TECHNICAL EFFICIENCY OF PUBLIC DISTRICT HOSPITALS IN VIETNAM

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ประสิทธิภาพทางเทคนิคของโรงพยาบาลชุมชนในสาธารณรัฐสังคมนิยมเวียดนาม

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การศึกษานี้มีวัตถุประสงค์เพื่อวัดประสิทธิภาพทางเทคนิคของโรงพยาบาลชุมชน ในประเทศเวียดนาม และเพื่อหาปัจจัยที่มีผลต่อประสิทธิภาพทางเทคนิคของโรงพยาบาลชุมชน โดยได้ประยุกต์ใช้แบบจำลอง Input-Oriented Data Envelopment Analysis (DEA) ในการวัดประสิทธิภาพทางเทคนิคของโรงพยาบาลชุมชน จำนวน 52 แห่ง จาก 6 จังหวัด ในประเทศเวียดนาม ปี 2557 นั้น หลังจากนั้นได้ใช้แบบจำลอง Tobit วิเคราะห์ปัจจัยที่มีผลต่อประสิทธิภาพทางเทคนิค

ผลการศึกษาของ DEA พบว่า มีความแปรปรวนของคะแนนประสิทธิภาพทางเทคนิคในสมมติฐานผลตอบแทนต่อขนาด ค่าเฉลี่ยของคะแนนประสิทธิภาพทางเทคนิคที่แท้จริง (VRSTE) และค่าเฉลี่ยของคะแนนประสิทธิภาพทางเทคนิคโดยรวม (CRSTE) เท่ากับ ร้อยละ 84.7 และ 77.2 ตามลำดับ ขณะที่ค่าเฉลี่ยของคะแนนประสิทธิภาพต่อขนาดเท่ากับ ร้อยละ 90.9 ในการศึกษานี้พบว่า โรงพยาบาลชุมชน จำนวน 35 แห่ง (ร้อยละ 67.3) ดำเนินงานอย่างไร้ประสิทธิภาพ นอกจากนี้รูปแบบการทำงานอย่างไร้ประสิทธิภาพแสดงให้เห็นว่าโรงพยาบาลชุมชน 44 แห่ง มีผลตอบแทนต่อขนาดลดลง

ผลการวิเคราะห์ด้วยแบบจำลอง Tobit พบว่า อัตราส่วนระหว่างเจ้าหน้าที่ทั่วไปกับแพทย์ และอัตราส่วนระหว่างการเข้ารับการรักษาของผู้ป่วยในกับแพทย์ มีความสัมพันธ์อย่างมีนัยสำคัญทางสถิติกับประสิทธิภาพทางเทคนิคที่แท้จริง (VRSTE) ที่ระดับความเชื่อมั่น ร้อยละ 95 ในขณะที่อัตราการครองเตียง อัตราส่วนระหว่างจำนวนผู้ป่วยนอกกับแพทย์ และอัตราส่วนระหว่างรายได้จากค่าธรรมเนียมของผู้ใช้บริการกับรายได้รวม พบว่าไม่มีความสัมพันธ์

ทั้งนี้ปัจจัยส่วนใหญ่เป็นไปตามที่คาดการณ์ไว้ ยกเว้นอัตราการครองเตียงที่มากเกินไปของโรงพยาบาลประเทศเวียดนามในปัจจุบัน และพบว่า อัตราส่วนระหว่างเจ้าหน้าที่ทั่วไปกับแพทย์เป็นปัจจัยที่มีผลกระทบมากที่สุด เนื่องจากมีค่าสัมประสิทธิ์สูงที่สุด

สาขาวิชา	เศรษฐศาสตร์สาธารณสุขและการจัดการบริการสุขภาพ	ลายมือชื่อนิสิต	....
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The objectives of this study aimed to evaluate the Technical Efficiency of public district hospitals in Vietnam and to determine factors affecting the hospitals' efficiency. Input-Oriented Data Envelopment Analysis (DEA) model was applied to estimate the technical efficiency scores among 52 public district hospitals in 6 provinces of Vietnam in 2014. Then, Tobit regression model was employed to explore the determinant factors.

Results of the DEA indicated that there were considerable variations of efficiency scores in terms of return to scale assumptions. The average variable return to scale technical efficiency (VRSTE) and constant return to scale technical efficiency (CRSTE) were 84.7% and 77.2%, respectively. While, mean scale efficiency (SE) was 90.9%. In this study, 35 (accounted for 67.3%) of DPHs were running inefficiently. In addition, the pattern of scale inefficiency showed that all 44 scale inefficient public district hospitals were increasing return to scale efficiency.

Results of the Tobit regression model revealed that non-medical staff-physician ratio (NMSPR) and inpatient admission-physician ratio (IPAPR) were significantly correlated to VRSTE at 95% Confidence Interval. While bed occupancy rate (BOR), outpatient visit-physician ratio (OPVPR) and revenue from user fee-total revenue ratio (RUFTRR) were found insignificantly. Besides, most of determinant variables have the same signs as expected, exception BOR due to the current overload in Vietnamese hospitals. Finally, the findings showed that NMSPR ratio was the most influent explanatory variable because of its highest value coefficient among significant variables.

Field of Study:	Health Economics and Health Care Management	Student's Signature	....
		Advisor's Signature	....
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LIST OF ABBREVIATIONS

CRS	Constant Return to Scale
CRSTE	Constant Return to Scale Technical Efficiency
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
DRS	Decreasing Return to Scale
GDP	Gross Domestic Product
IPD	Inpatient Department
IRS	Increasing Return to Scale
MDG	Millennium Development Goal
MOH	Ministry of Health
OPD	Outpatient Department
PDHs	Public District Hospitals
PHs	Public Hospitals
SE	Scale Efficiency
TE	Technical Efficiency
VRSTE	Variable Return to Scale Technical Efficiency
WB	The World Bank
WHO	World Health Organization

CHAPTER I

INTRODUCTION

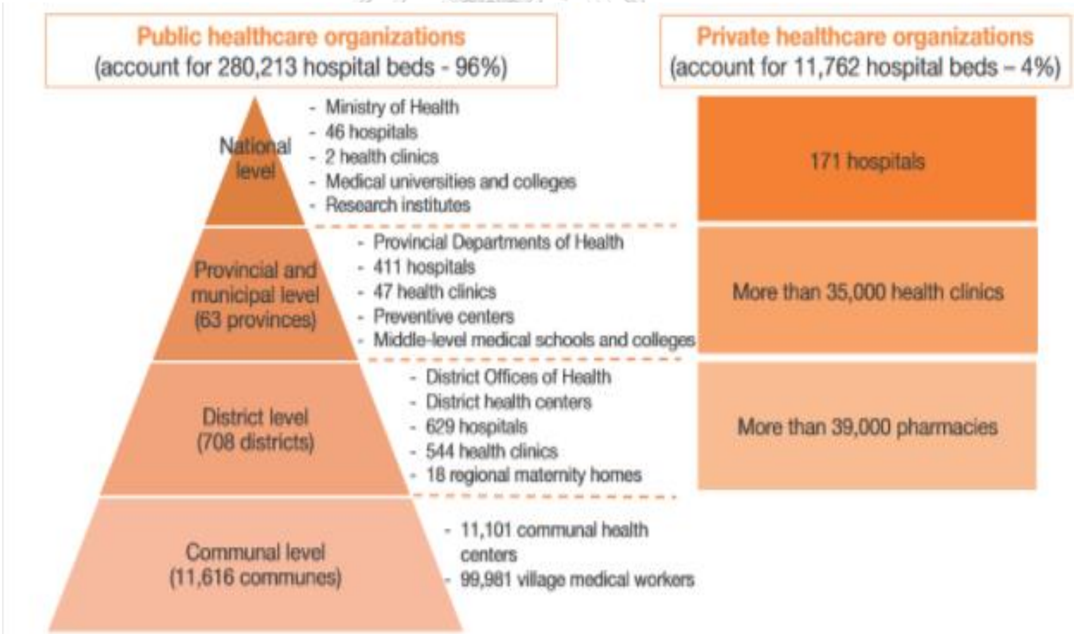
1.1 Study background

Nowadays, spending on health has impressively risen in comparison with GDP growth and total government spending increase in many countries, including Vietnam. This raises a great interest in efficiency and productivity of health care organizations. The current situation in Vietnam shows that the total health expenditures rose up to 6.8 percent in 2017 in comparison to 5.4 percent of GDP in 2009 (International Monetary Fund, 2017). In addition, Vietnam is located in one of hotspot area for infectious disease but at the same time, non-communicable diseases have rapidly emerged by recent and epidemiological shifts (Novartis Foundation, 2015). The growing burden of diseases, economic growth and demographic changes required a high increase in the demand for health care and posed new challenges to health care delivery. These challenges will force the national health care system in Vietnam to achieve a higher efficiency level in the future.

The high dependency on the public sector is one of the significant features of health care delivery in Vietnam. The system is basically divided into four levels of health establishments: central and regional hospitals at the central level managed by Ministry of Health; provincial hospitals at the provincial level directly administered by the provincial health departments; district hospitals at the district level also managed by provincial health departments; and commune health centers at the communal level managed by the district health offices. In 2017, there were 1,086 public hospitals (PHs) including 458 general hospitals while a small number of private hospitals was 171 with a provision of only 4% of the total hospital beds (Ministry of Health, 2017). This indicates that public health care organizations play a leading role in health care delivery system in Vietnam.

Furthermore, it can be seen in practice that a series of fundamental functions is enormously contributed by public hospitals in the health care system, especially public district hospitals. Public district hospitals are leading as organizational platforms for primary care activities. Their important role is both assisting commune health centers and performing as an entry to further immediate care (Minh et al., 2010). The majority of Vietnamese population, especially people living in rural areas, was recorded to seek treatments from public district hospitals (London, 2013). Moreover, among the health care network of 1086 public hospitals in the whole country, PDHs accounted for 57.9% (629 hospitals) (Ministry of Health, 2017). This proves a significant importance of public district hospitals in the health care delivery system.

Figure 1. 1: Public & Private Health Care Organizations in Vietnam in 2017



Source: Ministry of Health (2017)

In order to improve the efficiency of the Vietnamese health care system, many health sector reform programs were initiated since 1986, which transformed the way Vietnamese hospitals were operating and focused on input savings. Because the proportion of state budget spending on health gradually declined, comparing to the total government expenditure. In 1992, the National Health Insurance program was launched by Vietnamese government, targeting to control the increase of out of pocket spending. This program was applied at the national level, directing the registration of full time employees of state-owned organizations as well as private companies with over 10 staffs, and the retirees; whilst the voluntary scheme was implemented for other entitlements. After that, Vietnamese government has continuously issued a number of circulars and decrees to expand the percentage of compulsory enrollment of health insurance in the society. On the other side, an introduction of user fees gave its schedule for consultations and physical examinations, inpatient days, technical services, and lab tests in 1995. Afterward, the Decree 10/2002/ND-CP allowed public hospitals with limited financial autonomy to recover their operating costs, reduce staffs, and increase salaries for workers through surplus revenues. The autonomy became more comprehensive after the Decree 43/2006/ND-CP was implemented in 2006. So, public organizations must be accountable to their operations, organizations, finance and human resources of all the public services (Lieberman & Wagstaff, 2009). Regulatory changes along with hospital-specific characteristics could be causes of differences among hospital efficiency. Some studies found that user fees and institutional autonomy greatly contributed to technical efficiency enhancement (Uslu & Pham, 2008).

Nevertheless, according to some reports, such as that of WHO (2006), the operation of health care system still remains many other problems. Human resources and quality of services are the most critical issues. To meet the government’s top priority in an effective management of public hospitals, an evaluation of operation efficiency of hospitals is considerably needed. Indeed, there is an essential requirement for empirical analysis measuring hospital efficiency in a national-wide scale at the district level and exploring the determinant factors of the hospital efficiency.

In this study, the scores of technical efficiency among 52 public district hospitals in 6 provinces will be calculated, including: constant return to scale technical efficiency, variable return to scale technical efficiency and scale efficiency. Results from this study are expected to provide database as a starting point supporting for hospital managers and policy makers in making management decisions to improve the hospital efficiency. Besides, this database can bring primary evidences for managers to find the differences among the observed hospitals and the guidance to make a better inputs and outputs combination in the production process. Moreover, this study is also intended to economic regression model to identify the influential factors to technical efficiency scores. Overall, it can be stated that this study brings a significant contribution to the literature in technical efficiency of public district hospitals in Vietnam.

1.2 Research Questions

- What are the levels of technical efficiency scores of public district hospitals in Vietnam?
- What are the determinants affecting the technically efficient performances of public district hospitals in Vietnam?

1.3 Research Objectives

An answer of the first question indicates the technical efficiency score of each public district hospital in term of the technical and scale efficiency. Then, factors affecting on the technical efficiency score of each public district hospital are determined to response the second question. And, which factor is the most significant determinant on the technical efficiency scores of public district hospitals. Therefore, the research objectives are as follows:

General Objective

- To evaluate the technical efficiency of public district hospitals in Vietnam and then to identify determinants of their efficiency.

Specific Objectives

- To evaluate and compare the technical efficiency of public district hospitals.
- To determine the contributing factors on the technical efficiency.
- To find out the most affecting determinant on technical efficiency of Vietnamese public district hospitals.
- To provide policy implications for policy makers as well as managers of hospitals to develop the efficiency performance.

1.4 Scope of the study

This research study uses the secondary data which is collected at 78 public district hospitals and health centers in the 6 provinces represented for 6 geographic regions in Vietnam. Because of some inaccurate and omitted values, there was an elimination of 6 district hospitals. In order to create a homogeneous set of sample, 20 health care centers were also excluded. As the result, the sample had 52 hospitals in 6 provinces. Totally, 52 public district hospitals (PDHs) will involve in the study, as follows: (i) Hanoi: 20 PDHs, (ii) Dien Bien province: 1 PDHs, (iii) Binh Dinh province: 2 PDHs, (iv) Dak Lak province: 10 PDHs, (v) Dong Nai province: 9 PDHs, (vi) Dong Thap province: 10 PDHs. The data was collected in 2015 for the research time period from January to December 2014.

Table 1. 1: Description of Data Source

Region	Province	Poverty Rate	Per capita income	Number of DMUs
Red River Delta	Hanoi	1.0	2994.9	20
Northern Highlands	Dien Bien	35.2	819.4	1
North and South Central Coast	Binh Dinh	9.9	1719.0	2
Central Highlands	Dak Lak	12.3	1639.2	10
Southeast	Dong Nai	0.7	2576.7	9
Mekong Delta	Dong Thap	7.5	1665.5	10
Vietnam Nationality		7.8	1999.8	52

Source: (1) MOLISA Poverty Rate; (2) Vietnam Household Living Standard Survey 2012

1.5 Possible benefits

Technical Efficiency analysis of PDHs in Vietnam can greatly contribute to the quality improvement of health care services in this country. This study will provide an overview of both the efficient and inefficient performances. Additionally, it will also indicate their determinant factors. In shortly, all potential profits from this research study can be outlined in two following levels.

National level

At the national level, the outcome of this study may support policy makers in developing policies based on research evidences. Policy makers will be supplied information with a high reliability in designing guidelines or interventions to improve inefficient hospitals in a rational direction. Those new policies will make a great contribution in hospital development planning and managerial strategies in recent days.

Local level

At the local level, the efficiency profile of each public district hospital will provide information for its management purpose. Hospital managers are likely to realize shortcomings of input-output combination in their hospital then could decide how to allocate all resources efficiently in order to reach the best performance. For instance, the inefficient PDHs in Vietnam could run as efficiently as their counterparts on the best practice frontier either by decreasing the initialization of inputs or increasing the production of outputs.

The coming chapters of this study were organized as follows. The chapter two mentions the country's profile and health care system in Vietnam. The chapter three reviews comprehensive theory on the concept of TE in general and existing literatures on TE of PDHs at national and international level. The fourth chapter aims to describe the data and the research methodology with reasons why to select them. In chapter five, the results from using the Data Envelopment Analysis and the censor Tobit regression model will be presented and analyzed in detail. Finally, a conclusion and suggestions are mentioned in the chapter six.

CHAPTER II
HEALTHCARE SYSTEM IN VIETNAM

2.1 Country Profile

Vietnam is known as a tropical country with typical lowlands, hills, and densely forested highlands. This country is located in South-East Asia on the eastern margin of the Indochinese peninsula and occupies around 310,060 square kilometers. It's bordered in land by China to the north, Laos and Cambodia to the west; in sea by the Gulf of Thailand to the south, the Gulf of Tonkin and the East Sea to the east. (worldatlas.com)

The S-shaped country measures about 1,650 kilometers from the north to the south and nearly 50 kilometers in width at the narrowest point. The country is divided into 6 geographic regions, including: the Northern Highlands, the Red River Delta, the North and South Central Coast, the Central Highlands, the South East and the Mekong delta.

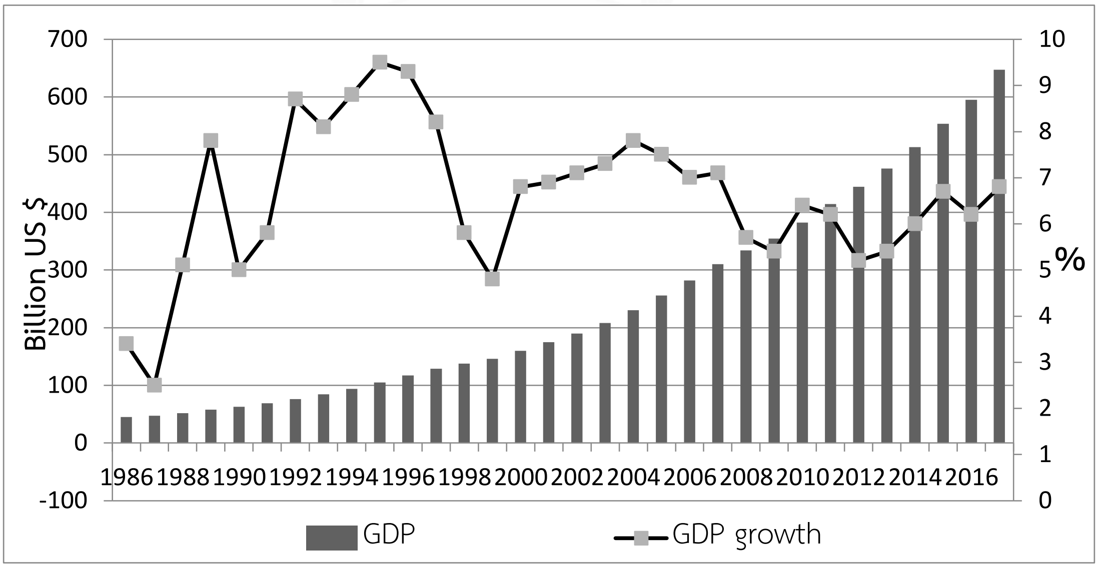
Figure 2. 1: Vietnam geography

Source: tigrai.org

Vietnam ranks in a group of the most inhabited nations worldwide with a population of 96.479.078 people and a density of 311 people/squared kilometers in 2018 (United Nation, 2018). The country is crowded and has a young population with an average age being 31 years old (danso.org). Viet Nam is ranked at the third in South-East Asia and the fourteenth in the world regarding the overall population size. The country has a diversity culture with 54 ethnic groups. King is the largest ethnic group, accounting for 86.2% of Vietnam's population.

Thanks to the impressive social and economic achievements from the "*Doi moi*" (renovation) policies, which were launched in 1986, the living standards of the Vietnamese people have been improved. From one of the world's poorest countries, Vietnam rises up and becomes a lower middle income nation. As can be seen from the Figure 2.2, the GDP amount increased sharply from 45.02 billion US dollars in 1986 to 647.4 billion US dollars in 2017. The GDP growth reached its peak at 9.5 percent in 1995. In recent years, this indicator was fluctuated around 6 percent. The GDP was $2,354 US dollars per capita in 2017 (International Monetary Fund, 2017).

Figure 2. 2: GDP (Billion US $) and GDP growth (%) in Vietnam from 1986 to 2017



Source: International Monetary Fund (2017)

In the health care sector, the Vietnamese health-related indicators have been upgraded significantly. Vietnam outperforms most of its counterparts in the South-East Asia region on some indicators despite these countries have higher levels of income per capita. For instance: The life expectancy at birth of Vietnam in 2015 was 75.6 years, greater than this indicator of Malaysia (74.5), Thailand (74.1), Indonesia (68.6), and the Philippines (68). In this year, the infant mortality rates of Vietnam recorded at 17.6 death per 1,000 live births compared to 22.2 in the Philippines and 22.9 in Indonesia in 2015 (World Health Organization, 2015). The table 2.1 presented an updated summary of key indicators in the recent.

Table 2. 1: Healthcare Indicators in Vietnam

Healthcare Indicator	Data
Birth rate	15.5 births/1,000 population (2017)
Death rate	5.9 deaths/1,000 population (2017)
Urbanization	34.9% of total population (2017)
Sex ratio at birth	1.11 male(s)/female (2017)
Infant mortality rate	17.3 deaths/1,000 live births (2017)
Life expectancy at birth	Male: 71.2 years (2017) Female: 76.4 years (2017)
Health expenditures	7.1% of GDP (2014)
Physicians density	1.18 physicians/1,000 population (2013)
Human Development Index	0.683 (2015)

Source: CIA World Fact Book (2017)

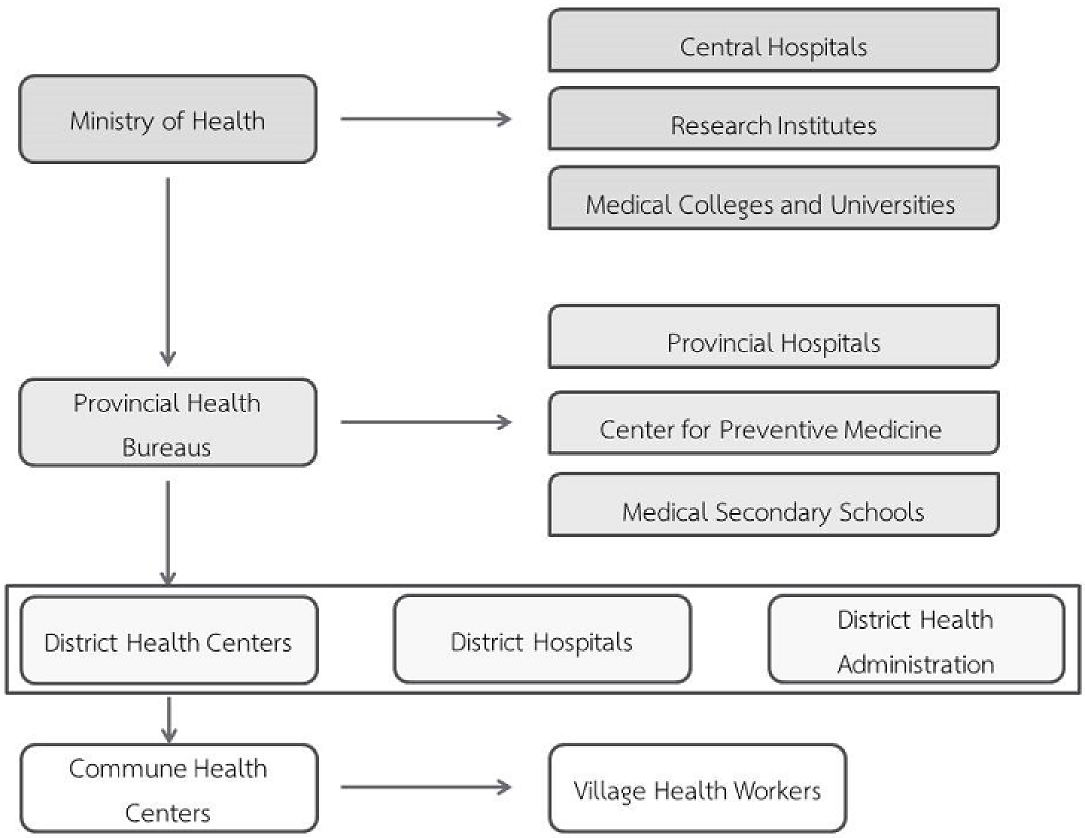
However, the above statistic is unlikely to hide the fact that Vietnam health care system is facing to tremendous challenges, which are mentioned in the following.

2.2 Health Care System in Vietnam

2.2.1 Structure of health care delivery

The health care delivery in Vietnam is administratively structured as a four tiered system, which widely covers from central to grassroots levels. The health policy and programs in the whole country are formulated and executed by the Ministry of Health, along with the Provincial, District and Commune People's Committees. The MOH is a leading authority in the health care sector at the national level. The management in health care system is decentralized as follows. There were 46 central hospitals and 2 health clinics under the central-level management by the MOH. In the second tier, there were 411 hospitals and 47 health clinics managed by 63 Provincial Departments of Health. 708 District Offices of Health ensured a managerial accountability for 629 hospitals and 544 health clinics at district level and a large number of 11.101 commune health centers in the fourth tier (Ministry of Health, 2017).

Figure 2. 3: Administrative structure of Vietnamese health care system



Source: World Health Organization (2011)

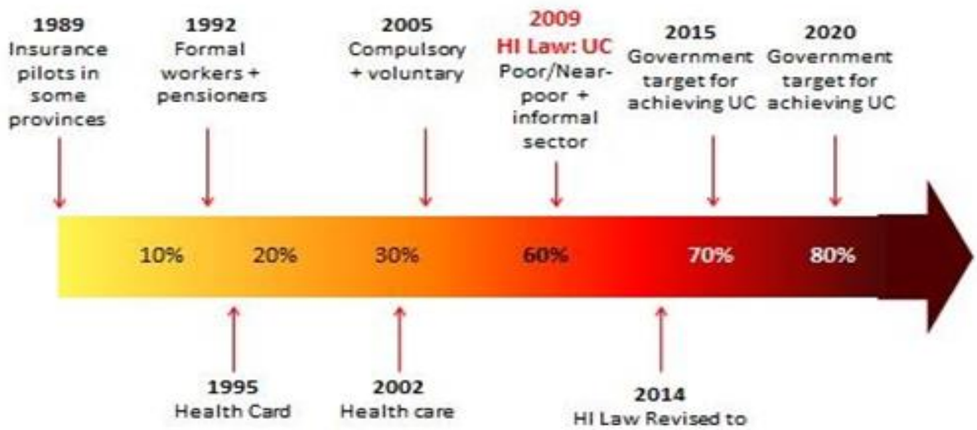
The classification into the central, provincial, district and commune level of health facilities aims to point out the different kinds of cure: general treatment or specialized treatment. General hospitals, in particular, supply both inpatient and outpatient health care services. Besides, central and provincial general hospitals typically have more specialties than district hospitals. At the communal level, the primary care services, including maternity health and infectious disease prevention, are provided by commune health centers. In 2013, the MOH issued the Circular No. 43/2013 / TT-BYT to replace for the Decision 23/2005/QD-BYT, which mentioned a referral guide to define clear functions to each level of the system. So, a referral structure among diverse levels of the health care system was implemented in Vietnam. In principle, people are requested to register with their local health facility, normally a district hospital or a commune health center. They interact with this facility first when they seek treatment of primary care. Provincial and central hospitals are expected to provide secondary or tertiary care. Nonetheless, a commonly stringing issue is bypass at lower levels (typically, district and communal levels) in contrast an over-crowded situation or very high occupancy rates at the provincial and central levels. The weak capacity to provide services and inability to attract patients of lower-level hospitals might be a main reason, which urges patients choosing to access upper-level counterparts directly. Because of autonomy, high-level hospitals with better capacities have competitive advantages in attracting and retaining patients. Last but not least, the current referral system is still weak and the payment methods and financial mechanisms are not supportive enough for the lower level hospitals to deliver better quality services (Oanh et al., 2015).

On the one side, it can be said that Vietnam nowadays is quite capable of training an adequate number of health workers. On the other side, the current constraints can be observed in the management of human resource in health care sector. There is a “brain drain” of skilled health workers moving out of the public sector, or the specific field such as the preventive medicine. This context witnesses a shortage of human resources in this sector. The benefits and encouragements for health workers like inducements, working conditions and career development opportunities are not adequate to attract and hold this workforce. This situation raises a competition to attract human resource among hospitals in different regions. At the same time, another issue related to human resources is the redundant of government employees in the public sector in general and in the public hospitals in particular (State Audit of Vietnam, 2016). These situations reveal the efficiency problems of hospitals in Vietnam in term the inefficient usage and management of existing resources.

2.2.2 Health care financing system

Previously, public hospitals in Vietnam were fully funded by the government. However, after the reform process with an attendance of the user fees payment method and health insurance programs, the financial structure in Vietnamese hospitals has become diverse. As reforms were implemented, out-of-pocket spending on health significantly raised, touching at the level of 71 percent in 1993 and continuously rising to 80 percent in 1998 over total health spending (Lieberman & Wagstaff, 2009). The National Health Insurance Program was firstly operated under a multiple financial structure with provincial health insurance funds, and a national reserve fund. In 1998, all health insurance funds were gathered into a single national fund administered by the Ministry of Health. The Vietnam Social Security (VSS) was established in 2003 and became a single public health insurer in Vietnam. Nevertheless, the introduction of Law on Health Insurance in 2008 allowed decentralizing revenue collection and spending at provincial level. Starting with several schemes, nowadays health insurance comprises the compulsory scheme which includes three programs: social health insurance, health care for the poor and free health care for children under 6 years old and voluntary schemes which target on groups like: farmers, the self-employed and students. Social health insurance is considered as a main measure to achieve the national goal by ensuring that all of society takes responsibility for health. However, compulsory scheme is not included any payments for dependent members in the family. Universal access to quality health services is a primary goal of the Vietnamese government. The Master Plan for Universal Coverage, which was approved in 2012 by the Prime Minister, targets on expanding coverage further, to at least 80 percent by 2020.

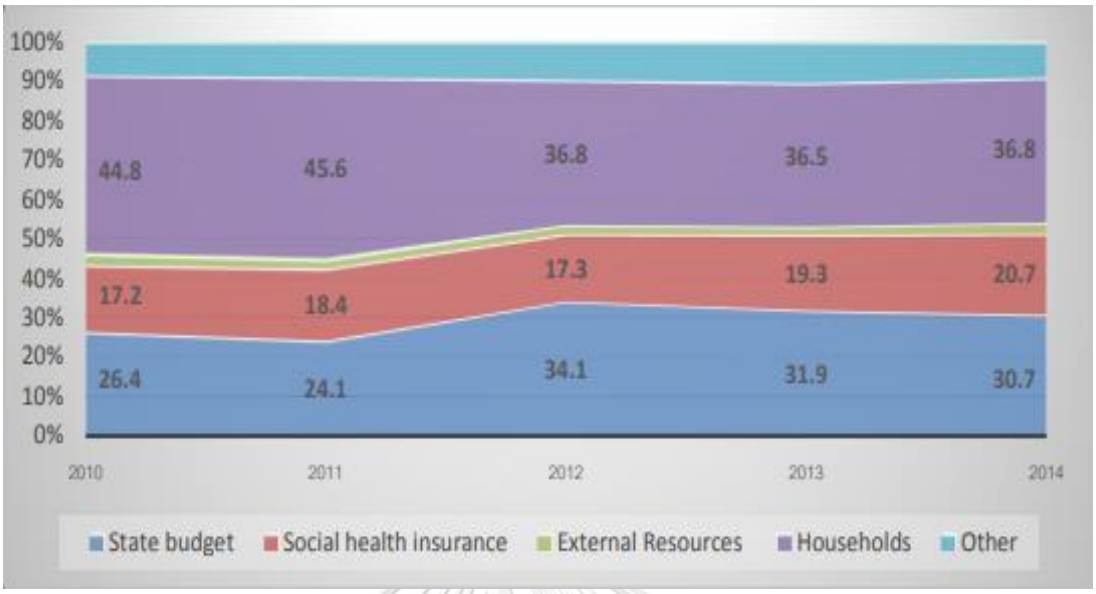
Figure 2. 4: Movement toward Universal Coverage of Social Health Insurance



Source: World Bank (2014)

During the reform process by implemented *Doi Moi* policies, health care financing in Vietnam switched from a system mainly based on tax to a multiple-source system. This system involved financial funding from the state budget, foreign aid, households, social health insurance, and other sources. These other sources come from external aid, official development assistance (ODA) and private health insurance accounted for a minor proportion. There is an increasing expansion of health insurance coverage in the recent days. Nonetheless, some big challenges from health insurance schemes are obstructing the collection of revenue, such as: levels of health insurance contribution are still low; insures under compulsory insurance schemes only occupy a small rate of sharing; in the voluntary health insurance scheme there is an existence of adverse selection. As a consequence, there is now a funding deficit from health insurance sources. Although, the funding for health care rose, the out of pocket spending has also grown and records at the largest share of total health expenditure at 36.8 percent in 2014. Whilst, spending from state budgets recorded a gradually decreasing trend in recent years.

Figure 2. 5: Structure of health financing resources (2010 – 2014)



Source: Ministry of Health (2016)

On this side, nowadays hospitals have the mainly financial support from the state budget, the other financial sources of health insurance reimbursement and user charges/OOP payments of households. On the other side, the state budget to hospitals has progressively declined; this situation causes an increasingly important role of user fees and health insurance as alternative financial sources. In order to overcome these financial burdens, Vietnamese public hospitals are trying to improve their performance.

In conclusion, an overview of the country's profile and the current performance along with opportunities and challenges of Vietnamese health care sector are discussed in this chapter. The burning issues are increasingly deteriorated by the inefficient usage of existing resources like human resources and the limitation of financial resources. The subsequent chapter will present a literature review about efficiency studies at the level of public district hospitals.

CHAPTER III
LITERATURE REVIEW

3.1 Basic Concept of Efficiency

The research study of Farrell in 1957 set a foundation in understanding concept of efficiency. Farrell described the efficiency of Decision Making Units (DMUs) in production obtaining a given level of output by the least quantity of inputs consumed or vice versa maximizing the output production from a given quantity of input usages. According to his work, there are two components contributing to the efficiency of any production unit, including: technical and allocative efficiency. In Farrell's framework, the most efficiency firm would be located on the production frontier (Farrell, 1957).

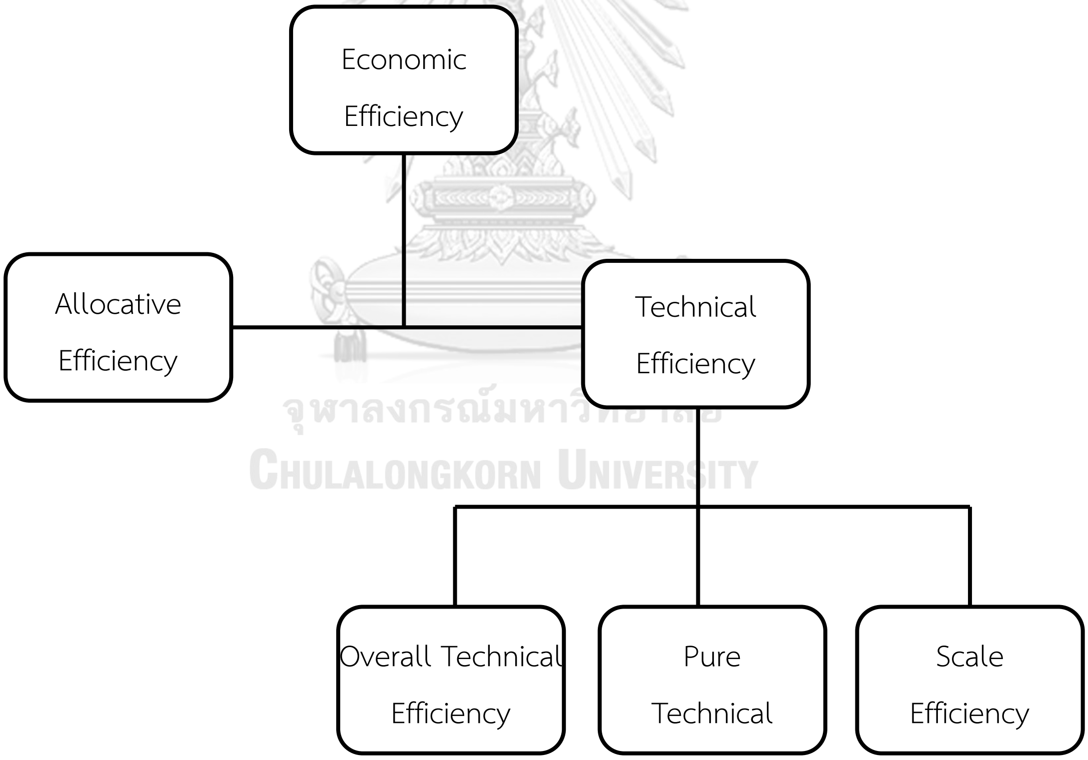
Efficiency is a successful combination of a production unit when it produces outputs by using its resources. It shows the difference between the observed use and the optimal use of resources to produce outputs at a certain quality.

Technical efficiency can be determined when the use of inputs at the most technologically efficient manner to produce quantities of outputs. In other words, there is a physical transformation of physical inputs such as labor, raw materials and capitals into outputs. The degree, to which the observed ratio of input-output combination matches the achieved ratio from the best practice, is a way to define technical efficiency. It could be indicated as the potential to increase quantities of outputs from given quantities of inputs (Worthington, 2004).

Allocative efficiency could appear on any levels of production. It indicates the relationship between the usage of inputs at its optimal size given their relevant prices and an available production technology. The firm achieving the allocative efficiency is required to choose the best combination of inputs that are already technically efficient but would maximize the production of outputs to the maximum (Worthington, 2004).

In summary, all components are known as producers of economic efficiency. It is assumed that a firm can use the best combination of inputs and outputs in order to produce maximum outputs keeping inputs constant or to reduce the inputs usage in producing the same level of outputs. The following figure will describe types of economic efficiency.

Figure 3. 1: Classification of economic efficiency

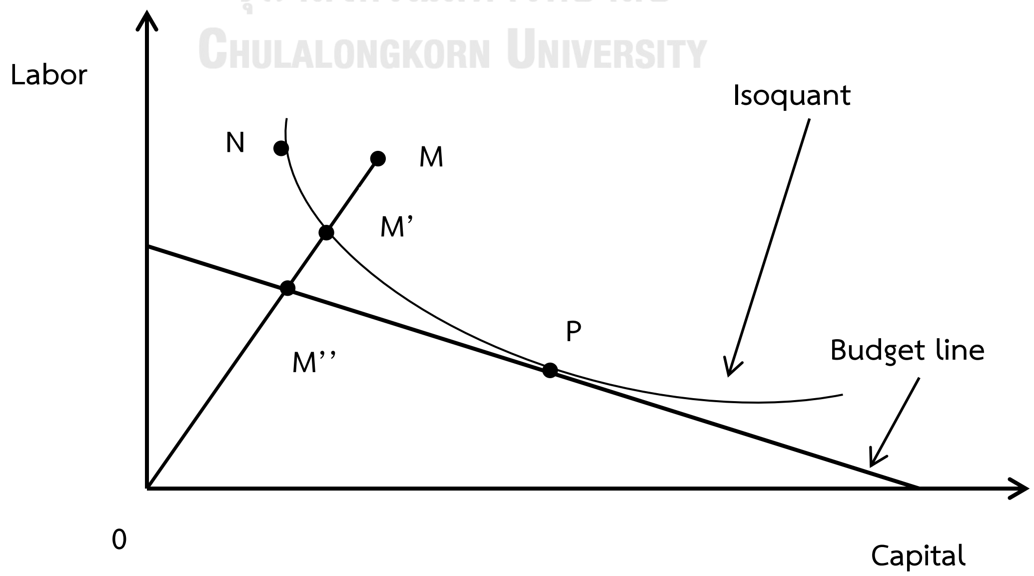


Source: Sherman (1984)

Scale Efficiency is likely to offer a measure by comparing the technical efficiency measures corresponding to the assumptions of Constant Return to Scale (CRS) and Variable Return to Scale (VRS). The technical efficiency measure derived under CRS assumption is considered as **overall technical efficiency**. It estimates inefficiencies based on a combination of inputs to produce outputs and the scope of operations. The technical efficiency measure derived under VRS assumption is considered as **pure technical efficiency**. It calculates the inefficiency based on an underperformance in management.

A simple example as illustrated in the figure 3.2 can be a clarifying explanation for the concept of efficiency. A firm using two inputs (labor and capital) and one output can be considered in which the required arrangements of the inputs for production of the output. The isoquant frontier presents the minimum amount of inputs for the output production. When a firm produces outputs at a point located on the isoquant curve, it then is technically efficient. The budget line contains the combination of inputs that has the same costs. It can clearly see that point M is technically inefficient as a larger amount of inputs usage. The firm at point M was required to produce the output at the level on the isoquant curve. At the point N, the firm is technically efficient; while point P is cost efficient since the cost of the output production is lower and its slope (isoquant curve) is tangent to the budget line.

Figure 3. 2: Concept of efficiency



Source: Coelli (1996)

If there has a movement from point M to P, the technical efficiency of the firm will raise by 0M-0M'/0M, then its allocated efficiency will gain by 0M'-0M''/0M' and also its cost efficiency will rise by the distance 0M-0M''/0M.

The efficiency of a firm entails two components. The first component is technical efficiency. It indicates the capability of a firm in achieving the maximum output from the given input. The remaining component is allocated efficiency. It shows the talent of a firm in using inputs given their prices in optimal proportion. These two measures are combining to provide the measurement of total economic efficiency (Coelli, 1996).

3.2 Concept of Hospital Efficiency

In economics, the efficiency mentions a society optimizing use of limited resources to meet its demands and wants. The term "efficiency" could come up with several different meanings however all of them focus on how a market could satisfy its consumers by allocating its scarcity in resources. General speaking, allocating these inputs is one of the strengths of the market mechanism, however in some cases the market can face to failures. Developing countries, where majority of health care facilities, which are financially supported by state budget, are more interested in measuring efficiency, but may not have the necessary data to carry out a study.

The sustainable health care financing is facing numerous challenges in the different countries. Nowadays, there remains a sharp escalation in demand for health care services and inflationary cost of services in the worldwide. This situation raises a major source of concern for the policy makers at the national agenda and managers in both private and public sector. An exclusive attention to the efficient operation and hospital performance is becoming more noticeable. Similar to other fields, in the health care system, an evaluation of efficiency plays a key importance and may be the first step in auditing the individual performance. Subsequently, a rational distribution of human and capital resources could be analyzed on basis of the efficiency measurement. Efficiency is a popular term, which is widely deployed in the modern Economics. This term refers to wise utilization of resources in supplying services. Among types of efficiency, technical efficiency is commonly chosen to measure the effective use of inputs in producing outputs (Moshiri., Aljunid., & Amin., 2010).

When a hospital operates on the efficiency frontier, it is considered to be technically efficient. In the original Farrell framework, the entire observation on a given sample are assumed to have access to same technology (Farrell, 1957).

The technically efficiency of a hospital exists if an input reduction causes a drop in at least one single output or a rise in at least another input. Otherwise, a rise in any output causes an increase in at least one single input or a decrease in at least another output (Fare, Grosskopf, Lindgren, & Roos, 1994). On the other side, allocative efficiency happens when inputs or outputs are combined to their best possible uses in the economy domain so that no further gains in output are possible.

To gain a high accuracy in measuring the hospital efficiency, a selection of hospital's outputs must be highly noticed. There is a fact that outputs in the health care sector are usually measured by number of treatments or patient days. These indicators often refer to intermediate outputs. There are many aspects that can be considered for a measurement of hospital's outputs, for instance: number of outpatient visit, number of inpatient day, number of surgery, number of lab test, average length of stay, bed occupancy rate, nurse-physician ratio, non-medical staff-physician ratio and others (Moshiri. et al., 2010).

A hospital is able to indicate constant return to scale (CRS), decreasing return to scale (DRS) or increasing return to scale (IRS). Returns to scale stimulate health policy makers and hospital managers what could happen, for instance, they rise up hospital's inputs by the same percentage or amount (Grosskopf & Valdmanis, 1987). Three different outcomes could be resulted in three following scenarios: (i) CRS – doubling of inputs may cause doubling of outputs; (ii) IRS – doubling of inputs could result in more than a doubling of outputs; (iii) (DRS) doubling of all inputs causes less than doubling of outputs. The suggestions for policy will be drawn at the timing point which a scenario revealed (Kirigia et al., 2010).

3.3 Methods for Hospital Efficiency Measurement

There are a series of different methods used for measuring hospital efficiency. A comparative analysis of performance among similar decision making units is allowed to apply in these measurement methods.

Since 1998, Hollingsworth et al. did a research study to review non-parametric methods and applications. This study stated that information and data of the production and cost function frontier are needed in order to evaluate efficiency or productivity (Hollingsworth, Dawson, & Maniadakis, 1998).

An extension study to explore the parametric programming function method was implemented in 2004 by Worthington. This study revealed an agreement that the frontier estimation requires data of targeted firms while measuring efficiency. The frontier is structured by the most efficient units from the sample data. It reveals the DMUs which could use the least inputs to create a certain quantity of outputs or produce maximum outputs from a given amount of inputs (Worthington, 2004).

In parametric and non-parametric methods mentioned above, the best practice frontier is computed by the efficiency of clearly defined DMUs relative to the line. The frontier measures which level of a firm performance related to the firm performed best (Moshiri. et al., 2010).

The study done by Maniadakis et al., (2009) discussed about these two approaches to measure efficiency: the economic method (stochastic) and mathematical programming (deterministic). In the economic approach, the model makes room and accounts for random noise or error term in the sample data. The model also proposes a specific functional formula for the production frontier, is thus termed Parametric. In the difference from the econometric approach, the mathematical programming approach could take either a Parametric or a Non-Parametric form and does not involve for data errors. While the parametric form, similar to the econometric approach take a functional form; the non-parametric approach does not entail any functional form but takes assumptions of the frontier shape (convexity or non-emptiness) (Maniadakis, Kotsopoulos, Prezerakos, & Yfantopoulos, 2009). The most famous version of the non-parametric method is known as a linear programming tool named Data Envelopment Analysis (DEA) (Moshiri. et al., 2010).

The below is a brief description of all methods for efficiency and productivity measurement summarized by Hollingsworth et al., in 1998.

Table 3. 1: Analytical methods of measuring efficiency and productivity

	Parametric	**Non-parametric**
Deterministic	Parametric Mathematical Programming	Data Envelopment Analysis (DEA)
	Deterministic (econometric)	Malmquist Productivity Index

	Frontier Analysis	
Stochastic	Stochastic (econometric) Frontier Analysis	Stochastic Data Envelopment Analysis

In addition, there have several other methods can calculate magnitude of hospital efficiency determinants, as follow:

Ratio Analysis: in this method, different ratios for a group of comparable hospitals are used in order to discover relations that are typically high or low. The ration could be cost per patient day, cost per patient, and personnel full-time equivalents per patient (Sherman, 1984).

Econometric Regression Technique: This technique is used to discovery the hospital cost and production relationship. Regression analysis technique is broader than simply ration analysis because it can contain multiple inputs and outputs. However, some other problems are faced. The usage of least square regression methods draws estimates of average associations, which are not necessarily efficient associations. In the second issue, an estimation of the hospital cost function from using this method may cause a mean relationship. It indirectly set up positions for inefficient hospitals (Sherman, 1984).

The study of H. David Sherman in 1984 also pointed out that Data Envelopment Analysis could resolve the restrictions related to two techniques mentioned above: ratio analysis and regression techniques.

3.4 Data Envelopment Analysis

The Data Envelopment Analysis methodology is a liner programming technique developed by (Charnes, Cooper, & Rhodes, 1978). This non-parametric approach uses different techniques to envelope data, either statistical or mathematical programming, respectively. The DEA makes a comparison in a set of a firm's actual inputs used to produce their actual outputs over a usual production period. The multiple inputs and outputs combination of a hospital can be explicitly considered by the DEA. This could gain an overall evaluation of the hospital technical efficiency. In addition, it can integrate other hospital outputs, such as: teaching, research, and community education programs, to gain a comprehensive hospital efficiency measurement (Sherman, 1984).

There is a longstanding debate and no outright statement on which is the best method to use in measuring the technical efficiency of health care facilities. This study chooses the DEA in order to evaluate the technical efficiency of public district hospitals in Vietnam because of two main reasons. Firstly, in some previous studies implemented in Turkey (Sahin & Ozcan, 2000), in Kenya (Kirigia, Emrouznejad, & Sambo, 2002), in Ghana (Osei et al., 2005), in Namibia (Zere et al., 2006), and in Malawi (Lilongwe, 2008), the DEA is used popularly with middle and low income countries like Vietnam. These studies prove that the DEA does not entail a relative between inputs and outputs; they are able to carry on different types of units. Secondly, comparing to other econometric methods, the DEA does not need an intensive data about inputs and outputs prices as well as a big sample size. Therefore, it's likely to be suitable when there is insufficient information like the health care sector. The DEAP version 2.1 designed by Tim Coelli is the software that has been commonly used by researchers and economists in assessing hospital efficiency performance.

In term of objectives of this study, the standard DEA model is sufficient to provide results that meet the research objectives. The DEA would properly inform hospital managers and policy makers: which hospitals are the most efficient; which are inefficient; and which hospital becomes a benchmark to ensure that its methods and activities are optimal. The basic DEA is able to identify by how much use of inputs could be decreased to yield current level of outputs thus potentially saving resources.

The DEA, similar to other analysis tools and methods, has some strengths and weaknesses. Clearly understanding the pros and cons of the DEA brings a significant meaning in ensuring the research study's efficiency. They are outlined in the following points:

Strengths:

- Multiple inputs and outputs could be handled
- No requirement for relations between inputs and outputs
- Different units of inputs and outputs could be acceptable
- Existing direct comparisons among peers

Weakness:

- Significant issues may result by measurement errors
- No "absolute" efficiency could be determined
- Inapplicable statistic examinations
- Big issues could require an intensively mathematical calculation

3.5 Previous studies on Hospital Efficiency Measurement

In this section of the research, a literature review of previous studies on technical efficiency in the health care sector is summarizes. It is focused exclusively on performance of public district hospitals. It additionally presented types of hypothesis and methods of implemented studies. In the actual, a number of economic studies on the hospital performance, especially public district hospitals in Vietnam is quiet modest. However, there still have been a series of researches measuring on the technical efficiency of the health care sector in other developing countries. These studies are implemented spreading all aspects of this field: from basic to further intensive level of health care, outpatient care to inpatient care, the whole health care structure to health care suppliers and administrative organizations. These empirical researches motivated on the hospital technical efficiency and productivity underneath the health care reform roadmap (Pham, 2011). The previous studies focusing on public district hospitals in several developing countries like Turkey, Kenya, Ghana, Namibia, and others could be listed below.

In **Turkey**, the study by Sahin and Ozcan in 2000 evaluated the technical efficiency of 80 public hospitals by employing the DEA. Six variables to constitute the inputs in this study included beds, specialists, general practitioners, nurses, other allied professors and revolving fund expenditure. The output variables were outpatient visits, discharged patients and hospital mortality rate. The results showed that more than 55% of public hospitals in Turkey were recorded inefficiently. Turkish inefficient hospitals overused resources of inputs to produce an inadequate quantity of outputs than their efficient ones. By cutting down the number of unused beds, specialist, other labor in health, and the overspendings, the inefficient hospitals would protect above 600 million dollars during five years in their budget (Sahin & Ozcan, 2000).

In **Kenya**, Kirigia et al., (2002) employed basic DEA frameworks, including: Constant Return to Scale and Variable Return to Scale, in order to measure technical efficiency scores among 54 PDHs during two years 1998 and 1999. There were mainly eleven inputs including: medical officers/pharmacists/dentists; clinic officers; nurses (including enrolled, registered, and community nurses); administrative staff; technician/technologists; other staff; subordinated staffs; pharmaceuticals; non-pharmaceutical supplies; maintenance of fixed assets; and food and rations. Then, eight outputs were produced such as: outpatient visits; special clinic visits; MCH/FP visits; dental care visits; general medical admissions; pediatric admissions; maternity admission; and amenity award admissions. 74% of whole studied hospitals were indicated at the technically efficient level. An average technically efficient score of inefficient hospital was 84 percent. And 70.4 percent achieved scale efficiency (Kirigia et al., 2002).

An exploratory study in **Ghana** evaluating the technical efficiency among 17 district hospitals and 17 health centers was implemented by using the DEA**.** The study divided inputs into 3 categories: labor; materials; and capital. The outputs included a number of hospital service types. 47 percent of public district hospitals and 70 percent of health centers were technically inefficient and their scale inefficiency occupied 59 percent and 47 percent, respectively. The results showed that these inefficient hospitals can develop efficiently by decreasing their existing quantity of specialist staffs and hospital beds, or rising up the quantity of maternal and child care visits, deliveries and discharges. While, health care centers can operate a higher level of efficiency due to raise patient visits for health care (Osei et al., 2005)**.**

In **Namibia**, Zere (2006) explored the technical efficiency of Namibian 26 public district hospitals in a five-year period between 1997 and 2001 by using hospital capacity utilization ratios along with the DEA. The Jackknife technique examining the robustness was employed. There are three inputs (total recurrent expenditure, beds and nursing staff) and two outputs (total outpatient visits and inpatient days) using in this model. The results showed that over 50 percent of observed district hospitals were recorded a technical inefficiency by both variable returns to scale technical inefficiency and scale inefficiency. The increasing returns to scale pattern was attributed dominantly to inefficient scores. To become efficient, hospitals should reduce their surplus inputs used from 26 to 37 per cent or manage small hospitals by a merger after the primary care units are expanded (Zere et al., 2006).

In **Malawi**, a study in 2008 aimed to estimate technical efficiency among 40 district hospitals during the period 2005 to 2006 applying the DEA approach. Inputs were hospital beds, nursing staff and physician. While, outputs mentioned to outpatient and inpatient visits. The results showed that average technical efficiency under constant return to scale (CRSTE) of the studied hospitals was 60.4 percent. There were only 9 among 40 hospitals running efficiently. More than haft of the hospitals recorded a small percentage of efficiency at 50 percent. The study also implied that without changing the input level, there is a potential to change the outputs to 40 percent overall (Lilongwe, 2008).

In **Vietnam**, the efficiency performance of 17 hospitals together 27 medical centers from several different provinces was analyzed in the research year of 2002. The study used number of laborers and net capital as input variables; and use net revenue as an output variable. In results, hospitals presented more efficiently than medical centers by the mean scale efficiency scores were 77.4% and 58.7%, respectively. There was no influence on the efficiency by the difference in location, such as Hanoi or Ho Chi Minh City. But the impact of net capital-labor ratio conveyed that these facilities appear to operate in labor-intensive ways (Nguyen & Giang, 2004).

Another studies in **Vietnam** implemented by Uslu and Pham (2008) using an analysis in two phases for a data set of 101 general public hospitals. The first phase used the DEA, and the Tobit regression was employed to result on impacts of regulatory changes in the second stage. The analysis was applied on two inputs (beds and personnel) and three outputs (outpatient visits, inpatient days and surgical operation). The results proved a productivity improvement of hospitals in Vietnam from 1998 to 2006, a progress of 1.4% per year. The technical efficiency under constant return to scale (CRSTE) and technical efficiency under variable return to scale (VRSTE) were 66.4% and 72%, respectively. These studies also found out the explanatory factors from regulatory change (user fee and autonomy) and hospital-specific characteristics (location) affected on these hospitals (Uslu & Pham, 2008).

After that, in 2011, based on the same data set, Pham's study employed the input-oriented DEA model with variable returns to scale assumption to measure the technical efficiency. Then, Malmquist total factor productivity index method was used to estimate these hospitals' productivity. In results, an overall growth in technical efficiency scores recorded by 11 percent over the study period (Pham, 2011).

Last but not least, the ownership and level of competition in **Vietnam** related to VRSTE were estimated by the latest research in 2018. Four inputs were associated with labor (number of medical doctors, assistant doctors, and nurses) and capital (number of actual beds). The outputs consisted of the number of inpatient discharges and outpatient physician visits. The explanatory variables in the truncated regression analysis included: average length of stay, Harfindahl-Hirschman Index, number of competing hospitals, number of competing private hospitals, ownership type, regional type, and time trend. The result reveals the mean of the efficiency scores of provincial, district, and private hospitals being 0.767, 0.793, and 0.774, respectively. And, the number of competing public and private hospitals had a remarkably negative correlation to the hospitals efficiency (Hideaki, 2018).

In conclusion, this chapter has reviewed various concepts of efficiency on both theoretical and practical points of view in the health care sector. Actually, there are no precious studies focusing on technical efficiency and determinant factors in public district hospitals in Vietnam. This study, therefore, is interested in finding out about this topic.

CHAPTER IV
RESEARCH METHODOLOGY

4.1 Study design

This research study is designed to bring an overview of public district hospitals' performance in term of technical efficiency for policy makers and managers based on the available data.

At the first stage of this empirical study, Data Envelopment Analysis (DEA), a non-parametric approach, aims to estimate the technically efficient scores for public district hospitals in Vietnam. Three inputs and three outputs are employed for calculation of the DEAP program version 2.1, designed by Coelli Tim (1996). Results of the first stage measure the technical and scale efficiency due to an input oriented DEA approach under a Constant Return to Scale and a Variable Return to Scale. A set of data from a survey implemented at Vietnamese public district hospitals in 2014 is employed for inputs and outputs variables. A calculation and a measurement of the technical efficiency scores among public district hospitals are designed as core objectives of this study.

In addition, determination of influent factors affecting technical efficiency is secondarily assessed in the study. The technical efficiency score of each hospital would be considered as a dependent variable. Explanatory variables would be regressed to determine key variables that could influence on hospitals' efficiency. The Tobit regression model to define the determinant factors is estimated by the eViews 9 software.

4.2 Type and source of the study

The study uses the secondary data for the target population of 52 public district hospitals out of 78 public district hospitals and health care centers due to the removal of some mistaken and omitted values. The data was collected via questionnaire interviews by the Health Strategy and Policy Institute in the framework of the Vietnam District and Commune Health Facility survey 2015 under supervision of World Bank technical group. The time period was from January to December 2014.

4.3 Conceptual Framework

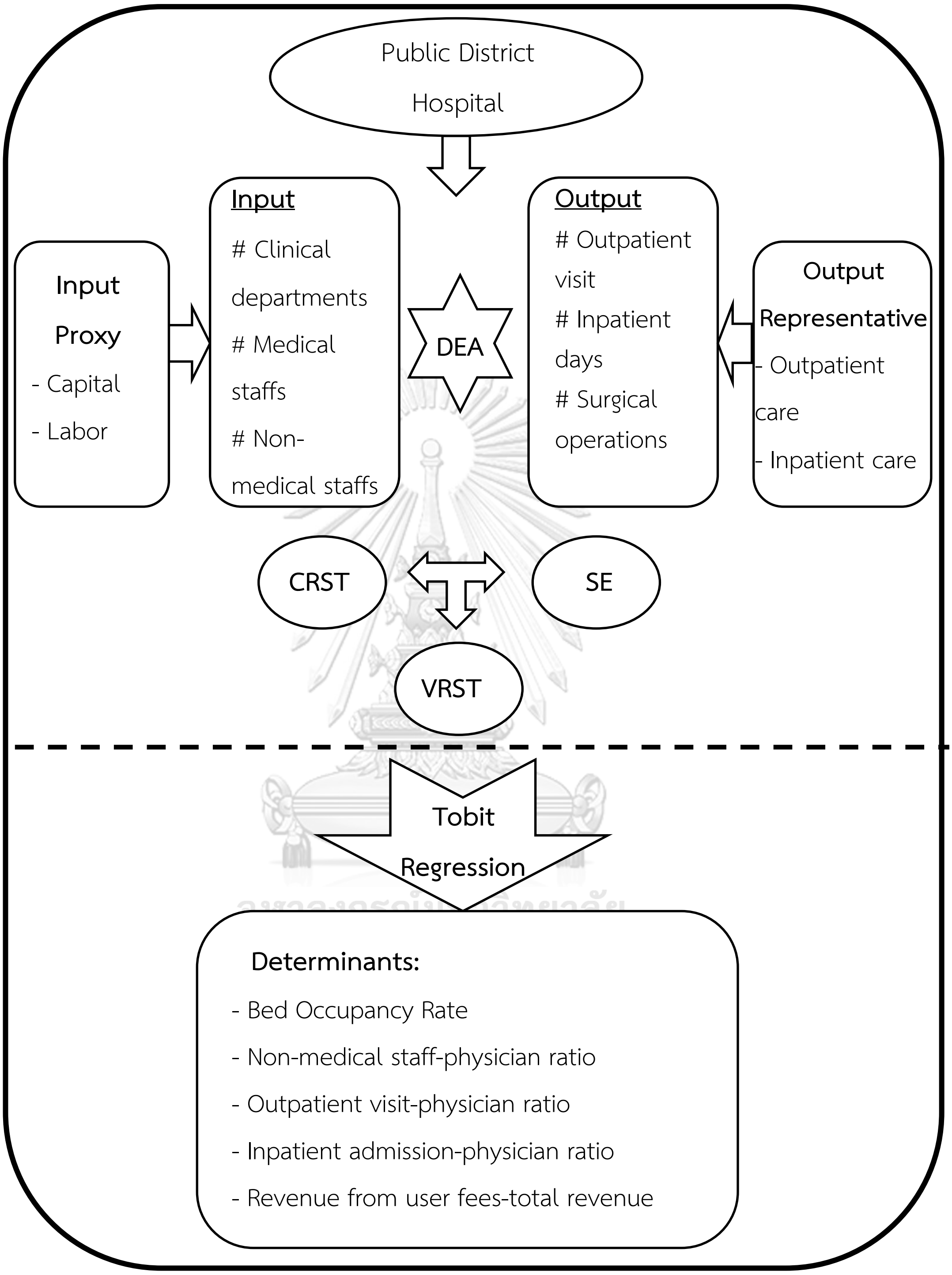
The study is implemented in two different stages to achieve both general and specific objectives.

At the first stage, an evaluation of the technical efficiency of Vietnamese public district hospitals is measured by the input-oriented Data Envelopment Analysis approach. This model let us know at the same level of outputs, which amount of inputs should be cut down. So, this model is a great choice for managers to minimize limited inputs as much as possible. The technical and scale efficiency scores would be calculated under a Constant Return to Scale (CRS) and Variable Return to Scale (VRS). CRS means with a double rise of inputs, there is a double rise of outputs, too. While, VRS means that if all inputs rise by a given proportion, the quantity of outputs rises by a lower or higher proportion. The result of this first step will show the technical efficiency scores of each hospital under CRSTE and VRSTE. And, another outcome of this analysis would also indicate the scale efficiency score.

In the second stage, because of efficient DMUs having a DEA efficiency score of 1 and a relatively large number of fully efficient DMU being estimated, the distribution of efficiency is truncated above from unity. Therefore, censored Tobit regression model, an economic technique, is used to explore in detail about determinants of technical efficiency (Uslu & Pham, 2008). The variable return to scale technical efficiency score is used as a dependent variable. Explanatory variables have identified by assuming critical way to describe the efficiency of these hospitals.

All methods of analysis are described in the following conceptual framework at Figure 4.1.

Figure 4. 1: Conceptual Framework



4.4 Rational of the selected variables in the study

When analyzing the technical efficiency using the DEA, multiple inputs and outputs can be applied concerning the natural of production process. In order to choose relevant inputs and outputs, several questions should be clarified, including: Which products of a public district hospital are provided? Which units of inputs and outputs variables should involve? Is there a need to specify the technical relationship among inputs and outputs? On the other side, the availability of adequate and appropriate data is also taken into consideration in selecting inputs and outputs.

4.4.1 Input variables

According to other studies of Chen (2006), Ferrari (2006), and Harris et al., (2000), three inputs are selected as proxies of diverse factors: labor and capital resource (Chen, 2006; Ferrari, 2006; Harris, Ozgen, & Ozcan, 2000). The selection of these inputs based on the current hospital production process, is mostly administrative, delivers many kinds of health care services, and broadly employs the qualified labor of medical and non-medical staffs, and the number of clinical departments to produce health outputs. Two aggregated inputs including: number of medical staffs and number of non-medical staffs play a key role in human resources in providing health care as labor resource. And, the number of medical staff in supplying health services is used as an input of the capital resource. As discussed above, the DEA model would be run with the followings inputs:

Medical staffs: The total number of medical staff in PDHs who graduate from schools of medicine, pharmacy and nursing; are licensed to work in medical departments; and are full-time employees. They are a key input variable in the health care sector and also account for a large consumption in operational and capital expenditure in PDHs in Vietnam. A strong belief presents that the age and experience of medical staffs could effect on the hospitals' efficiency. Therefore, the number of medical staffs is used in this study as an important input to define its contribution on the hospital efficiency.

Non-medical staffs: The total number of employees who work in the non-clinical departments relating to administration, logistics, HR and management. The non-medical staffs variable is a key input in the production function to help hospitals run smoothly.

Clinical departments: The total number of department relates to medical treatment. This input variable is used as a proxy for capital. Because hospitals need invest into build up a number of clinical departments to be able to run the production process. The volume of clinical departments can enhance hospitals to perform economically useful work. This study is not mention to land as a capital because in public hospitals, land is under the government's administration.

Table 4. 1: Description of PDHs' input variables

Input variables	Abbr.	Operational definition	Units
Medical staffs	MS	Total number of medical doctors who graduate from any school of medicine and are licensed to work as a medical doctor	Person
Non-medical staffs	NMS	Total number of employees who work in the non-clinical departments relating to administration, HR or management	Person
Clinical departments	DEPT	Total number of departments relating to medical treatment	Unit

4.4.2 Output variables

Following the study of (Pham, 2011), there are three output variables including number of outpatient visits, inpatient days and surgical operations added to the model that play as a representative role of output: outpatient care and inpatient care. These outputs are represented for outpatient and inpatient care in different combinations. The output variables from 52 PDHs are considered in measuring the technical efficiency, as follows.

Outpatient visits: The total number of both the scheduled and unscheduled visits recorded to emergency rooms and outpatient department during a year. A large number of patients are checked up and treated as outpatients before registering an inpatient admission later. When being discharged, they can attend follow up treatment from the outpatient department. So, outpatient visits variable is one of important outputs among the overall running activities of hospitals, which is designed for the treatment of outpatients.

Inpatient days: The total admission days of inpatient care in inpatient department during a year. It is given as another output which showed different functions and required a higher consumption in resources than outpatient visit. Moreover, by following the findings of Grannemann et al., the inpatient day factor is a more medically homogeneous unit than the inpatient factor; therefore the use of inpatient days can provide a more favorable output of hospitals (Grannemann, Brown, & Pauly, 1986).

Surgical operations: The total number of surgical operations counts for all inpatient and ambulatory surgical operations in one year. This output variable is employed to show the different mixtures of inputs. From a medical perspective, surgical operations are performed by different levels of skilled clinicians suitable for various levels of immediate treatments. During a surgical operation, it is involved a various types of medical materials like equipment and drugs.

Table 4. 2: Description of PDHs' output variables

Output variables	Abbr.	Operational definition	Units
Outpatient visits	OPV	Total number of outpatient visits to the hospital in 2014	Visit
Inpatient days	IPD	Total number of days that inpatients stayed in hospital beds and received inpatient services in 2014	Day
Surgical operations	SUR	Total number of inpatient and ambulatory surgical operations in 2014	Time

4.5 Determinants of Hospital Efficiency

The hospital efficiency performance may also be accompanied with organizational and policy environmental factors. The collection of hospital efficiency determinants is supported by several different reasons from previous studies. In this study, a selection of explanatory variables for regression analysis is considered on basic of contextual issues such as the bed occupancy rate, the non-medical staff-physician ratio, the outpatient visit-physician ratio, the inpatient admission-physician ratio; moreover, the policy environment affecting on PDHs via the revenue from user fees-total revenue ratio. These determinants include environmental and organizational factors.

The Bed Occupancy Rate (BOR) is measured as a proxy of utilization of hospital resources. Higher BOR shows that most of the beds in the hospital are being utilized by the patients throughout the year. It should be positive because it creates more outcomes by using resources (Chang, 1998).

The Non-Medical Staff-Physician Ratio (NMSPR) expresses an inputs' arrangement of other personnel and physician. The expected sign is negative because of the redundancy's other staffs in public sectors in Vietnam (State Audit of Vietnam, 2016).

The Outpatient Visit-Physician Ratio (OPVPR) is a proxy in order to determine the effect of outpatient service delivered by a physician. The more a doctor examines OPD patients, the better are hospital efficiency. It is positive related with efficiency (Ozcan & Cotter, 1994).

The Inpatient Admission-Physician Ratio (IPAPR) is a proxy for defining the effect of inpatient service delivered by a physician. The more a doctor examines IPD patients, the better are hospital efficiency. It has a positive influence on efficiency (Ozcan & Cotter, 1994).

The Revenue from User Fees-Total Revenue Ratio (RUFTRR) is a proxy to show the impact of the user fee and autonomy policy on the hospital efficiency. The more revenue from user fees is, the more autonomy for hospitals is. It is expected positively. This study design offers for both stakeholders and health care provider views.

All expected signs correlated VRSTE scores are summarized in the below table:

Table 4. 3: The expected signs of determinant variables of VRSTE scores

Dependent variables	Determinant variables of VRSTE scores				
	BOR	NMSPR	OPVPR	IPAPR	RUFTRR
VRSTE scores	+	-	+	+	+

4.6 Data Envelopment Analysis (DEA) Model

4.6.1 DEA mathematical Formula

The Data Envelopment Analysis (DEA) method is a non-parametric approach to access the efficiency of organizations with multiple inputs and outputs. Each organization is named as an individual decision-making unit (DMU). The DEA takes to weight the inputs and outputs, then help it to gain the most potential efficiency. Therefore, it arrives at a weighting of the relative importance of the input and output variables. Then DEA gives all the other DMUs the same weights and make a comparison in the resulting efficiencies with that for the noticed DMU. This DMU receives a maximum efficiency score if it shows at least as well as any others. But if there is any other DMU looking better than the noticed DMU, the weights having been computed to be most favorable to the noticed DMU, then it will obtain an efficiency score less than maximum. In other words, DEA plots an efficient frontier line using combination of inputs and outputs from the best performing DMU. Those compose the best practice frontier assigning an efficiency score of 1 (100%) while others are below the frontier allocating scores in the range of 0 to 1. The DMU with score of 1 will be considered as a benchmark for ranking the others.

A multi-factor productivity can support to estimate DMUs' efficiency according to the DEA approach. The efficiency score is calculated in a mathematic formula with multiple inputs and outputs, as:

$$\textbf{Efficiency} = \frac{\textbf{Weighted sum of outputs}}{\textbf{Weighted sum of inputs}}$$

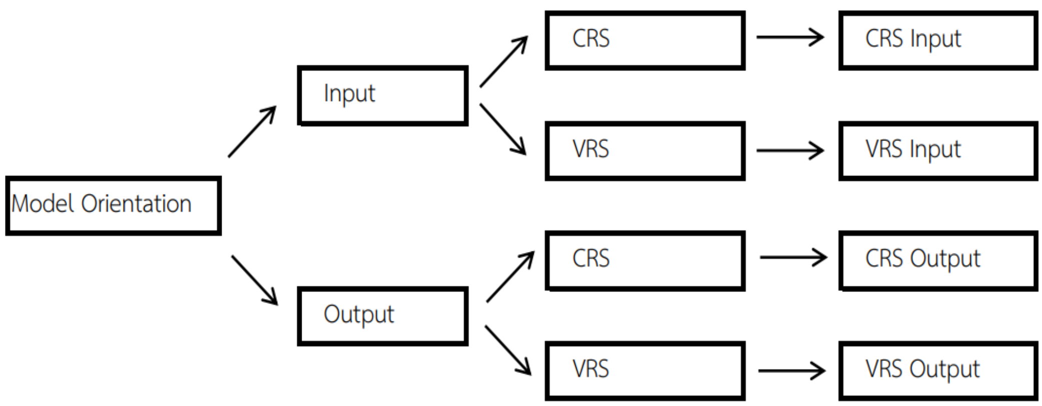
4.6.2 Model orientation

When applying the DEA approach, the DMU's efficiency could be analyzed by input or output orientation with a CRS or VRS assumption.

On the one hand, the input orientation keeps outputs constant while evaluating the minimal use of inputs. It brings an answer for the question: at the unchanged level of outputs, how much use of inputs could be cut down. On the other hand, the output orientation keeps input constant while exploring the proportional increase of outputs. This addresses a question: at the same level of input, how much quantity of outputs could be risen up (Jacobs, Smith, & Street, 2006).

As an inefficient DMU under an input orientation, it also becomes inefficient under an output orientation. But, values of these technical efficiency scores are typically different.

Figure 4. 2: Basic DEA model classification



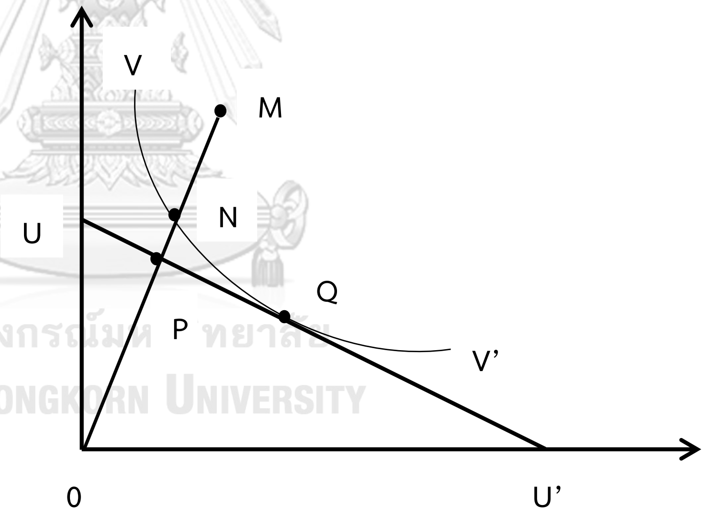
Source: Jacobs et al. (2006)

To evaluate efficiency, either assumption of a CRS or VRS could be employed and would be discussed in the next part. But, in this part, CRS is used to exhibit the model.

Input-oriented technical efficiency measures

A simple example supposes a DMU using two inputs: doctors and nurses to yield one output (patients treated). As can be seen from Figure 4.3, it is assumed that the production frontier is represented by the curve VV'. Any DMUs lying above the production frontier are likely to use too many inputs in order to generate a given quantity of the output. They are inefficient. UU', a budget line, is constructed for the full efficient DMUs.

Figure 4. 3: Technical efficiency under an input orientation

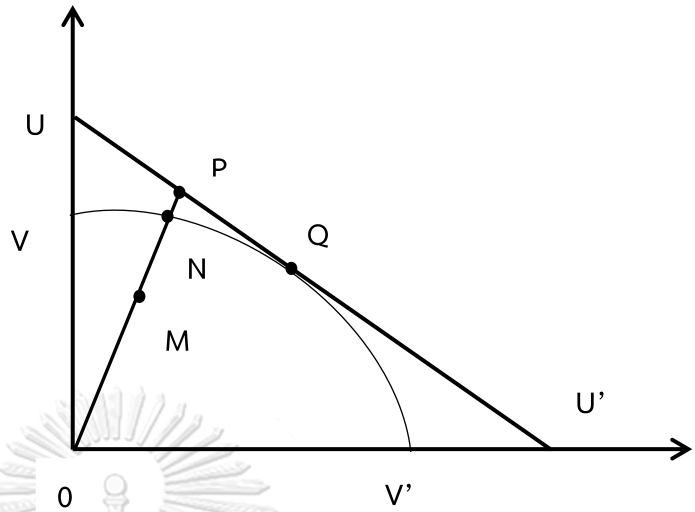


Source: Jacobs et al. (2006)

In this figure, the assumed hospital at point M operates inefficiently since it doesn't lie on the optimal production frontier. Using input orientation, this hospital should deduct their amount of doctors and nurse usage in operating process while keeping the constant number of patients treated.

Output-oriented technical efficiency measures

Figure 4. 4: Technical efficiency under an output orientation



Source: Jacobs et al. (2006)

A proposed example of a DMU produces two outputs: inpatient treatments and outpatient visits by using a single input (staffs). From the Figure 4.4, the curve VV' is represented for the production frontier. Any DMUs lying inside or below the curve are inefficient. In output orientation approach of efficiency measures, hospitals lying under the production frontier, like hospital M, should expand their quantity of inpatient treatments and outpatient visits when holding the unchanged level of input use (Jacobs et al., 2006).

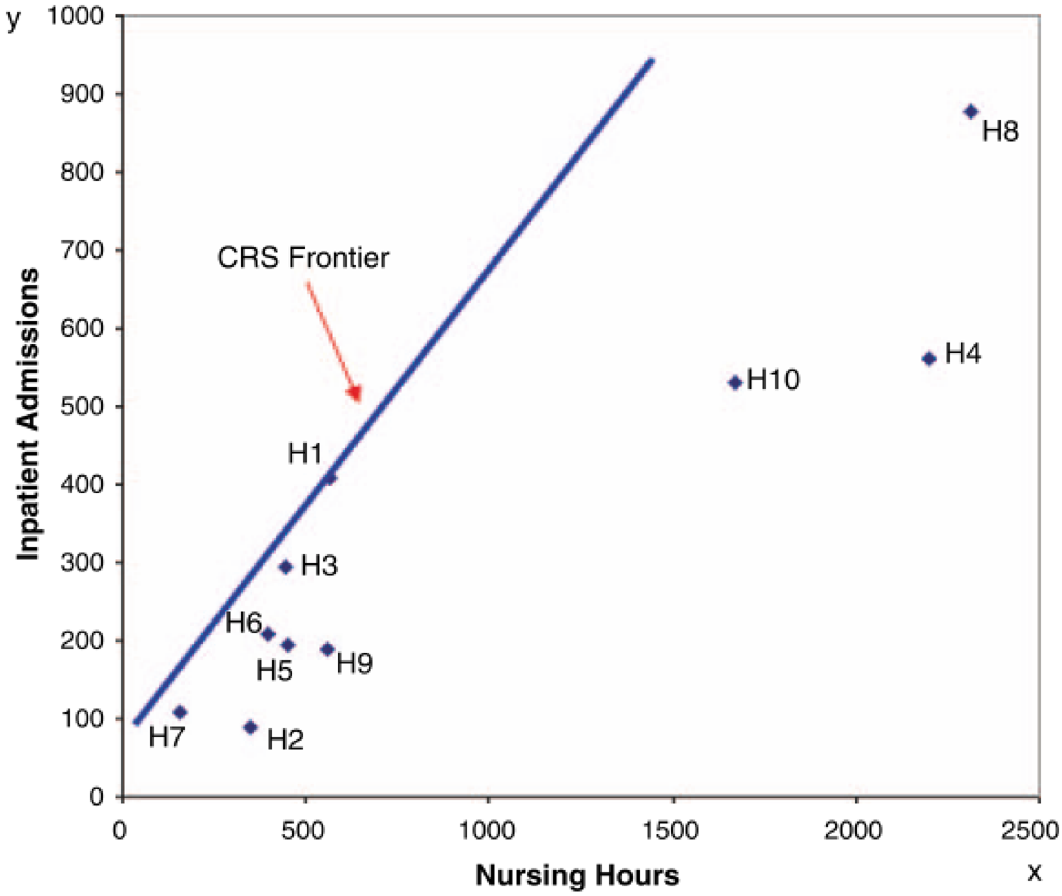
An input orientation DEA approach is applied in this study to measure the technical efficiency. Today, an input orientation has become commonly used on the efficiency measurement for hospitals. It thus, is selected over the alternative output orientation for several reasons. Firstly, demands on health care services in terms of quantity and quality are growing; though, it is difficult to estimate these demands. This means it is challenging for hospitals to estimate how many outputs they should supply in the future. Therefore, to gain efficiency, the reduction in inputs of producing process will be more feasible. Secondly, the input-oriented approach deems to be more stable with the current public hospitals context. Again, managers could have ability in controlling inputs (resources) more than outputs (service production). Lastly, this approach also reveals the primary goal set by policy makers in the existing situation of Vietnam. Public hospitals are trying in progress to meet all people's demands of health care services and they should moderate input use or diminish costs. Generally, any analysis results by using DEA method provide merely a picture of hospital performance at the certain time.

4.6.3 Basic Frontier Models

In 1978, an input orientation model under CRS was suggested by Charnes, Cooper and Rhodes. Other assumptions coming later, such as: Banker, Charnes and Cooper who offered VRS model in 1984 (Coelli, 1996). In fact, the production of a firm could be possibly subjected to either CRS or VRS. Under a CRS model, if an increase of inputs use accounts for a specific percentage, the outputs also witnesses a rise by the same proportion. Whilst in a VRS model, if all inputs increase by a proportion, outputs rise by a lower or higher proportion. It can be said that VRS production presents the economies or diseconomies of scale.

Constant Return to Scale

Figure 4. 5: Conceptualization of CRS frontier

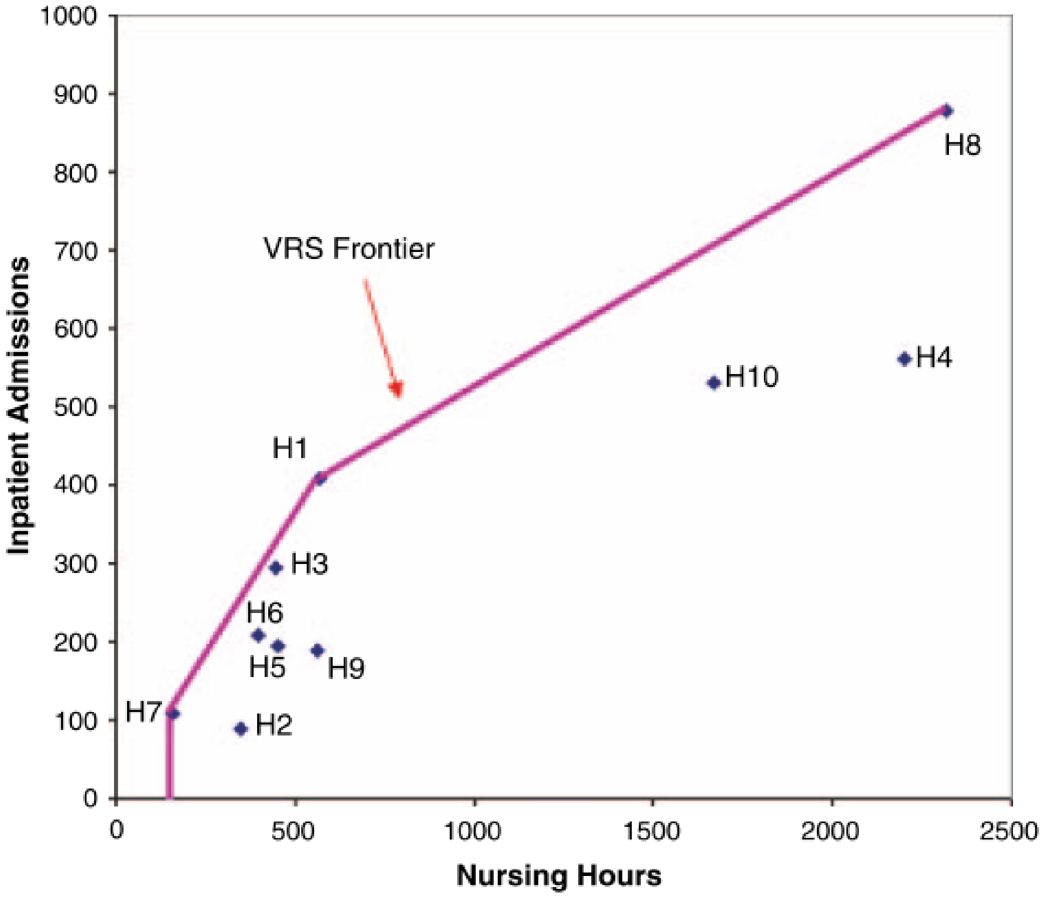


Source: Ozcan (2008)

There is a persistent ratio of substitution between inputs and outputs proposed by the CRS model. It is clearly observed in Figure 4.5, hospital 1 (H1) lies on the CRS efficiency frontier, considering one output and one input. Those hospitals aiming to lie on the frontier must shift to the left or the top to reach this constant line.

Variable Return to Scale

Figure 4. 6: Conceptualization of VRS frontier



Source: Ozcan (2008)

The figure shows that Hospital 7 (H7), Hospital 1 (H1) and Hospital 8 (H8) lie on the different part of the production frontier. The line among Hospital 7 and Hospital 1 presents a dramatic rise due to the sharpness of its slope. The segment between Hospital 1 and Hospital 8 also displays an increase but in a decreasing pattern as its slope is less steep than one of H7 & H1. Other hospitals including Hospital 2 (H2), Hospital 3 (H3), Hospital 5 (H5), Hospital 6 (H6) and Hospital (H9) (nearby H7 & H1) exhibit increasing return to scale while Hospital 4 (H4) and Hospital 10 (H10) expect decreasing return.

4.7 Regression Methodology

4.7.1 The Censored Tobit Regression Model

The censored Tobit regression model will estimate results from the DEA analysis using the available data from the first phase. Technical efficiency scores are considered as dependent variables which were regressed against a set of key independent variables. These explanatory factors are strongly believed to have an influence on the efficiency of public district hospitals' performance contextually with the local views. They are listed respectively as the Bed Occupancy Rate (**BOR**), the Non-Medical Staff-Physician ratio (**NMSPR**), the Outpatient Visit-Physician ratio (**OPVPR**), the Inpatient Admission-Physician ratio (**IPAPR**) and the Revenue from User Fee-Total Revenue ratio (**RUFTRR**). The results of Tobit regression analysis will provide the factors contributing on the technical efficiency scores of public district hospitals in Vietnam.

Because the technical efficiency score resulted by the DEA approach belongs to the interval between 0 and 1, the dependent variable is considered as a limited dependent variable. Tobit regression is a good choice when the dependent variable is bounded from above, below or both with positive possibility pile up at the end of the interval by being censored (Wooldridge, 2010). As a consequence, the censor Tobit regression model is applicable in cases where the dependent variable is constrained in some ways. The censored Tobit regression model could be determined as following:

$$´Y^{*} \; ; \; 0 \leq ´Y^{*} \leq 1$$

$$´Y = 0; \; ´Y^{*} < 0;$$

$$1; \; 1 < ´Y^{*}$$

$$´Y^{*} = \beta xi + \varepsilon t$$

Where

$\acute{Y}$ is the VRSTE score, εt ~ i e N $(0,\sigma 2)$

$\acute{Y}^{*}$ is a latent variable

β is the vector of unknown parameters which determines the relationship between the independent variables and the latent variable

xi is the vector of explanatory variables

The model to undertake the analysis in this study is presented:

$$VRSTEi = \beta 0+\beta 1\ BOR+\beta 2\ NMSPR+\beta 3\ OPVPR+\beta 4\ IPAPR+\beta 5\ RUFTRR+\ \varepsilon t$$

Where:

VRSTEi:	Variable Return to Scale technical efficiency scores
$\beta 0$	Constant term
$\beta 1$	Coefficient of BOR
$\beta 2$	Coefficient of NMSPR
$\beta 3$	Coefficient of OPVPR
$\beta 4$	Coefficient of IPAPR
$\beta 5$	Coefficient of RUFTRR
εt	Error term that captures other possible factors no specified

4.7.2 Hypothesis

Factors such as the Bed Occupancy Rate, the Non-Medical Staff-Physician ratio, the Outpatient Visit-Physician ratio, the Inpatient Admission-Physician ratio and the Revenue from User Fee-Total Revenue ratio of the hospitals probably effect on the PDHs technical efficiency after they are measured through econometric technique of regression model analysis.

H1: The bed occupancy rate should be positive for the technical efficiency of public district hospitals.

H2: The Non-Medical Staff-Physician Ratio is expected to have a negative impact on the technical efficiency.

H3: The Outpatient Visit-Physician Ratio may have positive correlation with the technical efficiency results.

H4: The Inpatient Admission-Physician Ratio is expected to have a positive influence on the technical efficiency scores.

H5: The Revenue from User Fees-Total Revenue Ratio is expected positively for the technical efficiency.

In conclusion, this chapter discussed about the methodology and the description about variables. The input-oriented DEA model under CRS and VRS approaches was applied to evaluate the technical and scale efficiency scores among observed public district hospitals. Then, the VRSTE scores are regressed by the censored Tobit regression method to identify the determinant factors. The significant impact of explanatory variables such as: the Bed Occupancy Rate, the Non-medical Staff-Physician ratio, the Outpatient Visit-Physician ratio, the Inpatient Admission-Physician ratio and the Revenue from User Fee-Total Revenue ratio will be investigated. The DEA program will be run by the DEAP version 2.1 software developed by Tim Coelli (1996). And, the eViews 9 software will be employed for the censored Tobit regression analysis.

CHAPTER V
RESULTS AND DISCUSSIONS

This chapter will present various outcomes obtained from the DEA and censored Tobit regression analysis over a sample of 52 public district hospitals. There are three main parts organized in this chapter. The first part shows the descriptive analysis of multiple inputs and outputs using in DEA approach. The second one explores results of using the DEA to measure the technical and scale efficiency of DMUs in 2014 using an input orientation under CRS and VRS. The third section outlines the results of censored Tobit regression for the technical efficiency scores derived from the input-oriented DEA model.

5.1 Descriptive analysis of inputs and outputs

In the Table 5.1, a statistic description of inputs variables was performed from a data set of 52 public district hospitals. There are three inputs such as: the number of medical staffs, non-medical staffs and clinic departments. The statistic description of inputs variables in this 2014 study is displayed in detail in term of mean, standard deviation, minimum and maximum values. Results obtained confirm that there is a wide variation in the resource endowment. It seems that some of hospitals are understaffed in term of medical and non-medical staffs compared to other counterparts in the overstaffed situation. This causes a wide range of clinical departments' number from 4 to 27. Besides, the analysis shows that the average number of medical staffer is nearly 5 times higher than one of non-medical staffs.

Table 5. 1: Descriptive Statistics for Inputs Variables

Inputs	Mean	Standard Deviation	Minimum value	Maximum value
Medical Staffs	204.48	116.65	66	685
Non-medical staffs	41.98	27.93	10	123
Clinical Departments	9.56	4.49	4	27

Similarly, the descriptive statistics including: mean, standard deviation, minimum and maximum of PDHs' outputs is depicted in the table 5.2. Three outputs are mentioned including: the number of outpatient visits, inpatient days and surgical operations. It can be seen that there are wide variations in the performance of researched DMUs measured by the volume of health care services provision, such as the number of outpatient visits, inpatient days and surgical operations. Remarkably, the number of surgical operations ranges from 0 to 8,728.

Table 5. 2: Descriptive Statistics for Outputs Variables

Outputs	Mean	Standard Deviation	Minimum value	Maximum value
Outpatient visits	20,378.77	59,874.12	21	407,324
Inpatient days	89,303.42	56,879.29	22,476	345,269
Surgical operations	1,368.37	1,818.71	0	8,728

5.2 Results from DEA

5.2.1 Descriptive statistics of Technical and Scale Efficiency scores

The technical efficiency scores among 52 PDHs in Vietnam were explored using DEAP Version 2.1 software. Table 5.3 shows the descriptive statistic of technical and scale efficiency scores for the given research study.

Table 5. 3: Descriptive Statistic of Technical and Scale Efficiency

	CRSTE	VRSTE	SE
Mean	0.772	0.847	0.909
Median	0.778	0.855	0.932
Standard Deviation	0.174	0.151	0.100
Maximum	1.000	1.000	1.000
Minimum	0.441	0.549	0.441
PDHs on frontier	8	17	8
Observations	52	52	52

The descriptive statistic of DEA results figured out to verify the central tendency of technical and scale efficiency score of PDHs. Results show that the average CRSTE and VRSTE are 77.2 percent and 84.7 percent, respectively. The average VRSTE indicates that inefficient PDHs need to reduce inputs by 15.3 percent to become efficient while keeping the certain production of outputs and quality of services. However, it can be seen that there are wide gaps between inefficient and efficient hospitals in CRSTE and VRSTE. The gaps are from 44.1 percent and 54.9 percent, in turn, comparing to 100 percent. Table 5.4 below will explain about these gaps. Inefficiency levels ranging from 15.3 - 22.8 percent are detected. This indicates that if inefficient hospitals operated as efficiently as their peers on the efficiency frontier, the health care system would have gained efficiency amounting to 15.3 - 22.8 percent of the total resources used in running hospitals.

The mean scale efficiency is quite high, accounted for 90.9% in 2014. This reveals that the hospitals in this study shift closely to a point at the most efficient scale. It means a little opportunity for the technically inefficient hospitals can be taken in order to optimize at the best level.

Table 5. 4: Average technical efficiency scores by regions under per capita income ranking

Region	Red River Delta	South East	North & South Central Coast	Mekong Delta	Central Highlands	Northern Highlands
Province	Hanoi	Dong Nai	Binh Dinh	Dong Thap	Dak Lak	Dien Bien
CRSTE	0.756	0.756	0.709	0.782	0.857	0.441
VRSTE	0.806	0.832	0.765	0.840	0.952	1.000
SC	0.934	0.903	0.915	0.923	0.898	0.441
Per capita income	2,994.9	2,576.7	1,719.0	1,665.5	1,639.2	819.4

Table 5.4 displays that the average CRSTE of hospitals located in Central Highland and Mekong Delta regions are 85.7% and 78.2%, correspondingly; and the mean VRSTE scores are 95.2% and 84.0%. Following closely these scores are those of hospitals located in Red River Delta, South East and North and South Central Coast regions. All five regions show their technical efficiency much higher than Northern Highlands region’s one. These results display that hospitals may have performed differently in the different regions. Additionally, there is no relation between the per capita income index to the level of constant return to scale technical efficiency by regions, exception the Northern Highland regions. Due to the current context of this

mountainous region, the observed province represented for this region named Dien Bien province. This province ranks among the group of the Vietnamese poorest provinces and has a large group of population from ethnic minorities. In Vietnam, there is a lack of full-qualified medical staffs at the health care facilities, particularly in the poor areas. This affects to the quality of care in this region. In contrast, there is a relevant relationship between the per capita income ratio and the scale efficiency. This may express that there is a difference in the investment on the hospitals infrastructure depending on the economic development status of each province.

Table 5. 5: Frequency and distribution of Technical and Scale Efficiency Scores

Efficiency Range	CRSTE		VRSTE		SE	
	Freq.	%	Freq.	%	Freq.	%
100%	8	15.4%	17	32.7%	8	15.4%
80-99%	15	28.8%	15	28.8%	39	75.0%
60-79%	18	34.6%	16	30.8%	4	7.7%
< 60%	11	21.2%	4	7.7%	1	1.9%
Total	52	100%	52	100%	52	100%

Table 5.5 presented a summary of the classified technical efficiency scores of the public district hospitals in Vietnam. The DEA results revealed that there were substantial differences of technical efficiency scores from the best practice frontier. The results of CRSTE and VRSTE scores from input oriented DEA shows that out of 52 PDHs, only 8 and 17 hospitals, respectively, are efficient, accounted for 15.4 percent and 32.7 percent, in turn. Appendix A contains more information in detail on technical and scale efficiency of the individual PDHs under input oriented DEA with assumptions of CRS and VRS.

According to Table 5.5, a majority of PDHs run in their overall technical and scale inefficiency, accounted for 44 (84.6 percent). There are 21.2 percent PDHs in case of very low overall technical efficiency (under 60 percent).

The distribution of CRSTE, VRSTE and SC scores of the study PDHs are reveals in another way following three below column charts.

Figure 5. 1: Distribution of Constant Return to Scale Technical Efficiency score

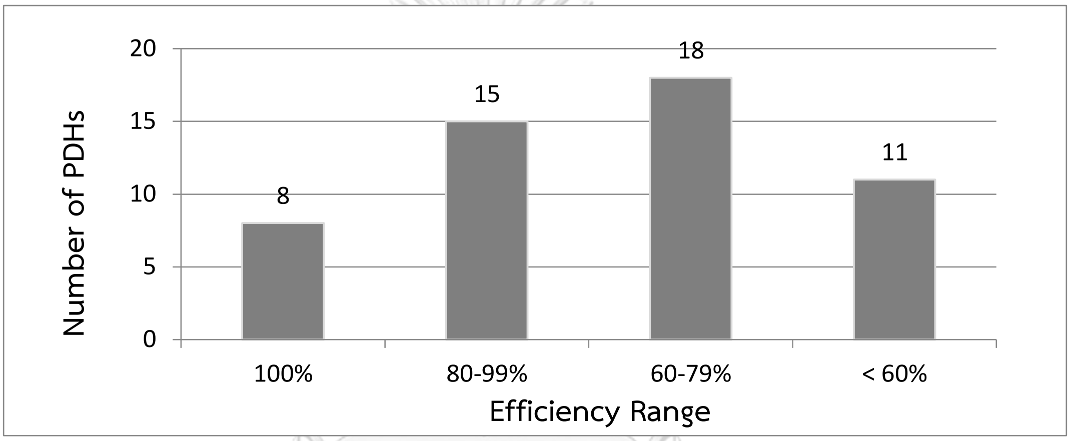


Figure 5. 2: Distribution of Variable Return to Scale Technical Efficiency score

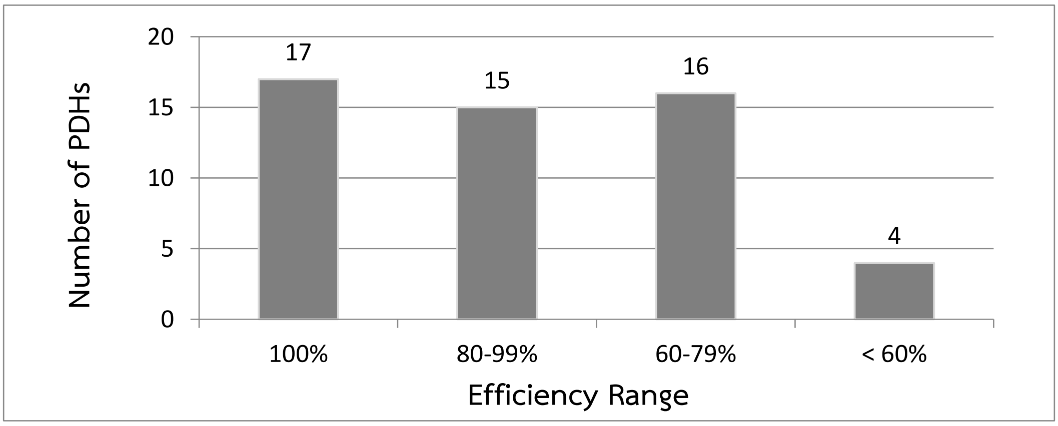
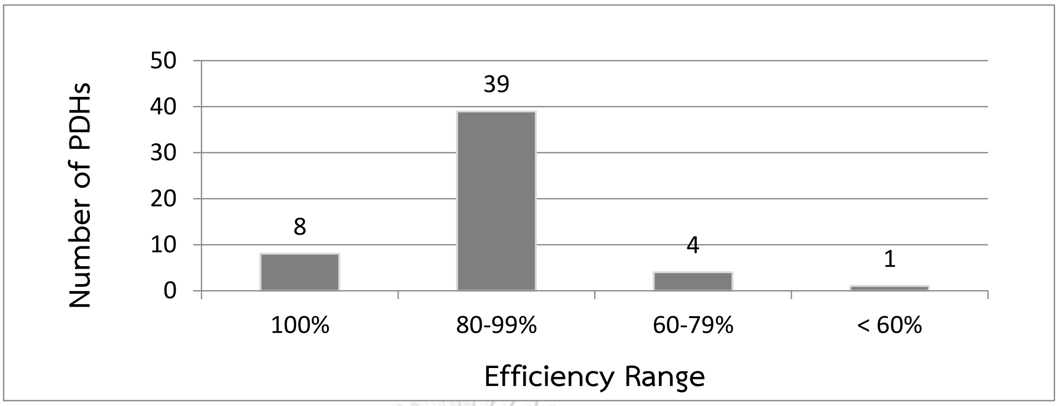


Figure 5. 3: Distribution of Scale Efficiency scores



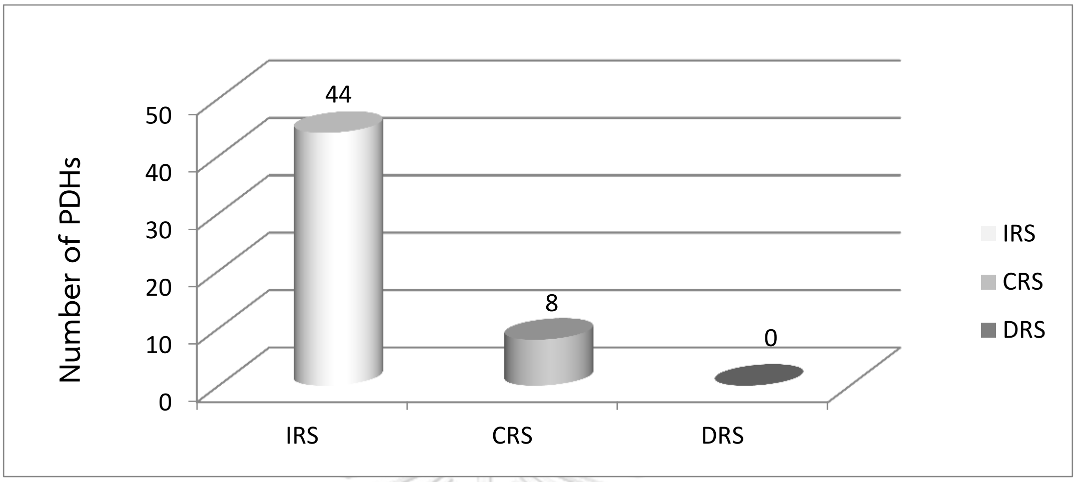
5.2.2. Return to scale efficiency

The input oriented DEA results revealed that 8 (15.4%) out of 52 PDHs were operated at optimal production size for the given input-output combination, while 44 (84.6%) were scale inefficient. This study released the pattern of scale efficiency into only increasing return to scale (IRS). The results revealed that no PDHs exhibited with decreasing return to scale (DRS). From the table 5.6, among the scale inefficient PDHs, the increasing return to scale (IRS) accounted for 44 PDHs (84.6 percent), which was expected for their expansion to be transformed as the most productive scale size. Thus, results indicated a large percentage of PDHs are inefficient in size, the observed PDHs are either bigger or smaller comparing to the optimal size.

Table 5. 6: Pattern of scale efficiency from Input Oriented DEA model

Public District Hospitals	Status of scale efficiency - input oriented DEA				
	Scale efficiency	Scale Inefficiency	Total	Pattern of scale inefficiency	
				IRS	DRS
Frequency	8	44	52	44	0
Percentage (%)	15.4	84.6	100	84.6	0

Figure 5. 4: Return to scale patterns of public district hospitals



Comparing with the findings of other previous studies examining the technical efficiency of PDHs, the findings from this study are similar to the hospital efficiency in those research studies. Firstly, according to the study on hospital efficiency over three years: 2011, 2012 and 2013 in Vietnam (Hideaki, 2018), the mean VRSTE scores of PDHs was 0.793 comparing to 0.847 in 2014 in this study. It displays that the technical efficiency of Vietnamese PDHs have recorded an upward trend. This indicates that levels of hospital efficiency scores are becoming better during the time. Secondly, another comparison could look at the study in Namibia. This country ranks itself in the group lower middle-income countries (https://qz.com/454505). And the study implemented by Zere et al., in 2006 measure the technical efficiency at the similar level of public district hospital. The DEA model estimated for the period 1997/1998 to 2000/2001 indicates the average CRSTE scores ranging from 62.7 percent to 74.3 percent. Inefficiency levels ranging from 26 – 37 percent are witnessed (Zere et al., 2006). It's pretty similar with the inefficiency levels of 22.8% in PDHs of Vietnam in 2014. Moreover, a similar point from the findings by (Pham, 2011) show that the VRSTE played a main role in attributing to the overall technical inefficiency in Vietnamese PDHs.

5.3 Tobit Regression Analysis Results

The second target of this study was to identify the determinant factors that affecting the performance of public district hospitals. Findings from the input oriented DEA showed that the majorities of PDHs are not efficient and perform inefficiently. Therefore, a censored Tobit regression model is conducted to determine the contributing factors.

The censored Tobit regression model was employed to determine the affecting factors on the technical efficiency of PDHs. The VRSTE from the input oriented DEA model was used as a dependent variable. There are five explanatory variables including: the Bed Occupancy Rate (BOR), the Non-medical Staff-Physician ratio (NMSPR), the Outpatient Visit-Physician ratio (OPVPR), the Inpatient Admission-Physician ratio (IPAPR) and the Revenue from User Fee-Total Revenue ratio (RUFTRR). The Dependent and Independent variables for Tobit regression model will be contained in detail in Appendix D. The below table will present an overview of descriptive statistics of all variables using in the regression model.

Table 5. 7: Descriptive statistics of dependent and independent variables

Variables	Observation	Mean	Std. Dev.	Min.	Max.
VRSTE	52	0.847	0.151	0.549	1.000
BOR	52	109.249	20.434	61.000	155.800
NMSPR	52	0.707	0.309	0.142	1.656
OPVPR	52	322.744	952.097	0.567	6,364.438
IPAPR	52	258.667	100.330	53.631	535.062
RUFTRR	52	0.153	0.054	0.050	0.258

The results, after running the Tobit regression analysis using the eViews 9 software, revealed in Table 5.8, using VRSTE scores as dependent variables at Confidence Interval 95%.

Table 5. 8: Tobit Regression results, dependent variable VRSTE, input-oriented model

Variable	Coefficient	Std. Error	z-Statistic	Prob.
BOR	-0.000754	0.000907	-0.831118	0.4059
NMSPR	-0.312893	0.063498	-4.927611	0.0000
OPVPR	7.44E-06	1.78E-05	0.417261	0.6765
IPAPR	0.001356	0.000229	5.926188	0.0000
RUFTRR	0.062438	0.289195	0.215932	0.8290
C	0.788021	0.095000	8.294989	0.0000

Table 5.8 presents that non-medical staff-physician ratio (NMSPR) and inpatient admission-physician ratio (IPAPR) are significant, whereas bed occupancy rate (BOR), outpatient visit-physician ratio (OPVPR) and revenue from user fees-total revenue ratio (RUFTRR) are insignificant. The NMSPR variable reversely correlated to VRSTE scores because its coefficient had a negative sign. This is understandable in the current Vietnamese context with a largely redundant number of government officers in the operating apparatus. The IPAPR variable is positively related with efficiency. In other words, the more a doctor treats IPD patients, the better is hospital efficiency. Besides, most of determinant variables have the same signs as expected, exception BOR. This is explained by the current overload in Vietnamese hospitals. Overall; it can explain that if IPAPR rose up, VRSTE scores tended to go up, giving other things were constant. If NMSPR decreased, VRSTE scores were likely to increase, giving others were constant. And, the most influent explanatory variable of VRSTE

scores was NMSPR ratio because its coefficient recorded the highest value among two significant variables.

In conclusion, this study attempted to analysis the technical efficiency among 52 public district hospitals in Vietnam. The results discovered that a majority of PDHs was running at less than optimal level. There were 17 PDHs operating efficiently under assumption of VRS, accounted for 32.7 percent, while the remaining of 67.3 percent was inefficient. Also, this chapter presented that two indicators related to human resource distribution such as: the Non-medical Staff-Physician ratio and the Inpatient Admission-Physician ratio, out of five explanatory variables, could affect the performance of the public district hospitals.

CHAPTER VI
CONCLUSION AND RECOMMENDATIONS

6.1 Conclusion

In the context of increasingly threatened financial resources in health care sector, the government has to obtain the maximum benefit from utilizing inputs. This study, thus aimed to measure the public district hospitals' technical efficiency by using the input orientation DEA model and then to identify affecting determinants by employed Tobit regression model. These methods were applied to analyze the data of 52 PDHs located in 6 geographic regions represented for the whole country of Vietnam.

The DEA analysis indicated that the average scores for CRSTE was 77.2 percent, for VRSTE recorded at 84.4 percent, and for scale efficiency was 90.9 percent. The results showed only 8 PDHs running at the desired optimum level under assumption of CRS, and 17 PDHs operating efficiently under assumption of VRS. Furthermore, all of 44 scale inefficient PDHs exhibited the IRS, accounted for 84.6 percent, which should have the scale up in order to be transformed as the most productive scale size.

The results of censored Tobit regression revealed that from five independent variables (BOR, NMSPR, OPVPR, IPAPR and RUFTRR), only NMSPR and IPAPR recorded significantly with coefficient of 0.312893 and 0.001356, respectively. The NMSPR variable reversely correlated to VRSTE scores because of its negative sign, whereas the IPAPR variable was positively related with efficiency. Three remaining variables were insignificant.

This study brings an overview about the technical efficiency of public district hospitals in Vietnam, so policy makers and hospital managers could use and analyze this information to improve inefficient hospitals. The inefficient PDHs could follow their efficient counterparts as a role model.

6.2 Limitations of the study

When using DEA approach to evaluate the technical efficiency, there are many types of inputs and outputs could be employed. However, the selection of inputs and outputs highly depended on the objectives and limitations in this study. The following issues may limit the complete potential of the study. Firstly, there were a small number of 52 public district hospitals attending in this study. Secondly, some inaccurate and missing values made several interesting variables excluded or omitted. This was a retrospective study, so the data unavailability is likely to understand. Additionally, the health information system was mostly paper-based and manually created in Vietnam, especially in rural areas. This caused many challenges for researchers to collect the accurate data. Last but not least, due to lack of quality data, there was not any statement on the qualitative measure of the hospitals' efficiency.

6.3 Recommendations

This study evaluated the technical efficiency of PDHs in six geographic regions of Vietnam and provided an overview of their efficiency performance in 2014. Policy makers in health care sector and hospital managers can improve the inefficient PDHs in proper directions by analyzing inputs and outputs of each inefficient PDH.

The results from regression analysis displayed in wide range areas regarding human resource distribution and health care service. The excess medical and non-medical labor forces should be considered. The productivity of physicians in inpatient department could bring to concerns of hospital managers, to decide how to allocate and manage all resources efficiently in order to have a technically efficient hospital.

The pattern of scale inefficiency among inefficient PHDS should be analyzed for the policy makers and hospital managers' purposes. A guideline should be developed to progress the scale efficiency in a rational direction. Such as: the IRS pattern hospitals should be enhanced through up-sizing. Additionally, details information of each inefficient hospital should be explored and analyzed with its individual results derived from the DEA and regression analysis.

A finding database from this study becomes a set of supporting documents, which encourages the Ministry of Health to develop the national policy for evaluating public hospital in period time. In cases of inefficient hospitals, it can be a sensitive problem. Therefore, a summary of results should contain in various levels or differently classified groups, for example: very good, good, moderate and poor.

A collection of observations for a hospital efficiency measure should be considered carefully. Since, a group of observed hospitals is relatively compared together through selected multiple inputs or outputs. Therefore, the studied hospitals should be under the similar context for a justice of evaluation.

The results derived from the DEA and regression analysis are employed for an efficiency evaluation of hospitals. Therefore, these results directly create an impact to studied hospitals in case of either positive or negative results. It can be stated that the correction of data using in this analysis is highly essential.

For further studies, qualitative study combining with quantitative study could bring the research closed to the practical. Because, in some cases, adaptions in the level of inputs usage or the production of outputs are unlikely to change inefficient hospitals to efficient ones. The combination of these methods would be helpful for policy makers and hospital managers, thus, is highly recommended. Besides, some other factors such as qualitative variables related to socio-culture aspects should be considered as independent variables in the regression model.

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APPENDIX

Appendix A: Results from input oriented data envelopment analysis approach

Province	Facility ID	CRSTE	VRSTE	SCALE	Pattern
HA NOI	10202	0.778	0.973	0.800	irs
	10404	0.633	0.635	0.997	irs
	10505	0.751	0.801	0.937	irs
	10808	0.662	0.730	0.906	irs
	10909	0.993	1.000	0.993	irs
	11010	0.623	0.720	0.866	irs
	11111	0.485	0.606	0.801	irs
	11313	0.680	0.745	0.912	irs
	11414	1.000	1.000	1.000	crs
	11515	0.999	0.999	0.999	irs
	11717	0.660	0.706	0.935	irs
	11818	0.779	0.841	0.926	irs
	11919	0.543	0.597	0.909	irs
	12020	0.794	0.799	0.994	irs
	12222	1.000	1.000	1.000	crs
	12323	0.718	0.766	0.937	irs
	12424	0.823	0.871	0.945	irs
	12525	0.663	0.742	0.894	irs
	12626	0.818	0.822	0.995	irs
	12727	0.723	0.768	0.941	irs
DIEN BIEN	110202	0.441	1.000	0.441	irs
BINH DINH	520707	0.908	0.934	0.972	irs
	520808	0.510	0.596	0.857	irs
DAC LAK	660101	0.525	0.605	0.869	irs

Province	Facility ID	CRSTE	VRSTE	SCALE	Pattern
	660202	0.970	1.000	0.970	irs
	660303	0.972	1.000	0.972	irs
	660404	1.000	1.000	1.000	crs
	660606	0.888	0.990	0.896	irs
	660707	0.735	0.968	0.759	irs
	660808	0.996	1.000	0.996	irs
	660909	0.830	1.000	0.830	irs
	661010	0.806	1.000	0.806	irs
	661111	0.848	0.957	0.885	irs
DONG NAI	750101	0.496	0.596	0.831	irs
	750202	1.000	1.000	1.000	crs
	750303	0.547	0.731	0.748	irs
	750404	0.571	0.623	0.916	irs
	750505	1.000	1.000	1.000	crs
	750606	0.785	1.000	0.785	irs
	750707	0.772	0.786	0.982	irs
	750808	0.871	0.935	0.932	irs
	750909	0.764	0.815	0.937	irs
DONG THAP	870101	1.000	1.000	1.000	crs
	870202	0.867	0.869	0.998	irs
	870303	1.000	1.000	1.000	crs
	870404	0.505	0.687	0.736	irs
	870606	0.933	1.000	0.933	irs
	870707	0.511	0.549	0.932	irs
	870808	0.748	0.827	0.905	irs
	870909	1.000	1.000	1.000	crs

Province	Facility ID	CRSTE	VRSTE	SCALE	Pattern
	871010	0.570	0.633	0.900	irs
	871111	0.688	0.835	0.824	irs

Appendix B: Input slacks from DEA

Province	Facility ID	Inputs		
		Medical Staffs	Non-medical staffs	Clinical Departments
HA NOI	10202	48.840	2.350	0.000
	10404	0.000	0.000	0.000
	10505	0.261	0.000	0.000
	10808	0.000	7.674	0.000
	10909	0.000	0.000	0.000
	11010	0.000	0.000	0.100
	11111	0.000	0.000	1.617
	11313	0.000	0.000	0.000
	11414	0.000	0.000	0.000
	11515	6.977	0.000	0.000
	11717	4.963	0.000	0.000
	11818	0.658	0.000	0.000
	11919	0.000	1.639	2.377
	12020	0.000	0.000	0.000
	12222	0.000	0.000	0.000
	12323	0.000	3.504	0.000
	12424	0.000	0.000	0.000
	12525	0.000	0.000	0.000

Province	Facility ID	Inputs		
		Medical Staffs	Non-medical staffs	Clinical Departments
	12626	0.000	0.000	0.000
	12727	0.000	0.000	0.000
DIEN BIEN	110202	0.000	0.000	0.000
BINH DINH	520707	0.000	0.446	2.856
	520808	0.000	0.317	0.000
DAC LAK	660101	0.000	0.000	0.000
	660202	0.000	0.000	0.000
	660303	0.000	0.000	0.000
	660404	0.000	0.000	0.000
	660606	0.000	3.928	1.538
	660707	0.000	0.000	0.351
	660808	0.000	0.000	0.000
	660909	0.000	0.000	0.000
	661010	0.000	0.000	0.000
	661111	0.000	1.715	0.000
DONG NAI	750101	0.000	0.000	0.000
	750202	0.000	0.000	0.000
	750303	5.657	0.000	0.000
	750404	0.000	8.048	1.420
	750505	0.000	0.000	0.000
	750606	0.000	0.000	0.000
	750707	3.620	1.061	0.000

Province	Facility ID	Inputs		
		Medical Staffs	Non-medical staffs	Clinical Departments
	750808	0.000	0.000	0.000
	750909	0.000	3.961	0.084
DONG THAP	870101	0.000	0.000	0.000
	870202	4.386	0.000	0.000
	870303	0.000	0.000	0.000
	870404	0.000	0.000	0.769
	870606	0.000	0.000	0.000
	870707	0.000	0.000	0.000
	870808	0.000	0.000	0.000
	870909	0.000	0.000	0.000
	871010	0.000	9.500	1.754
	871111	0.000	0.000	1.187

Appendix C: Output slacks from DEA

Province	Facility ID	Output		
		Outpatient visits	Inpatient days	Surgical Operations
HA NOI	10202	94,039.371	41,866.358	0.000
	10404	0.000	0.000	0.000
	10505	0.000	0.000	1,509.077
	10808	45,391.122	0.000	0.000
	10909	0.000	0.000	0.000
	11010	0.000	0.000	0.000
	11111	0.000	0.000	0.000
	11313	0.000	0.000	107.903
	11414	0.000	0.000	0.000
	11515	50,183.363	0.000	0.000
	11717	7,279.600	0.000	208.357
	11818	0.000	0.000	0.000
	11919	28,629.469	0.000	0.000
	12020	8,316.768	0.000	0.000
	12222	0.000	0.000	0.000
	12323	588.359	0.000	124.872
	12424	15,115.088	0.000	0.000
	12525	0.000	0.000	279.568
	12626	0.000	0.000	0.000
	12727	1,466.698	0.000	319.016
DIEN BIEN	110202	0.000	0.000	0.000
BINH	520707	1,979.421	0.000	0.000

Province	Facility ID	Output		
		Outpatient visits	Inpatient days	Surgical Operations
DINH	520808	0.000	0.000	0.000
DAC LAK	660101	27,851.411	0.000	0.000
	660202	0.000	0.000	0.000
	660303	0.000	0.000	0.000
	660404	0.000	0.000	0.000
	660606	704.129	0.000	8.948
	660707	0.000	0.000	7.542
	660808	0.000	0.000	0.000
	660909	0.000	0.000	0.000
	661010	0.000	0.000	0.000
	661111	0.000	0.000	0.000
DONG NAI	750101	0.000	0.000	68.068
	750202	0.000	0.000	0.000
	750303	786.833	0.000	72.495
	750404	1,118.699	0.000	295.220
	750505	0.000	0.000	0.000
	750606	0.000	0.000	0.000
	750707	0.000	0.000	628.435
	750808	4,684.110	0.000	0.000
	750909	0.000	0.000	407.938
DONG THAP	870101	0.000	0.000	0.000
	870202	42,333.255	0.000	0.000
	870303	0.000	0.000	0.000
	870404	0.000	0.000	0.000

Province	Facility ID	Output		
		Outpatient visits	Inpatient days	Surgical Operations
	870606	0.000	0.000	0.000
	870707	0.000	0.000	0.000
	870808	0.000	0.000	0.000
	870909	0.000	0.000	0.000
	871010	0.000	0.000	0.000
	871111	1,185.855	0.000	0.000

Appendix D: Summary of Dependent and Independent variables for censored Tobit regression

Province	Facility ID	Dependent variable	Independent variables				
		VRSTE	BOR	NMSPR	OPVPR	IPAPR	RUFTRR
HA NOI	10202	0.973	90	0.44	126.64	53.63	0.24
	10404	0.635	129.32	0.70	397.98	214.14	0.15
	10505	0.801	99	0.60	1,074.85	123.54	0.05
	10808	0.730	112.2	1.25	116.70	348.70	0.13
	10909	1.000	144.3	0.54	331.39	275.18	0.15
	11010	0.720	154	0.53	101.49	176.58	0.22
	11111	0.606	86.87	0.48	157.12	126.96	0.06
	11313	0.745	132.2	0.54	134.11	234.86	0.16
	11414	1.000	92	0.68	394.32	248.02	0.17
	11515	0.999	120	0.48	26.42	292.20	0.20
	11717	0.706	96.33	0.18	22.34	88.20	0.08

Province	Facility ID	Dependent variable	Independent variables				
		VRSTE	BOR	NMSPR	OPVPR	IPAPR	RUFTRR
	11818	0.841	120.4	0.67	1,711.55	292.73	0.23
	11919	0.597	88	1.00	259.53	229.84	0.13
	12020	0.799	112	0.38	54.68	174.57	0.15
	12222	1.000	122	0.40	1,574.23	336.24	0.21
	12323	0.766	102	0.76	11.67	210.17	0.13
	12424	0.871	104	0.58	64.40	234.94	0.15
	12525	0.742	105	0.57	30.55	207.74	0.14
	12626	0.822	130	0.90	205.21	341.18	0.24
	12727	0.768	119	0.55	10.03	155.71	0.16
DIEN BIEN	110202	1.000	61.57	0.35	0.57	101.24	0.07
BINH DINH	520707	0.934	147.4	1.44	27.02	417.78	0.12
	520808	0.596	104.74	1.08	85.90	252.85	0.12
DAC LAK	660101		80				

Province	Facility ID	Dependent variable	Independent variables				
		VRSTE	BOR	NMSPR	OPVPR	IPAPR	RUFTRR
		0.605		0.71	109.03	168.94	0.13
	660202	1.000	139.3	0.69	28.47	398.94	0.08
	660303	1.000	124	0.59	1,917.32	322.54	0.15
	660404	1.000	155.8	0.47	107.80	394.39	0.14
	660606	0.990	128	0.79	33.68	369.71	0.15
	660707	0.968	112	0.43	25.51	171.71	0.07
	660808	1.000	104	0.63	49.92	380.08	0.10
	660909	1.000	98.7	0.73	21.86	347.41	0.06
	661010	1.000	104	0.86	56.50	304.73	0.09
	661111	0.957	118	0.83	73.79	266.03	0.11
DONG NAI	750101	0.596	61	0.69	39.19	91.71	0.14
	750202	1.000	87.9	1.66	6,364.44	535.06	0.22
	750303	0.731	86	0.73	12.68	219.80	0.10

Province	Facility ID	Dependent variable	Independent variables				
		VRSTE	BOR	NMSPR	OPVPR	IPAPR	RUFTRR
	750404	0.623	98.13	0.78	19.67	150.45	0.14
	750505	1.000	109	1.27	2.25	351.84	0.24
	750606	1.000	95	0.62	53.17	366.47	0.21
	750707	0.786	97	1.32	257.47	309.96	0.16
	750808	0.935	99.16	0.61	3.72	249.21	0.22
	750909	0.815	95.97	0.97	378.83	256.27	0.19
DONG THAP	870101	1.000	111.29	0.83	33.17	350.43	0.24
	870202	0.869	122.65	1.20	75.00	439.69	0.26
	870303	1.000	130.8	0.40	84.05	269.93	0.21
	870404	0.687	95.6	0.49	17.14	191.95	0.19
	870606	1.000	118.16	0.30	5.38	255.65	0.17
	870707	0.549	89.42	0.71	20.41	182.03	0.18
	870808		125.1				

Province	Facility ID	Dependent variable	Independent variables				
		VRSTE	BOR	NMSPR	OPVPR	IPAPR	RUFTRR
		0.827		0.57	36.34	270.89	0.17
	870909	1.000	113.25	0.14	5.11	192.46	0.11
	871010	0.633	102.4	0.96	24.13	189.64	0.18
	871111	0.835	107	0.68	7.96	315.79	0.13

Appendix E: Results from Tobit regression model

Dependent Variable: VRSTE
Method: ML - Censored Normal (TOBIT) (Quadratic hill climbing / EViews legacy)

Sample (adjusted): 1 52
Included observations: 52 after adjustments
Left censoring (value) at zero
Convergence achieved after 4 iterations
Coefficient covariance matrix computed using second derivatives

Variable	Coefficient	Std. Error	z-Statistic	Prob.
BOR	-0.000754	0.000907	-0.831118	0.4059
NMSPR	-0.312893	0.063498	-4.927611	0.0000
OPVPR	7.44E-06	1.78E-05	0.417261	0.6765
IPAPR	0.001356	0.000229	5.926188	0.0000
RUFTRR	0.062438	0.289159	0.215932	0.8290
C	0.788021	0.095000	8.294989	0.0000
	Error Distribution			
SCALE:C(7)	0.105340	0.010329	10.19804	0.0000

Mean dependent var	0.847250	S.D. dependent var	0.151380
S.E. of regression	0.113237	Akaike info criterion	-1.394012
Sum squared resid	0.577021	Schwarz criterion	-1.131344
Log likelihood	43.24430	Hannan-Quinn criter.	-1.293311
Avg. log likelihood	0.831621		
Left censored obs	0	Right censored obs	0
Uncensored obs	52	Total obs	52

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