For scale efficiency scores, there were 32 efficient DMUs from 50 DMUs. The results revealed that beds-physician ratio, other personnel-physician ratio, nurses-physician ratio, trained interns-physician staff ratio, and trained interns-physician staff ratio were related to pure technical efficiency scores. For scale efficiency scores, in-patient visits adjusted with relative weight of DRG per physician was related to scale efficiency scores. All above information could be used for policy makers in health sector and hospital managers improve the inefficient regional hospitals in proper direction such as most of patterns of scale inefficiency were the increasing returns to scale which can be improved through up-sizing and should supported medical education in regional hospitals which have competency.

CHAPTER III

RESEARCH METHODOLOGY

3.1 Study design

This is a descriptive study employing econometric for analysis. A cross sectional model with secondary panel data in the year 2009-2010 are used for data envelopment analysis (DEA) and regression analysis using ordinary least squares (OLS).

3.2 Target and study population

The target population includes all health centers in Bangkok Metropolitan Area in Thailand. There are sixty eight health centers under BMA in year 2009 and 2010.

3.3 Source of data

Annual report of health centers in year 2009 and 2010

3.4 Analysis technique

This study consists of two stages.

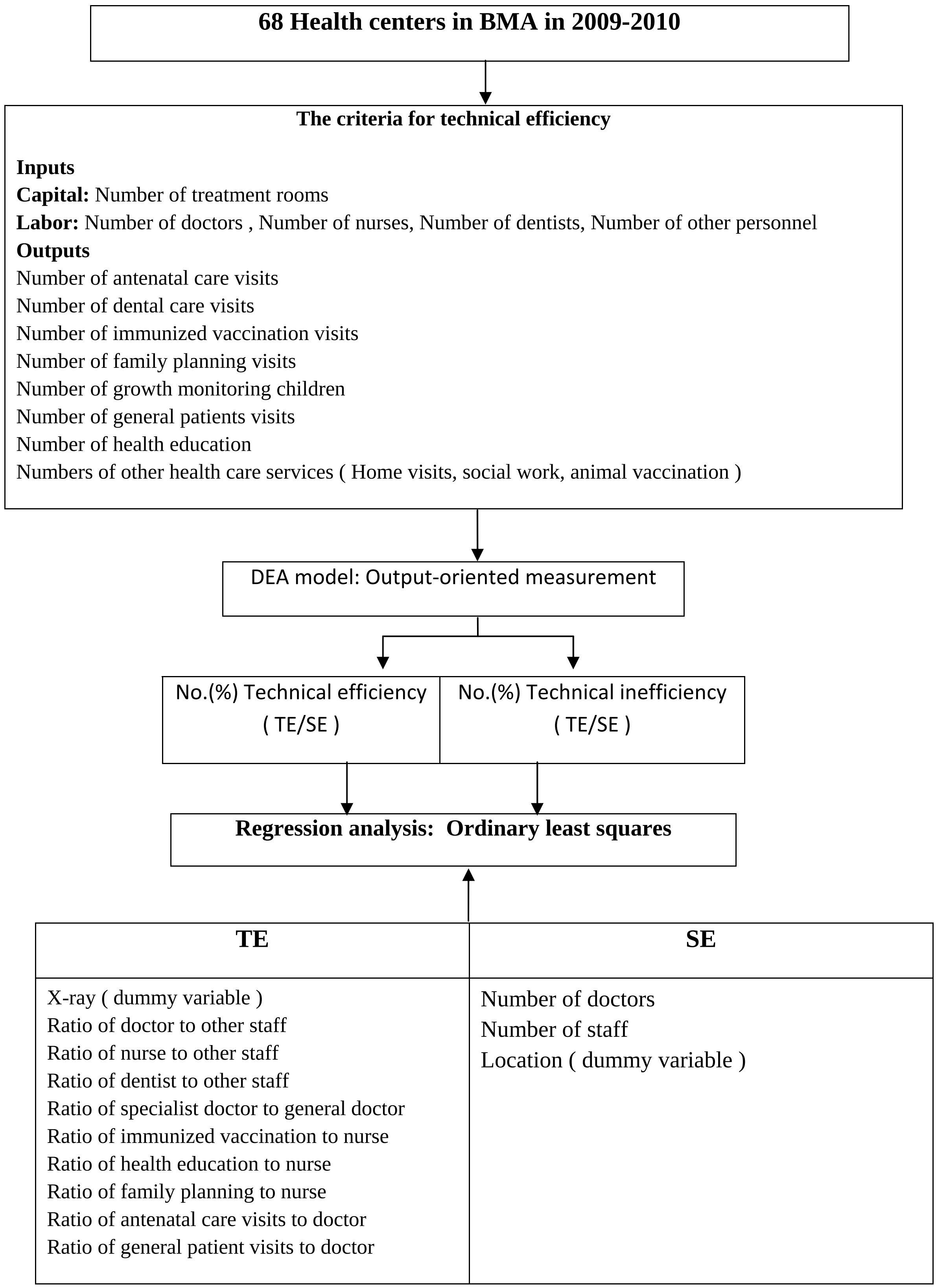
1) Data envelopment analysis (DEA)
2) Regression analysis using ordinary least squares (OLS)

3.5 Conceptual framework

The study consists of two stages. The first stage is to measure the technical efficiency and scale efficiency of health centers under BMA in Bangkok with DEA using output oriented measurement. The results of DEA are technical efficiency under variable return to scale (TEvrs) scores and scale efficiency (SE) scores.

The second stage is to identify the factors affecting efficiency of health centers with regression analysis using ordinary least square (OLS). Technical efficiency under variable return to scale (TEvrs) and scale efficiency (SE) are dependent variable and thirteen explanatory variables will be estimated the magnitude and direction of their relation.

Figure 3.1 Conceptual framework



3.6 Type of data

Secondary data are collected in year 2009 and 2010.

3.7 The DEA output-oriented model

Inputs:

Numbers of room: count for every treatment rooms in the health center in year 2009 and 2010.

Numbers of doctors: count for every doctor in the health center in year 2009 and 2010.

Numbers of nurses: count for every nurse in the health center in year 2009 and 2010.

Numbers of dentists: count for every dentist in the health center in year 2009 and 2010.

Number of other personnel: count for every other personnel in the health center in year 2009 and 2010.

Output:

Number of antenatal care: count for every visit of antenatal care for whole year in each health center in year 2009 and 2010.

Number of dental care visits: count for every visit of dental care for whole year in each health center in year 2009 and 2010.

Number of immunized vaccination visits: count for every immunized vaccination visit for whole year in each health center in year 2009 and 2010.

Number of family planning: count for every family planning for whole year in each health center in year 2009 and 2010.

Number of growth monitoring children: count for every growth monitoring child for whole year in each health center in year 2009 and 2010.

Number of general patient visits: count for every general patient visits for whole year in each health center in year 2009 and 2010.

Number of health education: count for every health education for whole year in each health center in 2009 and 2010.

Numbers of other health care services (home visits, animal vaccination, social work) : count for every home visit, animal vaccination, social work for whole year in each health center in year 2009 and 2010.

Some studies in hospital efficiency used number of bed is a proxy of capital input but in this study uses number of room. Because health centers produce only number of outpatient that there are difference from hospitals which outputs are outpatient and inpatient. This study uses immediate outputs are the proxies of outputs.

The outcome of DEA variable return to scale are technical efficiency scores and scale efficiency.

3.8 Regression analysis

Simple linear regression model using ordinary least square is use to identify the factors affecting on the technical efficiency scores of health centers under BMA. The efficiency scores from the calculation using DEA are made with assumption of homogenous inputs, outputs, and operating characteristics. But they are various respects. To identify and evaluate the impact of determinants on efficiency, the technical efficiency score and scale efficiency score are used as dependent variable while independent variables represent as the efficiency determinants.

Relation between independent variable to TE score

$$TEvrs_i = C_o + C_1{*}Xray_i + C_2{*}D\_other_i + C_3{*}N\_other_i + C_4{*}Dent\_other_i + C_5{*}SD\_D_i + C_6{*}ANC\_D_i + C_7{*}GPT\_D_i + C_8{*}Fam\_N_i + C_9{*}Vac\_N_i + C_{10}{*}Hedu\_N_i + e_i \quad (3\text{-}1)$$

Table 3.1 Explanatory variables of TEvrs score, Name, Definition, and Hypothesis

Variable	Name	Definition, Unit	Hypothesis
Xray	X-ray	Xray = 1 if health centers provide x-ray service.	Positive
D_other	Ratio of doctor to other staff	Number of doctors divide by total of other staffs	Positive
N_other	Ratio of nurse to other staff	Number of nurses divide by total of other staffs	Positive
Dent_other	Ratio of dentists to other staff	Number of nurses divide by total of other staffs	Positive
SD_D	Ratio of specialist doctors to general doctors	Number of specialist doctors divide by general doctors	Positive
ANC_D	Ratio of antenatal care visits to doctors	Number of antenatal care visits divide by total doctors	Positive
GPT_D	Ratio of general patients visits to doctor	Number of general patients visits divide by total doctors	Positive
Fam_N	Ratio of family planning to nurse	Number family planning divide by total nurses	Positive
Vac_N	Ratio of immunized vaccination to nurse	Number of immunized vaccination divide by total nurses	Positive
Hedu_N	Ratio of health education to nurse	Number of health education divide by total nurse	Positive

Hypothesis:

Xray (X-ray) has a positive relationship with TE. X-ray represents the high technology in health centers that only twenty-one health centers provide this service. This factor will improve the quality of health services offering to patients. If health centers have X-ray, it attracts patients to come more than the others.

D_others (Ratio of doctor to other staff) has a positive relationship with TE. This factor is a proxy for size determination of input labor combination between doctor and other personnel. Increase in number of doctor for services will increase efficiency because of deficiency's problem of doctor.

N_others (Ratio of nurse to other staff) has a positive relationship with TE. This factor is a proxy for size determination of input labor combination between nurse and other personnel. Nurses can be a complementary and a substitute for doctors. If health centers have more nurses, doctors will have more time to provide more outputs.

Dent_others (Ratio of dentist to other staff) has a positive relationship with TE. This factor is a proxy for size determination of input labor combination between dentist and other personnel. The higher dentist will provide more outputs of health care services.

SD_D(Ratio of specialist doctor to general doctor) has a positive relationship with TE. This factor is a proxy for size determination of input labor combination between specialist doctor and general doctor. It impact to improve quality of care. Increase in number of specialist doctor for services will increase efficiency because specialist doctor can take care more complex outpatient cases and may attract more patients to come than the others.

ANT_D (Ratio of antenatal care visits to doctor) has a positive relationship with TE. Increasing in this ratio means increasing in output that makes higher efficiency.

GPT_D (Ratio of general patients visits to doctor) has a positive relationship with TE. Increasing in this ratio means increasing in output that makes higher efficiency.

Immun_N (Ratio of immunized children to nurse) has a positive relationship with TE. Increasing in this ratio means increasing in output that makes higher efficiency.

Fam_N (Ratio of family planning to nurse) has a positive relationship with TE. Increasing in this ratio means increasing in output that makes higher efficiency.

Hedu_N (Ratio of health education to nurse) has a positive relationship with TE. Increasing in this ratio means increasing in output that makes higher efficiency.

Relation between independent variable to SE score

$$SE_i = C_o + C_1*D_i + C_2*Staff_i + C_3*Loc_{1i} + C_4*Loc_{2i} + e_i \qquad (3\text{-}2)$$

Table 3.2 Explanatory variables of SE score, Name, Definition, and Hypothesis

Variable	**Name**	**Definition, Unit**	**Hypothesis**
D	Number of doctors	Number of total doctors	Positive
Staff	Number of staffs	Number of total staffs	Positive
Loc_1	Location	Loc_1=1, if location in Inner district =0, if location in the others	Positive
Loc_2		Loc_2 =1, if location in Outer district =0, if location in the others	Negative

Hypothesis:

Doc (Number of doctors) has a positive relationship with SE. This variable is a proxy of size of health centers. The higher doctor will provide more outputs and increase quality of health care services by having time to pay more attention to patients.

Staff (number of staff) has a positive relationship with SE. This variable is a proxy of size of health centers. Larger staffs represent larger area of health center. From the previous study found that large size of hospitals was more efficiency than small ones.

BMA divide Bangkok into 3 that are inner city, intermediate city, and outer city. This study followed to BMA to classified Bangkok into 3 areas and uses intermediate city as a reference base.

Loc_1 (Location in inner city)has a positive relationship with SE. Inner city includes Prahakhon, Pomprabsattrupai, Sampantavong, Yannawa, Sathorn, Bangrak, Pathumwan, Phayathai, Rajthevee, Sue Dusit, Bangkholaem, Huay Kwang, Khlong Toei, Khlong San, Bangkok Noi, Bangkok Yai, Chatuchak, Thonburi, Wattana, Din Dang. Inner city is a central zone area and has high population density in Bangkok that is reason of overloading in health system.

Loc_2 (Location in outer city) has a negative relationship with SE. Outer city includes Minburi, Donmueng, Nongjok, Ladkrabang, Taling Chan, Nong kham, Bang khun tien, Lak si, Klongsamwa, Bang bon, Tawee wattana. Suburb is the lowest population density in Bangkok.

CHAPTER IV

RESULTS AND DISCUSSIONS

This chapter will present the results and discussions of the data envelopment analysis method to evaluate the technical and scale efficiency of health centers in Bangkok Metropolitan Area and the ordinary least square model to analyze the factors effecting technical and scale efficiency scores.

4.1 General description of data

Bangkok as the capital of Thailand includes into 50 districts and is divided into 3 areas that are Inner district, Intermediate district, and Outer district.

Inner district includes Phra Nakon, Pom Prap Sattru Phai, Sampanthawong, Phathum Wan, Bang Rak, Yan Nawa, Sathon, Bang Kho Lam, Dusit, Bang Sue, Phaya Thai, Rachathewi, Huai Khwang, Khlong Toei, Chatuchak, Thonburi, Khlong San, Bangkok Noi, Bangkok Yai, Din Daeng, Watthana.

Intermediate district includes Phra Khanong, Prawet, Bang Khen, Bang Kapi, Lat Phrao, Bueng Kum, Bang Phlat, Phasi Charoen, Jomthong, Rat Burana, Suan Luang, Bang Na, Thung Khru, Bang Khae, Wang Thonglang, Khan Na Yao, Saphan Sung, Sai Mai.

Outer district includes Min Buri, Don Mueang, Nong Chok, Lat Krabang, Taling Chan, Nong Khaem, Bang Khun Thian, Lak Si, Klong San, Bang Bon, Thawi Watthana.

Table 4.1 Number of health centers under BMA in each area

Area	No. of districts	Health center
Inner district	21	35
Intermediate district	18	21
Outer district	11	12

Descriptive statistics for input and output variables of data envelopment analysis are presented by following table:

Table 4.2 Descriptive statistics for output variables

	N	Minimum	Maximum	Mean	Std. Deviation
No. of antenatal care	136	77.00	3061.00	876.6691	620.30905
No. of dental care visits	136	18.00	16530.00	5167.0588	2944.97100
No. of family planning	136	.00	811.00	347.7794	158.17326
No. of growth monitoring visits	136	76.00	6104.00	2362.4706	1281.81733
No. of general patient visits	136	109.00	51422.00	22807.4853	10625.80126
No. of vaccination visits	136	2038.00	25439.00	9024.1838	4327.56623
No. of health education	136	462.00	835823.00	65215.5074	86565.84440
No. of other health care services	136	227.00	18634.00	5348.5662	3329.31305

Table 4.2 showed that the average number of health education was highest (65215.51) with standard deviation (S.D.) of 86565.84. The average number of general patient visits, other health care services, Immunized vaccination visits, dental care visits, growth monitoring children, and antenatal care were the second, the third, the forth , the fifth, and the sixth (22807.49, 5348.57, 9024.18, 5167.06, 2362.47 and 876.67) with S.D. 10625.80, 3329.31, 4327.57, 2944.97, 1281.82 and 620.31 respectively. The lowest was the average of family planning that was 347.78 with S.D. of 620.31.

Table 4.3 Descriptive statistics for input variables

	N	Minimum	Maximum	Mean	Std. Deviation
No. of treatment rooms	136	2.00	8.00	3.1029	1.43129
No. of doctors	136	1.50	6.30	2.9794	1.15053
No.of dentists	136	1.00	3.00	1.9235	.54964
No. of nurses	136	6.00	19.00	10.6250	2.38184
No. of other personnel	136	9.00	28.00	15.5735	4.82529

Table 4.3 showed that the average number of treatment room and doctors were relatively equal (3.10 and 2.98) with S.D. of 1.43 and 1.15 respectively. The average number of dentist was 1.92 with S.D. of 0.55 and the average number of nurse was 10.63 with S.D. of 2.38. The average number of other personnel was highest (15.57) with S.D. of 4.83.

4.2 Technical efficiency from DEA model

Table 4.4 Data of technical efficiency scores

Health centers	TEcrs		TEvrs		SE		Pattern of scale inefficiency	
	2009	2010	2009	2010	2009	2010	2009	2010
1	0.665	0.711	0.707	1	0.94	0.711	irs	irs
2	0.607	0.478	0.702	0.521	0.865	0.919	irs	irs
3	0.579	0.639	0.753	0.832	0.768	0.768	drs	drs
4	0.94	0.883	1	0.972	0.94	0.909	drs	drs
5	1	1	1	1	1	1	-	-
6	0.722	0.973	1	1	0.722	0.973	irs	irs
7	1	0.987	1	1	1	0.987	-	drs
8	1	1	1	1	1	1	-	-
9	0.875	0.665	0.967	0.824	0.905	0.807	drs	drs
10	1	0.962	1	1	1	0.962	-	irs
11	0.487	0.549	0.49	0.579	0.995	0.949	irs	irs
12	0.978	0.93	1	1	0.978	0.93	irs	irs
13	0.954	0.929	1	0.969	0.954	0.959	irs	irs
14	0.816	0.789	1	1	0.816	0.789	irs	irs
15	1	1	1	1	1	1	-	-
16	0.858	0.881	0.858	0.952	1	0.952	-	irs

17	1	0.995	1	1	1	0.995	-	irs
18	0.934	1	0.964	1	0.969	1	irs	-
19	0.784	0.736	0.799	0.773	0.982	0.952	drs	drs
20	0.6	0.612	1	1	0.6	0.612	irs	irs
21	0.932	0.984	1	1	0.932	0.984	drs	drs
22	0.732	0.963	0.726	0.981	0.996	0.982	irs	irs
23	0.56	0.556	0.65	0.661	0.861	0.841	drs	drs
24	0.68	0.701	0.769	0.758	0.884	0.926	drs	drs
25	1	1	1	1	1	1	-	-
26	0.964	0.913	0.974	0.92	0.99	0.993	irs	irs
27	1	0.988	1	0.989	1	0.999	-	irs
28	0.695	0.624	0.695	0.639	1	0.977	-	irs
29	1	1	1	1	1	1	-	-
30	1	1	1	1	1	1	-	-
31	0.883	0.896	0.884	0.901	0.998	0.994	irs	irs
32	0.928	0.658	1	1	0.928	0.658	irs	irs
33	0.959	0.929	0.968	0.935	0.991	0.994	irs	irs
34	1	0.985	1	1	1	0.985	-	irs
35	1	0.97	1	0.97	1	0.999	-	drs
36	0.964	0.943	1	1	0.964	0.943	irs	irs
37	1	1	1	1	1	1	-	-
38	0.744	0.731	0.763	0.748	0.975	0.977	irs	irs
39	1	1	1	1	1	1	-	-
40	1	1	1	1	1	1	-	-
41	1	1	1	1	1	1	-	-
42	1	1	1	1	1	1	-	-
43	1	0.937	1	0.963	1	0.972	-	drs
44	0.803	0.766	0.948	0.825	0.847	0.928	irs	irs
45	1	1	1	1	1	1	-	-
46	1	1	1	1	1	1	-	-
47	0.938	0.968	1	1	0.938	0.968	irs	irs
48	1	0.945	1	0.946	1	0.999	-	drs
49	0.858	0.894	0.866	0.907	0.991	0.986	irs	irs
50	1	1	1	1	1	1	-	-
51	0.504	0.429	0.523	0.429	0.964	1	irs	-
52	1	1	1	1	1	1	-	-
53	0.845	1	0.867	1	0.975	1	drs	-
54	1	1	1	1	1	1	-	-
55	0.988	0.96	1	1	0.988	0.96	irs	irs
56	1	1	1	1	1	1	-	-
57	1	1	1	1	1	1	-	-
58	1	1	1	1	1	1	-	-
59	0.867	0.885	0.961	1	0.902	0.885	irs	irs
60	0.699	0.921	0.763	0.939	0.916	0.982	irs	irs
61	1	1	1	1	1	1	-	-
62	0.886	0.901	0.986	1	0.898	0.901	irs	irs

63	0.973	1	1	1	0.973	1	irs	-
64	1	1	1	1	1	1	-	-
65	0.975	1	1	1	0.975	1	irs	-
66	1	0.805	1	0.916	1	0.879	-	irs
67	0.526	0.471	0.657	0.479	0.8	0.984	irs	irs
68	0.688	0.74	0.72	0.759	0.956	0.975	irs	irs

There were 21 from 68 health centers which had all three efficiency scores (TEcrs, TEvrs, SE) such as health centers number 5, 8, 15, 25, 29,30, 37, 39, 40, 41, 42,45, 46, 50, 52, 54, 56, 57, 58, 61, and 64 as table 5. There were 17 from 68 health centers which had all three inefficiency scores (TEcrs, TEvrs, SE) such as 2, 3, 9, 11, 19, 22, 23, 24, 26, 31, 33, 38, 44, 49, 60, 67, and 68. The pattern of scale inefficiency had two types; 1) increasing return to scale (irs) in both years , 2) decreasing return to scale (drs) in both years. There were 4 health centers which the pattern of scale inefficiency improved from increasing return to scale (irs) to scale efficiency such as health centers number 18,51. 63, and 65 and only 1 health center (health center number 53) which improved from decreasing return to scale (drs) to scale efficiency pattern . There were 6 health centers which worsened from scale efficiency to increasing return to scale such as health center number 16, 17, 27, 28, 34, 66 and 4 health centers were worsened from scale efficient to decreasing return to scale pattern such as 7, 35, 43, and 48.

There were 2 from 68 health centers which improved all three inefficiency scores (TE crs, TEvrs, and SE) to efficiency scores such as health center number 18 and 53.

Table 4.5 Descriptive statistics for TEcrs, TEvrs, and SE

	N	Minimum	Maximum	Mean	Std. Deviation
TEcrs	136	.43	1.00	.8866	.15451
TEvrs	136	.43	1.00	.9268	.13294
SE	136	.60	1.00	.9553	.07876

The summary of technical efficiency scores is given in the table 6. The results of the average technical efficiency for constant return to scale, technical efficiency for variable return to scale, and scale efficiency scores in the estimated DEA model are

0.8866, 0.9268, and 0.9553 respectively. The results show that all of health centers under BMA are quite high technical efficiency score. This result may be affected that people in Bangkok are convenient accessing to health care services in health centers under BMA. It may cause from universal coverage scheme that primary health care units are the first contract point for the beneficiaries to receive services and It is free. These may encourage patients to visit health centers.

The average scale efficiency of health centers under BMA are 0.9553 (or 95.53%). This means that, on average, these health centers may have needed 95.53% of the current inputs to get the current outputs.

Table 4.6 TEcrs and TEvrs by interval of score in 2009 – 2010

Score	TEcrs		TEvrs	
	DMUs	%	DMUs	%
< 40%	0	0.00	0	0.00
40 – 59.9%	10	7.35	6	4.41
60 – 79.9%	23	16.91	18	13.25
80 – 99.9%	48	35.29	28	20.59
100%	55	40.44	84	61.76
Total	136	100.00	136	100.00

There were 55 efficient DMUs from 136 DMUs for TEcrs . From 55 efficient DMUs, half of efficient DMUs were located in inner city that there were 27 DMUs (38.6% of total DMUs in inner city). There were 18 DMUs that located in intermediate city (42.8% of total DMUs in intermediate city), and there were 10 DMUs that located in outer city (41.6% of total DMUs in outer city). Most of technical inefficiency under constant return to scale (TEcrs) scores were in range of 80 – 99.9%. There were 10 DMUs were in range of 40 – 59.9% that there were 8 inefficient DMUs in inner city, and there were 2 inefficient DMUs in outer city.

There were 84 efficient DMUs from 136 DMUs for TEvrs. From 84 efficient DMUs, they equally located in inner city and intermediate city that there were 39 DMUs (55.7% of total DMUs in inner city) and 32 DMUs (76% of total DMUs in intermediate city). There were 13 efficient DMUs that located in outer city (54% of total DMUs in outer city). Most of technical inefficiency under variable return to scale (TEvrs) scores were in range of 80 – 99.9%. There were 6 DMUs from 136 DMUs were in range 40 – 59.99% that there were 5 inefficient DMUs in inner city and 1 inefficient DMUs in outer city. In Bangkok, there are many health facilities such as private clinics, hospitals, and other health facilities especially in inner city. People are easy access to higher professional skill, technology equipments, and better services than health center under BMA. As a result, only 38.6% of total DMUs in inner city and 55.7% of total DMUs in inner city were in the best frontier for TEcrs and TEvrs respectively.

Table 4.7 Scale efficiency (SE) scores by interval of score in 2009 – 2010

Score	SE	
	DMUs	%
< 40%	0	0.00%
40 – 59.9%	0	0.00%
60 – 79.9%	8	5.88%
80 – 99.9%	70	51.47%
100%	58	42.65%
Total	136	100.00%

There were 58 efficient DMUs from 136 DMUs for scale efficiency (SE) score. They equally located in inner city and intermediate city that there were 25 DMUs in inner city and 24 DMUs in intermediate city (35.7% of total DMUs in inner city, and 57% of total DMUs in intermediate city). There were 9 efficient DMUs that located in outer city (37.5% of total DMUs in outer city). Most of scale inefficiency (SE) scores were in range of 80 – 99.9% that there were 51.47% of total DMUs.

Table 4.8 Tabulation of return to scale

Value	Count	Percent
CRS (constant return to scale)	58	42.65
DRS (decreasing return to scale)	19	13.97
IRS (increasing return to scale)	59	43.38
Total	136	100.00

There were 58 from 136 DMUs were constant return to scale. Frequency of increasing return to scale pattern were three times of decreasing return to scale pattern. The predominant from scale inefficiency was increasing return to scale, implying that these health centers theoretically should attempt to increase efficiency by scaling their production upwards. For scale inefficiency under decreasing return to scale, they could improve their efficiency levels by scaling down their production.

Table 4.9 Descriptive statistics for TEcrs by each area

Area	Number	Minimum	Maximum	Mean	S.D.
Inner district	70	0.43	1.00	0.8692	0.16975
Intermediate district	42	0.66	1.00	0.9437	0.09390
Outer district	24	0.47	1.00	0.8985	0.15378

From the table 4.9, technical efficiency under constant return to scale (TEcrs) in all three areas (Inner district, Intermediate district, and Outer district) were not much difference. The highest was in intermediate district and the lowest was in inner district.

Table 4.10 Descriptive statistics for TEvrs by each area

Area	Number	Minimum	Maximum	Mean	S.D.
Inner district	70	0.43	1.00	0.9067	0.14901
Intermediate district	42	0.72	1.00	0.9708	0.07245
Outer district	24	0.48	1.00	0.9200	0.13206

From the table 4.10, technical efficiency under variable return to scale (TEvrs) in all three areas were quite equally. The highest was in intermediate district and the lowest was in inner district.

Table 4.11 Descriptive statistics for SE by each area

Area	Number	Minimum	Maximum	Mean	S.D.
Inner district	70	0.60	1.00	0.9586	0.09242
Intermediate district	42	0.66	1.00	0.9718	0.06228
Outer district	24	0.80	1.00	0.9730	0.05274

From the table 4.11, scale efficiency (SE) scores were quite equally in three district areas. The highest was in outer district and the lowest was in inner district.

Table 4.12 The distribution of scale efficiency pattern by each area

	Inner city	Intermediate city	Outer city
IRS	32	16	11
CRS	25	24	9
DRS	13	2	4

Table 4.12 show the distribution of scale efficiency pattern in three areas in Bangkok. Increasing return to scale pattern was the most scale inefficiency pattern in all three areas.

In Bangkok, there are high competitive in health care services because there are many health facilities such as private clinics, hospitals, and other health facilities especially in inner city. People are easy access to higher professional skill, technology equipments, and better services than health center under BMA. As a result, the average score of three efficiencies was lowest in inner city.

4.3 OLS regression

Ordinary least square model was used to explore the factors affecting on technical efficiency and scale efficiency scores of health centers in Bangkok Metropolitan Area. TEvrs and SE from DEA were used as dependent variables.

$$TEvrs_i = C_o + C_1*Xray_i + C_2*D\_other_i + C_3*N\_other_i + C_4*Dent\_other_i + C_5*SD\_D_i + C_6*ANC\_D_i + C_7*GPT\_D_i + C_8*Fam\_N_i + C_9*Vac\_N_i + C_{10}*Hedu\_N_i + e_i \qquad (4\text{-}1)$$

There were 10 independent variables of technical efficiency under variable return to scale assumption (TEvrs) in equation 4-1. The independent variables of TEvrs were x-ray (xray), doctor-other staff ratio (D_ other), nurse-other staff ratio (N_other), dentist-other staff ratio (Dent_other), specialist doctor-general doctor ratio (SD_D), antenatal car-doctor ratio (ANC_D),general patient visit-doctor ratio (GPT_D), family planning-nurse ratio (Fam_N), immunized vaccination-nurse ratio (Vac_N), and health education_nurse ratio (Hedu_n).

Table 4.13 Descriptive statistics of explanatory variables of TEvrs scores

	N	Minimum	Maximum	Mean	Std. Deviation
Xray	136	.00	1.00	.3088	.46372
D_other	136	.05	.18	.1061	.03106
N_other	136	.31	.96	.5391	.12305
Dent_other	136	.03	.11	.0677	.01981
SD_D	136	.00	.95	.0732	.1651
ANC_D	136	30.80	1255.50	321.8405	255.3387
GPT_D	136	49.55	19537.00	7975.2658	3253.9401
Fam_N	136	.00	87.14	34.4910	18.1888
Vac_N	136	185.27	2119.92	862.4335	407.7744
Hedu_N	136	42.00	83582.30	6309.4480	8640.2492

Table 4.13 showed statistical information of explanatory variables of TEvrs that showed the number, mean, minimum, maximum, and standard deviation (S.D.). From the table we can see that a wide gap can be seen between the observations in terms of all indicators.

There were 4 independent variables of scale efficiency scores in equation 4-2.

$$SE_i = C_o + C_1 * D_i + C_2 * Staff_i + C_3 * Loc_{1i} + C_4 * Loc_{2i} + e_i \qquad (4\text{-}2)$$

The independent variables of SE were number of doctor (Doc), number of total staff (Staff), location in inner city (loc1), location in outer city (loc2).

Table 4.14 Descriptive statistics of explanatory variables of SE scores

	N	Minimum	Maximum	Mean	Std. Deviation
Doc	136	1.50	6.30	2.9794	1.15053
staff	136	21.20	53.50	31.1015	7.61030
Loc1	136	.00	1.00	.5147	.50163
Loc2	136	.00	1.00	.1765	.38263

Table 4.14 summarizes statistical information of all explanatory variables of SE scores. Gaps between the observations were not quite wide.

Result of regression analysis

TEVRS = 0.4716 - 0.0288*XRAY + 1.6262*D_OTHER + 0.2258*N_OTHER
(5.455) (-1.166) (3.988)* (2.539)*
- 2.0691*DENT_OTHER + 0.0740*SD_D + 3.12e-05*ANC_D +
(-4.089)* (1.127) (0.636)
0.0142*GPT_D + 0.0024*FP_N + 3.04e-05*VAC_N + 1.90e-06*HEDU_N
(5.552)* (4.123)* (1.009) (1.767) (4-3)

Table 4.15 OLS regression result of TEvrs

Explanatory variables	Parameters	Coefficient	t-statistic	p-value
C	C_0	0.471674	5.455372	0.0000
XRAY	C_1	-0.028882	-1.166577	0.2456
D_OTHER	C_2	1.626192	3.987864	0.0001
N_OTHER	C_3	0.225787	2.538707	0.0124
DENT_OTHER	C_4	-2.069145	-4.088749	0.0001
SD_D	C_5	0.073995	1.127421	0.2617
ANC_D	C_6	3.12E-05	0.636186	0.5258
GPT_D	C_7	0.014205	5.551695	0.0002
FP_N	C_8	0.002471	4.122610	0.0001
VAC_N	C_9	3.04E-05	1.009179	0.3148
HEDU_N	C_{10}	1.90E-06	1.767027	0.0797
N = 136, Probability (F-statistic) = 0.00000		R^2 = 0.441193,		

Most of explanatory variables of TEvrs were significant except xray, SD_D, ANC_D, Vac_N, and Hedu_N that were insignificant to TEvrs scores because their p-value were more than 0.05 as table 15. There were 2 explanatory variables had negative relationship with TEvrs scores because their coefficient had negative sign such as xray and Dent_other.

From the hypothesis, X-ray represents for high technology aspect was expected to positive relationship with TEvrs score. However, the result showed a negative sign and statistical insignificant. Therefore, high technology is not the important factor for improving efficiency in health centers under BMA.

Human resources that included the ratio of doctor to other staff and nurse to other staff were positive relationship with TEvrs score as expectation. The ratio of dentist to other staff showed negative relationship with TEvrs score and was statistical significant. As a result, health centers have more nurse and doctor will improved pure technical efficiency because of the deficiency's problem. The higher number of doctor and nurse will provide more output of health care services. For decreasing return to scale health centers, they should reduce the number of other staff to increasing TEvrs scores but increasing return to scale health centers should increasing the number of doctor and nurse to improve TEvrs. The decreasing in number of dentist will increase TEvrs scores because of the over number of dentist relative to other staff. Decreasing return to scale health centers should reduce the number of dentist to improve TEvrs. On the other hand, increasing return to scale health centers should increase tne number of other staff to improve TEvrs. A dentist can provide only dental care while a doctor and a nurse can produce diversity of outputs such as health promotion and prevention, and curative care. Therefore, doctors and nurses are very important human resources in health centers.

The ratio of specialist doctor to generalist doctor was positive relationship with TEvrs scores as expectation but there was statistical insignificant. Therefore, specialist doctor was not the important factor to improve TEvrs in health centers.

For the work load aspect, only general patient visits to doctor ratio and family planning to nurse ratio were statistical significant and positive relationship with TEvrs score. Both activities might have much variation in each health centers but the other activities might have not much variation in each health centers so they did not show the effect to technical efficiency. Health centers that had high efficiency scores have higher family planning visits than the low efficiency score health centers. Therefore, this variable showed the effect to pure technical efficiency (TEvrs). Health centers should produce more family planning and general patient visits to improve TEvrs scores. However, other health promotion and prevention such as antenatal care, immunized vaccination, child growth monitoring, health education are necessary to be produce more in health centers even though there were not statistical significant in regression analysis because health prevention is better and cheaper than cure, and produce more outputs will increase efficiency scores.

R-squared value (R^2) was quite low (0.4), but low R^2 are typically observed in cross-section data. The Probability (F statistic) was less than 0.05 meaning these variables were statistical significant.

For the detection of heteroskedasticity problem, the result of Breusch-Pagan-Godfrey test showed that the Obs*R-squared had Prob. Chi-Square is less than 0.05. Therefore, the null hypothesis that is not heteroskedasticity was rejected. It means that there was heteroskedasticity problem in this model. Therefore, I solved this problem by using White heteroskedasticity-consistent standard errors & covariance to correct the standard error that show in appendix.

Result of regression analysis after solving heteroskedasticity's problem was not difference from the previous result that there were 5 explanatory variables statistical significant to TEvrs score.

$$
\begin{array}{l}
TEVRS = \underset{(4.323)}{0.4716} - \underset{(-1.292)}{0.0288*XRAY} + \underset{(4.00)^*}{1.6262*D\_OTHER} + \underset{(2.444)^*}{0.2258*N\_OTHER} \\
\quad - \underset{(-3.250)^*}{2.0691*DENT\_OTHER} + \underset{(1.832)}{0.0740*SD\_D} + \underset{(0.659)}{3.12e\text{-}05*ANC\_D} + \\
\quad \underset{(3.983)^*}{0.0142*GPT\_D} + \underset{(4.062)^*}{0.0024*FP\_N} + \underset{(1.265)}{3.04e\text{-}05*VAC\_N} + \underset{(1.861)}{1.90e\text{-}06*HEDU\_N} \qquad (4\text{-}4)
\end{array}
$$

It can explain that if doctor-other staff ratio (D_other) increase one unit, TEvrs will increase 1.626 units, giving other things constant. If nurse-other staff ratio (N_other) increase one unit, TEvrs will increase 0.226 units, giving other things constant. If dentist-other staff ratio decrease one unit, TEvrs will increase 2.069 units, giving other things constant. If general patient visit-doctor ratio increases one unit, TEvrs tend to increase 0.0142, giving other things constant. If family planning-nurse ratio increases one unit, TEvrs will increase 0.002 units, giving other things constant.

$$SE = 0.6111 + 0.0076*DOC + 0.0077*STAFF - 0.0018*LOC1 - 0.0047*LOC2 \quad (4\text{-}5)$$
$$(13.494) \quad (3.678)^* \quad (0.5515) \quad (-0.0775) \quad (-0.1482)$$

Table 4.16 OLS regression result of SE

Explanatory variables	Parameters	Coefficient	t-statistic	p-value
C	C_0	0.611131	13.49403	0.0000
DOC	C_1	0.007590	3.678683	0.0022
STAFF	C_2	0.007677	0.551516	0.5023
LOC1	C_3	-0.001820	-0.077460	0.9384
LOC2	C_4	-0.004733	-0.148264	0.8824

N = 136, R^2 = 0.232404
Probability (F-statistic) = 0.000034

Most of explanatory variables of scale efficiency (SE) scores were insignificant, only number of doctor (Doc) was significant to SE scores because p-value was less than 0.05. There were two explanatory variables; loc1 and loc2, were negative correlation with SE scores because their coefficient had negative sign but there were not statistical significant. There was one variable; Doc, was positive relationship with SE scores. Number of doctor represents size of health centers. It means that large size of health centers were more scale efficiency than a small one.

Number of total staff that represent of area of health centers was statistical insignificant because p-value was more than 0.05. Number of doctor may more appropriate for represent the size of health centers than number of total staff. The more doctors in health centers will have more flexible in work tasks and have variety of skills that they work more efficient than health centers that there were low number of doctors.

Location was insignificant to SE score because p-value was more than 0.05. Different area of Bangkok may not much different in regulatory environment, socio-economic status, and demographic characteristics.

If the number of doctor (Doc) increase one unit, scale efficiency score will increase 0.007590 units, giving other things constant.

R-squared value (R^2) was quite low (0.232), but low R^2 are typically observed in cross-section data. The Probability (F statistic) was less than 0.05 meaning these variables were statistical significant.

For the detection of heteroskedasticity problem, the result of Breusch-Pagan-Godfrey test showed that the Obs*R-squared had Prob. Chi-Square is higher than 0.05. Therefore, the null hypothesis that is not heteroskedasticity was accepted. It means no heteroskedasticity problem in this model.

In conclusion, policy makers in health sector of BMA can improve the inefficient health centers in proper direction by analyzing each inefficient health centers and support the positive determinants by increasing the ratio of doctor to other staff and the ratio of nurse to other staff for increasing TEvrs scores and should decrease the ratio of dentist to other staff for increasing TEvrs scores. Furthermore, the increasing of work load such as general patient visits and family planning also increase TEvrs scores. For scale efficiency, the number of doctor was statistical significant and had a positive relationship with scale efficiency scores. The doctor was the important human resources in health centers. It also associated with both technical and scale efficiency because increasing in doctors will improve both efficiencies; pure technical and scale efficiency. The large size of health centers were more scale efficiency than a small one. Therefore, increase the size of health centers by merge nearby health centers together should be considered for increasing scale efficiency scores. If it is not appropriate to physical merging, these health centers must cooperate among themselves to act as a single health center.

It may appropriate in the district that have more than one health centers located.

Table 4.17 Results and discussions

Results	Discussions	Variable
Finding significantly correlated between the ratio of doctor to other staff, nurse to other staff, and dentist to other to pure technical efficiency (TEvrs)	BMA should adjust human resource by increasing proportion of doctor to other staffs and nurse to other staffs to increase TEvrs and decrease proportion of dentist to other staffs to increase TEvrs. There was the deficiency's problem of doctors in health centers. The doctor was the important human resources in health centers. It also associated with both	From the equation (4-4) D_other: the ratio of doctor to other staff N_other: the ratio of nurse to other staff Dent_other: the

and correlate between number of doctor to scale efficiency.	technical and scale efficiency, therefore, increasing in doctors will improve both efficiencies; pure technical and scale efficiency. BMA should adjust the structure of health centers by increase number of doctor in health centers to increase TEvrs and SE.	ratio of dentist to other staff From the equation (4-5) Doc: number of doctor
Finding significantly correlated between the ratio of family planning to nurse and the ratio of general patient visits to doctor to pure technical efficiency (TEvrs).	Health personnel in health centers should produce more outputs in both health promotion and prevention, and curative care to increase pure technical efficiency (TEvrs) especially in family planning and general patient visits. BMA should implement health prevention and promotion strategy and method to induce the necessary demand for services in order to reduce technical inefficiencies in health centres. The other activities should be studied about patient's satisfaction for the services to know the value of that activity.	From the equation (4-4) Gpt_d: the ratio of general patient visits to doctor Fam_n: the ratio of family planning to nurse
Finding significantly correlated between number of doctor to scale efficiency (SE).	Increasing the size of health centers by merge nearby health centers together should be considered for increasing scale efficiency scores	From the equation (4-5) Doc: number of doctor
The pattern of scale inefficiency in health centers found in increasing return to scale pattern and decreasing return to scale pattern.	The pattern of scale inefficiency should be analyzed to be a guideline to improve the inefficiency health centers in proper direction such as for the increasing return to scale pattern health centers should improve efficiency by increasing outputs produced. The decreasing return to scale pattern health centers should improve efficiency through down- sizing and shift the resources toward to the increasing return to scale health centers. This recommends to avoid further investment in decreasing return to scale health centers, as their health services do not	The scale efficiency pattern: increasing return to scale (IRS) and decreasing return to scale (DRS)

	seem to be proportional to the health resources invested in them. On the other hand, increasing return to scale health centers may be preferred for future expansion. For the increasing return to scale health centers, expansion of outputs and inputs requires an increasing in demand for health care. BMA should increase the potential of the services and improve the quality of health care in order to redistribute the OPD cases from general hospitals and attract more patients to visit health centers for expansion of outputs.	
The average TEcrs, TEvrs, and SE scores were 0.89, 0.93, and 0.96 respectively.	It is necessary to use resources effectively. BMA should routine measure health center efficiency monitoring and selecting health centers producing on the efficient frontier that define the best practice are the role model for inefficient health centers to observing.	

CHAPTER V

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The objective of this study are to measure technical and scale efficiency of health centers in Bangkok Metropolitan Area and identify the determinants of technical and scale efficiency score. Data of all health centers in BMA that there are 68 health centers. DEA was used to analyze technical efficiency and scale efficiency and ordinary least square (OLS) regression was used to determine the factor affecting technical and scale efficiency score.

The result of DEA showed the average technical efficiency under constant return to scale assumption was 0.8866, the average technical efficiency under variable return to scale assumption was 0.9268, and the average scale efficiency was 0.9553. There were 55 efficient DMUs from 136 DMUs for overall technical efficiency scores that 40.44% of DMUs were overall technical efficiency. There were 86 efficient DMUs from 136 DMUs that 61.76% of DMUs were pure technical efficiency and there were 58 efficient DMUs from 136 DMUs that 42.65% of DMUs were scale efficiency.

The technical efficiency scores of health centers in BMA in year 2009 – 2010 were good because half of DMUs performed in efficient level in all three types of efficiency scores; overall technical efficiency 40.44%, pure technical efficiency 61.76%, and scale efficiency 42.65%. The minimum scores of all three types of efficiency scores were 0.43 for overall technical efficiency score, 0.43 for pure technical efficiency score, and 0.60 for scale efficiency score.

Most of inefficient DMUs were in range 80 – 99.9% of all three types of inefficiency; 48 overall technical inefficient DMUs from 136 DMUs (59.26% of inefficient DMUs), 28 pure technical inefficient DMUs from 136 DMUs (53.85% of inefficient DMUs), and 70 scale inefficient DMUs from 136 DMUs (89.74% of inefficient DMUs).

There was not much difference of the average overall technical efficiency score, the average pure technical efficiency score, and the average scale efficiency score in three areas; inner city, intermediate city, outer city but the lowest average efficiency scores was in inner city.

This study found significant association between human resources (the ratio of doctor to other staff, the ratio of nurse to other staff, and the ratio of dentist to other staff), and workload (the ratio of general patient visits to doctor, the ratio of family planning to nurse) for pure technical efficiency scores. The ratio of doctor to other staff, the ratio of nurse to other staff, the ratio of general patient visits to doctor, and the ratio of family planning to nurse had a positive relationship with pure technical efficiency scores. The ratio of dentist to other staff had a negative relationship with pure technical efficiency scores. And the most influential explanatory variable of pure technical efficiency scores was the ratio of dentist to other staff. If doctor-other staff ratio (D_other) increase one unit, TEvrs will increase 1.626 units, giving other things constant. If nurse-other staff ratio (N_other) increase one unit, TEvrs will increase 0.226 units, giving other things constant. If dentist-other staff ratio decrease one unit, TEvrs will increase 2.069 units, giving other things constant. If general patient visit-doctor ratio increases one unit, TEvrs tend to increase 0.0142, giving other things constant. If family planning-nurse ratio increases one unit, TEvrs will increase 0.002 units, giving other things constant.

For scale efficiency scores, the result of OLS regression revealed only one explanatory variable; the number of doctor that the proxy of size of health center had a positive relationship with scale efficiency scores. If the number of doctor (Doc) increase one unit, scale efficiency score will increase 0.007590 units, giving other things constant.

Policy makers in health sector of BMA can improve the inefficient health centers in proper direction by analyzing each inefficient health centers and support the positive determinants by increasing the ratio of doctor to other staff and the ratio of nurse to other staff for increasing TEvrs scores and should decrease the ratio of dentist to other staff for increasing TEvrs scores. Furthermore, the increasing of work load such as general patient visits and family planning also increase TEvrs scores. For scale efficiency, the number of doctor was statistical significant and had a positive relationship with scale efficiency scores. Large size health centers were more efficient than a small size health centers.

5.2 Recommendation

From the result of this study, recommendations as follow:

1. It is necessary to use resources effectively. BMA should routine measure health center efficiency monitoring and selecting health centers producing on the efficient frontier that define the best practice are the role model for inefficient health centers to observing. These may encourage health center managers and health personal to better perform. Efficiency in health centers can be improved through better resource allocation such as the decreasing return to scale pattern health centers should improve efficiency through down-sizing and shift the resources toward to the increasing return to scale health centers. To achieve this, policy makers need information regarding relative

performance of providers and facilities, in order to plan a strategy for optimal service provision.

2. The pattern of scale inefficiency should be analyzed to be a guideline to improve the inefficiency health centers in proper direction. Large size health centers were more scale efficiency than small size health centers. The predominant scale inefficiency was increasing return to scale pattern. Increasing the size of health centers by merge nearby health centers together should be considered for increasing scale efficiency. If physical merging is not possible or not practical, these health centers must cooperate among themselves to act as a single health center to improve scale efficiency.
3. Family planning visits and general patient visits had the effect to TEvrs. BMA should implement health prevention and promotion strategy and method to induce the necessary demand for services and should increase the potential of health care and improve the quality of health care in order to redistribute the OPD cases from general hospitals and attract more patients to visit health centers for expansion of outputs. Furthermore, OPD service should be extended to full day instead of half day morning for expansion of outputs.
4. BMA should support the positive determinant by increasing the number of doctor in health centers. The doctor is the important human resource in health center but most of them have the deficiency's problem of doctors.

5.3 Recommendation for further study

Measuring technical efficiency in all primary health care facilities in Bangkok and allocative efficiency (AE) should be very helpful for BMA to improve inefficient health centers to efficient health centers in the proper direction. Furthermore, quantitative study combining with qualitative study to get more detail of information of each health center. Information from both qualitative and quantitative studies is necessary for BMA to improve their inefficient health centers.

5.4 Limitations

1. This study focused only on technical efficiency and not allocative efficiency. Therefore, the scores do not capture total efficiency or inefficiency.

2. This study covered only health centers under BMA and not other primary health care units such as PCU in private clinics, and CMU in hospitals. Therefore, this study does not reflect the whole picture of technical efficiency in Bangkok. It showed technical efficiency only in health centers under BMA. It would not be advisable to generalize the findings to the whole Bangkok and/or country.

3. This study used secondary panel data to increase in the number of observations but data availability is only two years in 2009 and 2010. Data before

2009 was not available because the Health Department, BMA could not support data before 2009.

REFERENCES

Akazili, J. et al.(2008). *Using data envelopment analysis to measure the extent of technical efficiency of public health centers in Ghana. BMC International Health and Human Rights,* 8:11. [online]. Available from: http://www.biomedcentral.com/1472-698X/8/11 [2008, November 20].

Banker R., Charnes A. and Cooper, William. W. (1984). *Some model for estimating technical and scale efficiencies in Data Envelopment Analysis.* Management Science 30: 1078-109.

Bahurmoz, A. M. (1998). *Measuring efficiency in Primary Health Care Centers in Saudi Arabia.* J.KAU. Econ & Adm,12: 3-18.

Bhirombhakdi, K. (2008). *Technical efficiency of university hospitals in Thailand.* Master's Thesis,Department of Health Economics, Faculty of Economics, Chulalongkorn University.

Charnes A, Cooper W, and Rhodes E. (1978). *Measuring the efficiency of decision-making units.* European Journal of Operations Research 3: 429-444.

Chilingerian, J. A. (1995). *Evaluating physician efficiency in hospitals: A multivariate analysis of best practices.* European Journal of Operational Research 80: 548-574.

Chang H. (1998). *Determinant of hospital efficiency: the case of central government-owned hospitals in Taiwan.* Omega, International Journal of Management Science 26: 307-317.

Coelli, T.J. (1998). *A guide to DEAP version 2.1: A DEA program. CEPA working paper* 96/8, university of New England, Department of Econometrics.

Charunwatthana, W. (2007). *Measuring hospital efficiency of public hospitals under office of permanent secretary of Ministry of Public Health in Thailand:a data envelopment analysis approach.* Master's Thesis, Department of Health Economics, Faculty of Economics, Chulalongkorn university.

Corredoira R.A., and Kimberly J. R. (2006). *Efficiency in Addiction treatment: A DEA Clinic Efficiency in Maryland.* The Journal of the Operational Research Society;46. 573-582.

Farrell, M. J. (1957). *The measurement of productive efficiency.* Journal of the Royal Statistical Society, 253-290.

Hollingworth, B., Dawson, P. J., and Maniadakis, N. (1998). *Efficiency measurement of health care: a review of non-parametric methods and applications.* University of Newcastle upon Tyne, UK, Health Care Management Science 2: 161-172.

Kirigia, J. M., Sambo, L.G .,and Scheel H. (2001). *Technical efficiency of public clinics in Kwazulu-Natal province of South Africa.* East African Medical Journal, 78:39-45.

Kontodimopoulos,N, et al. (2007). *The effect of environmental factors on technical and scale efficiency of primary health care providers in Greece.* Cost Effectiveness and Resource Allocation , 5:14. [online]. Available from: http//www.resource-allocation.com/content/5/1/14. [2007, November 17].

Osei D., et al. (2005). *Technical efficiency of public district hospitals and health centres in Ghana: a pilot study.* Cost Effectiveness and resource. [online] Allocation. Available from: http//www.resource-allocation.com/content/3/1/9 [2005, February 9].

Pamasiriwat, D. (2007). *Study on efficiency of medium size community hospitals in Thailand, the case study of 166 community hospitals under MOPH.* Economic Research and Training Centre, Thammasart university . [online]. Available from: http://www.google.co.th/ [2009, December 11] (in Thai).

Pavananunt, P. (2004). *Efficiency of public community hospitals in Thailand.* School of Public Administration, National Institute of Development Administration .

Phoung, L. D. (2009). *Technical efficiency of commune health centers in rural red rever delta of Vietnam.* Master's Thesis, Department of Health Econonics, Faculty of Economics, Chulalongkorn university.

Renner A. et al.(2005). *Technical efficiency of peripheral health units in Pujehum district of Sierra Leone: a DEA application.* Biomed Central Ltd. [online]. Available from: http://www.biomedcentral.com/472-6963/5/77. [2005, December 14]

Thailand (2008). *Thailand health profile.* Nonthaburi:Ministry of Public Health, Thailand.

Thianjaruwatthana, W. (2009). *Technical efficiency and its determinant in regional hospitals in Thailand.* Master's Thesis, Department of Health Economics, Faculty of Economics, Chulalongkorn University.

APPENDIX

Output orientated DEA

Scale assumption: VRS

Two-stage DEA method

EFFICIENCY SUMMARY:

firm	crste	vrste	scale	
1	0.665	0.707	0.940	irs
2	0.607	0.702	0.865	irs
3	0.579	0.753	0.768	drs
4	0.940	1.000	0.940	drs
5	1.000	1.000	1.000	-
6	0.722	1.000	0.722	irs
7	1.000	1.000	1.000	-
8	1.000	1.000	1.000	-
9	0.875	0.967	0.905	drs
10	1.000	1.000	1.000	-
11	0.487	0.490	0.995	irs
12	0.978	1.000	0.978	irs
13	0.954	1.000	0.954	irs
14	0.816	1.000	0.816	irs
15	1.000	1.000	1.000	-
16	0.858	0.858	1.000	-
17	1.000	1.000	1.000	-
18	0.934	0.964	0.969	irs
19	0.784	0.799	0.982	drs
20	0.600	1.000	0.600	irs
21	0.932	1.000	0.932	drs

22	0.723	0.726	0.996	irs
23	0.560	0.650	0.861	drs
24	0.680	0.769	0.884	drs
25	1.000	1.000	1.000	-
26	0.964	0.974	0.990	irs
27	1.000	1.000	1.000	-
28	0.695	0.695	1.000	-
29	1.000	1.000	1.000	-
30	1.000	1.000	1.000	-
31	0.883	0.884	0.998	irs
32	0.928	1.000	0.928	irs
33	0.959	0.968	0.991	irs
34	1.000	1.000	1.000	-
35	1.000	1.000	1.000	-
36	0.964	1.000	0.964	irs
37	1.000	1.000	1.000	-
38	0.744	0.763	0.975	irs
39	1.000	1.000	1.000	-
40	1.000	1.000	1.000	-
41	1.000	1.000	1.000	-
42	1.000	1.000	1.000	-
43	1.000	1.000	1.000	-
44	0.803	0.948	0.847	irs
45	1.000	1.000	1.000	-
46	1.000	1.000	1.000	-
47	0.938	1.000	0.938	irs

48	1.000	1.000	1.000	-
49	0.858	0.866	0.991	irs
50	1.000	1.000	1.000	-
51	0.504	0.523	0.964	irs
52	1.000	1.000	1.000	-
53	0.845	0.867	0.975	drs
54	1.000	1.000	1.000	-
55	0.988	1.000	0.988	irs
56	1.000	1.000	1.000	-
57	1.000	1.000	1.000	-
58	1.000	1.000	1.000	-
59	0.867	0.961	0.902	irs
60	0.699	0.763	0.916	irs
61	1.000	1.000	1.000	-
62	0.886	0.986	0.898	irs
63	0.937	1.000	0.937	irs
64	1.000	1.000	1.000	-
65	0.975	1.000	0.975	irs
66	1.000	1.000	1.000	-
67	0.526	0.657	0.800	irs
68	0.688	0.720	0.956	irs
69	0.711	1.000	0.711	irs
70	0.478	0.521	0.919	irs
71	0.639	0.832	0.768	drs
72	0.883	0.972	0.909	drs
73	1.000	1.000	1.000	-

74	0.973	1.000	0.973	irs
75	0.987	1.000	0.987	drs
76	1.000	1.000	1.000	-
77	0.665	0.824	0.807	drs
78	0.962	1.000	0.962	irs
79	0.549	0.579	0.949	irs
80	0.930	1.000	0.930	irs
81	0.929	0.969	0.959	irs
82	0.789	1.000	0.789	irs
83	1.000	1.000	1.000	-
84	0.881	0.952	0.925	irs
85	0.995	1.000	0.995	irs
86	1.000	1.000	1.000	-
87	0.736	0.773	0.952	drs
88	0.612	1.000	0.612	irs
89	0.984	1.000	0.984	drs
90	0.963	0.981	0.982	irs
91	0.556	0.661	0.841	drs
92	0.701	0.758	0.926	drs
93	1.000	1.000	1.000	-
94	0.913	0.920	0.993	irs
95	0.988	0.989	0.999	irs
96	0.624	0.639	0.977	irs
97	1.000	1.000	1.000	-
98	1.000	1.000	1.000	-
99	0.896	0.901	0.994	irs

100	0.658	1.000	0.658	irs
101	0.929	0.935	0.994	irs
102	0.985	1.000	0.985	irs
103	0.970	0.970	0.999	drs
104	0.943	1.000	0.943	irs
105	1.000	1.000	1.000	-
106	0.731	0.748	0.977	irs
107	1.000	1.000	1.000	-
108	1.000	1.000	1.000	-
109	1.000	1.000	1.000	-
110	1.000	1.000	1.000	-
111	0.937	0.963	0.972	drs
112	0.766	0.825	0.928	irs
113	1.000	1.000	1.000	-
114	1.000	1.000	1.000	-
115	0.968	1.000	0.968	irs
116	0.945	0.946	0.999	drs
117	0.894	0.907	0.986	irs
118	1.000	1.000	1.000	-
119	0.429	0.429	1.000	-
120	1.000	1.000	1.000	-
121	1.000	1.000	1.000	-
122	1.000	1.000	1.000	-
123	0.960	1.000	0.960	irs
124	1.000	1.000	1.000	-
125	1.000	1.000	1.000	-

126	1.000	1.000	1.000	-
127	0.885	1.000	0.885	irs
128	0.921	0.939	0.982	irs
129	1.000	1.000	1.000	-
130	0.901	1.000	0.901	irs
131	1.000	1.000	1.000	-
132	1.000	1.000	1.000	-
133	1.000	1.000	1.000	-
134	0.805	0.916	0.879	irs
135	0.471	0.479	0.984	irs
136	0.740	0.759	0.975	irs
mean	0.886	0.927	0.955	

Note: crste = technical efficiency from CRS DEA

vrste = technical efficiency from VRS DEA

scale = scale efficiency = crste/vrste

Eviews' OLS estimation for TEvrs

Dependent Variable: TEVRS
Method: Least Squares
Date: 03/15/11 Time: 21:56
Sample: 1 136
Included observations: 136

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.471674	0.086460	5.455372	0.0000
XRAY	-0.028882	0.024758	-1.166577	0.2456
D_OTHER	1.626192	0.407785	3.987864	0.0001
N_OTHER	0.225787	0.088938	2.538707	0.0124
DENT_OTHER	-2.069145	0.506058	-4.088749	0.0001
SD_D	0.073995	0.065632	1.127421	0.2617
ANC_D	3.12E-05	4.91E-05	0.636186	0.5258
GPT_D	0.014205	3.86E-06	5.551695	0.0002
FP_N	0.002471	0.000599	4.122610	0.0001
VAC_N	3.04E-05	3.01E-05	1.009179	0.3148
HEDU_N	1.90E-06	1.08E-06	1.767027	0.0797

R-squared	0.441193	Mean dependent var	0.926816
Adjusted R-squared	0.396489	S.D. dependent var	0.132941
S.E. of regression	0.103276	Akaike info criterion	-1.625392
Sum squared resid	1.333252	Schwarz criterion	-1.389810
Log likelihood	121.5267	Hannan-Quinn criter.	-1.529657
F-statistic	9.869085	Durbin-Watson stat	2.225428
Prob(F-statistic)	0.000000		

Heteroskedasticity test of explanatory variables of TEvrs scores

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	6.694668	Prob. F(9,126)	0.0000
Obs*R-squared	43.99563	Prob. Chi-Square(9)	0.0000
Scaled explained SS	72.92584	Prob. Chi-Square(9)	0.0000

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 03/21/11 Time: 00:48
Sample: 1 136
Included observations: 136

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.081717	0.013924	5.868734	0.0000
XRAY	-0.008636	0.003968	-2.176656	0.0314
D_OTHER	-0.239947	0.066627	-3.601322	0.0005
N_OTHER	-0.053119	0.014296	-3.715730	0.0003

DENT_OTHER	0.287806	0.082501	3.488531	0.0007
SD_D	-0.006574	0.010721	-0.613201	0.5408
ANC_D	1.64E-05	7.99E-06	2.057499	0.0417
GPT_D	-2.84E-06	6.18E-07	-4.592291	0.0000
FP_N	-0.000354	9.78E-05	-3.616704	0.0004
VAC_N	-5.04E-06	4.92E-06	-1.023826	0.3079

R-squared	0.323497	Mean dependent var	0.010048
Adjusted R-squared	0.275176	S.D. dependent var	0.019820
S.E. of regression	0.016874	Akaike info criterion	-5.255360
Sum squared resid	0.035878	Schwarz criterion	-5.041194
Log likelihood	367.3645	Hannan-Quinn criter.	-5.168328
F-statistic	6.694668	Durbin-Watson stat	2.118817
Prob(F-statistic)	0.000000		

Solved heteroskedasticity problem by using White heteroskedasticity-consistent standard errors & covariance

Dependent Variable: TEVRS
Method: Least Squares
Date: 03/17/11 Time: 20:03
Sample: 1 136
Included observations: 136
White heteroskedasticity-consistent standard errors & covariance

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.471674	0.109103	4.323209	0.0000
XRAY	-0.028882	0.022342	-1.292724	0.1985
D_OTHER	1.626192	0.406446	4.001004	0.0001
N_OTHER	0.225787	0.092392	2.443783	0.0159
DENT_OTHER	-2.069145	0.636521	-3.250710	0.0015
SD_D	0.073995	0.040372	1.832842	0.0692
ANC_D	3.12E-05	4.73E-05	0.659270	0.5109
GPT_D	0.014205	5.38E-06	3.983175	0.0001
FP_N	0.002471	0.000608	4.062600	0.0001
VAC_N	3.04E-05	2.40E-05	1.265346	0.2081
HEDU_N	1.90E-06	9.71E-07	1.861331	0.0621

R-squared	0.441193	Mean dependent var	0.926816
Adjusted R-squared	0.396489	S.D. dependent var	0.132941
S.E. of regression	0.103276	Akaike info criterion	-1.625392
Sum squared resid	1.333252	Schwarz criterion	-1.389810
Log likelihood	121.5267	Hannan-Quinn criter.	-1.529657
F-statistic	9.869085	Durbin-Watson stat	2.225428
Prob(F-statistic)	0.000000		

Eviews' OLS estimation for SE

Dependent Variable: SE
Method: Least Squares
Date: 03/15/11 Time: 13:47
Sample: 1 136
Included observations: 136

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.611131	0.045289	13.49403	0.0000
DOC	0.007590	0.002087	3.678683	0.0022
STAFF	0.007677	0.013762	0.551516	0.5023
LOC1	-0.001820	0.023496	-0.077460	0.9384
LOC2	-0.004733	0.031921	-0.148264	0.8824

R-squared	0.232404	Mean dependent var	0.870750
Adjusted R-squared	0.208966	S.D. dependent var	0.134805
S.E. of regression	0.119896	Akaike info criterion	-1.368314
Sum squared resid	1.883129	Schwarz criterion	-1.261231
Log likelihood	98.04534	Hannan-Quinn criter.	-1.324798
F-statistic	4.915685	Durbin-Watson stat	2.101388
Prob(F-statistic)	0.000034		

Heteroskedasticity test of explanatory variables of SE scores

Heteroskedasticity Test: Breusch-Pagan-Godfrey

F-statistic	1.757059	Prob. F(4,131)	0.1414
Obs*R-squared	6.924962	Prob. Chi-Square(4)	0.1399
Scaled explained SS	22.43149	Prob. Chi-Square(4)	0.0002

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 03/21/11 Time: 00:50
Sample: 1 136
Included observations: 136

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.046441	0.010203	4.551898	0.0000
DOC	0.004103	0.003100	1.323460	0.1880
STAFF	-0.000211	0.000287	-0.733890	0.4643
LOC1	0.001530	0.005293	0.289059	0.7730
LOC2	0.002548	0.007191	0.354259	0.7237

R-squared	0.088426	Mean dependent var	0.013847
Adjusted R-squared	0.060592	S.D. dependent var	0.027867
S.E. of regression	0.027010	Akaike info criterion	-4.349157
Sum squared resid	0.095569	Schwarz criterion	-4.242074
Log likelihood	300.7427	Hannan-Quinn criter.	-4.305641
F-statistic	1.757059	Durbin-Watson stat	2.050642
Prob(F-statistic)	0.141376		

BIOGRAPHY

Name:	Ms. Cheeranun Chinarksorn
Nationality:	Thai
Country:	Thailand
Education:	Bachelor of Science (Physical therapy)
	Faculty of Allied Health Science, Chulalongkorn University