TECHNICAL AND SCALE EFFICIENCY OF

GOVERNMENT DISTRICT BASE HOSPITALS IN SRI LANKA

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A Thesis Submitted in Partial Fulfilment of the Requirements

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ประสิทธิภาพทางเทคนิคและประสิทธิภาพต่อขนาดของโรงพยาบาลรัฐประจำเขต ในประเทศศรีลังกา

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นายรันจัน วิพูลา จันทรา นาคะเสนา อราชชิลาเก: ประสิทธิภาพทางเทคนิคและประสิทธิภาพต่อขนาดของโรงพยาบาลรัฐประจำเขตในประเทศศรีลังกา (TECHNICAL AND SCALE EFFICIENCY OF GOVERNMENT DISTRICT BASE HOSPITALS IN SRI LANKA) อ.ที่ปรึกษาวิทยานิพนธ์หลัก : รศ.ดร. ไพฑูรย์ ไกรพรศักดิ์, 80 หน้า.

วัตถุประสงค์ของการวิจัยคือการศึกษาประสิทธิภาพทางเทคนิคและประสิทธิภาพต่อขนาดรวมถึงการศึกษาปัจจัยที่อาจมีผลกระทบต่อประสิทธิภาพในโรงพยาบาลรัฐประจำเขตในประเทศศรีลังกา ภายใต้กรอบการวิเคราะห์ข้อมูลที่เรียกว่า Data Envelopment Analysis (DEA) และใช้เครื่องมือการวิเคราะห์การถดถอยที่เรียกว่า TOBIT

หน่วยที่ใช้ในการวิเคราะห์ DEA จำนวน 168 หน่วย (DMUs) นำมาใช้ในการประเมินเกี่ยวข้องกับ 56 โรงพยาบาลในระยะเวลาสามปี (พ.ศ.2549-2551) ผลจากการศึกษาพบว่าว่ามีระดับประสิทธิภาพทางเทคนิคอยู่ในช่วงระหว่าง 0.383 และ 1 ระดับคะแนนเฉลี่ย 0.818 ในขณะที่ระดับประสิทธิภาพต่อขนาดอยู่ระหว่าง 0.412 และ 1 มีคะแนนเฉลี่ยคือ 0.905 นอกจากนี้พบว่าร้อยละ 71 ของ DMUs ไม่มีประสิทธิภาพทางเทคนิคในขณะที่ร้อยละ 83 พบว่าไม่มีประสิทธิภาพต่อขนาด ในกลุ่ม DMU ที่ไม่มีประสิทธิภาพต่อขนาด ร้อยละ 32 ของ DMUs แสดงผลตอบแทนต่อขนาดเพิ่มขึ้นและร้อยละ 68 แสดงผลตอบแทนต่อขนาดลดลง

หลังจากที่ประเทศศรีลังกาได้ประกาศใช้แผนหลักด้านสุขภาพปี 2007-2016 พบว่าประสิทธิภาพทางเทคนิคและประสิทธิภาพต่อขนาดมีแนวโน้มสูงขึ้น การวิเคราะห์การถดถอย TOBIT พบว่าอัตราส่วนการเข้าพักเตียงมีความสัมพันธ์ทางบวกกับประสิทธิภาพทางเทคนิค [0.299, p = 0.017] และอัตราส่วนเตียงต่อแพทย์มีความสัมพันธ์ทางลบกับประสิทธิภาพทางเทคนิค [0.0008, p = 0.044] และโรงพยาบาลของกระทรวงสาธารณสุขจะมีประสิทธิภาพในทางเทคนิค มากกว่าโรงพยาบาลประจำจังหวัด แต่ปัจจัยเหล่านี้ไม่มีนัยสำคัญทางสถิติ โรงพยาบาลขนาดใหญ่ (ประเภท A) จะมีระดับประสิทธิภาพทางเทคนิคและประสิทธิภาพต่อขนาดมากกว่าขนาดเล็ก (ประเภท B) จำนวนผู้ป่วยเข้ารักษาที่โรงพยาบาลก็พบว่ามีความสัมพันธ์เป็นบวกกับประสิทธิภาพต่อขนาด [-1.34E-06, p = .00] จากผลการศึกษา โรงพยาบาลส่วนใหญ่มีผลตอบแทนต่อขนาดลดลง ดังนั้นจึงแนะนำให้ลดจำนวนเตียงของโรงพยาบาลเหล่านี้ซึ่งน่าจะทำให้โรงพยาบาลมีประสิทธิภาพ.

สาขาวิชา เศรษฐศาสตร์สาธารณสุขและการจัดการบริการสุขภาพ ลายมือชื่อนิสิต.....

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RANJAN VIPULA SHANTHA NAGASENA ARACHCHILAGE: TECHNICAL AND SCALE EFFICIENCY OF GOVERNMENT DISTRICT BASE HOSPITALS IN SRI LANKA. ADVISOR: ASSOC. PROF. PAITOON KRAIPORNSAK, Ph.D. 80 pp.

The objective of this study was to study of technical and scale efficiency and to observe the factors affecting on efficiency in government district base hospitals in Sri Lanka. Data envelopment analysis or DEA with Tobit regression analysis were used to find solutions.

168 decision making units or DMUs were evaluated concerning 56 hospitals for three years (2006, 2007, and 2008). Initial relative efficiency results show that technical efficiency level has ranged between 0.383 and 1.0, average score level was 0.818 while the scale efficiency level has ranged between 0.412 and 1.0, its' average score was 0.905. Moreover, 71% of DMUs has been operating at technical inefficiently while 83% were scale inefficiently. Among scale inefficient DMUs, 32% DMUs show increasing returns to scale and 68% of DMUs show decreasing returns to scale. After implementation of health master plane 2007-2016, there is an increasing trend on technical and scale efficiency.

Secondly, Tobit regression analysis found that bed occupancy ratio positively related with technical efficiency [.299, p = .017] and bed physician ratio negatively associate with technical efficiency [.0008, p = .044] and also hospitals belong to MoH are technically efficient rather than provincial hospitals. When increase the ratio of nurses' physician and allied health personnel physicians, technical efficiency will be increased. However, these factors are statistically insignificant. Large hospital (Type A) technically and scale efficient than smaller hospitals (Type B). Number of admissions tended to increase scale efficiency [-1.34E-06, p = .00].

Majority of institutions are operating at decreasing returns to scale. So, the reducing bed size from those institutions is recommended. It will be directed them towards efficiency because of the bed occupancy ratio highly positively associated as well as the bed physician ratio related with it.

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

Academic Year : 2010 Advisor's Signature: .....

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LIST OF ABBREVIATIONS

AMO	Assistant Medical Officers
CRS	Constant Returns to Scale
DBH	District Base Hospital
DEA	Data Envelopment Analysis
DMU	Decision Making Unit
IP	In Patient
MDG	Millennium Development Goals
MoH	Ministry of Health
NCD	Non Communicable Diseases
OPD	Out Patient Department
RMO	Registered Medical Offices
SE	Scale Efficiency
TE	Technical Efficiency
VRS	Variable Returns to Scale

CHAPTER I

INTRODUCTION

1.1 Problem and its significance

Increasing healthcare delivery cost has become a big issue which has been mainly discussed in every common agenda in the international health sector by the health policy makers, providers and the economist all over the world. It has been created the number of barriers to the health system because of the government healthcare services of Sri Lanka is totally free for Sri Lanka at the point of delivery. Introducing new health technology to the healthcare system and strengthening of the infrastructures are significantly poor. So this condition might be indirectly or directly affect to reduce the quality of care and make the disparity among social groups.

Ministry of health in Sri Lanka has identified recently several major problems (the 3 E's Challengers) which has been emerged from previous two decades, should have to be solved. These are:

- Changing Epidemiological pattern.

Since last fifteen year, there has been created demographic and epidemiological transition as a consequence of social development in Sri Lanka. For instance, it is very important to emphasize that increasing of the elderly population with respect to the workforce, drastically changing disease pattern from communicable diseases to non-communicable diseases (NCD) while remaining the communicable diseases problems in declining trend in many parts of the country are main problems; meanwhile, evolving problems such as accidents, suicides and homicides has been increased.

- Increasing Expectation on health care.

Because of demographic and epidemiological change as well as public interventions such as improving preventive care services, mainly immunization, improving sanitation, providing safe water, good practice of solid waste management as well as improving of nutrition and health promotion have made the extra demand

for healthcare consumption. In addition to that people's expectation on quality healthcare has been increasing over the time.

- Demand on Efficiency.

Above mentioned all the challengers as well as global cost escalating phenomenon of the healthcare have created a greater financial burden on the health system emphasizing a requirement of an alternative financing mechanism additionally government budget allocation, and also MoH has identified that necessity of improving productivity and efficiency of the delivery care services which are operating under more variation of efficiency and productivity levels among facilities.

Therefore, there has a challenge to utilize the efficient allocation of the scare resources, while at the same time offering better quality healthcare services.

To overcome these problems and the existing matters and also make an adequate preparedness for threats we may have to face in the future, MoH has initiated ten year health master plan 2007-2016 with the assistant of Japan International Corporation Agency(Ministry of Health [MoH],2007b). Main objective of this is to address health need of the people by strengthening the health system more effectively, efficiently and a sustainable way.

National health policy (Minstry of Health Highways and Social Services [MoHHS],1996) of Sri Lanka also has mentioned that efficiency, cost effectiveness and fair resources allocation should be concerned in the formulation of new policies and interventions.

Historically, health outcome figures of the country have a higher level in comparing with same income countries and some developing countries and also have achieved MDGs satisfactorily. However, there is a significant variation of the health outcome among district or geographical regions so far (MoH,2007a). When we are emphasizing on health facility utilization, especially hospitals, there is a big imbalance in terms of resources utilization on efficiently even though overall health system efficiency retains at a satisfactory level compare with south Asian countries (Somanathan et al., 2006). For instance, tertiary care and some secondary care

hospitals are always crowded even basic illness while low utilization in the secondary and primary care hospitals (Ravi Rannan-Eliya, 2006).

Another situation is that span of the hospital utilization rates is more varying in between secondary, tertiary and primary care hospitals because of most of the time patient is bypassing the lower level services (keeping occupancy rates at low rate in peripheral hospitals) without referrals due to the pleasant facilities in the big hospitals. (Attanayake and de Silva, 1992). This phenomenon has also highlighted in the health master plane as a problem that is faced.

The trend of hospital utilization since last two decades has shown by figure 1.1. The year 1993 is critical point because this year seems to be a milestone in the history of inpatient services. That year saw the shift in the share of annual admissions from primary care to tertiary care. On the other hand, the number of admissions in secondary and tertiary overtook those in primary care facilities.

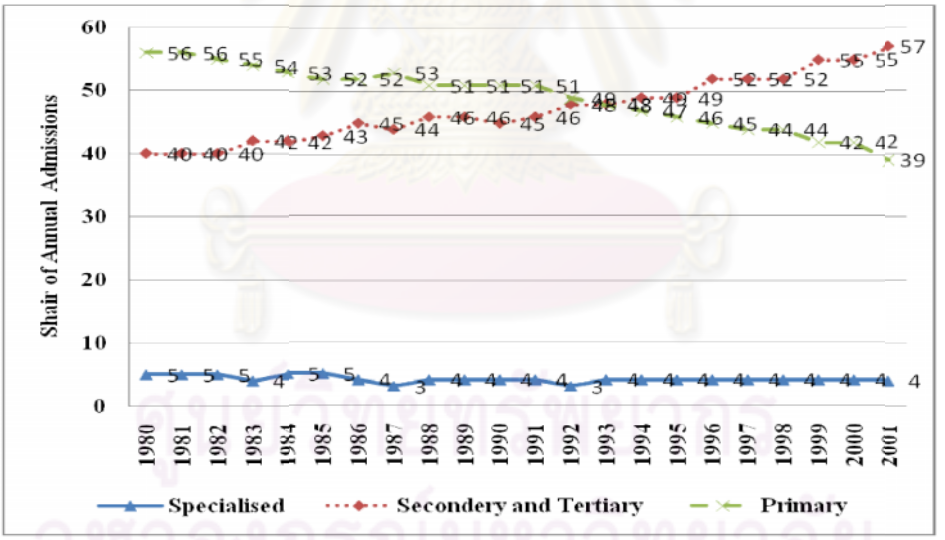

Figure I.1 Share of annual admissions at government health facilities – 1980-2001

Source: Annual Health Bulleting

1.2 District base hospital (Study focal point)

This study focuses to analyze efficiency of the district base hospitals (DBH) in Sri Lanka. At the time of studying, there are 65 hospitals in the country. Recently, hospital name changed as District base hospital according to the hospital re-categorization, and before it was named as Base hospital. District base hospitals consist of two types of sub hospitals called type A and type B. Type A hospital tend to be large hospital relatively type B hospitals, and hospital type was determined based on population and geographically reasons.

According to the whole hospital structure, there are two levels of hospitals are over DBH (District general and Teaching hospitals) and four levels of hospitals have lower (Divisional hospitals A, B and C and Primary medical care units).

As higher level of hospital, district general and Teaching hospitals established based on province (9 provinces) and DBH based on district (25 District). As a low level tertiary care facility (presently 65) and as a middle level gateway, district base hospital has a major role in the system to;

- Control the congestion of the upper level facilities.
- Reduce the cost of healthcare delivery by high utilization.
- Reduce economic cost of the patients such as time cost, lost income, traveling cost and other cost).
- Attain the overall system efficiency by optimal resource allocation.

Main facilities in these hospitals can be summarized as follows. Therefore, whole the hospitals still failed to fulfill these all the facilities as same level so far. This is the potential facility capability among DBH can be improved in the future to maintain a facility based service (MoH,2007).

1. Out Patient Department with separate Preliminary Care Unit, Emergency Care Unit and screening facilities
2. Clinic facilities
3. In ward facilities
    - 2 Medical unit
    - 2 Surgical unit
    - 2 Gynecology & Obstetric unit

- 2 Pediatric unit
- 1 ENT surgical unit
- 1 Eye surgical unit
- Anesthesia Unit

4. Intensive Care Units
    - Medical Intensive Care Unit (MICU)
    - Surgical Intensive Care Unit (SICU)
5. Operation Theatres
6. Diagnostic services
    - Radiology Dept.
    - Pathology Dept. with Histopathology, Hematology and Microbiology Units
7. Medico-legal Department
8. Medical Records Unit
9. Psychiatry, Rheumatology, STD/AIDS or any other relevant unit will be added according to the need.

Promoting technical, scale and allocative efficiency of the hospital is one of the best solutions for Sri Lankan health system by allocating resources in the proper manner among health institutions in each level. So, micro level hospital efficiency analysis can fulfill this gap understanding efficiency level of each type of hospital and factors related with efficiency as well. The results comes from this study may useful to encourage the hospitals which are inefficient, observing peers who are efficient. It might be able to reduce poor utilization of resources by reallocating extra (Slack) resources.

Subsequently, this study focuses to evaluate the level of efficiencies before and after implementation of the health master plan, whether there is any impact to enhance the technical and scale efficiency raising important strategies which was formulated in the health master plan for short run.

1.3 Relationship with hospital efficiency and health system efficiency

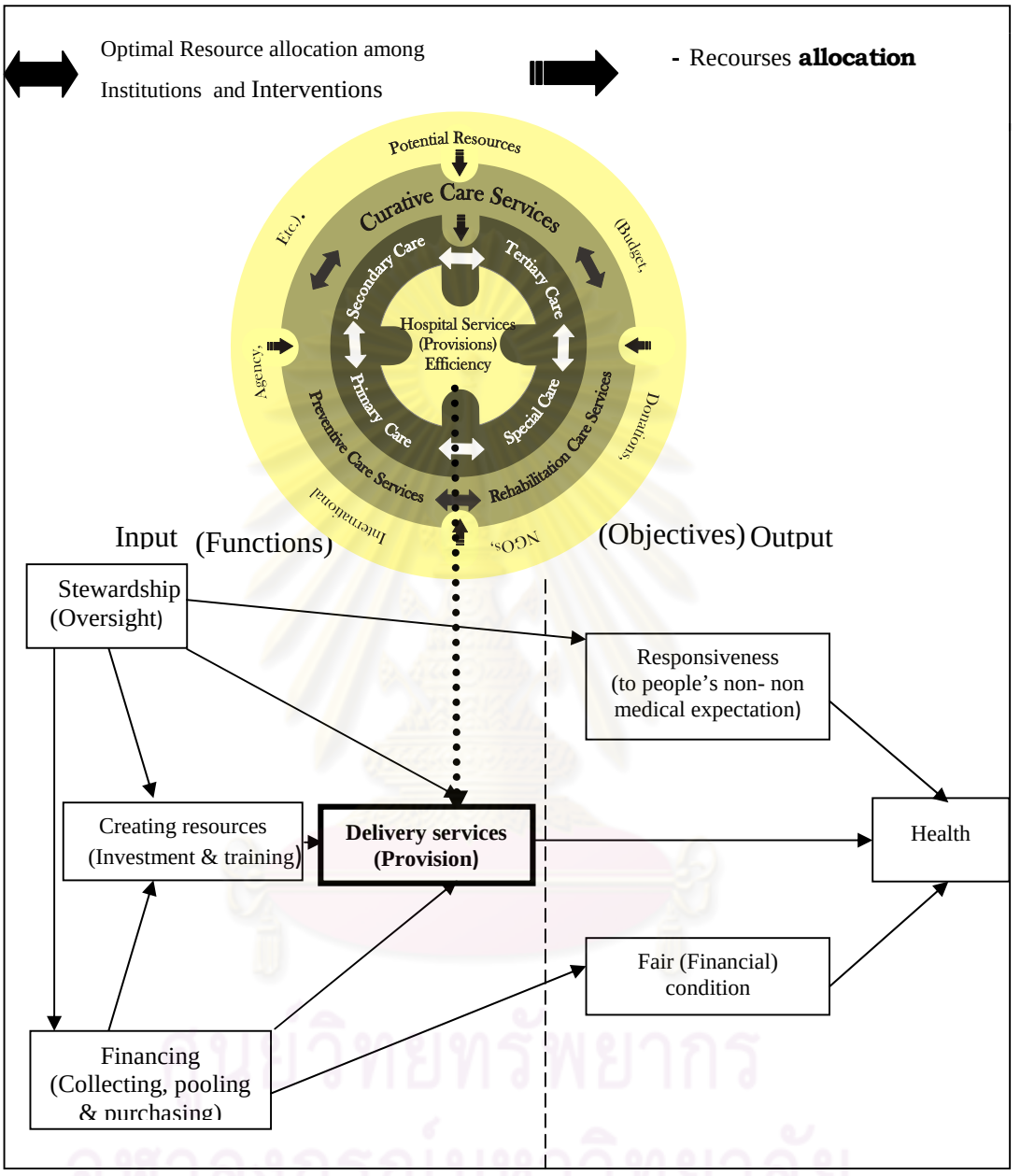

Figure I.2 Relationship with hospital efficiency and health system efficiency

Source: The World Health Report 2000.

Figure 1.2 depicted that relationship with health system efficiency and hospital efficiency. According to the world health report 2000, objectives and functions of a health system has shown by lower part of the figure 1.2. In this case, outcomes of a health system should be consist with three categories namely (I) maximum health

status (II) responsiveness to the patients and (III) fair financing. These three are the ultimate objective of a health system.

To realize those objectives, there are four main functions were distinguished such as (me) stewardship, (II) creating resources, (III) finance and (IV) delivery services. When concerning about health system efficiency, health system function and objectives can be described as the input and the output respectively. To maintain health system efficiency, it is needed to guarantee the efficiency of each function in the health system.

Hospital care service has shown by upper part of the figure 1.2. Optimal resource allocation in different facility level in terms of hospital provisions in the country lead to maintain efficient delivery care provisions which has identified as an input in the health system of the country by World Health Organization [WHO] (2000). Therefore, hospital service provision efficiency is very important and crucial factor which should be realized by the health sector for efficiency of health system. So, Potential financial and non financial recourses should be allocated among main health care services efficiently and rightly. Then, need to allocate those resources among various types of interventions such as different level of hospitals in curative care, different types of project in preventive and rehabilitative care. Finally, if we try to maximize the efficiency of whole hospital services, it is directly influence to increase the health system efficiency of a country because delivery care system consist with mainly hospital services and other interventions. This relationship show by the dotted line between efficient hospital care services with delivery services function in above figure.

1.4 Research questions.

This study aims to solve two research questions.

1. What is the technical efficiency & scale efficiency of government district base hospitals in Sri Lanka?

2. Which factor may determine the efficiency of district base hospitals?

1.5 Research objectives.

1.5.1 General objective - To study technical efficiency (TE) and scale efficiency (SE) of the government district base hospitals in Sri Lanka.

1.5.2 Specific objectives –

- To evaluate the technical efficiency (TE) of government district base hospitals in Sri Lanka.
- To evaluate the scale efficiency (SE) of government district base hospitals in Sri Lanka.
- To determine the factors affecting to change efficiency in government district base hospitals.
- To evaluate policy impact towards efficiency before and after initiates of health master plan 2007-2016 in 2007.

1.6 Scope of the study.

This study undertakes to analyze the efficiency of government district base hospitals in Sri Lanka in 2006 – 2008. Secondary panel data of these hospitals are used for 3 years.

1.7 Benefits of this study

1. Basically hospital managers can identify their relative efficiency level in the whole district base hospital in Sri Lanka. It may be good information to them.
2. This study shows hospital managers which are inefficient that what may be the causes of inefficiency to deeply concern and what way can improve the efficiency by following peers or efficient hospitals.
3. This findings help policy makers to evaluate the policy (Health Master Plan) whether there is any impact for improving efficiency.
4. Moreover, for future planning and policy implication, the policy makers can be used these findings as guideline.

CHAPTER II

BACKGROUND OF SRI LANKA AND ITS HEALTH SYSTEM

2.1 Geographical and economic status

Sri Lanka, 66,000-square-kilometer Island in the Indian Ocean is tropical country in the South Asia Region. Only 15 percent of Sri Lanka's 20 million people live in cities.

As a Democratic Socialist Republic country, the legislative powers of the country is belonging to parliament and the executive authority is exercised by a Cabinet of Ministers presided over by an Executive. In addition to the President and Parliament, there are Provincial Councils to administer provinces, Municipal Councils and "Pradeshiya Saba" for local administration under the 13th constitutional amendment. Sri Lanka is low income country with per capita income approximately Rs. 109,248.00 (US$ 993, the exchange rate 1 US$ = 110 Rupees) 2009/10. It has increased by 41% compare with 2006/07. Sri Lanka was historically based on agricultural, but since hundred years ago Sri Lanka has been a famous destination for trading. Because of that, many European countries had influenced, mainly British. As a result of these influences, export economy was emerged by exporting tea, rubber and coconut which introduced by European. And Cash crop exports brought prosperity and a trade surplus, and their taxation gave the government a ready revenue source.

Under the new government which was introduced economic liberalization in 1977, Sri Lanka was one of the first developing country to embark on economic liberalization, pursued ever since. As a result of that trade was liberalized, export taxes on cash crops removed, and the economy totally opened up. In return, Sri Lanka benefited from substantial Western aid inflows for more than a decade.

These policies created the substantial improvement in economic growth (Table 2.1), averaging 3 to 4 percent real per capita income growth ever since and country moved the position from least income level to lower middle income level.

Table 2.1 Economic indicator in Sri Lanka 1930 - 2005

Year	GDP per capita (1990 US$)	GDP per capita (1990 PPP$)	Revenue (% GDP)	Expenditure (% GDP)	External debt (%GDP)	ODA (% GDP)
1930	180	945	~10	~10	~0	~0
1950	273	935	16	20	3	0
1970	316	1130	20	27	18	1.7
1990	577	1935	22	31	72	5.7
1995	704	2636	20	31	67	4.5
2000	844	3626	17	27	55	0.4
2005	962	4390	16	24	48	3.4

Sources: Good Practice in Health Financing. Washington, the World Bank (p. 313).

Note. ODA – Official Development Assistant

2.2 Health status of the nations in Sri Lanka

As main provider, Sri Lankan government health sector which control mainly under the ministry of health (central government) and the provincial councils (provincial government) provides all the healthcare needs free for people (i.e. preventive, curative and rehabilitative) irrespective of their status, income or geographic location. Health system of Sri Lankan has achieved satisfactory health outcomes, particularly relative to neighboring countries with a similar income group. Another important thing is equity and equality of the health care system in terms of financing has maintained at satisfactory level. It shows by the resent study done by Owen, Somanathan, and Adhikari (2008), by concentration index 0.47, Kakwani0.085. In fact, there are several factors which have directly and indirectly influenced to that can highlight. Three main social development programmes, namely free healthcare services, free primary, secondary and tertiary education and food subsidies for selected income parties implemented by consecutive government which came to power in Sri Lanka during the last 60 years are important. These social welfare programme resulted substantial improvement in literacy rate up to 90.7 in 2001, infant mortality rate up to 11.2 per 1,000 live birth in 2003 and maternity mortality rate declined up to 27.5 per 100,000 in 2002 as well as life expectancy at birth has increased up to 72 and 76 for Male and Female respectively. Another important thing is that health system almost approached MDGs established by the

world health organization. These positive improvements are gradually changing social structure, people expectation and aspiration of the society such as aging population, life style related diseases (NCD). Most important health figures have shown by Table 2.2.

Table 2.2 Health indicator of Sri Lanka 1930-2007

Year	Infant mortality rate (1,000)	Maternity mortality rate (1,000)	Life expectancy at birth (Female)	Life expectancy at birth (Male)	Total fertility rate	Population growth rate (%)
1930	175	21	39	41	-	1.4
1950	82	6	55	56	5.3	2.8
1970	47	2	67	64	4.2	2.2
1990	19.5	1	73	67	2.2	1.0
1995	16.5	<1	75	68	1.9	1.1
2000	13.3	<1	76	70	1.9	1.4
2003	11.2	<1	76	71	1.8	1.3
2007	11.17	<1	76	71.7	1.8	1.1

Sources: Good Practice in Health Financing. Washington, The World Bank (p. 315).
Annual health bulleting, 2007

2.3 Expenditure on health

As a consequence of free government health services as well as increasing health care cost phenomenon, the total health expenditure as a percentage of GDP has been gradually increased from 3.6 in 1998 to 4.2 in 2007 (Table 2.3, Figure 2.1). Therefore, these figures are at satisfactory level compare with other regional country (The World Bank [WB],2008). As a percent of total health expenditure, the government general health expenditure was (GGHE) 47.5 in 2007, and private expenditure on health (PvtHE) was 52.5 percent as a percentage of THE.

Most important thing is that private health expenditure as a percentage of THE became a dominant source of finance on health even though government it provide free, and proportionately more than 80 percent private health expenditure comes from out of pocket (OOP) payments. Then, as a monetary term, the health expenditure for 2007 was Rs 150,295 million, (approximately US$ 1366 Million, 1$ = Rs.110). And it is an increase of 18 per cent over the year 2006. This increase is quite higher compared with the increase in 2005 over 2004 (12 percent in 2005). The per capita

health expenditure was increased from Rs.4, 134 (US$ 37.59) in 2003 to Rs 7,515 (US$ 68.34) in 2007.

Table 2.3 Health care expenditure of Sri Lanka in 1998 - 2007

Spending/Source	1998	2000	2003	2005	2007
Total expenditure on health (The world bank) as % GDP	3.6	3.7	3.8	4.0	4.2
Financing Sources					
External resources on health as % of THE	1.3	0.3	1.7	1.2	1.7
Government expenditure on health (GGHE) as % THE	48.6	47.9	41.3	46.2	47.5
Private expenditure on health (PvtHE) as % of THE	51.4	52.1	58.7	53.8	52.5
- Out of pocket expenditure on health as % of PvtHE	86.8	83.3	84.2	86.0	86.7
- Private insurance	9.9	12.2	8.7	9.6	9.1

Source: National health account report (WHO).

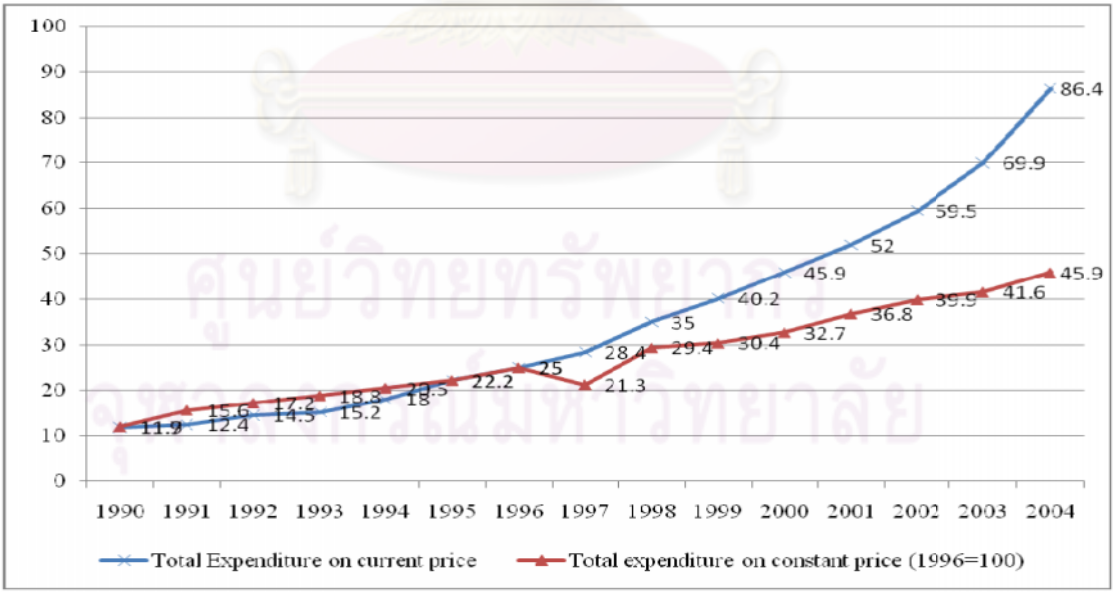

Figure 2.1 Trend of expenditure on health, 1990-2004

Source: National Health Accounts, 2002-2003 in Sri Lanka

Higher amount of public health services expenditure have been funded by using government direct and indirect tax financing. This fact has proof that the continuously

increasing health care cost has made a challenge to developing countries such as Sri Lanka (Hsuan-Lien, Shuen-Zen Liu, and James, 2002). Furthermore, the incidence of increasing per capita health expenditure as well as higher proportion of the out of pocket payment concerns the importance of an alternative financing mechanism.

2.4 Healthcare provisions of Sri Lanka

Sri Lankan health care services consist of several medical systems. The allopathic which cover more than 85% and, subsequently Ayuvedic, Unani Siddha and Homeopathy methods are legalized source of medical systems. Sri Lanka is a distinguished country as a system of "good health at low cost" In providing health care among developing and some developed countries (Hsiao, 2001).

Free public health services range from antiretroviral for HIV/AIDS patients to coronary bypass surgery. Accessing all services is reinforced by a policy of permitting patients to visit any hospital in the country without restriction, and with no enforcement of a referral system. These kinds of services are provided through 615 different levels of inpatient care facilities, 441 only outpatient facilities and 291 preventive care services centers or MOH (Medical officer of health division's) and several campaigns (Malaria, HIV/AIDS, Tuberculosis, Filarial, etc…) in Sri Lanka. Broad hospital classification has shown by Table 2.4.

As mentioned before, Sri Lankans benefit from extensive and organized health services, consisting of public and private sectors. Most of the private sectors perform mainly in urban area which covers 17% of population living in. Private sector mainly provides 55% of outpatient care services and 5% of inpatient care services out of whole health care need. Public hospitals mainly provide 95% of inpatient care and 45% of outpatient care from difference levels of hospitals(MoH,1992). In addition to that most of the government physicians and specialists provide ambulatory care services under guidance of MoH through private clinics and channeling centers except from their duty ours.

Before in 2007, three levels of services ware catered their services by ten types of hospital levels. This categorization has shown by the Table 2.4.

Table 2.4 Types of hospitals in Sri Lanka before in 2007

	Types of Hospital	No. Institution	Types of service
1	National Hospital	01	Tertiary care level
2	Teaching Hospitals	16	
3	Special Hospitals	46	
4	General Hospitals	12	Secondary care level
5	Base Hospital	44	
6	District Hospital	161	Primary care level
7	Peripheral Unit	95	
8	Rural Hospital	182	
9	Central Dispensary and Maternity Home	59	
10	Central Dispensary	441	

Sources: Annual health bulleting, 2007

After 2007, these ten types of hospitals has re-categorized into eleven groups according to hospital re-categorization paper, emphasizing to build up a facility based hospital mechanism to ensure the equity of the health care delivery system for people. New health institution re-categorization has mentioned in table 2.5.

Ministry of health has planned to upgrade these hospitals over the next five years accordingly following criteria. Main objective of hospital re-categorization is to buildup facility based health care delivery institution to reduce the bypassing of facilities due to the huge facility variation among difference types of institutions. This project has implemented according to the findings of health care facility survey conducted in Sri Lanka in the year 1992. The healthcare facility survey (1992) has found that utilization of lower level health facilities is quite low and unit cost of care is very high due to the low occupancy and turnover rate, and suggested to increase the utilization of this kind of hospitals need to be expand their facilities such as human resource, technology and infrastructures.

Criteria for re-categorization of hospitals.

1. Number of hospital beds
2. OPD attendance
3. Number of admissions
4. Number of deliveries per month
5. Bed occupancy rate
6. Number of transfers
7. Availability of supportive services such as quarters etc.
8. Distance to the nearest tertiary care hospital
9. Access to hospitals including availability of Public Transport facilities
10. Availability of land for expansion
11. Catchments area population and geographical location of the hospital
12. Availability of resources (funds, manpower etc.)

Table 2.5 Types of hospitals in Sri Lanka after re-categorization in 2007

	New Name	**No. Institution**	**Types of services**
1	National Hospital	01	Tertiary care level
2	Teaching hospitals	21	
3	Provincial general hospitals	03	
4	District general hospitals	18	
5	Special Hospitals	46	
6	District base hospital type A	20	
7	District base hospital type B	45	
8	Divisional hospitals type A	39	Secondary care level
9	Divisional hospitals type B	143	
10	Divisional hospitals type C	277	
11	Primary Medical Care Unit	474	Primary care level

Source: Annual health statistics - Ministry of health Sri Lanka

2.5 National health policy

As mentioned before Sri Lanka has achieved a remarkable health status in terms of traditional health indices and MDGs in relation to Gross Domestic Product (GDP). As I mentioned before, this has been mainly due to the social policies adopted by successive governments in the past few decades. In this case, national health policy published in 1996 is a main policy document which was directed at consolidating the earlier gains as well as adopting new policies to raise the health status of the people.

Mainly national health policy provides a broad path way to further upcoming policies by its broad sense. According to the national health policy (1996), there are main two broad aims as follows:

- *"To further increase life expectancy by reducing preventable deaths due to both communicable and non-communicable diseases."*
- *"To improve the quality of life by reducing preventable disease, health problems and disability; and also emphasizing the positive aspects of health through health promotion."*

2.6 Health master plan 2007-2016

As a resent policy document, health master plan (HMP) implemented in 2007 for next 10 years (2007-2016) concerned to strengthen quality of care, accessibility of services and sustainability health system for the people of Sri Lanka. This involvement mainly committed to innovatively overcome of new challenges which experienced in last two decades (as mentioned before) faced by the health sector in Sri Lanka and build up a preparedness for future challengers somehow.

There are five strategies have formed in it, namely;

1. Ensure the delivery of comprehensive health services, which reduce the disease, burden and promote health.
2. Empower communities (including households) towards more active participation in maintaining their health.
3. Improve the management of human resources for health.

4. Improve health financing, resource allocation and utilization and efficiency of the health system.
5. Strengthen stewardship and management functions of the health system.

According to this study, the fourth strategy highly relates with the study and resource allocation and efficiency. There are several objectives under this strategy as outlined below,

1. To increase government financial support at all levels to strengthen the financial sustainability of the health sector
2. To improve allocative efficiency of public funds.
3. To make optimal use of existing financial resources.
4. To strengthen financial management.
5. To improve financial equity and related equity of access.
6. To identify and test alternative financing mechanisms.
7. To optimize private sector contribution, initially establishing an information sharing mechanism to include: reporting on service use and quality as well as financing.

CHAPTER III

LITERATURE REVIEW

3.1 Concept of Efficiency

Efficiency is a management concept with a long history, comes from scientific management to business process reengineering. This concept has been mainly used in the industrial sector (product based).

Ferrel M.J., (1957), he put a path-breaking step to the efficiency which has been discussed in production technologies, by introducing a new concept to use in none product organizations, none for profit organizations as well as different types of welfare organizations to measure their efficiency (relative efficiency) for economics and other purposes.

Main principle behind this concept is that institutions or units which are been undertaken to analysis must be homogeneous and their input and outputs will be aggregated to measure their relative efficiency using leaner programming techniques. According to Farrel.M.J, (1957) there are mainly two components in efficiency. First one is technical efficiency, which reflects the maximum ability to produce output under a given input mix and another is allocative efficiency, which reflects how to use their input mix optimally gain maximum output under their relative prices. These two efficiencies can be calculated by considering two dimensions. One is input oriented model, which is focus on cost minimization by reducing input while output remaining the same. Second is output oriented model, which focused on revenue or output maximization by increasing output while input remaining the same.

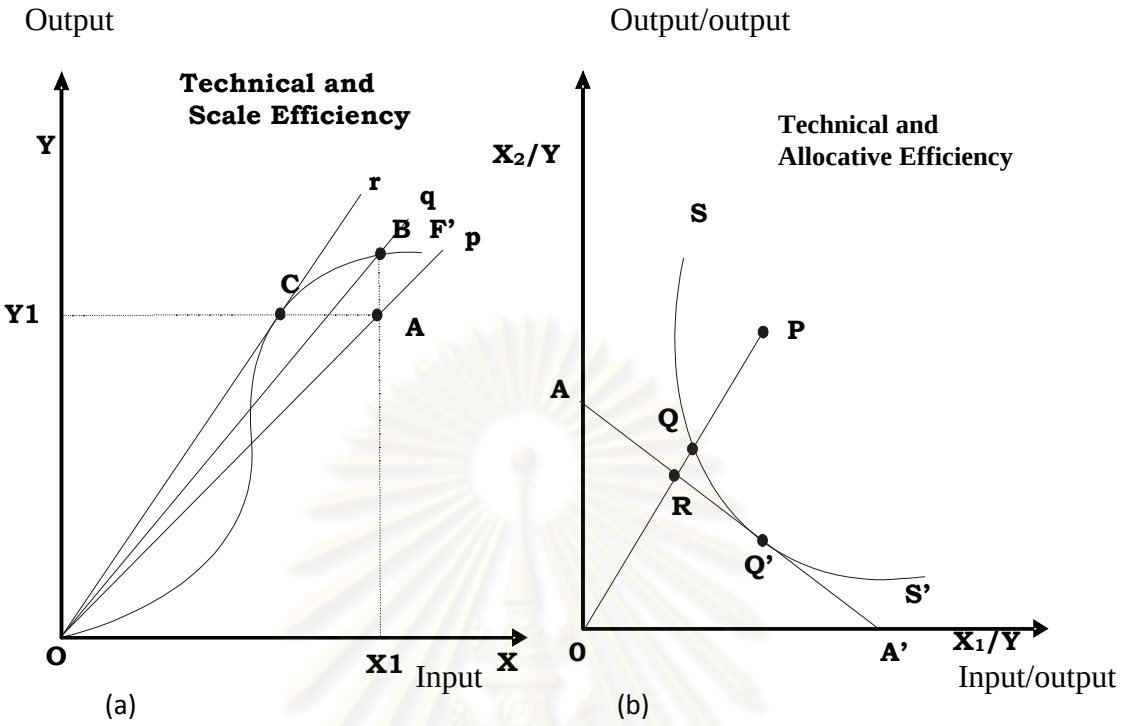

Figure 3.1 (a) and (b). Technical, Scale and Allocative efficiency.

Figure 3.1 (a) depicted that the Inefficiency point has determined at A where beneath the OF production frontier producing Y1 amount of output using X1 amount of input because this output level can be produced by using fewer amounts of input at C or output level can be increased up to B while input remains same level. So, B and C are technically efficient production combinations under constant return to scale assumption (CRS) which introduced by Chaenes. A, Cooper.W.W, and Rhodes.E., (1978) because of these points are on the OF' maximum production frontier.

In the real world, when a firm produces good or services at efficiently, it can gain productivity using scale economies under the assumption of variable return to scale (VRS) which developed by Banker.R.D., Charnes.A., and Cooper.W.W.,(1984) where from B to C. it means, the firms can produce at the most efficient economy of scale and at the pure technical efficiently under the assumption of variable returns to scale.

Figure 3.1 b shows that, firm use two inputs ($x_1$and x_2) to produce one output (y), under the constant returns t scale assumption. Allocative efficiency is shown at Q' where in the tangent of AA' (relative price ratio curve) and isoquant curve. It means

that this is the most efficient resource allocation that can produce SS' level of production under determined input prices. On economic perspective, the marginal rate of technical substitution is equal to the ratio of input prices at this point (Q').

There are three types' potential productivity gain pattern or scale efficiency types called (I) Increasing returns to scale, IRS, (II) Decreasing returns to scale, DRS and (III) Constant returns to scale, CRS.

When increase or decrease input, the proportionately change in the output is higher than change in the input, it is called increasing returns to scale. On the other hand, marginal effect of output is higher than the marginal effect of the input at the IRS situation. When the output change is less than the input change, it is called decreasing returns to scale, and if they are equal, it is called constant returns to scale.

Moreover, the output and the input oriented measures will provide only equivalent measures of technical efficiency when constant returns to scale exist (Fare.R and Lovell, 1978).

3.2 Methods of efficiency calculation

Several methods which were widely used by the researchers, the practitioners and the students can be identified, and summarized as follows.

3.2.1 Ratio Measures

The simplest and widely using way of measuring efficiency is simple ratios, such as the number of OPD visits per health worker and consumption of drugs and supplies per health worker. Inpatient service efficiency is often expressed as average length of stay, bed occupancy rate, and turnover rate. Pabon.L and Hipolito (1986) have pointed out some ratios for relative performance analyzing in similar facilities such as 1.) Length of stay, 2.) occupancy rate and 3.) turnover rate.

These analytical tools can be helped to quick analyze and identification of those similar facilities which performing strongly and poorly. Moreover, it provides

some factors that can affect for them. Main advantage is easy to calculate using routinely data even short periodically. However, the lack of appropriate weight for aggregating different types of output is a weakness of this method. It is good fit for single type of hospital rather than multi-product nature of hospitals. Hospital bed occupancy rate, Average length of stay and Caesarean section rate is the mostly using efficiency indicators in Sri Lanka (Ministry of health)

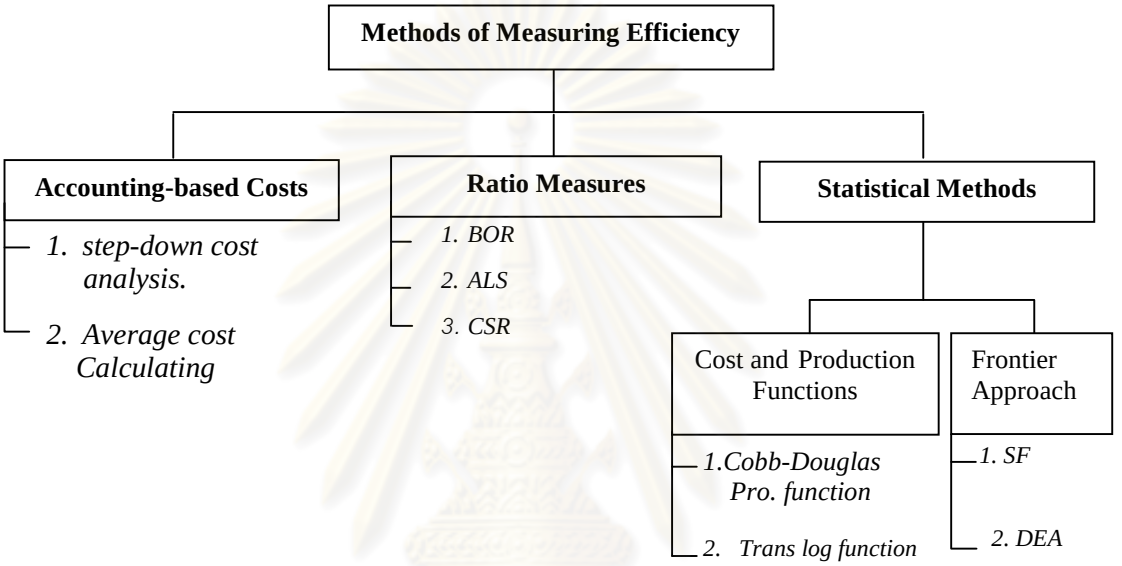

Figure 3.2 Methods of measuring efficiency

Note: Bed Occupancy Ratio = Total Inpatient days / (Number of Beds x 365)
Average Length of Stay = Total Inpatient Days/ Total Admissions
Caesarean Section Rate = Number of Caesarean done / Total live birth x 100
SF = Stochastic Frontier Analysis
DEA = Data Envelopment Analysis

3.2.2 Accounting-based Cost

Two types of important studies have identified by Barnum.H and Kutzin.J, (1993) that used accounting-based costs in the literature.

First method is Step-down cost analyses. Step down costing is time consuming study and invariably these studies most appropriate for the small number of facilities (Attanayake and de Silva, 1992; Somanathan, 1998).

Second method is average cost calculation using aggregated accounting data together with assumptions about the relative resource intensity of different activities (e.g.

Outpatient visits and inpatient days). There can be clearly identified trade-off of facilities and resource allocation between them and data should be available.

Disadvantages of such studies are that they produce estimates of average costs, not marginal costs. It is a huge limitation, which the results can be used to make inferences about conventional measures of economic efficiency such as economies of scale and scope.

3.2.3 Statistics Methods

There are two main approaches can be distinguished namely cost and production function and frontier approaches. First approach is ***cost and production function,*** which is the traditional way to measure efficiency. This method has used in Feldstein's (1967) study of National Health Service hospitals, and in studies of U.S. facilities by Goldman and Grossman (1982).

Trans log model is also a most famous econometric method which has been used to analyze the efficiency. Some of them are (Rajiv, Robert, and Robert, 1986), (Douglas, 1988), (Hollingsworth, 2008)

There are several disadvantages of this method. First, the approach is deterministic in the sense that the entire deviation from predicted cost or output is measured as inefficiency. Second, there is an assumption that the technology or cost function is the same at the frontiers in the middle of the data (C. A. K Lovell, 1993) . Finally, the estimated parameters may be sensitive to the choice of functional form of econometric.

Second approach is ***frontier methods***. In this case *Stochastic Frontiers (SF)* and Data Envelopment Analysis (DEA) are very advance tools.

In this case, SF method attempt to take into account of random factors of outside the control in hospital administration and systematic inefficiency, which can increase efficiency (Battese and George, 1992; Forsund, Lovell, and Schmidt, 1980). In this method, Random and Systematic error are captured in a composed error that can be broken down into its stochastic and systematic components. The limitation of

this method is that it relies on un testable assumptions about the distribution of the error components (Newhouse, 1994; Skinner, 1994).

Data Envelopment Analysis (DEA)

Data Envelopment Analysis is a Linear programming method that has been quite extensively used in the health and other service based sectors such as education, Insurance and welfare services to study technical inefficiency and scale efficiency (Gary and Vivian, 1996; Kornpob Bhirombhakadi, 2008; C.A.K Lovell, Lawrence, and Wood, 1994; Ozcan and Luke, 1993).

This production frontier is estimated by setting out the relationship between inputs and outputs as a linear programming problem. The solution comes from DEA (i.e. A distance function) indicates that either the amount by which output could be expanded using the same inputs, or the amount by which inputs could be reduced while maintaining the same level of output. This is the key advantage is to use widely this method as nonparametric. An also DEA has the ability to handle multiple inputs and multiple outputs to measure efficiency.

It is not concern to specify the error in the same way as either the stochastic frontier model or econometric approach. However, it is similar to the cost function approach and deterministic and attributes the entire residual to inefficiency. In the first time Charnes, Cooper and Rhodes (1978) (CCR) have introduced input and output oriented DEA models assuming the constant return to scale (CRS), and after Banker, Chanes and Cooper (1984) developed this techniques assuming variable return to scale (VRS) regarding changing economies of scale for both input and output oriented.

Another non-parametric method is total factor productivity (TFP). This method widely used with aggregate time-series data to analyze technical change and/or TFP. (Sherman, 1984)

3.3 Hospital efficiency

Hospital efficiency is a topic that is been widely discussed in every health sector forum because of increasing cost of the health care delivery and biomedical

technology is a challenge to the developing country. This phenomenon is emphasized by the world health report (2000), The World health report, (2006), Health Master Plane 2007-2010, (2007).

However, the measuring hospital efficiency is a quite difficult practice. Because it is complicated to measure ideal output comes from input deployed to the hospital (Hollingsworth, 2008; Sherman, 1984). Furthermore, extreme hospital output should be the good health status or quality of life of the people but it is not easy to calculate, because it seems to be related by many factors such as multi dimension, highly individual, heavily dynamic and environmental and socio economics. To overcome this problem, most of the efficiency studies are using intermediate outputs such as the number of OP patients, IP patients and Research conducted (Chang H, 1998). And it might be reasonable because this output directly influenced to increase health status or quality of life of the people anyway.

However, some study shows that the service mix approach focused on supply side output analysis is a good approach. And also this is a good enough analysis in which the nature of a hospital's output is determined by the character and range of its facilities and services. In contrast, the case-mix approach is another analysis which hospital output determined by concerning demand for each hospital output concerns case load of each hospital's case load which determined by the needs of and demand of the population served with facilities (Tatchell, 1983).

When analyzing the efficiency of the government hospitals in Sri Lanka, It is wise to pay attention, by the way of input oriented. (I.e. input oriented DEA model), because there is no relationship between staff payments and level of served in the hospitals. On the other hand, there is no supplier inducing demand (SID) can be significantly identified in providing services in public hospitals. If there is a trend to SID, policy makers and responsible authorities had to pay greater attention to control output over the use of inputs. Furthermore, lack of human resources in the health sector of Sri Lanka such as doctors, specialist and nurses is also a problem (MoH,1992).

3.4. Some studies about hospital efficiency in Sri Lanka

Although, there are many studies on hospital efficiency in developed and developing country, which have done by different aspects and using different methodology. However, there is very poor intervention in Sri Lanka on the hospital efficiency study. Only few studies have found, mainly discussed about hospital efficiency and health system efficiency using whatever methods.

Sri Lanka is well known country that has achieved very good health outcomes at low cost (Hsiao, 2001). The survey of health facilities in (1991) conducted by the world bank found that average costs of healthcare in public sector health facilities were very low by international standards.

One study has been done by Somanathan et al, (2006)to observe the optimization of the configuration of public hospital infrastructure at the district level among three south Asian counties, Sri Lanka, Nepal and Bangladesh using data of the public facility survey conducted in 1998 in Sri Lanka and Bangladesh for year 1997 and for Nepal, data for the year 2000 were obtained from public the facility survey conducted in 2003. They have used mixed of techniques to address the issue of efficiency; (1) Producing a profile of hospital infrastructure by developing standardize district. (2) Measuring marginal product. (3) Analysis of technical efficiency.

In the case of technical efficiency, they have used simple ratios named varied unit costs approach, bed occupancy ratio and length of stay. So, findings show that Sri Lankan hospitals are having the least unit cost for inpatient care; it was less than 5% of the per capita GDP because of high utilization ratio of Sri Lankan health facilities to others (i.e. it is 20-50 times higher than Nepal and Bangladesh) it is a similar pattern in outpatient care as well.

Bed occupancy ratio also significantly highest in Sri Lanka and higher the gap shows in complex facilitated hospitals than small hospitals due to the bypass of primary care facilities (MoH,1992). Further, they have found that higher bed occupancy rate significantly associates with low inpatient unit cost in these three countries. Average length of stay is almost equal to Bangladesh but Nepal is the

higher, and length of stay is positively related to admission cost as the cumulative costs of care are higher for higher length of stay.

In the analysis of marginal product, it has done by cob-Douglas function, and they have found that marginal product of the number of beds is higher in all facilities in Sri Lanka, and it was statistically significant with technical efficiency. Number of doctors, nurses and paramedical staff also gain positive higher marginal product than other two countries but these were not significant. Finally, they strongly recommended by the exceeded marginal product than the average product of beds, the bed capacity in secondary and primary care facilities should be increased to operate at the optimal economies of scale. It means these facilities are not operating at the optimal scale.

Somanathan, A., Hanson, K., Dorabawila, T., and Perera, B,. (2000) have found from their study that there is a considerable variation among facilities offering similar services even though unit cost is low, suggesting that there is potential for improving efficiency.

Further, the study shows that average length of stay (ALS) is relatively low compared with international norms. ALS is highest in the complex facilities, probably because of their more complex case mix and patient's higher willingness to admit this type of hospitals because of satisfactory facilities. Average bed occupancy rates (BOCR) vary considerably among facility types, with a highly utilization rate in complex facilities (average occupancy of 93 percent) and underutilization rate in basic and intermediate facilities (averages of 48.6 and 55.6 percent respectively).

Somanathan, A., (1998) has conducted a study to analyze unit cost analysis of public and private health facilities in Sri Lanka using scenario building technique. So, The results suggested that public facilities are less costly than private facility, and public small inpatient and outpatient facilities have least cost, and also cost of public tertiary care facilities were higher than the lower level facilities. This is because of same phenomenon mentioned before.

Many of the findings in the cost studies were conducted in Sri Lanka can be summarized as follows. These findings have based on inpatient care and outpatient care delivery cost only.

Table 3.1 Unit cost studies of the indoor patient care services in different facilities.

Study	Reported cost per bed per day (Rupees)
de Silva (1994) Medical ward	228 (1992)
de Silva (1994) Surgical ward	326 (1992)
Siriwardena (1997) – Base hospital	232 (1997)
(Somanathan, et al., 2000) - Complex	635 (1998)
(Somanathan, et al., 2000) – Intermediate	394 (1998)
(Somanathan, et al., 2000) – Basic	627 (1998)
Edirisinghe (2002) District Hospital	602 (2002)

Source: Review of Costing Studies Conducted in Sri Lanka 1990-2004, p. 37

Considering inpatient care facilities, complex hospitals show the higher unit cost (635 Rupees) of in indoor care due to the patients with more severe cases and senior staff in these facilities. Furthermore, lower level facilities bear the relatively higher cost (627 Rupees) due to the low occupancy and less turnover rate because of bypassing the lower level facilities. This results show that there is a problem in utilization or utilization disparity among facilities.

Table 3.2 Unit cost studies of the outdoor patient care services in different facilities.

Study	Reported cost per Outpatient visit (Rupees)
de Silva (1994)	37 (1992)
Somanathan (1998) Complex	207 (1992)
Somanathan (1998) Basic	23 (1992)
De Lanerolle	28 (195)
(Somanathan, et al., 2000) - Complex	153 (1998)
(Somanathan, et al., 2000) – Intermediate	26 (1998)
(Somanathan, et al., 2000) – Basic	32 (1998)
(Somanathan, et al., 2000) – Only out patient	35 (1998)
Edirisinghe (2002) District Hospital	143 (2002)

Source : Review of Costing Studies Conducted in Sri Lanka 1990-2004, p. 37.

In OPD care cost, tertiary care facilities show a relative high cost due to the senior and qualified staff. Basic care facilities show least cost in point of put patient care services.

Somanathan et al (2000) conducted a study aiming (I) to explore different methods for quantifying the magnitude of technical and economic inefficiency in service provision by public sector providers and (II) to identify institutional and behavioral factors which explain differences in efficiency using variety of techniques including standard service indicators (length of stay, occupancy rate, turnover rate), average costs, and econometric cost and production functions.

The study found that average cost of care in 1997 continued to be below international norms, but that there remained an important degree of variation among similar facilities, with ratios of high: low cost facilities ranging from 4.3 (for cost per patient day in complex inpatient facilities) to almost 30 (for outpatient visits in basic inpatient facilities). Differences in average length of stay and occupancy rate explain

only a small proportion of the variation in facility cost. Indicators of management characteristics do not seem to explain much of the variation in costs either.

3.5 Studies on efficiency in developing countries.

Umakant.D, Vaishnavi.S.D, and Muraleedharan.V.R, (2010) have done a study in Thamil Nadu district in India to analyze and compare 29 district level hospitals, which have undertaken by several health sector reforms, analyzing technical and scale efficiency. Finally they found that 52 percent hospitals were inefficient and rest of them were efficient Further, the average scale efficiency among the inefficient hospitals was 81 per cent, which implies that the scale inefficient hospitals could reduce their size by 19 percent without reducing their current output levels. And they provided strong implications in terms of further policy making by the result as well as hospital administrators to monitor the progress of the identified underperforming units.

Hsuan-Lien, et al (2002) have conducted a study to identify whether the responsibility centers, total quality management and physician fee program improve the hospital efficiency in Taiwan. They used DEA and Tobit methods regression methods, and found that responsibility centers system and physician fee program tend to increase hospital efficiency while physician fee program significantly affect to increase efficiency of the hospitals in Taiwan.

Another study conducted in Taiwan by Chang. H, (1998) to study about efficiency in central governed hospitals with DEA and OLS. From this, He found that scope of service and proportion of retired veteran patients significantly and negatively associate with efficiency. He has used the complexity as the scope of service. Furthermore, bed occupancy rate is also significant factor to increase efficiency. And also show that efficiency has been improved over the period gradually along with the anticipated implementation of the NHI Programme.

CHAPTER IV

METHODOLOGY

4.1 Research design

This study is a descriptive study focus on provider perspective. The secondary panel data which collected from Ministry of Health used to analyze hospital technical and scale efficiency for three years (2006-2008).

4.2 Conceptual framework

Figure 2 depicted that the conceptual framework of this study. 56 district base hospitals consider for evaluation as a target population out of 65 hospitals. There are mainly two stages, first is relative efficiency calculation both technical and scale using data envelopment analysis (DEA) which widely using the method in this field, under the setting of Input oriented.

And secondly sensor regression Tobit model use to provide more details about efficiency and production characteristics. So reciprocal efficiency score used as a dependent variable (1/TE and 1/SE) and explanatory variables, which have identified in concerning internal and external factors to explore the relationship with efficiency of the hospitals.

This study used four aggregate inputs (number of beds, number of physicians number of nurses and number of allied health personnel) and four outputs (number of IP days, number of OP visits, number if clinic visits and number of deliveries) to measure relative efficiency using as the proxy of labor, capital and quality of care for input selections, and output represented the main common outcomes produced from this type of hospitals.

There are two initial findings comes from DEA. One is the technical efficiency score, and another is scale efficiency scores. Then, these two initials scores used in censor regression Tobit model getting its reciprocal form for which computational convenient and censoring to one as a dependent variable. Explanatory variable has identified by assuming critical way to describe the efficiency of these

hospitals. And finally test the hypothesis with the result derived from two regression models.

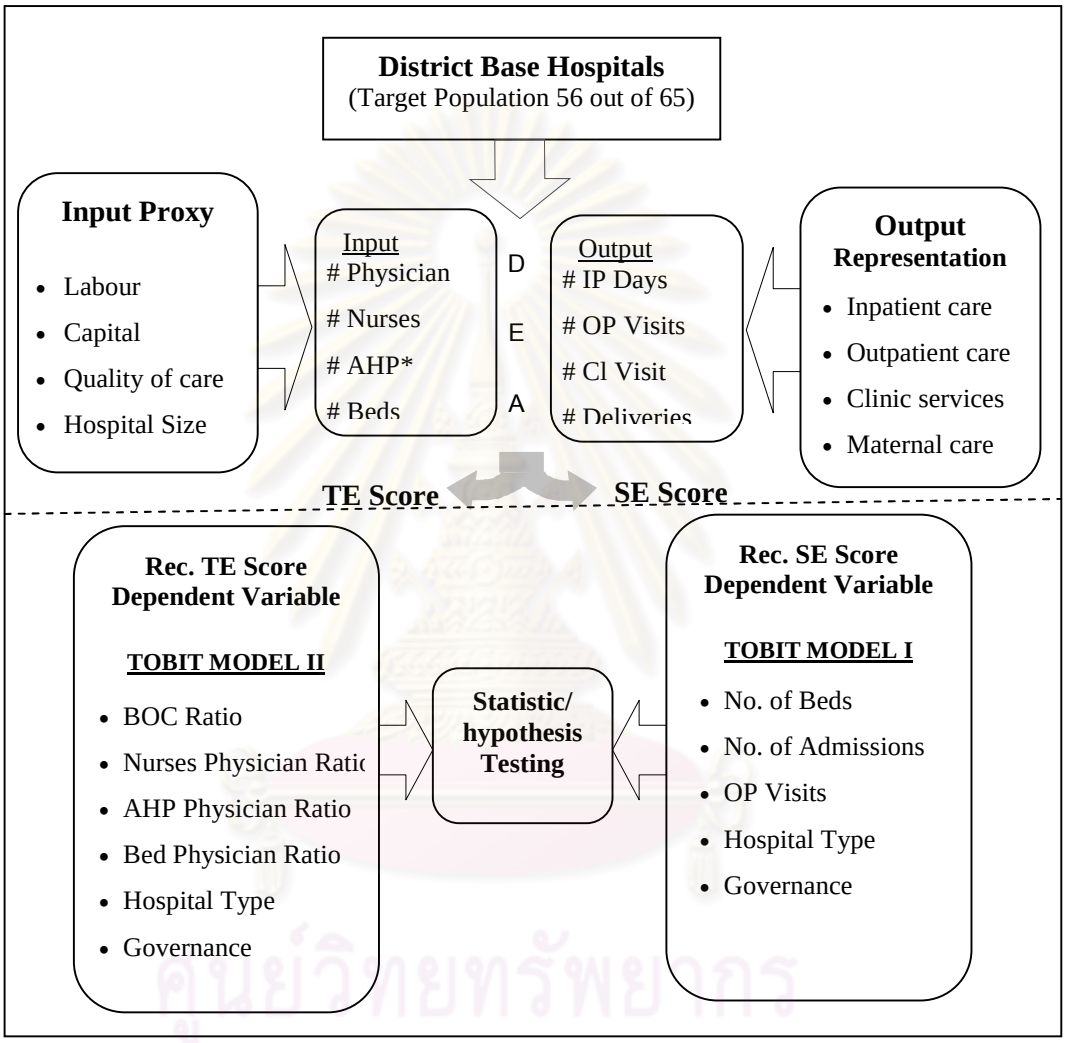

Figure 4.1 Conceptual framework

4.3 Study Total and Target Population and data.

Total population of this study is 65 district base hospitals. And target population is 56 hospitals because of data unavailability of rest of the hospitals due to the past war in north province hospitals and uncompleted data in some hospitals. Data collected from MoH and annual health bulleting, 2006, 2007.

4.4 Technical efficiency and Scale efficiency with Data Envelopment Analysis.

As mentioned before, DEA is a very strong technique in efficiency calculation that is widely using developed by Farrel, M.J (1957).

First, CRS model which is described under assumption that a firm operates at the most efficiency manner or most economies of scale. It means that, TE of both dimensions (output oriented and Input oriented) is same. On the other hand, marginal effect of factors of production is equivalent to marginal effect of outcome.

Underlain principle of calculating efficiency using multiple input and output is that it becomes to analyze weighted input and output for derive frontier according to the maximum resource allocation and after that calculate efficiency for each DMU with respect to previous frontier. How far from it? Distance to have frontier determines the magnitude of inefficiency.

This phenomenon can be described mathematically as follows. For each DMU we would like to obtain a measure of the ratio of all output over input, such as $u'y_i/v'x_i$, where u is an M x 1 (M is output for each DMU) vector of output weight and v is a K x 1 (K is input for each DMU) vector of input weights. To select optimal weight we specify mathematic programming problem;

$$\begin{aligned} &Max_{u,v}(u'y_i / v'x_i), \\ &St \quad u'y_j / v'x_j \le 1,\ j = 1,2,N \\ &\qquad u, v \ge 0. \end{aligned} \tag{1}$$

This involves finding value of u and v, such that the efficiency measure of the ith DMU is maximized, subject to the constraint that all efficiency measures must be less or equal to 1. One problem with this particular ratio formulation is that it has an infinite number of solutions. To avoid this one can impose the constraint $v'x_i = 1$ which provides: Where the notation change from u and v to μ and v reflects the transformation or marginal rate of technical substitution.

$$\begin{aligned} &Max_{\mu,v}(\mu'y_i), \\ &St \quad v'x_i \le 1, \\ &\qquad \mu'y_j - v'x_j \le 0,\ j = 1,2,N \\ &\qquad \mu, v \ge 0. \end{aligned} \tag{2}$$

This form is knows as multiplier form of liner programming problem.

Using the duality in linear programming, one can derive an equivalent envelopment form of this problem:

$$\begin{aligned} &Min_{\theta,\lambda}\theta, \\ &St \quad -y_i + Y\lambda \geq 0, \\ &\quad \theta x_i - X\lambda \geq 0, \\ &\quad \lambda \geq 0. \end{aligned} \qquad \textbf{3)}$$

Where θ is a scalar and λ is an N x 1 vector of constraints. This envelopment form involves fewer constraints than the multiple form (K+M < N+1). And hence is generally the preferred form to solve. The value of θ obtained will be the efficiency score for the i^{th} DMU. It will satisfy θ < 1, with the value of 1 including a point on the frontier and hence a technically efficient DMU, acceding to the Farell (1957) definition. Note that the linear programming problem must be solve N times, once for each DMU in the sample. A value of θ is then obtained for each DMU.

The piecewise linear form of the non-parametric frontier in DEA can cause a few difficulties in efficiency estimation. The problem arise because of the section of the piecewise linear frontier which run parallel to the exes which de not occur in most parametric functions.

It can be described as follows:

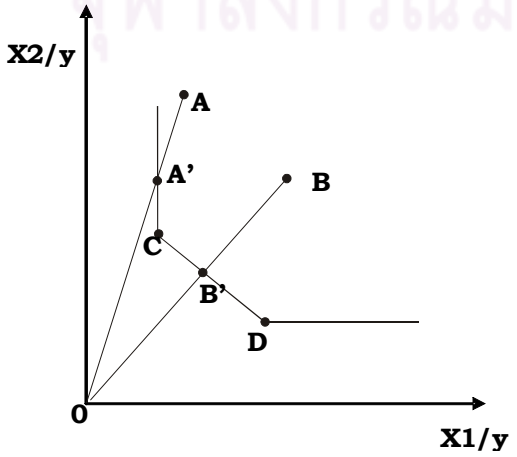

Figure 4.2 Piecewise linear frontier

Figure 4.2 depicted that C and D efficient DMUs while A and B inefficiency DMUs. According to the Farell (1957) efficiency of A' and B' as defined as A'0/A0 and B'0/B0 respectively. It is debatable as to whether A' is efficient point one could reduce the input of X_2 used (from A' to C) and still produce same output.

This situation has interpreted as the input slack or excess input by the researcher, (Koopaman's 1951) (Tjarllin, 1951).

However when $Y\lambda - y_i = 0$, output slack will be zero. And input slack will be zero only if $\theta x_i - X\lambda = 0$, (for the given λ and θ.

Some authors have suggested the solution of a second stage linear programming problem to move to an inefficient frontier point to an efficient point (Ali and Seiford 1993).

This model can be described as follows:

$$
\begin{aligned}
&Min_{\lambda,OS,IS} -(M1'OS + K1'IS), \\
&Subject\ \ to \\
&\qquad -y_i + Y\lambda - OS = 0, \\
&\qquad \theta x_i - X\lambda\ - OS \geq 0, \\
&\qquad \lambda \geq 0, OS \geq o, IS \geq 0,
\end{aligned}
\qquad \textbf{(4)}
$$

Where OS is a Mx1 vector of output slacks, IS is a K x 1 vector of input slacks, and MI and KI are M x 1 and K x 1 vectors of ones, respectively. Note that in the second stage linear program, θ not a variable; its value is taken from the first-stage results. Furthermore, note that this second-stage linear program must also be solved for each N DMU's involved.

There are two major problems associated with this second stage LP. The first and most obvious problem is that the sum of slack is maximized rather than minimized. Hence it will identify not nearest efficient point but furthest efficient point. The second problem associate with the above second stage approach is that it is

not invariant to unit of measurement. The alteration of the units of measurement, say for a fertilizer input from kilograms to tones (while leaving other measurement unchanged), could result in the identification of different efficient boundary point and hence different slack and lambda measures.

As a result of these problems, many studies simply solve the first-stage LP for the values of the Farrell radial technical efficiency measures (θ) for each DMU and ignore the slack completely, or they report both the radial Ferrell technical efficiency score (θ) and residual slack, which may be calculated as $OS = -y_i + Y\lambda$ and $IS = \theta x_i - X\lambda$.

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

Second, under the variable return to scale, there was an assumption that, a firm is achieving highest economies of scale in all the time. But many environment factors such as imperfect competition, financial constraints, technological deficiency, etc cause to DMU to maintain the optimal scale in long term. Banker, Charnes and Cooper (1984) suggested as extension of the CRS DEA mode to account for VRS situations. The use of the CRS specification when not all DMU's are operating at the optimal scale will permit the calculation of TE devoid these scale efficiency effects.

The CRS linear programming LP, problem can be modified to account for VRS by adding the convex constraint: $N1'\lambda = 1$ Where N1 is and N'1 vector of ones.

$$
\begin{aligned}
&Min_{\theta,\lambda}\theta, \\
&St \quad -y_i + Y\lambda \geq 0, \\
&\quad \theta x_i - X\lambda \geq 0, \\
&\quad N1'\lambda = 1 \\
&\quad \lambda \geq 0,
\end{aligned}
\qquad \textbf{(5)}
$$

This approach forms a convex hull of intersecting planes which envelop the data points more tightly than the CRS conical hull and thus provides technical efficiency

scores which are greater than or equal to those obtained using the CRS mode. This VRS model has been widely used since 1990s.

Scale efficiency calculation – TE score obtained from CRS can be decomposed to two segments as one due to SE and another due to pure TE. As follows;

$$TE_{i,CRS} = TE_{i,VRSC} X \ SEi \quad \textbf{(6)}$$

For more understanding, a hypothetical hospital example can be illustrated this instance and concept as follows. One input and one output were considered in 5 DMUs for convenient.

Table 4.1 Hospital efficiency example

Hospital (DMU)	Admission (Output)	Doctors(Input)
1	100	3
2	200	6
3	300	4
4	400	7
5	500	8

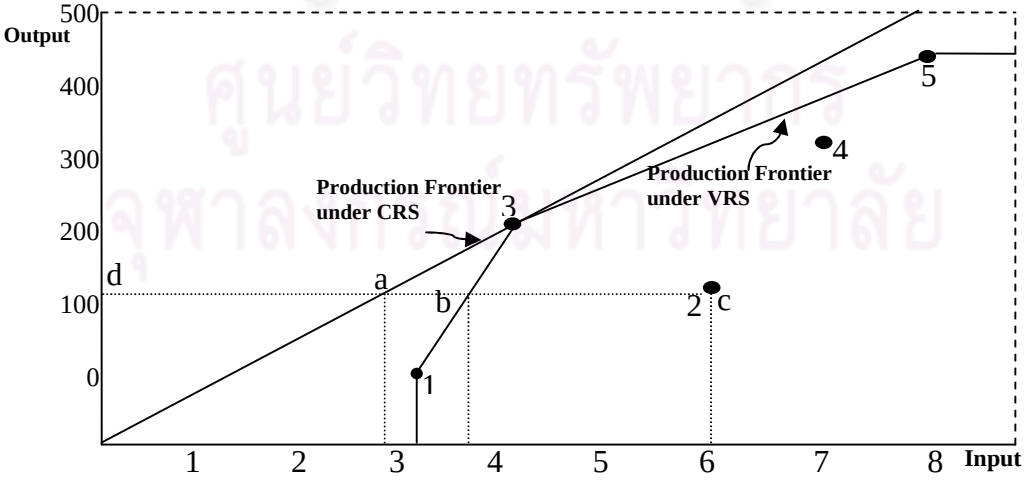

Figure 4.3 VRS and CRS input dimension DEA frontiers

Figure 4.4 depicts the scatter diagram according to the input and output data in each DMU (1,..,5) in Table 4.1. In addition to that it shows difference frontiers under CRS and VRS relatively best performance hospital (i.e. CRS through 3 and VRS through 1,3,5 hospitals). Efficiency value can be illustrated using hospital 2 which is inefficiency in both CRS and VRS assumption. The CRS TE is equal to 2.75/6 = 0.46 (da/dc) and VRS TE equal to 3.7/6 = 0.62 (db/dc), then, SE equal to the ratio of TE_{CRS} and TE_{VRS} according to above explanation. Then, SE equal to 0.46/0.62 = 0.74. Hospital 2 is operating at IRS according to the best operating hospital (peer) because the marginal effect of output is greater than marginal input effect. Moreover, 4 and 5 hospitals operate at DRS while hospital 3 operates at constant returns to scale at both assumptions according to the theory.

4.4.1 Input & Output variable for DEA.

When analyze the efficiency using DEA, we can use multiple input and output concerning the nature of the production process. As a result of complexity of this sector, most key inputs are selected as a proxy of different factors such as labor factor, capital expenditure, and quality of care, size of hospitals, work load and severity. For this study, I use four aggregated input shown in Table 4.1 as a proxy of labor factor, capital expenditure and quality of care. Number of physicians including specialists, doctors, dental surgeons and RMO/AMO and number of nurses including matrons, nurses, nursing sisters and midwives are very important human resources in providing health care. Number of beds is used as a proxy of capital expenditure. Number of allied health staff including MLTs, pharmacist, dispensers and ECG, EEG operators is used as a proxy for quality of care.

Four output variables have added to the model that representing distinguish output in district base hospitals (Table 4.1).

Table 4.2 Input and output variable for DEA

Variable		**Definition**	**Unit of measurement**
Input	NPHY	Number of Physician	The number staff
	NBED	Number of Beds	The number of beds
	NNUS	Number of nurses	The number staff
	NAHP	Number of Allied Health Personnel	The number staff
Output	INPD	Inpatient Days	The number of days
	OPDV	Out Patient Visit	The number of visits
	CLIV	Clinic Visit	The number of visits
	DELV	Number of Delivery	The number of live deliveries

4.5 Sensor Regression Tobit model analysis

Efficiency measurement itself is far away from the whole picture, wanted to visualize through the study. Both qualitative and quantitative reasoning was employed to help for depth understanding the efficiency score (TE & SE) that extracted from DEA analysis under VRS. Significant change in efficiency of hospitals will be given attention to find out the reason. The effect of hospital size, hospital structures, and resources substitutability and other factors may reflect the hospital efficiency.

Tobit regression model or sensor regression model is an extension to Probit regression model, developed by James Tobin (Gujarati, 2003), and it is a very favorable technique specially with limited dependent variable instances such as in DEA.

Technical and scale efficiency scores computed by DEA models are highly bounded by zero and one. However, it can be zero in theoretically but in practically, it will not equal to the exactly zero at all.

Before the estimation, we get the reciprocal value of the TE and SE score, because many of the efficiency scores are very close to one, and they are showing

narrow gap among the efficiency scores. So, after obtaining the reciprocal value, magnitude of the inefficiency score will be spread out greater than one with higher variation. Then, reciprocal efficiency score take in order to analyze as left sensor mode estimation, that censoring point at one.

Furthermore, when the case reciprocal dependent variable, we cannot use OLS, because the dependent variable is not a linear (i.e. reciprocal value, 1/TE, 1/SE). In addition to that, if we use TE and SE as dependent variables with OLS regression assuming the homoscedastic distribution of the error, efficiency score would be made bias and inconsistent parameter estimates because of expected error will not equal to zero (Maddala, 1992). Tobit model most appropriate for this study Because of this instances, and sensor Tobit specification as well as TE and SE score conversion equation as follows;

The basic Tobit model can be described as follows.

$$y_i^* = \beta_1 + \beta_2 X_i + u_i \tag{7}$$

y* is a latent variable that is observed for value greater than truncation point (T) (in our case 1) and censored otherwise. So, the observed y can defined as follows

$$y_i = \begin{cases} y^* & \text{if } y^* > T \\ T_y & \text{if } y^* \leq T \end{cases} \tag{8}$$

The model that assumed T = 1(i.e. Data are censored at 1). Then we can change equation as:

$$y_i = \begin{cases} y^* & \text{if } y^* > 1 \\ 1 & \text{if } 1 \leq 1 \end{cases} \tag{9}$$

Equation 9 shows our study model for the estimation sensor point at one. (Amy Puenpatom.R and Rosenman, 2006) has also used this model as same way.

$$RTE = 1/TE \quad \text{and} \quad RSE = 1/SE \tag{10}$$

RSE = Reciprocal scale efficiency score and RTE = Reciprocal technical efficiency score.

Thus, negative sign of coefficients that calculated from Tobit reflect the positive relationship with Technical efficiency and Scale Efficiency because of our dependent variable used as the reciprocal form of the real efficiency score.

Models are as follows;

4.5.1 The Model I: for Scale Efficiency:

$$RSE_{it} = \left[\frac{1}{SE_{it}}\right] = \beta_0 + \beta_1\ NOBD_{it} + \beta_2 ADDS_{it} + \beta_3 OPDV_{it} + \beta_4 HOST_{it} + \beta_5 GOVN_{it} + \varepsilon_{it} \quad \textbf{(10)}$$

Where

RSEit = Reciprocal Scale Efficiency score of the i-th hospital for t year.

β_0 = constant term

β_1 = coefficient of NOBD independent variable

β_2 = coefficient of ADDS independent variable

β_3 = coefficient of OPDV independent variable

β_4 = coefficient of HOST independent variable

β_5 = coefficient of GONV independent variable

NOBDit = Number of Beds in the i-th hospital for t year.

ADDSit = Number of admissions of the i-th hospital for t year.

OPDVit = OPD Visits of the i-th hospital for t year.

GOVNit = Governance of the i-th hospital for t year.

Dummy variable 1 = Belongs to ministry of health

0 = Otherwise.

HOSTit= Hospital Type of the i-th hospital for t year.

Dummy variable 1 = Type A hospital (Large)

0 = Type B hospital (Small)

ε = Classical Error term

Table 4.3 Expected sign of coefficients

Variable	Description	Expected Sign
1. NOBD	The number of beds	+
2. ADDS	The number of admissions	+
3. OPDV	The number of OPD visits	+
4. GOVN	Hospital governance	+
5. HOST	Hospital type	+

4.5.2 The Model II: for Technical Efficiency:

$$RTE_{it} = \left[\frac{1}{TE_{it}}\right] = \beta_0 + \beta_1 BOCR_{it} + \beta_2 NPYR_{it} + \beta_3 AHPY_{it} + \beta_4 BPYR_{it} + \beta_5 HOST_{it} + \beta_6 GOVN_{it} + \varepsilon_{it} \quad (11)$$

Where

RTE_{it} = Reciprocal Technical Efficiency score of the i-th hospital for t year.

β_0 = Constant term

β_1 = Coefficient of BOCR independent variable

β_2 = coefficient of NPYR independent variable

β_3 = coefficient of AHPY independent variable

β_4 = coefficient of BPYR independent variable

β_5 = coefficient of HOST independent variable

β_6 = coefficient of GOVN independent variable

$BOCR_{it}$ = Bed Occupancy Ratio of the i-th hospital for t year.

$NPYR_{it}$ = Nurses Physician ratio of the i-th hospital for t year.

$AHPY_{it}$ = Allied Health staff Physician ratio of the i-th hospital for t year

$BPYR_{it}$ = Bed Physician ratio of i-th hospital for t year.

$GOVN_{it}$ = Governance of it hospital for t year.

Dummy variable 1 = Belongs to ministry of health

0 = Belongs to provincial department of health.

$HOST_{it}$= Hospital Type of the it hospital for t year.

Dummy variable 1 = Type B hospital

0 = Type A hospital

ε_j = Classical Error term

Table 4.4 Expected sign of coefficients

Variable	Description	Expected Sign
1. BOCR	Bed occupancy ratio	+
2. NPYR	Nurses physician ratio	+
3. AHPY	Allied health personnel physician ratio	+
4. BPYR	Bed physician ratio	-
5. HOST	Hospital type	+
6. GOVN	Hospital governance	+

4.6 Hypothesis of the study

4.5.1 Determination of Technical efficiency (TE).

1. ***Bed occupancy ratio*** - Bed occupancy rate included as a proxy of utilization of hospital resources. Higher bed occupancy ratio shows that most of the beds in the hospital are being utilized by the patients throughout the year. It means this hospital has created much output in terms of inpatient care. So, the relationship between technical efficiency and bed occupancy ratio should be positive because it creates much out comes by using resources.

On the other hand higher bed occupancy rate shows us their high committed service capacity while lower committed service capacity by low rate (Chang H, 1998),(Rajiv, et al., 1986).

2. ***Physician and Nurses ratio*** - It says how many nurses for one physician or proportion. This combination has also positive relationship with technical efficiency. Physicians and nursing staff including, midwives have a substitution relationship to somewhat, not all the situation. I like to do hypothesis this combination with maternity care facilities because nurses and midwives have strong ability to manage delivery which is uncomplicated pregnancies.(Wiegers, 2003) ,(Chutima and Albert, 2006) and also some limited other treatment units. Majority of the district-base hospital in Sri Lanka more likely handles general cases except some hospitals in terms of delivery care because there is a regulation that mother who is first time pregnant should be facilitated in the tertiary care hospital or another hospital which is a specialist appointed.

3. ***Allied health staff physician ratio*** - There has a positive relationship with technical efficiency as a complementary relationship between Physician and Allied health staff. Because of allied health professionals are technical staff, which is supporting to physicians at their treatment process in terms of quality improvement (if we think about MLT) and use of optimal productivity from physicians. When allied health staff (if we think about pharmacist) physician ratio increase, we can believe that the queue in the pharmacy will short and patient who need another treatment can move. It means this optimal combination can create more output. Moreover, it can be

happened on increasing allied health staff under a same number of physicians or number of physicians can be reduced while allied health personnel remain the same. In Sri Lanka, there has a deficit in allied health staff. (Chutima and Albert, 2006)

4. ***Beds physician ratio*** - Bed physician ratio determines a negative effect to the efficiency. Because, when the bed-physician ratio increases, it is difficult to maintain patient investigations (Take time), and it may be causing to increase the length of stay. And also quality of care (time allocation for one patient has to limit) can be fallen. On the other hand, high ratio may be deployed excess beds. On the economic aspect, they are complementary (Chutima and Albert, 2006). So, we can increase efficiency of the hospital by reducing the ratio by which is increasing physicians under the fixed number of beds or reducing the number of beds while numbers of physicians remain the same.

5. ***Hospital Type (Dummy)*** – Type A (Large) district base hospitals are more technical and scale efficient than type B (Small) hospitals. Type A hospitals most often have some specialists such as VOG, Pediatrician and Ent Surgeon and this condition may help to acquire more referrals from lower level facilities and also people more willing to go this type of hospitals because of pleasant facilities in there. It may cause to be gain scale efficiency also technical efficiency with respect to type B hospitals (MoH, 2007c).

6. ***Governance (Dummy)*** - if hospitals belong to the ministry of health (LM hospitals), they are more technically and scale efficient than hospitals belonged to the provincial department of health services (PDHS) (Provincial hospitals). Because of there are mainly two administrative body for most cases has to follow by the provincial hospitals namely Regional director of health services(RDHS) and Provincial director of health services (PDHS). It takes time for decision making and for routing procedures. For some cases need central level approval. However, LM hospitals can directly contact with MoH and it is quite fast in decision making and resource allocation. These conditions make LM hospital technically efficient, and also they are gaining economies of scale.

4.5.2 Determination of Scale efficiency (SE).

1. ***Number of IP admissions*** - IP admissions (proxy for resources utilization) have a positive relationship with scale efficiency. It is obvious that when more patients admit to the hospital, hospital can create economy of scale respectively other peers (Gary and Vivian, 1996).

2. ***Number of OPD visits*** – there is a positive relationship to scale efficiency. It is also the same phenomenon mentioned in the number of inpatient days (Gary and Vivian, 1996)

3. ***Number of beds*** - and scale efficiency has a positive relationship. Amount of bed is the foremost indicator to resource allocation and determines hospital size among health economists, policymakers and other interest parties. Therefore, relatively bed capacity higher hospitals are likely to be a more facilitated and high complex hospital. This phenomenon significantly influences to gain scale efficiency. Ozcan Y.A and Luke R. D (1993) have mensioneded this. District base hospital relatively belongs to this category and people more willing to go there for treatment even unnecessary conditions. It will create much output to the hospitals.

4.6 Analyzing data

DEAO Version 2.0, and Eviews 6.0 computer software provided technical facilities in measuring efficiency and regression analysis. In technical and scale efficiency analysis, data was undertaken separately for 56 DMUs (for each year) to explore the efficiency trend and the impact of the health master plan. Later, it takes in order to aggregate analysis using same data set as 168 DMUs (56 hospitals X 3 years) for both efficiency scores and Tobit regression analysis to determine the factors of efficiency.

CHAPTER V

RESULT AND DISCUSSION

5.1 Empirical descriptive statistics.

First, descriptive analysis calculated from input and output data might be useful to understand the trend of them by different aspect. Data was collected from 56 district base hospitals for three years 2006-2008.

Table 5.1 Hospital proportion by hospital type

Type of Hospital	Number of Hospitals
Type A hospitals	18
Type B hospitals	38
Total	**56**

Table 5.2 Hospital proportion by administration.

Type of Hospital Administration	Number of Hospitals
Governed by ministry of health	03
Govern by provincial health department	53
Total	**56**

Table 5.3 Aggregate statistics, 2006-2008

Variable	Mean	Std Dev	Minimum	Maximum
Inpatient Days	45034.95	38260.36	3546.00	133374.00
Clinic Visits	44703.04	38303.08	1666.00	172043.32
OPD Visit	123894.27	64818.96	10660.00	377825.00
Deliveries	1568.17	1655.66	11.00	5964.00
Beds	196.14	125.87	26.00	562.00
Physician	32.52	33.91	2.00	172.00
Nurses	73.79	69.76	3.00	289.00
Allied Health Personals	9.76	7.60	1.00	34.00
** Observation - 168				

Average number of Physician (NOPY) was increased from 30.2 to 34.39 and number of nurses from 65.5 to 80.8. OPD visit (OPDV) and Inpatient days (NIPD) have increased from 119201.36 to 130139.39 and from 41956.96 to 130139.39 and 49308.27 respectively while bed size has increased from 188.54 to 200.18 over three years (Table 3). Number of beds has ranged from 103 to 530 in the type A (large) hospitals while it was determined from 34 to 462 in the type B (small) hospitals. Data are shown by Table 5.4, 5.5, 5.6.

According to the data on type A (Large) hospitals, Average number of beds has been increased from 278.72 in 2006 to 316.28 in 2008 and minimum 102 and 104 respectively 2006, 2008. Maximum bed capacity shown as 481 in 2006 and 562 in 2008 (Table 5.7, 5.8, and 5.9).

Average number of bed strength has been increased from 145.82 in 2006 to 145.18 2008 in Type B (Small) hospital while without change in minimum bed strength is 38 respect year and maximum beds has decreased from 508 to 394 over three years. Results shown in Table 5.10, 5.11, 5.12.

Table 5.4 All group descriptive statistics in 2006.

Variable	Mean	Std Dev	Minimum	Maximum
Inpatient Days	41956.96	36760.32	5040.00	122689.00
Clinic Visits	42222.02	37987.41	1666.00	158866.00
OPD Visit	119201.36	72640.87	10660.00	377825.00
Deliveries	1461.98	1590.57	17.00	5333.00
Beds	188.54	126.52	38.00	508.00
Physician	30.20	29.53	4.00	114.00
Nurses	65.50	60.59	6.00	232.00
Allied Health Personals	8.84	7.11	1.00	30.00
** Observation - 56				

Table 5.5 All group descriptive statistics in 2007.

Variable	Mean	Std Dev	Minimum	Maximum
Inpatient Days	43839.63	38157.43	6783.00	123465.00
Clinic Visits	43211.06	38148.25	2123.00	172043.32
OPD Visit	122342.07	58223.61	40368.00	323475.00
Deliveries	1636.23	1687.35	14.00	5964.00
Beds	199.71	127.05	26.00	519.00
Physician	31.68	32.65	2.00	143.00
Nurses	74.23	71.08	7.00	273.00
Allied Health Personals	9.84	7.77	2.00	32.00
** Observation - 56				

Table 5.V.6 All group descriptive statistics in 2008.

Variable	Mean	Std Dev	Minimum	Maximum
Inpatient Days	49308.27	40097.28	3546.00	133374.00
Clinic Visits	48676.04	39138.09	6310.00	165932.00
OPD Visit	130139.39	63450.79	52362.00	364796.00
Deliveries	1606.29	1711.30	11.00	5923.00
Beds	200.18	125.96	38.00	562.00
Physician	34.39	35.68	5.00	172.00
Nurses	80.80	74.98	3.00	289.00
Allied Health Personals	10.64	7.99	1.00	34.00
** Observation - 56				

Trend of the variables by annually and type of the hospital (Type A).

Table 5.7 Descriptive statistics by Hospital Type in 2006 – (Type A Group)

Variable	Mean	Std Dev	Minimum	Maximum
Inpatient Days	75136.89	39499.79	17651.00	122689.00
Clinic Visits	72056.94	45535.75	17654.00	158866.00
OPD Visit	155585.61	82054.52	15979.00	313448.00
Deliveries	3039.94	1651.55	181.00	5333.00
Beds	278.72	130.32	102.00	481.00
Physician	60.28	30.60	8.00	114.00
Nurses	129.11	60.76	24.00	232.00
Allied Health Personals	16.11	7.61	5.00	30.00
** Observation - 18				

Table 5.8 Descriptive statistics by Hospital Type in 2007 – (Type A Group)

Variable	Mean	Std Dev	Minimum	Maximum
Inpatient Days	80832.22	38563.95	17239.00	123465.00
Clinic Visits	60774.71	47198.04	12746.00	172043.32
OPD Visit	165092.22	69497.16	79256.00	323475.00
Deliveries	3281.11	1764.58	160.00	5964.00
Beds	306.78	119.37	104.00	519.00
Physician	62.78	37.33	8.00	143.00
Nurses	145.17	73.94	24.00	273.00
Allied Health Personals	17.56	7.70	5.00	32.00
** Observation - 18				

Table 5.9 Descriptive statistics by Hospital Type in 2008 – (Type A Group)

Variable	Mean	Std Dev	Minimum	Maximum
Inpatient Days	87166.11	36303.44	22811.00	133374.00
Clinic Visits	87889.17	41516.81	26584.00	165932.00
OPD Visit	179296.89	73515.90	74577.00	364796.00
Deliveries	3419.67	1658.87	101.00	5923.00
Beds	316.28	124.23	104.00	562.00
Physician	67.61	42.62	8.00	172.00
Nurses	153.67	83.96	3.00	289.00
Allied Health Personals	19.06	7.33	9.00	34.00
** Observation - 18				

Trend of the variables by annually and type of hospital type (Type B)

Table 5.10 Descriptive statistics by hospital type in 2006 – (Type B Group)

Variable	Mean	Std Dev	Minimum	Maximum
Inpatient Days	27240.16	20418.44	5040.00	97934.00
Clinic Visits	28089.68	23541.87	1666.00	123187.00
OPD Visit	101966.71	61653.41	10660.00	377825.00
Deliveries	714.53	849.89	17.00	3404.00
Beds	145.82	100.80	38.00	508.00
Physician	15.95	14.74	4.00	54.00
Nurses	35.37	29.32	6.00	107.00
Allied Health Personals	5.39	3.27	1.00	15.00
** Observation - 38				

Table 5.11Descriptive statistics by hospital type in 2007 – (Type B Group)

Variable	Mean	Std Dev	Minimum	Maximum
Inpatient Days	26316.82	22359.11	6783.00	88535.00
Clinic Visits	34891.44	30308.27	2123.00	125650.74
OPD Visit	102092.00	38856.28	40368.00	207717.00
Deliveries	857.08	928.37	14.00	3293.00
Beds	149.00	96.08	26.00	484.00
Physician	16.95	15.86	2.00	63.00
Nurses	40.63	37.30	7.00	138.00
Allied Health Personals	6.18	4.45	2.00	19.00
** Observation - 38				

Table 5.12 Descriptive statistics by hospital type in 2008 – (Type B Group)

Variable	Mean	Std Dev	Minimum	Maximum
Inpatient Days	31375.61	27511.97	3546.00	123160.00
Clinic Visits	30101.39	19561.26	6310.00	75270.00
OPD Visit	106854.26	42059.28	52362.00	220220.00
Deliveries	747.32	855.20	11.00	2977.00
Beds	145.18	82.65	38.00	394.00
Physician	18.66	16.32	5.00	65.00
Nurses	46.29	36.21	8.00	145.00
Allied Health Personals	6.66	4.41	1.00	20.00
** Observation - 38				

5.2 Technical & Scale efficiency result from DEA

DEA results which calculated by separately in each year (2006, 2007, 2008 and 56 DMU) have shown by table 5.13 and 5.14. The average efficiency score under CRS is 0.73, 0.84 and 0.88 and minimum was 0.43, 0.53 and 0.55 respectively while the maximum is 1 in each year. The findings under the assumption of VRS are 0.85, 0.90 and 0.91 and minimum efficiency scores were 0.45, 0.56 and 0.60 in respective year. The average scale efficiency was 0.86, 0.92 and 0.66 while minimum score was 0.52, 0.69, and 0.78 for respective years.

Proportion of the hospitals that efficient and inefficient (CRS) shown by Table 5.16. 12 hospitals (21%) or DMUs were efficient in 2006, and it has increased to 13, (23%) and 22 (39%) in 2007 and 2008 respectively.

Under the assumption of VRS, 24 (43%), 28 (50%) and 32 (57%) hospitals or DMUs were technically or pure efficient in 2006, 2007, 2008.

12 (21%), 14 (25%) and 22 (39%) hospitals are scale efficient for year 2006, 2007 and 2008 respectively, (percentage value shown by the parenthesis) and rest of them are scale inefficient. However, the initial results comes from DEA shows that (Table, 5.15, 5.16, 5.17) there is increasing trend on technical efficiency under CRS and VRS and scale efficiency.

Overall efficiency which calculated using 168 DMU (2006-2008) shows that average technical efficiency under CRS is 0.73 while 0.81 under the assumption of VRS. Scale efficiency score is 0.90 with proportion of 45 DMUs showing increasing returns to scale, 99 DMUs showing decreasing returns to scale and rest of 24 DMUs showing constant return to scale. Technical efficiency (VRS) was ranged from 0.38 3to 1. Average scale efficiency determined as 0.90 and minimum as 0.41. Maximum efficiency score is 1. This is shown by table 5.14.

Table 5.13 Efficiency summery - Annually

	2006			2007			2008		
	TE (CRS)	TE (VRS)	SE	TE (CRS)	TE (VRS)	SE	TE (CRS)	TE (VRS)	SE
Average	0.733	0.849	0.864	0.836	0.904	0.924	0.879	0.917	0.958
Minimum	0.434	0.435	0.518	0.532	0.559	0.692	0.546	0.604	0.776
Maximum	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000

** 56 DMUs

TE (CRS) = Technical efficiency score under CRS assumption.

TE(VRS) = Technical efficiency score under VRS assumption.

SE = Scale efficiency score.

Table 5.14 Efficiency summery – Aggregated (2006 - 2008)

	TE (CRS)	TE (VRS)	SE
Average	0.738	0.818	0.905
Minimum	0.340	0.383	0.412
Maximum	1.000	1.000	1.000
Irs:drs:crs	45:99:24		

** 168 DMUs

Table 5.15 TE (CRS) score level classification by annually

Range	TE(CRS)		
-	**2006**	**2007**	**2008**
100%	12 (21%)	13 (23%)	22 (39%)
90%-99.99%	7 (12%)	9 (16%)	8 (15%)
80%-89.99%	2 (4%)	14 (25%)	6 (11%)
70%-79.99%	4 (7%)	9 (16%)	14 (25%)
60%-69.99%	11 (20%)	5 (9%)	3 (5%)
< 60%	20 (36%)	6 (11%)	3 (5%)
Total	56 (100%)	56 (100%)	56 (100%)

Table 5.16 TE (VRS) score level classification by annually

Range	TE(VRS)		
-	**2006**	**2007**	**2008**
100%	24 (42%)	28 (50%)	32 (57%)
90%-99.99%	6 (11%)	6 (11%)	4 (7%)
80%-89.99%	4 (7%)	9 (16%)	12 (22%)
70%-79.99%	6 (11%)	8 (14%)	4 (7%)
60%-69.99%	11 (20%)	3 (5%)	4(7%)
< 60%	5 (9%)	2 (4%)	0 (-)
Total	56 (100%)	56 (100%)	56 (100%)

Table 5.17 SE score level classification by annually

Range	SE		
-	**2006**	**2007**	**2008**
100%	12 (21%)	14 (25%)	22 (39%)
90%-99.99%	17 (30%)	22 (39%)	24 (43%)
80%-89.99%	11 (20%)	13 (23%)	6 (11%)
70%-79.99%	5 (9%)	6 (11%)	4 (7%)
60%-69.99%	8 (15%)	1 (2%)	0 (-)
< 60%	3 (5%)	0 (-) -	0 (-)
Total	56 (100%)	56 (100%)	56 (100%)
Irs:drs:crs	7:37:12	15:26:15	16:18:22

irs = Increasing return to scale: drs = Decreasing return to scale:

5.3 Scale efficiency pattern

The results in 2006 show that 7 hospitals were determined at increasing return to scale (irs) while 37 hospitals were decreasing return to scale (drs) rest of institutions (12) are performing at constant return to scale (Table. 5.18). This result has gradually changed over the time as a ratio of irs:drs to 15:26 in 2007, and 16:18 in 2008. In this case irs shows that increasing trend and drs shows decreasing trend.

5.4 Input savings (Input Slack)

Technical efficiency level in the base hospital in Sri Lanka is observed from 38% to 100%. This shows that, if the inefficient hospital were increased the efficiency at optimal level by omitting their extra input (Slack amount), whole the district base hospitals could have to gain more extra efficiency using optimal resource in services. On the other hand, this omitted amount of resources can be saved or utilized other hospitals. Input slack value shown by Appendix B. For instance, No 2 hospital can reduce 17 physicians under same output level. And No 10 hospital can omit 10 nurses from their production without reducing output compare with peers.

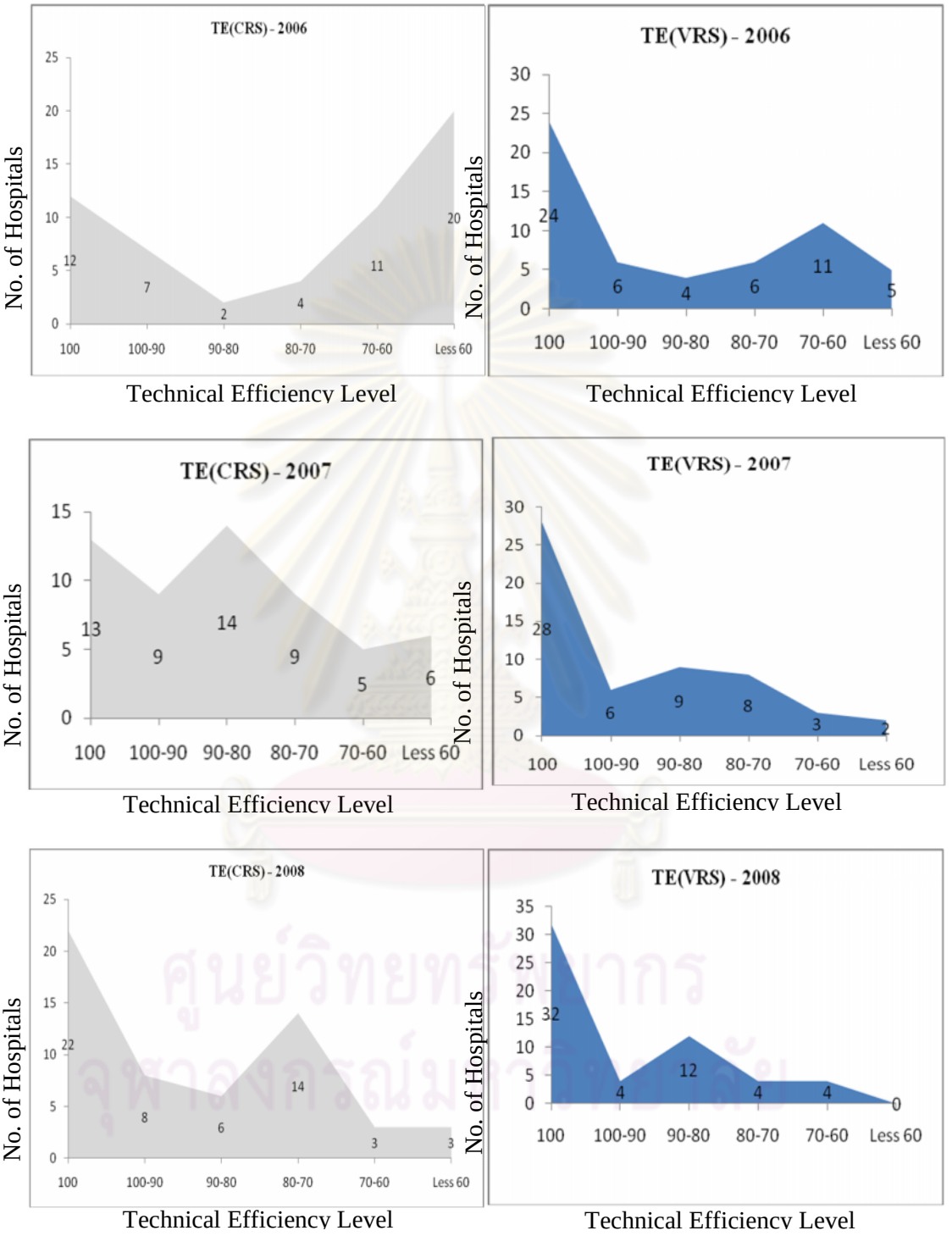

Figure 5.1 TE (CRS) Score and TE (VRS) Score graphs 2006-2008.

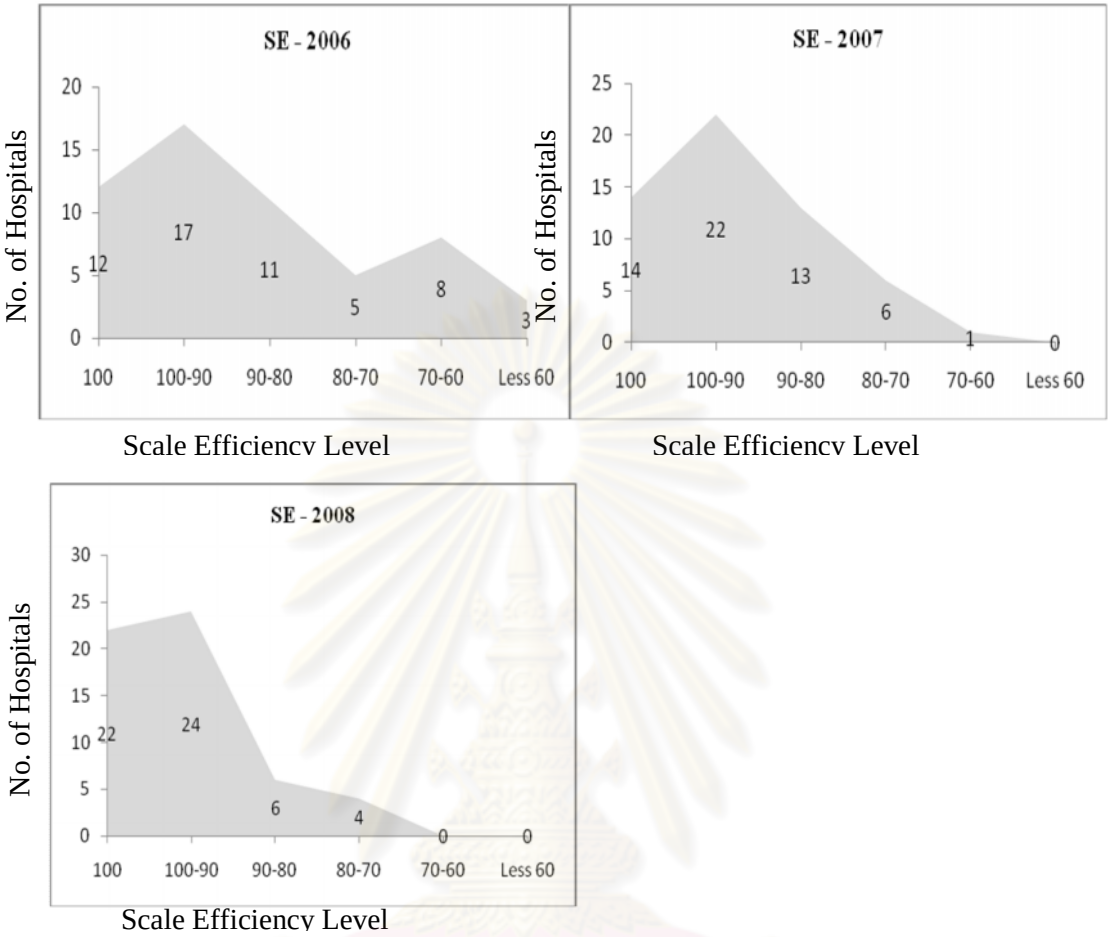

Figure 5.2 SE score graph 2006-2008

5.5 Impact of health master plan 2007-2016.

Due to the lack of data to represent the health master plane to identify the impact of health master plan, never applied any variable to the statistic model. Another reason is there is no significant structural change that can identify in the hospital after implementation of the master plan 2007-2016. This study emphasized that what was the average efficiency level of the district base hospitals and proportionately there are any significant changes after implementing health master plan in 2007 in district base hospitals.

This result shows that average TE(VRS) before implementation of health master plan was 85% and after one year later it the has reached up to 92%. When compare about proportion of TE (VRS), it seems to that 24 hospitals were on the frontier and 10 hospitals were showing good efficiency level between greater than

80% and less than 100%. Therefore, this combination has bee changed that 32 hospitals are in the frontier and 16 hospitals between 100 % and 80% after the master plane, and also lowest efficient hospital was 43% before but after the master plan it was increased up to 60% minimum level.

Average scale efficiency level has increased from 86% up to 94%. Additional 8 hospitals met scale efficiency, and proportionally it has increased up to 32 hospitals

According to this result, we can believe that there has influence to increase efficiency of the district base hospitals.

Following reasons which can be effect for this phenomenon are;

I. Providing resource allocation criteria, norms and guidance which consistence with the national objective to provincial administrators to use their resources and other external recourse (Donations, Budget allocations) and reviewing continually by the ministry of health.

II. Contracting out non clinical services to gain more value for investment and reduce unit cost. eg. Laundry service, Food services.

III. Strengthening the hospital by concerning geographical and income groups among the province and within the province to provide more service for low income groups. (MoH, 2007c).

Table 5.18 Average TE and SE efficiency score as an impact of Health Master Plan

	Before Health Master Plan			After Health Master Plan			Gain/Loss (+/-		
	TE (CRS)	TE (VRS)	SE	TE (CRS)	TE (VRS)	SE	TE (CRS)	TE (VRS)	SE
Average	0.706	0.849	0.864	0.879	0.917	0.958	0.146	0.068	0.094
Minimum	0.434	0.435	0.518	0.546	0.604	0.776	0.112	0.169	0.258
Maximum	1.000	1.000	1.000	1.000	1.000	1.000	-	-	-

Table 5.19 Technical efficiency level as an impact of Health Master Plan

Range	TE(VRS)		
-	Before Health Master Plan	After Health Master Plan	Gain/Loss(+/-)
100%	24 (42%)	32 (57%)	8 (15%)
90%-99.99%	6 (11%)	4 (7%)	-2 (-4%)
80%-89.99%	4 (7%)	12 (22%)	8 (15%)
70%-79.99%	6 (11%)	4 (7%)	-2 (-4%)
60%-69.99%	11 (20%)	4(7%)	-7 (-13%)
< 60%	5 (9%)	0 (-)	-5 (-9%)

Table 5.20 Scale efficiency level as an impact of Health Master Plan

Range	SE		
-	Before Health Master Plan	After Health Master Plan	Gain/Loss(+/-)
100%	12 (21%)	22 (39%)	10 (18%)
90%-99.99%	17 (30%)	24 (43%)	7 (7%)
80%-89.99%	11 (20%)	6 (11%)	-5 (-9%)
70%-79.99%	5 (9%)	4 (7%)	-1 (-2%)
60%-69.99%	8 (15%)	0 (-)	-8 (-15%)
< 60%	3 (5%)	0 (-)	-3 (-5%)
Irs:drs:crs	7:37:12	15:26:15	16:18:22

5.6 Analysis of determinants of efficiency

A first-order measure of relative efficiency such as DEA among similar facilities provides important information about wide range efficiency both technical and scale under the assumption of homogeneous decision making units or DMUs. Therefore, it not provides more depth information about production characteristics or environment factors. So, when the studying in hospital efficiency especially technical and scale, analysis of determinants is very important to policy implications by observing relationship among efficiency and rational environmental factors and production characteristics.

5.6.1 Relationship with Technical efficiency (VRS) and explanatory variables.

Table 5.21 Result of technical efficiency and explanatory variables

	Coefficient	Std. Error	z-Statistic	Prob.
C	1.568004	0.153979	10.18325	0.0000
BOCR	-0.299782	0.126137	-2.376637	0.0175
NPYR	-0.020393	0.025072	-0.813401	0.4160
AHPY	-0.038294	0.023170	-1.652772	0.0984
BPYR	0.000866	0.002061	0.420291	0.0443
HOST	-0.020037	0.072386	-0.276805	0.7819
GOVN	-0.363255	0.144822	-2.508285	0.0121
Left censored observation	49	Right censored observation		0
Uncensored observation	119	Total observation		168

BOCR = Bed Occupancy Ratio.

NPYR = Nurses Physician ratio.

AHPY = Allied Health staff Physician Ratio.

BPYR = Bed Physician Ratio.

GOVN = Governance.

HOST = Hospital Type.

According to the result comes from Tobit regression analysis, which used reciprocal technical efficiency score as the dependent variable and six independent variables shows that negative sign of the coefficients implies the positive relationship with technical efficiency.

So, bed occupancy ratio, bed physician ratio and governance of the hospital are consisted with the study hypothesis with the expected sign, and they are statistically significant at p value less than 0.05 level. So, the higher bed occupancy ratio can create much output in terms of inpatient care by using resources, and also it is likely to be use maximum capacity of resources belongs to inpatient care.

Further, Increased bed physician ratio would be decreasing the technical efficiency. When more in-patients take cared by one physician, it seems to be time

consuming for investigation and follow the other clinical and administration procedures. This instance will create higher length of stay of inpatient words. On the other hand, higher ratio might be deployed excess beds as well.

Hospitals belong to the ministry of health are technical efficient than hospitals belongs to the provincial health departments. The hospitals that belong to line ministry operate under supervision and with direct contact. It seems to be operating with smaller span of control, and they can make their own decision faster than provincial hospitals, which consist of wide range of administration. On the other hand, fast resource allocation may be help to reduce the length of stay of line ministry hospitals such as drugs and consumables.

Coefficient sign of the nurses' physician ratio, allied health personnel physician ratio and type A hospitals (type A large and type B small) have also determined the technical efficiency with positive effect as we expected but they are not statistically significant.

5.6.2 Relationship with Scale efficiency and explanatory variables.

Table 5.22 Result of scale efficiency and explanatory variables

	Coefficient	Std. Error	z-Statistic	Prob.
C	0.918182	0.035690	25.72662	0.0000
OPD	8.14E-08	4.72E-07	0.172301	0.8632
ADD	-1.34E-06	2.87E-07	-4.672558	0.0000
BEDS	3.31E-06	2.41E-06	1.373867	0.1695
HOST	-0.036663	0.041809	-0.876919	0.0305
GOVN	0.005551	0.070380	0.078870	0.9371
Left censored observation	0	Right censored observation		28
Uncensored observation	140	Total observation		168

ADD = Number of Admissions.

OPD = OPD Visits

BEDS = Number of Beds.

GOVN = Governance.

HOST = Hospital Type.

In this step, this study observes that whether there is any relationship with hospital capacity and scale efficiency. On the other hand when a hospital operates in a relatively with higher capacity, it might be leading to gain economies of scale in economic point of view. So, the statistical results show that admissions and hospital types has positive relationship with scale efficiency as we expected and p value of them are statistically significant under 5% confidence level.

So, it means, when increase in-patient admissions, scale efficiency will be increased. It is of cause, when more patients get treatment from the hospital, it can be used resources by maximum capacity and also it can produce higher labor and capital productivity than hospitals with fewer admissions.

Type A hospitals (Large) have more facilities compare with type B (Small) as mention earlier. So, type A hospitals have a higher propensity to attend more referrals consist of clinic, inpatient and maternity from low level institutions than type B hospitals and also many people willing to go this type of hospitals to get treatments. In addition to that 95% inpatient service is provided by the public health sector hospitals. This phenomenon also can be significantly affected for increase number of admissions.

Number of OPD visits, number of beds and governance are not significant with scale efficiency and the coefficient values also show opposite sign as well. The public sector hospitals in Sri Lanka relatively provide low OPD services compare with private sector facilities (Rannan-Eliya and Sikurajapathy, 2009). So, our results might be implied that there is a more irrelevant fluctuation within the facilities showing OPD visits and scale efficiency insignificant and opposite sign as well.

Number of beds and scale efficiency has become insignificant and negatively related. Sometime it might be a reason of excess beds in these hospitals.

Governance of the hospitals is insignificant even sign also opposite direction, it may be due to small sample of the line ministry administrated hospitals.

CHAPTER VI

CONCLUSION, LIMITATIONS AND RECOMMENDATIONS

6.1 Conclusion.

This study focused on two main questions to solve based on district base hospitals in Sri Lanka using retrospective data belongs to 2006 - 2008 years. These questions are;

- What is the technical and scale efficiency of government district base hospitals?
- Which factor may determine the efficiency of district base hospitals?

The study was realized following several specific objectives through studying the technical and scale efficiency of the 56 district base hospitals.

- Technical and scale efficiency of the district base hospitals was evaluated.
- Factors those affecting to change efficiency were determined.
- Policy implications towards efficiency improvement were evaluated using period of before and after implementation of health master plan 2007-2016.

Widely using DEA method was used to analyze the comparative efficiency among district base hospitals in Sri Lanka and secondly Tobit regression model, which is the most fitted and also consistent method for this kind of study, was used in the same time. This study used four inputs and four outputs to measure efficiency concerning and choosing better proxies for inputs and most common outputs in such hospitals to avoid the biasness. Secondly, Tobit regression model was adopted to determine the reasons for inefficiency. Because, DEA result not much concern about environment or any other production and institutional characteristics. The study used nine difference types of variables that might be able to determine the technical and scale efficiency of the district base hospitals understanding hospital characteristics, governance type, size of the hospital, resource utilization, quality of care and input substitution.

Average value of the technical efficiency was 0.81 for considering 168 DMUs and minimum efficiency level was 0.383 while maximum level at 1.000. Average scale efficiency was 0.90 and it was ranged from 0.44 to 1.

There is an increasing trend of technical efficiency in the district base hospitals in Sri Lanka within this period. The results show that there are 24 hospitals in the frontier in 2006, and it has increased up to 32 in 2008, it is a 15% improvement with 2006. Average technical efficiency level was 0.849 in 2006, and it has improved up to 0.917 in 2008 showing improvement in minimum level of technical efficiency from 0.434 to 0.776. Scale efficient hospitals were also increasing by 18% (22) within this period. The scale efficiency pattern is changing from increasing returns to scale to increasing returns to scale.

The results derived from Tobit regression analysis has shown that bed occupancy ratio [-.2998, p =.0175] has positively associate with technical efficiency while bed physician ratio [.0009, p = .0443] is negatively related with it, and these factors are statistically significant. It means, if increase bed occupancy ratio, technical efficiency of the hospital will be increase. On the other hand, more utilization of the facilities significantly reflects the technical efficiency of district base hospitals. This relationship is consistence with previous study done by Somanathan and others in their studies (Somanathan, et al., 2000, 2006).

If bed physician ratio in hospital reduces, technical efficiency will be increase. Nurses physician ratio [.0204] and allied health personnel ratio [.0.0383] was not significant with technical efficiency but expected direction has consisted. So, when increase the number of nurses' under same physician or reducing physicians under same level of nursing staff can be improved the ratio of nurses' physician, and also technical efficiency. But this practice is difficult to justify in the every operational level. However, this relationship can be applied with limited types of services such as uncomplicated pregnancy which hypnotized by the study.

When increase allied health personnel and physician ratio [.0383], technical efficiency will be increase but this effect is greater than nurses' physician ration effect because magnitude of the coefficient is higher than nurses' physician ratio. So, when

increase the ratio by adding more allied health staff such as pharmacist or dispensers, patient load in the pharmacy can be reduce, and the patients who need another services for different cases can be moved. So, it will create more output to the hospital.

Number of admissions [-1.34E-06, p = .000] was became highly significant factor to determine the scale efficiency in district base hospitals. Type A or big hospitals [.0367, p = .0305] likely to be scale efficient than small (type B) hospitals.

The number of beds, OPD visits and the governance of the hospital are become insignificant with our hypothesis and show opposite sign. Therefore, the result is quite interesting to say that the number of beds and scale efficiency has shows a negative relationship. It might reflect the situation of excess bed capacity in district base hospitals. On the other hand, this finding indirectly shows us many of scale efficient hospitals bear a less amount of beds with respect to the beds strength in the inefficient hospitals.

The number of OPD visits is negatively associated with scale efficiency insignificantly. It is may be the problem of irregular fluctuation in OPD services among the facilities that are providing a low proportion (45%) from whole OPD service need, by public sector. Sometimes, other exogenous factors that omitted from this study may be related with utilization of OPD services such as geographical region, income level of the catchment population and factors of health service demand. Because of this instance, the factors neglected from this study might reflect the disparity of utilization of hospitals for OPD service.

Governance of the hospitals doesn't consistence with study hypothesis. It might be the problem of small sample of line ministry hospitals with respect to the provincial hospitals (Table 5.2).

6.2 Limitations

Some of the limitation of this study mentioned as follows;

- The study didn't apply perfect input variable to integrate quality of the services because of there are no any formal quality assurance mechanism has developed to standardize health sector performance such as accreditation.

- In selecting environment factors that may influence to the efficiency, there is not concern about demand of health for this facilities and catchment population because of unavailability of data and location of the hospital such as urban, semi urban and rural because it is not defined clearly.

6.3 Recommendations

Some recommendation can be stemmed from this study.

The main finding derived from this study shows that input deduction from the production is the best way to increase pure technical and scale efficiency because many of the district base hospitals are operating at decreasing returns to scale pattern. It is also shown by negative relationship of bed and scale efficiency. In the real world, it is a challenge, but it is one option to increase efficiency. Furthermore, decreasing number of beds of the inefficient hospitals will be driven them towards scale efficient hospitals.

Somehow, if the bed occupancy ratio that highly significant [-0.299782, p -0.01], increase by reducing beds, it will be skillful way to increase technical efficiency. Because reducing bed capacity tends to be decrease the bed physician ratio as well [0.000866, p 0.04]. So, the final result might create a dual effect to increase the efficiency.

Another possible way to increase efficiency by high occupancy rate is strengthening the referral system throughout the hospital system to catch more patients to the district base hospitals. Because of making demand for health care cannot control due to the inelastic demand in the nature.

Production and management characteristics that behind in line ministry hospitals should be observed and those significant characteristics might be able to increase efficiency in provincial hospitals, if those are applied. Sometime, another study may be required to understand these hidden reasons.

Number of admission is the foremost way for increasing scale efficiency [-1.34E-06, p – 0.00]. Again, good referral system may solve this gap rather than increasing demand for healthcare by the difficult way.

6.4 Suggestions to further study.

It is most important to pay attention about allocative efficiency concerning cost of the factors of production such as drug and utensils expenditure, labor and capital expenditure, or budget allocation. It might provide much important information rather than technical efficiency to policymakers also hospital administrator in Sri Lanka because cost containment is the main problem.

It is interesting that the paying attention to do a study emphasizing what will be the impact on efficiency based on patient satisfaction and health personal satisfaction, also incentives and salary mechanism.

The Significant variable derived from health master plan and management style should be raised to explore the impact of the health master plane in further efficiency analysis. Those information will be helpful to assess the effectiveness and of both policy and hospital management in long term period.

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APPENDICES

Appendix A

Efficiency results for 56 district base hospitals for three year

Hos No	2006				2007				2008			
	TE (CRS)	TE (VRS)	SE	TY	TE (CRS)	TE (VRS)	SE	TY	TE (CRS)	TE (VRS)	SE	TY
1	0.60	1.00	0.60	d	1.00	1.00	1.00	c	0.78	1.00	0.78	d
2	0.62	1.00	0.62	d	0.91	0.98	0.93	d	0.88	1.00	0.88	d
3	0.56	1.00	0.56	d	0.83	1.00	0.83	d	0.78	1.00	0.78	d
4	1.00	1.00	1.00	c	1.00	1.00	1.00	c	1.00	1.00	1.00	c
5	0.59	0.67	0.88	d	0.77	0.77	1.00	i	0.73	0.74	0.99	i
6	0.51	0.79	0.64	d	0.59	0.81	0.73	d	0.67	0.85	0.79	d
7	0.52	1.00	0.52	d	0.87	1.00	0.87	d	0.78	0.96	0.81	d
8	0.60	0.67	0.89	i	0.66	0.86	0.77	i	0.99	1.00	0.99	i
9	0.97	1.00	0.97	i	0.96	0.97	0.99	i	1.00	1.00	1.00	c
10	0.46	0.73	0.63	d	0.96	1.00	0.96	d	0.75	0.77	0.97	d
11	0.55	0.67	0.83	i	0.74	0.86	0.86	i	0.69	0.85	0.82	i
12	1.00	1.00	1.00	c	0.82	0.83	0.99	d	1.00	1.00	1.00	c
13	0.82	0.95	0.87	d	0.83	0.96	0.87	d	0.96	1.00	0.96	d
14	0.49	0.80	0.61	d	0.81	0.90	0.90	d	0.77	0.80	0.96	d
15	1.00	1.00	1.00	c	0.87	1.00	0.87	i	1.00	1.00	1.00	c
16	0.69	1.00	0.69	i	1.00	1.00	1.00	c	1.00	1.00	1.00	c
17	0.53	0.64	0.82	d	0.76	0.76	1.00	c	0.68	0.69	0.98	i
18	1.00	1.00	1.00	c	0.61	0.78	0.79	i	0.94	0.95	0.99	i
19	0.52	0.54	0.97	d	0.88	0.88	1.00	i	0.59	0.60	0.98	i
20	0.68	0.80	0.85	d	0.68	0.76	0.89	d	1.00	1.00	1.00	c
21	0.68	0.69	1.00	d	0.99	1.00	0.99	d	0.80	0.83	0.96	i
22	0.94	0.99	0.95	d	1.00	1.00	1.00	c	0.95	1.00	0.95	i
23	0.61	0.69	0.88	d	0.76	0.88	0.87	d	0.90	0.91	0.99	d
24	0.43	0.44	1.00	d	0.83	0.83	1.00	i	1.00	1.00	1.00	c
25	0.66	1.00	0.66	d	0.89	0.92	0.98	d	0.55	0.65	0.84	i
26	1.00	1.00	1.00	c	0.69	0.69	1.00	c	1.00	1.00	1.00	c
27	1.00	1.00	1.00	c	0.88	1.00	0.88	i	1.00	1.00	1.00	c
28	1.00	1.00	1.00	c	1.00	1.00	1.00	c	0.81	0.83	0.98	i
29	0.62	0.80	0.78	d	0.58	0.64	0.90	d	1.00	1.00	1.00	c
30	0.58	0.63	0.92	d	0.62	0.63	0.97	i	0.79	0.79	1.00	i
31	0.46	0.54	0.86	i	1.00	1.00	1.00	c	0.60	0.61	0.98	i
32	0.61	0.64	0.95	d	0.57	0.59	0.96	d	0.86	0.88	0.98	d
33	1.00	1.00	1.00	c	1.00	1.00	1.00	c	1.00	1.00	1.00	c
34	0.73	1.00	0.73	d	0.73	1.00	0.73	d	0.78	1.00	0.78	d
35	0.58	0.92	0.63	d	0.73	1.00	0.73	d	0.98	1.00	0.98	d
36	0.51	0.56	0.91	d	0.74	0.76	0.97	d	0.74	0.75	0.99	i
37	0.57	0.60	0.95	i	0.80	0.84	0.95	i	1.00	1.00	1.00	c
38	0.90	0.90	1.00	d	0.87	1.00	0.87	i	0.90	0.93	0.98	i
39	0.51	0.66	0.77	d	1.00	1.00	1.00	c	0.78	0.81	0.95	d
40	1.00	1.00	1.00	c	1.00	1.00	1.00	c	1.00	1.00	1.00	c
41	0.45	0.48	0.94	d	0.54	0.56	0.96	d	0.83	0.83	1.00	i
42	1.00	1.00	1.00	c	1.00	1.00	1.00	c	1.00	1.00	1.00	c
43	0.93	0.96	0.96	d	0.53	0.72	0.74	i	1.00	1.00	1.00	c
44	0.74	0.75	0.99	d	0.78	0.79	0.99	d	0.78	0.81	0.96	d
45	0.56	0.68	0.83	d	0.79	0.91	0.86	d	0.82	0.84	0.98	d
46	0.98	1.00	0.98	d	1.00	1.00	1.00	c	1.00	1.00	1.00	c

47	0.67	0.79	0.85	d	1.00	1.00	1.00	c	1.00	1.00	1.00	c
48	0.77	0.89	0.87	d	0.90	1.00	0.90	d	0.90	1.00	0.90	d
49	0.96	1.00	0.96	i	0.55	0.79	0.69	i	0.75	0.80	0.93	i
50	0.72	0.93	0.78	d	0.96	1.00	0.96	d	1.00	1.00	1.00	c
51	0.94	1.00	0.94	d	1.00	1.00	1.00	c	1.00	1.00	1.00	c
52	0.63	0.88	0.72	d	0.82	1.00	0.82	d	0.95	1.00	0.95	d
53	1.00	1.00	1.00	c	0.92	1.00	0.93	i	1.00	1.00	1.00	c
54	0.96	1.00	0.96	d	0.99	1.00	0.99	d	1.00	1.00	1.00	c
55	1.00	1.00	1.00	c	0.87	1.00	0.87	d	0.77	0.89	0.87	d
56	0.64	0.91	0.70	d	0.97	1.00	0.97	d	1.00	1.00	1.00	c

Note: TE(CRS) - Technical efficiency score under constant retunes to scale

TE(VRS) - Technical efficiency score under variable returns to scale

SE - Scale efficiency score

TY - Scale efficiency type: i = Increasing returns to scale
d = decreasing returns to scale
c = constant returns to scale

Appendix B

Input Slack value for three year

DMU No	Hos. No	Year	BEDS	DOCTORS	NURSES	ALLIED HEALTH STAFF
2	2	2006	0	16.621	0	0
6	6	2006	0	0	0	0.822
7	7	2006	0	2.626	0	4.408
10	10	2006	0	0	10.653	0
12	12	2006	0	0	0.059	0
13	13	2006	0	0.808	27.251	0
14	14	2006	0	0	15.767	0
19	19	2006	0	8.063	21.667	0
21	21	2006	0	0	0	0.808
22	22	2006	0	0	0	1.729
25	25	2006	0	0.695	0	1.269
27	27	2006	0	0	0	1.404
28	28	2006	0	6.096	0.54	0
31	31	2006	0	0	0	0.292
32	32	2006	0	13.893	9.956	0
34	34	2006	21.032	6.721	0	7.579
35	35	2006	0	0.092	9.559	0
36	36	2006	0	0	1.646	0
38	38	2006	0	0	1.894	0
40	40	2006	0	1.851	0	0
50	50	2006	0	1.05	0	0
52	52	2006	0	0	0	1.367
55	55	2006	0	5.548	17.565	0
57	1	2007	0	8.833	0	0
58	2	2007	0	15.425	0	0
60	4	2007	0	0	5.366	0
61	5	2007	0	0	1.339	0
62	6	2007	1.831	0	13.726	0
63	7	2007	44.003	24.515	0	8.056
65	9	2007	0	0.513	0	0
66	10	2007	0	2.613	0	0
67	11	2007	0	0	2.644	0
69	13	2007	0	3.453	21.617	0
70	14	2007	0	0	10.372	0
75	19	2007	0	20.175	28.547	0
76	20	2007	0	0	0	5.172
77	21	2007	0	0	0	0.628

78	22	2007	0	0.137	0	1.379
80	24	2007	0	0	0	2.619
85	29	2007	0	0	0	4.67
88	32	2007	0	4.002	5.756	0
92	36	2007	0	0	2.588	0
93	37	2007	0	0	0	0.033
94	38	2007	0	0	2.677	0
97	41	2007	0	0	0	0.425
100	44	2007	0	0	0.421	0
108	52	2007	0	0	0	1.516
110	54	2007	0	13.034	3.435	0
114	2	2008	0	12.116	6.825	0
117	5	2008	0	0	3.629	0
118	6	2008	0	0	32.901	0
120	8	2008	0	0	2.893	0
121	9	2008	0	0	0.839	0
122	10	2008	0	0	2.361	2.511
123	11	2008	0	0	3.439	0
124	12	2008	0	0	8.818	0
125	13	2008	62.734	0	44.786	0
126	14	2008	0	0	18.025	0
127	15	2008	19.385	0.893	17.142	0
131	19	2008	0	0.813	0	1.531
132	20	2008	0	0	0	2.165
133	21	2008	0	0	0	3.374
136	24	2008	0	0	0	2.767
139	27	2008	0	0	0	2.633
140	28	2008	0	6.04	58.727	0
141	29	2008	0	0	0	0.931
144	32	2008	0	0	2.569	0
148	36	2008	0	0	0.906	0
149	37	2008	0	0	11.066	0
150	38	2008	0	0	7.101	0
154	42	2008	0	1.081	0	0.119
155	43	2008	0	0	0	2.227
156	44	2008	0	0	0	2.176
157	45	2008	0	0	23.145	3.841
159	47	2008	0	0	5.388	0
162	50	2008	0	0	0	0.275
164	52	2008	0	0	0	0.205
165	53	2008	0	0	0	0.188
167	55	2008	0	3.375	13.577	0

Appendix C

Data for DEA

DMU	Hos. Name	Hos. No	No. In Days	Clinics Visits	OPD Visits	No. Delivery	No. Beds	No. MOO	No. NOO	No. AHP
1	Avissawella	1	122689	129345	266556	4570	477	85	207	24
2	Homagama	2	113034	121241	221854	2964	323	103	162	22
3	Watupitiwela	3	121912	158866	275999	4737	481	101	232	26
4	Kiribathgoda	4	10679	21960	112527	17	55	10	9	2
5	Meerigama	5	19096	30256	91674	33	116	13	27	5
6	Horana	6	111259	93904	220452	3581	422	81	206	25
7	Panadura	7	81787	139204	313448	3978	382	114	170	26
8	Pinbura	8	15195	14232	57932	21	150	7	18	2
9	Theldeniya	9	13561	36686	72082	170	118	10	6	4
10	Dambulla	10	37951	60940	131672	2869	215	45	108	14
11	Hettipola	11	11296	15886	62952	128	89	6	27	5
12	Rikillagaskada	12	17113	32432	64860	420	111	6	21	4
13	Balapitiya	13	103500	53217	112374	2761	325	58	132	11
14	Elpitiya	14	32086	26027	153936	549	120	25	69	7
15	Udugama	15	18206	6880	53842	204	152	6	23	2
16	Hiniduma	16	7714	12187	38305	340	113	4	20	1
17	Kamburupitiya	17	44843	47345	106108	1556	191	38	78	10
18	Deniyaya	18	18467	14003	53845	450	144	6	19	3
19	Tangalle	19	42296	25203	112947	679	155	57	125	10
20	Point Pedro	20	35042	38437	73837	1018	102	11	38	10
21	Thelippalai	21	17936	27049	40163	181	112	8	24	7
22	Chavakachcheri	22	12609	18898	94961	202	52	11	15	5
23	Kaluwanchikudy	23	22481	3076	112938	536	98	9	31	6
24	Valachchanai	24	16787	14543	97898	876	82	5	19	3
25	Dehiattakandiya	25	18765	1666	10660	519	92	31	36	10
26	Mahaoya	26	9259	8507	80350	210	93	5	8	3
27	Pothuwil	27	8801	4727	43047	567	484	4	12	4
28	Akkaraipattu	28	17228	16645	77851	561	108	23	23	3
29	Kalmunai North	29	81075	123187	377825	3404	267	54	107	15
30	Kalmunai South	30	77561	41377	82853	3292	298	53	116	14
31	Samanthurai	31	9615	13594	91805	389	112	9	29	8
32	Kantalai	32	28785	17824	118886	1296	170	33	50	5
33	Kinniya	33	12579	20847	117807	1308	38	8	37	5
34	Kuliyapitiya	34	117267	117387	207452	5333	429	85	202	30
35	Nikaweratiya	35	66692	48797	211189	3088	299	36	86	10
36	Dambadeniya	36	22496	24441	83826	135	169	15	37	4

37	Galgamuwa	37	10776	24146	96254	390	104	8	7	4
38	Polpithigama	38	16679	24470	68593	327	104	6	27	4
39	Marawila	39	65929	56360	99498	2116	508	43	86	12
40	Puttalam	40	87001	81036	149684	4967	354	41	107	14
41	Thambuttegama	41	20958	26439	82958	476	137	12	30	4
42	Kebithigollawa	42	5040	8818	66431	224	38	6	8	1
43	Padaviya	43	21367	11995	65593	397	142	6	18	3
44	Medirigiriya	44	15254	29083	113617	199	199	13	19	4
45	Diyatalawa	45	87610	80930	173265	3325	260	65	136	16
46	Mahiyanganaya	46	17651	17654	15979	3840	109	55	92	12
47	Walimada	47	21834	26485	103376	406	96	8	22	4
48	Wallawaya	48	18841	18164	124972	470	98	9	25	5
49	Siyambalannduwa	49	12089	13757	82899	283	88	7	17	4
50	Balangoda	50	75794	70702	150159	2689	167	45	97	11
51	Embilipitiya	51	117097	67384	129184	4779	283	65	148	17
52	Kahawatta	52	37978	58979	166028	739	162	17	56	9
53	Kalawana	53	18817	15096	63834	254	74	5	17	4
54	Karawanella	54	88535	55189	141335	1829	179	45	91	8
55	Mawanella	55	63956	55016	190914	1093	210	48	100	9
56	Warakapola	56	28722	41914	143990	126	102	12	36	5
57	Avissawella	1	122689	131932	258205	4303	519	172	289	24
58	Homagama	2	113034	123666	210652	3036	320	111	205	22
59	Watupitiwela	3	121912	172043	272334	4571	514	143	273	26
60	Kiribathgoda	4	11434	24399	108747	14	95	9	15	2
61	Meerigama	5	18475	33861	95882	28	245	11	22	4
62	Horana	6	111259	89782	213718	3777	443	101	248	25
63	Panadura	7	81787	121988	323475	4009	373	90	136	29
64	Pinbura	8	14985	13456	58262	14	137	7	20	3
65	Theldeniya	9	14939	34535	77172	173	118	11	13	2
66	Dambulla	10	37951	62345	132998	3433	234	61	120	16
67	Hettipola	11	11958	16204	60782	276	88	7	25	3
68	Rikillagaskada	12	15838	32767	79412	312	135	3	10	2
69	Balapitiya	13	103500	56767	110534	3650	344	68	152	14
70	Elpitiya	14	29485	28546	156251	661	155	26	71	8
71	Udugama	15	19023	6455	50672	140	30	6	23	2
72	Hiniduma	16	6783	11345	40368	288	75	2	18	3
73	Kamburupitiya	17	44843	52345	112460	1622	191	36	87	12
74	Deniyaya	18	18392	15345	54321	450	144	7	20	2
75	Tangalle	19	42296	26456	129698	2425	201	57	125	10
76	Point Pedro	20	35042	39765	102335	828	279	13	43	15
77	Thelippalai	21	17239	26456	79256	160	104	8	24	7
78	Chavakachcheri	22	13123	4534	102349	162	52	11	14	4

79	Kaluwanchikudy	23	22481	16445	126915	565	116	11	48	7
80	Valachchanai	24	12076	2123	104258	1132	93	12	32	9
81	Dehiattakandiya	25	12837	9865	122715	3293	92	31	36	10
82	Mahaoya	26	8234	5123	70285	238	55	6	7	2
83	Pothuwil	27	7859	16234	123987	2342	484	3	13	2
84	Akkaraipattu	28	17228	125651	119191	656	108	23	23	3
85	Kalmunai North	29	81075	43556	154067	1384	267	44	138	19
86	Kalmunai South	30	77561	12746	86809	2629	304	62	142	15
87	Samanthurai	31	8694	18180	82903	1421	123	6	22	5
88	Kantalai	32	28785	22345	80041	673	170	33	50	5
89	Kinniya	33	11958	119735	94643	824	146	8	11	5
90	Kuliyapitiya	34	117267	49773	188191	5776	440	39	222	32
91	Nikaweratiya	35	66692	26455	207717	2944	322	46	101	16
92	Dambadeniya	36	21858	25345	86840	103	169	15	42	5
93	Galgamuwa	37	11345	23434	79562	384	108	9	18	4
94	Polpithigama	38	15938	58346	64458	422	98	7	22	4
95	Marawila	39	65929	82657	108243	2196	394	58	117	16
96	Puttalam	40	87001	26968	136616	5964	347	10	114	17
97	Thambuttegama	41	20958	8994	92828	543	136	19	40	8
98	Kebithigollawa	42	19637	12235	59801	346	26	10	14	2
99	Padaviya	43	22859	27456	68403	288	142	7	18	4
100	Medirigiriya	44	15254	79845	110548	253	110	18	31	5
101	Diyatalawa	45	87610	18007	164041	3563	292	73	158	18
102	Mahiyanganaya	46	123465	27015	186202	4289	269	73	98	14
103	Walimada	47	22958	17565	120660	593	110	16	28	6
104	Wallawaya	48	19584	13545	123060	473	108	9	25	5
105	Siyambalannduwa	49	12958	71454	69819	162	87	7	19	4
106	Balangoda	50	75794	68732	146781	2649	195	49	116	13
107	Embilipitiya	51	117097	57345	140304	5313	214	62	190	17
108	Kahawatta	52	37978	15398	162887	710	161	21	65	10
109	Kalawana	53	16849	55987	66182	222	68	4	19	5
110	Karawanella	54	88535	57345	135445	2569	255	63	115	10
111	Mawanella	55	63956	43544	191491	2089	248	11	119	11
112	Warakapola	56	28722	35380	145380	289	131	21	38	6
113	Avissawella	1	128369	140798	251053	4063	519	172	289	15
114	Homagama	2	98403	128678	239952	3305	337	111	205	22
115	Watupitiwela	3	133374	165932	293900	4745	562	116	272	28
116	Kiribathgoda	4	10497	22582	122974	11	81	9	20	3
117	Meerigama	5	21469	30891	112059	32	143	13	37	5
118	Horana	6	116393	88095	235179	3798	460	96	266	28
119	Panadura	7	130007	138856	364796	3422	369	126	227	31
120	Pinbura	8	17982	15153	63693	20	145	8	27	2

121	Theldeniya	9	14053	39848	84378	174	118	15	29	5
122	Dambulla	10	76810	74493	160061	3781	219	41	130	18
123	Hettipola	11	12498	19094	71626	119	82	7	28	4
124	Rikillagaskada	12	27006	29602	84248	180	135	14	51	4
125	Balapitiya	13	114000	52396	134475	4159	363	53	172	15
126	Elpitiya	14	37056	42339	156432	1334	161	31	95	9
127	Udugama	15	20491	6310	62230	152	152	7	26	1
128	Hiniduma	16	12387	16986	53227	239	73	8	24	1
129	Kamburupitiya	17	44413	59400	113302	1544	191	41	87	12
130	Deniyaya	18	23454	8866	61060	419	144	9	27	3
131	Tangalle	19	63587	74131	136110	2985	188	53	134	17
132	Point Pedro	20	33143	52399	101435	720	282	13	43	12
133	Thelippalai	21	22811	38311	74577	101	104	8	26	9
134	Chavakachcheri	22	9918	22936	98030	144	46	5	14	5
135	Kaluwanchikudy	23	25331	10866	122694	440	120	11	48	7
136	Valachchanai	24	20986	19595	105399	876	95	13	36	9
137	Dehiattakandiya	25	78123	45538	123907	1067	156	42	63	14
138	Mahaoya	26	13141	8257	81231	139	70	13	21	5
139	Pothuwil	27	7090	11284	52362	441	45	6	17	5
140	Akkaraipattu	28	9852	13015	52505	1516	61	23	82	5
141	Kalmunai North	29	75985	54351	139835	2087	335	40	145	20
142	Kalmunai South	30	76876	45555	100535	3235	336	58	143	16
143	Samanthurai	31	100	9211	82903	272	123	10	25	6
144	Kantalai	32	36912	26584	139243	1323	219	40	90	11
145	Kinniya	33	19404	19452	144149	1330	129	13	18	5
146	Kuliyapitiya	34	110918	128112	196873	5663	437	87	217	34
147	Nikaweratiya	35	78060	59073	220220	2977	322	51	111	17
148	Dambadeniya	36	40328	33301	134933	454	157	30	68	8
149	Galgamuwa	37	12788	26309	81111	265	118	7	36	4
150	Polpithigama	38	16189	25528	70591	453	108	5	31	4
151	Marawila	39	62840	64490	129325	2086	394	6	8	1
152	Puttalam	40	92231	76598	138145	5923	348	37	120	17
153	Thambuttegama	41	20727	28162	114714	667	212	13	43	9
154	Kebithigollawa	42	3504	11002	66745	218	38	11	13	2
155	Padaviya	43	27246	10977	66531	208	141	9	20	6
156	Medirigiriya	44	37662	39340	115582	197	191	14	24	7
157	Diyatalawa	45	96527	96063	173881	3384	310	57	142	22
158	Mahiyanganaya	46	77100	124862	178749	3982	265	52	3	20
159	Walimada	47	20987	48808	105572	397	98	16	49	7
160	Wallawaya	48	19613	23624	128931	400	111	10	28	5
161	Siyambalannduwa	49	10873	13193	65385	104	81	8	18	5
162	Balangoda	50	76742	64613	164019	2478	195	43	112	12

163	Embilipitiya	51	124473	87803	151948	5631	214	66	192	19
164	Kahawatta	52	45876	28126	166175	594	161	20	51	8
165	Kalawana	53	18633	16780	81646	273	63	7	22	4
166	Karawanella	54	123160	75270	151151	2848	292	65	126	13
167	Mawanella	55	79537	67461	206437	2322	253	64	132	13
168	Warakapola	56	33328	44559	159582	255	138	23	42	7

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