HOSPITAL BEHAVIOR AND RESPONSE OF THAI PUBLIC HOSPITALS TO HEALTH INSURANCE PAYMENT SYSTEM

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จุฬาลงกรณ์มหาวิทยาลัย
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จากการศึกษาพฤติกรรมและการตอบสนองของโรงพยาบาลภาครัฐไทยในการให้บริการทางการแพทย์และต้นทุนบริการที่มีต่อการจ่ายเงินในระบบประกันสุขภาพ โดยใช้ข้อมูลการมารับบริการของผู้มีสิทธิสวัสดิการรักษาพยาบาลของข้าราชการและลูกจ้างประจำในโรงพยาบาลสังกัดสำนักงานปลัดกระทรวงสาธารณสุข จำนวน ๔๓๙ แห่ง ระหว่างปีพ.ศ. ๒๕๔๘ ถึง ๒๕๕๓ ก่อนและหลังการปรับเปลี่ยนวิธีการจ่ายเงินจากการจ่ายตามรายบริการมาเป็นแบบเหมาจ่ายตามกลุ่มวินิจฉัยโรคร่วมในปีพ.ศ. ๒๕๕๑ พบว่า มีการลดลงของจำนวนวันนอนเฉลี่ยในการให้บริการผู้ป่วยในของผู้ป่วยสิทธิข้าราชการในภาพรวมและในโรงพยาบาลทั่วไปและโรงพยาบาลชุมชน มีการลดลงของอัตราการรับไว้นอนในโรงพยาบาลของผู้ป่วยสิทธิข้าราชการในโรงพยาบาลทุกประเภท แต่พบการลดลงของสัดส่วนของผู้ป่วยในสิทธิข้าราชการเฉพาะในโรงพยาบาลชุมชน แต่ยังไม่พบการเพิ่มขึ้นของสัดส่วนผู้ป่วยนอกของผู้ป่วยสิทธิข้าราชการ นอกจากนี้ ยังพบอัตราการส่งต่อผู้ป่วยไปยังโรงพยาบาลในระดับที่สูงกว่ามีค่าเพิ่มขึ้นเฉพาะในโรงพยาบาลชุมชน สำหรับพฤติกรรมเกี่ยวกับต้นทุนการให้บริการ พบว่า ต้นทุนในการให้บริการผู้ป่วยในของผู้ป่วยสิทธิข้าราชการลดลงในโรงพยาบาลชุมชน ในขณะที่โรงพยาบาลศูนย์และโรงพยาบาลทั่วไปไม่เปลี่ยนแปลง โดยโรงพยาบาลทุกประเภทมีพฤติกรรมการลดต้นทุนในระยะสั้น แต่ไม่พบพฤติกรรมการลดต้นทุนในระยะยาว

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In the study on hospital behavior and response to health insurance payment system in service provision and hospital cost behavior, the data on hospital finance and healthcare utilization of patients in the Civil Servant Medical Benefits Scheme (CSMBS) of the hospitals under the Permanent Secretary Office of Ministry of Public Health from 2005 to 2010 before and after payment change from fee-for-service (FFS) to diagnosis-related-group (DRG) based payment in 2008 were employed. The findings showed an overall decrease in service intensity in term of average length of stay for CSMBS inpatient admissions and at the general and community hospitals. A decrease in the admission rate at all types of hospitals and a decrease in the proportion of CSMBS inpatient cases at the community hospitals were found. At present, the change in the proportion of CSMBS outpatient visits does not exist. In addition, an increase in the referred-out rate of CSMBS patients at the community hospitals was found. Regarding the hospital cost behavior, a decrease in hospital costs for CSMBS inpatients was found in community hospitals, but no change for general and regional hospitals. However, it is evident that short-run cost minimization behavior existed in all types of hospitals, but there is no evidence of long-run cost minimization behavior.

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CHAPTER I
INTRODUCTION

1.1 Background and Rationale

The health care expenditures are continuously increasing in many countries of the world including Thailand, but it is difficult to determine whether or not the rising health care expenditure is desirable and/or producing better outcomes for the population. Evaluating the performance of health care industry is needed to better understand the degree of inefficiency that exists and the sources of these inefficiencies.

The expenditure in hospital sector is a high proportion of total health care expenditure. Hospital behavior and conduct is the most important factor influencing the performance of hospital care industry.

There are several factors influencing the hospital behavior and response. They consist of hospital ownership, hospital market structure, hospital setting, patient characteristics and so on.

In addition, because of lack of perfect information (information asymmetry) on the part of consumers or patients, third-party payer has an important role to play in the health care system mainly as the purchaser of health care services for the patients. The way the hospitals are paid by the third-party payers or other purchasers also affects the behavior of the hospitals in the market-place.

The provider payment system has long been used as incentives or tools used by purchasers to influence provider behavior and what the provider have done would contribute to achieve the typical objectives of health care system namely quality, efficiency and accessibility (Jegers et al., 2002). In the other words, providers can be incentivized to act according to four importance objectives of health care delivery system 1) to prevent health problems 2) to provide quality services in order to solve health problems 3) to be responsive to people's needs, demand and legitimate expectations and 4) to contain health care costs (WHO, 2000).

To evaluate the performance of hospital service industry, it is important to examine the industry's structure, payment systems and their effects on hospitals' incentives, and the objectives of hospital decision maker. (Feldstein, 2005)

In Thailand, the rising medical expenditure is important issue as in other countries as well. The context of Thai health care system is different from other countries and the analysis of hospital and provider behavior in Thailand should consider the country-specific peculiarities carefully. One of the important aspects of Thailand's health care system is that the service providers are mainly public organizations and there are relatively small number of private for-profit hospital and few private not-for-profit hospitals. For health care financing, government plays a very important role as well. There are three main third-party payers, which are all government agencies. They cover almost the total population of the country. Private health insurance have small market share in some specific health care services.

Since the establishment of universal coverage scheme in 2001, several tools of financial management, including strategic purchasing, have been adopted and implemented. Demand side payment is one method of strategic purchasing that affect the hospital performance. The ultimate goals of strategic purchasing are to increase the access to health care and to control cost to achieve efficiency gain through changes in hospital behavior through better quality of care at a lower cost.

To achieve these goals the healthcare providers need to increase the efficiency and quality of service delivery to meet healthcare demand and need for insured individuals. In addition, resource management and cost containment are important measures to achieve those goals. After UCS implementation, the demand for health care utilization has continuously increased. In addition, a number of hospitals in some areas experienced financial loss.

In the past, a number of descriptive studies were carried out to understand the behavior of Thai hospitals and on how they respond to payment mechanisms, but empirical studies were not conducted mainly because of lack of data. Therefore, a rigorous empirical study of hospital behavior and performance will be very useful for Thai health care system. In the literature, however, there are a number of studies that examined hospital behavior and effect of payment system change on hospital outcomes. Since such studies have not been carried out in Thailand, careful analysis of hospital behavior for Thailand will provide information on how the hospitals behave under changing payment system and system-wide changes in structure and delivery of health care services.

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1.2 Research questions

How did the Thai public hospitals respond to changes in payment systems?

- Whether or not there were changes in healthcare provision behavior and if yes, what proportion of the change was due to moral hazard or other relevant reasons
- Whether or not changes in resource utilization for healthcare provision occurred

1.3 Research objectives

General Objectives

To examine hospital behavior and response to changes in health care payment system for beneficiaries of Civil Servant Medical Benefit Scheme (CSMBS) in Thailand

Specific Objectives

Topic #1: Intensity response of Thai public hospitals on the average length of Stay due to the changes in the payment system of CSMBS health insurance scheme
1) To examine the overall service intensity effect of change in payment system on the average LOS.
2) To decompose the overall intensity effect into three components, if possible, such as, moral hazard, change in patient selection and change in practice-style.

Topic #2: Volume response of Thai public hospitals to the changes in the payment system of CSMBS health insurance scheme
1) To examine the admission decision (change in hospital utilization) due to changes in payment system for Civil Servant Medical Benefit Scheme (CSMBS),
2) To examine the shift from inpatient service to outpatient care due to changes in the payment system
3) To examine changes in patient transfers from one hospital to another due to the change in the payment system

Topic #3: The effects of CSMBS DRG-based payment on hospital cost behavior in Thailand

1) To examine how the hospital cost function is affected due to changes in payment system for Civil Servant Medical Benefit Scheme (CSMBS),

2) To examine the relationship between the changes in service provision and hospital cost behavior associated with the change in the payment system

1.4 Health Care System in Thailand

1) Health care delivery system

The health care system in Thailand has evolved from self-reliance, informal care based on local wisdom for health promotion, prevention and curative care, to a well-developed modern medical care system. While the public sector is the main health care service provider, the private for profit and not for profit sector participate actively in the pluralistic health care service delivery system of the country. Despite rapid technological development in health sector, many people still depend on the traditional healing methods. With the expansion of modern health care delivery systems both in the public and the private sector, Thais are moving toward using more modern, western health facility based services.

The public hospitals under the office of permanent secretary, Ministry of Public Health (MoPH) in Thailand are classified along a hierarchical three-tier referral system reflecting the level of complexity of services rendered by the facilities. These levels are community hospitals (first-level), general hospitals (second-level) and regional hospitals (third-level). The community hospitals provide primary and secondary level of health care services. The general hospitals provide specialized secondary and some subspecialized health care services and receive the referral cases from the community hospitals. And the regional hospitals serve as referral center and center for excellence. Regional hospitals provide most highly specialized and complex health care services as tertiary care. They also provide teaching for last-year medical students and medical residents trained in specialized care.

Most of the provincial public facilities are under the Ministry of Public Health (MoPH). There are 25 regional hospitals, 69 general hospitals and 734 community hospitals (10-120 beds). There are also 9,768 rural health centers as the primary health care facilities covering all sub-districts that provide services in the rural districts. All hospitals in Thailand also provide primary care services. In addition, there are more than 13,000 private clinics, 284 municipal health centers, and 226 private hospitals outside MoPH. (Wibulpolprasert et al., 2011)

In terms of the number of modern health care facilities, public facilities outnumber private facilities, particularly in the rural areas as shown in table 1.

Table 1 Health care facilities in Thailand

Facilities	Bangkok	Provincial Areas
Medical schools	5	6
Specialized hospitals	13	48
Regional hospitals		25
General hospitals		
Public	26	131
Private	96	226
Community hospitals	-	734
Private clinics	3,878	13,793
Health centers	68	10,052

Source: Ministry of Public Health (as of 2009)

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2) Health care financing

Total health expenditure of Thailand has risen gradually from 3.1% of gross domestic product (GDP) in 1994 to 4.1% in 2010, more than the GDP growth rate or the rate of population growth, excluding the 1997 economic crisis. The average health spending increased 5.7% per annum in real terms, while the average annual GDP growth was 3.5%. The national health expenditure has climbed from 127,655 million baht in 1994 to 392,368 million baht in 2010. Public health expenditure has increased from 56,855 million baht accounted for 45 percent in 1994 to 293,378 million baht as 75 percent in 2010. During this time, population of Thailand increased from 59.09 million in 1994 to 63.87 million in 2010. Per capita health spending has jumped from 2,160 baht in 1994 to 6,142 baht in 2010. (Tangcharoensathien et al., 2012)

For health care financing system in Thailand there are three main health insurance schemes. The largest health insurance scheme is based on National Health Security Act, so-called Universal Coverage Schemes (UCS). The UCS covers about 47 million peoples, the majority of the population of the country. The budgets are tax-based. Since the launching of the universal coverage policy, the budget per capita increased from 1,202.40 baht in 2002 to 2,401.33 baht in 2010.

The second large health insurance scheme is operated by Social Security Office of the Ministry of Labor. The beneficiaries are formal workers of the economy, consisting of about 9 million people with dependents. The payment mechanism is capitation for both outpatient and inpatient services.

The last main health insurance scheme is for civil servant, so-called Civil Servant Medical Benefit Scheme (CSMBS), which covers about 2 million persons with dependents. Previously, the payment mechanism was fee-for-service (FFS) payment for both outpatient and inpatient services. The FFS led to rapid cost escalation and the payment system was changed to increase incentives for cost containment. The payment for inpatient services is now based on DRGs rather than FFS.

Regarding the payment system for health care services, each insurance scheme has its own payment mechanisms and methods for health care services.

The payment mechanisms used by UCS are capitation for outpatient services, health promotion and disease prevention (P&P) and DRG-based reimbursement for inpatient services under global budgets. In the previous period, the budgets were given to cover all healthcare service including outpatient, prevention and promotion, and inpatient services, called inclusive capitation. Under inclusive capitation, it is required that the hospitals have to pay for cases transferred to other facilities. However, in the next fiscal year only for public hospitals payment system changed to exclusive capitation system covering outpatient, prevention and promotion services, not inpatient services. The DRG-based prospective payment system was employed to reimburse the inpatient services instead. NHSO becomes responsible for the expenses incurred by the transferred cases. For emergency services, point system (fee schedule) with global budget is used in case of outpatient and per case DRG-based payment with global budget in case of inpatient. For high cost care, point system (fee schedule) with global budget is used.

Under the SSS scheme, capitation is used to purchase for both outpatient and inpatient services and fee-for-service for emergency services, high-cost care and medical instrument. No reimbursement for health promotion and disease prevention services (P&P) exists.

Under the CSMBS scheme, before 2008 fee-for-service is used for all healthcare services. Due to uncontrolled rapidly rising health expenditure, per case DRG-based payment with risk adjustment is used for inpatient services. Fee-for-service (FFS) method remains to be used to purchase for outpatient services, emergency services, high-cost care, medical instrument and health promotion and disease prevention services (P&P).

In addition, private health insurance for some diseases is supplementary and fee-for-service is used for reimbursement.

Changes in provider payment mechanisms of three main health insurance schemes in Thailand are summarized in table 2 below.

Table 2 Health insurance schemes and provider payment mechanisms

Insurance schemes and Services paid	Payment mechanisms	
	Previous	Present
1) UC scheme under global budgets		
- outpatient services	- capitation in 2001	- capitation
- inpatient services	- DRG (inclusive) in 2001	- DRG (exclusive) in 2002
- P&P services	- capitation	- capitation
2) CSMBS		
- outpatient services	- Fee-for-service (FFS)	- Fee-for-service (FFS) - direct disbursement in 2007
- inpatient services	- Fee-for-service (FFS)	- DRG in 2008
- P&P services	- Fee-for-service (FFS)	- Fee-for-service (FFS)
3) SSO scheme		
- outpatient services	- Capitation	- No change
- inpatient services	- Capitation	- No change
- P&P services	- Not covered	- Fee-for-service (FFS) in 2006

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1.5 Conceptual framework

This framework revealed the relationship between the strategic purchasing and payment system and hospital behavior and response under the healthcare system as figure 1 below.

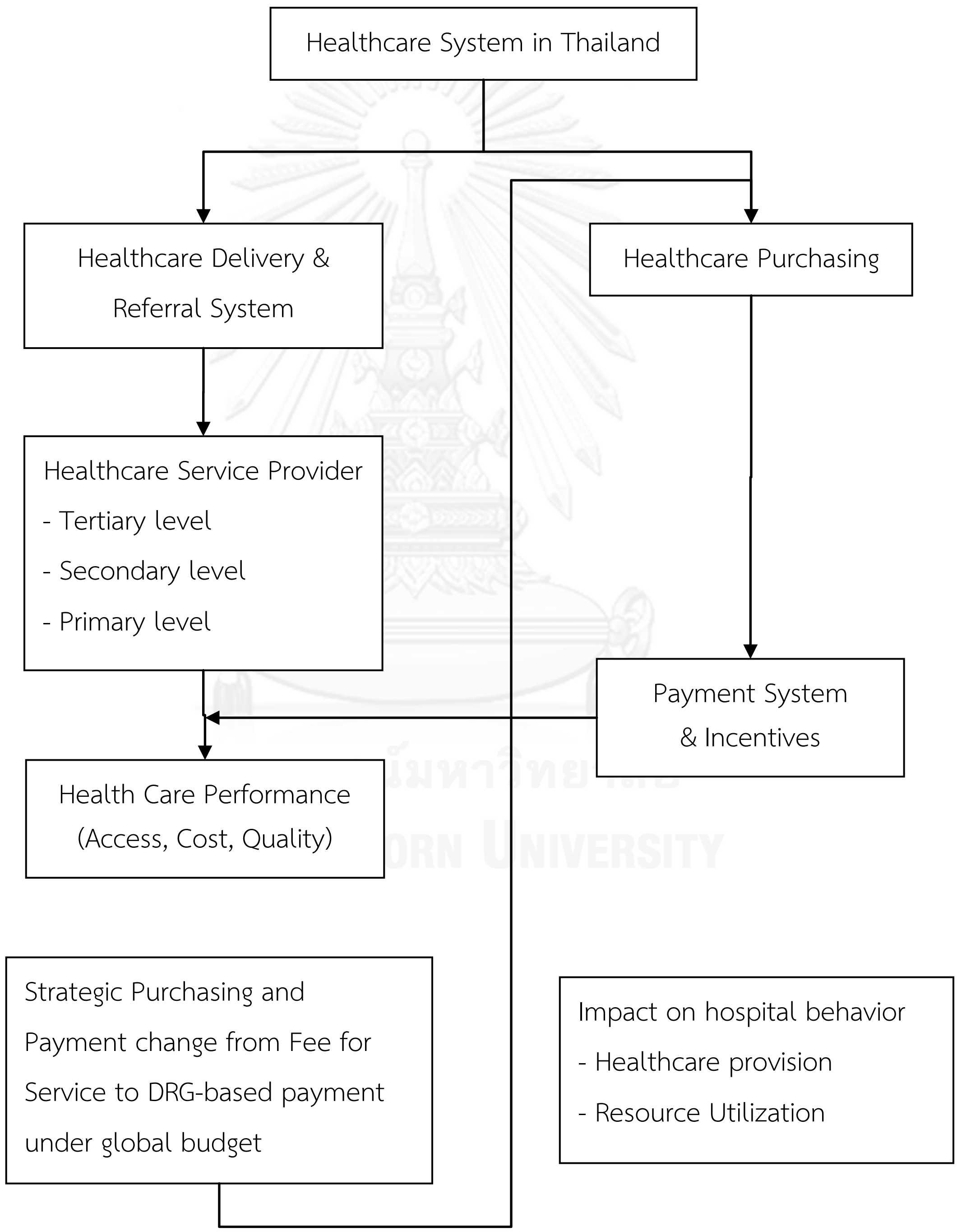

Figure 1 Conceptual Framework

As described above, the purchasers employ the payment system for healthcare services as a tool to incentivize the healthcare providers. So, it is hypothesized that payment system change would affect the hospital behavior in healthcare service provision and resource utilization in particular the hospital costs.

1.6 Scope of the study

The purpose of this study is to examine the hospital behavior and the responses of hospitals in terms of service provision and hospital costs due to changes in payment system. This study will examine the changes observed in public hospitals namely the regional, general and community hospitals under the Office of Permanent Secretary of Ministry of Public Health (MoPH) in Thailand.

1.7 Benefit of research

Although there are some descriptive studies examining provider response to changes in payment method, none of the studies conducted rigorous empirical analyses to identify responses of hospitals to payment changes in quantitative terms. This study is an attempt to conduct the much-needed empirical modeling. This study would contribute to new evidence-based knowledge in Thai context of health care system. The benefits of study will be as follows:

1) To reveal the behavior and response of Thai public hospitals to payment method changes under the health insurance systems.
2) To determine the policy implication of the payment system changes

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CHAPTER II
LITERATURE REVIEW

2.1 Determinants of Hospital Behavior and Response

According to industrial organization triad (Structure, Conduct and Performance paradigm) as shown in figure 2, the performance of hospital service industry inevitably relies on its structure and conduct. (Santerre and Neun, 2000) Thus, hospital conduct and behavior directly affect the performance of hospital service industry.

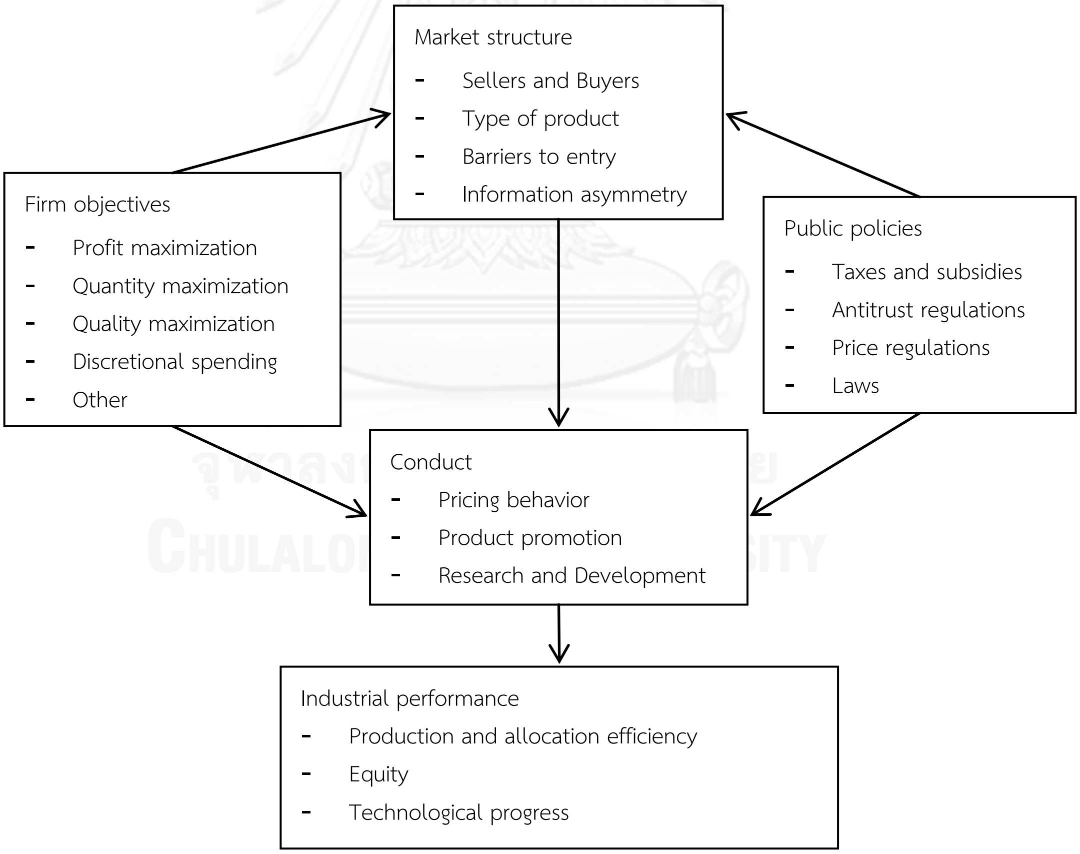

Figure 2 Industrial organization triad

To understand and analyze hospital behavior, it is necessary to analyze structural conditions under which the hospitals operate. These structural conditions should include the market structure of hospital sector and the internal structure of the hospital being analyzed. This analysis should reveal at least two fundamental and interesting characteristics of the hospital sector. The first is the nature of that hospital including ownership, functional type and level, medical care services provided, teaching status, location, etc. The second is its decision-making process of hospital manager under government regulation. (Mcguire, 1985)

In health care system third-party payer has an important role in purchasing health care services on behalf of patients due to information asymmetry. Purchaser uses the payment mechanisms as a tool to direct the provider to meet the goal of health care system. However, whether health care purchasing will improve the health care performance depends on the way the providers respond to changes in payment mechanisms. Several critical factors that influence the way providers respond to purchasing include policy consistency and continuity, the degree of providers' desire and competency, providers' perception, the degree of decision rights and autonomy, market exposure and competitiveness, incentives in the contract and complexity of the provider organization. (Maarse et al., 2005)

Therefore the factors that influence the hospital conduct and behaviors and should be evaluated for the analysis of hospital performance are

1) Hospital ownership and decision maker's objectives
2) Hospital market structure and its determinants
3) Government regulations (price regulation)
4) Hospital payment systems and their effects on hospitals' incentives

2.1.1 Hospital ownership and decision maker's objectives

The hospital market is served by firms of different ownership type namely 1) private for-profit hospitals, 2) private not-for-profit hospitals, and 3) publicly owned and operated (government) hospitals.

The ownership type of hospital influences their response to policy changes because it reflects the objective of the firms. Then, the alternative objectives of different ownership type result in pricing and cost differences or affect the relative willingness of providing the charitable care to the indigent. (Santerre and Neun, 2000)

The different ownership types of hospital have different characteristics based on the theory of organization behavior in terms of 1) non-distribution constraint, 2) altruistic nature of decision maker, and 3) soft budget constraint. (Duggan, 2000)

In terms of non-distribution constraint, private not-for-profit hospitals are not allowed for distributing residual profits to individuals who make decision and manage the firm (Hansmann, 1980) like public hospitals but unlike for-profit one. Then, profits are less valuable benefits to these firms than they are to private for-profit firms, so these firms have incentives to expend them for service provision instead of keeping the profits. In addition, compensation for public hospitals is strictly regulated. This theory implies that private for-profit hospitals are more responsive to financial incentives and performances than public and private not-for-profit hospitals.

For the altruistic nature of decision makers, those in private not-for-profit hospitals have different preferences from altruistic nature of those in private for-profit hospitals (Rose-Ackerman, 1996), so do those of public hospitals. Administrators in public hospitals may have a strong sense of mission and intend to maximize the wellbeing of the people served. If so, then these hospitals will behave more generously in response to an increase in their budget. For example, these hospitals give better medical care to their poor patients than for-profit hospitals.

Based on these reasons above, it is not surprising that in the US health care system private not-for-profit hospitals are of dominant type because of information asymmetry problems.

Lastly, in terms of soft budget constraint, public firms may have more financial constraints than do private firms if their budgets might be reduced by their owners as their revenues increase. This is because difference in the legal rights and mission of private and public organizations. If so, then public hospitals will be less responsive than private firms to change in financial incentives.

Theoretically, public and private not-for-profit hospitals are less responsive to changes in financial incentives than private for-profit hospitals.

Based on the property rights and public choice model, for-profit hospitals may operate more efficiently than not-for-profit and public hospitals respectively because not-for-profit and public hospitals have no owners or residual claimants, thus no one monitors the performance of management and correct when the problems occur. Also, public hospitals can rely on direct funding from government, thus they have no incentives to minimize costs. Unlike private not-for-profit and for-profit, all or most revenues come from the patients. (Santerre and Neun, 2000)

Cost differences among private for-profit and not-for-profit hospitals are not clear. It may suggest that physician may act as residual claimants in not-for-profit hospitals and thus have a financial stake in keeping such hospital efficient. In addition, public hospitals are much more likely to provide uncompensated care defined as bad debt and charity for poor and deprived people (Mann et al., 1997) such that private hospitals provide less uncompensated care when public hospitals exist in the area (Thorpe and Brecher, 1987).

Hospital behavior in the market-place depends on the objective and owner-type of the hospitals. For different ownership-types, different hospital models are proposed. In the following paragraphs, we present the hospital behavior models by major ownership types.

2.1.1.1 For-profit hospitals

The model of hospital behavior for for-profit hospitals is called *the profit maximizing model*. This model represents the United States' private for-profit hospitals, where earning profit is one of the most important objectives. To maximize profits, the hospital would choose the price on demand curve where its marginal cost equals to marginal revenue and can increase profits by price discrimination.

2.1.1.2 Not-for-profit hospitals

For not-for-profit hospitals, there are several models of hospital behaviors.

Firstly, *the quantity maximizing model* assumes that the hospital administrator has an important role in the hospital that manages production and allocates the resource. The hospital's objective is to maximize output for a given quality subject to break-even level of profits. Managers attempt to expand sales at the expense of profits because executive salaries and prestige are more strongly correlated with firm size than with profits. Hospital produces output up to the point where the average cost equal to average revenue such that hospital produces more output and charges a lower price than a profit-maximizing hospital (Baumol, 1967).

Hospitals also use the pricing strategy that involves cross-subsidization to maximize the number of patients (Davis, 1972).

The clinicians are not as important because they are not hired, paid and directed by hospital and do not provide services directly sold by the hospital to the patient. They just play a role as an agent for the patient, then they don't influence directly on hospital's objective. (Brown, 1970; Feldstein, 1968; Rice, 1966) Secondly, *the utility maximizing model* assumes that the managers attempt to maximize utility that is related to increased pay, perquisites, power, prestige and patronage (Lee, 1971; Reder, 1965; Santerre and Neun, 2000). This model can be divided into a number of models based on the variables in the utility functions of decision makers including

1) quality maximizing model
2) quantity-quality maximizing model
3) managerial expense preference model

The first is *quality maximizing model*. It stated that managers obtain utility from the quality of hospital care provided for the patient.

Lee (1971) explained that managers attempt to enhance status or prestige of their hospitals that related to expansion of the range of services, expensive and highly specialized equipment, and medical personnel especially specialist doctors in order to maximize utility. That way is consistent with enhancement of hospital quality and likely to increase the production cost and move towards duplication of resources and overspecialization.

The second is *quantity-quality maximizing model* that assumes that the administrator maximizes the quantity and quality of service outputs under budget constraint and the medical staff also reinforces maximization of the quality of output (Feldstein, 1971; Newhouse, 1970). In this model the beneficiaries are decision makers, namely managers, trustees and administrative staff. One of hospital objectives is to maximize output by maximizing the profits and then invest those profits to result in the largest increase in their output, either in additional capacity, cost-saving technology, or facilities and services. Hospitals also have incentives to minimize their costs, which can be used to increase output. Theoretically, the output would be that point on demand curve where price equal to marginal cost.

In addition, the quality is another element in the maximand of utility function of the hospital decision maker. So, other than investing the profits in increased quantity, hospitals also invest in increased quality. The decision maker has to determine the relative weights to be placed on the quantity-quality trade-off. (Newhouse, 1970) In a price-competitive market, in the view of consumers, price and quality corresponded to what they are willing to pay (WTP) rather than quantity and quality, so quality would increase in response to consumer demands for quality.

However, hospitals might make unprofitable investments and maintain unprofitable services, as long as these services added prestige to the institution. Cross subsidization of money losing services most likely occurred in the non-profit firms, but not in for-profit ones that resulting in cream skimming. Also, there might be some slack in the administrative task and then include a slack variable in the manager's utility function.

The last model is *the managerial expense preference model* that explained the large firms with high monopoly power. Managers behave on profit maximizing basis and use their authority to serve their own self-interests by using profits earned to increase discretionary expenditure. That is to increase compensation, expand the number of support staff for the purpose of enhancing power and prestige or offer more perquisites. This behavior might lead to inefficient resource allocation and usage without cost-minimizing behavior. (Lee, 1971; Reder, 1965)

Goldfarb, Hornbrook, and Rafferty (1980) presented a utility maximizing objective function that is defined over the number of inpatient admissions, case mix measures, the quality of care and profits, under the constraints of reimbursement method, treatment technology, patient availability and other health care resources.

Hornbrook and Goldfarb (1983) presented utility maximizing model with six dimensions of preferences including one financial measure and five patient care related measures.

In addition to the manager and board of trustees, physician also plays an important role in the allocation of medical resources. There are two models that explain such a role: 1) the physician control model and 2) the supplier-induced demand model.

The physician control model assumes that physicians were major beneficiaries and effectively control the hospital, not the community nor the administrative staff, so hospital decisions reflect the physicians and medical staff's objectives. The model states that physicians attempt to maximize their income and residual profits for own interests. (Pauly and Redisch, 1973) This behavior can be pursued through the clinician's cartel that causes entry restrictions and market inefficiencies. (Shalit, 1977)

Physicians combine the treatment inputs so as to increase their productivity and income and also have incentives to minimize total treatment cost since higher input costs represent forgone revenue to the physicians. Physicians may force the hospital to employ other inputs up to the point of the zero marginal product and beyond the efficient level, thus the costs increase and excess capacity develops.

In addition, physicians would favor either an increase in their hospital's capacity or an investment to increase their productivity and income, even though it may be duplicative for the community resulting in economic inefficiency. They would also prefer some hospital slack if it enables them to economize on their own time. (Pauly and Redisch, 1973)

The supplier-induced demand model is caused from information asymmetry that forces the patients to rely on the advice of their physicians. Thus, it may be possible for physicians to provide unnecessary services such as office visits, medical tests, and medical treatments to increase their own economic interests. Although increased medical services mostly do no harm, but it increases overall cost of health care.

Since an introduction of DRG-based prospective payment system (PPS) and Medicare system in 1983, hospitals could make profits and losses and thus their behavior could change. In PPS system, the number of inpatient discharges (service volume) and the quantity of services per discharge (service intensity) could affect financial status of hospitals. So, profit or net revenue could be one argument in the utility function of hospital behavior and the hospital output consists of is decomposed into the number of inpatient cases and the quantity of services per case.

Ellis and McGuire (1986) proposed the hospital behavior maximizing profits and could bring about the moral hazard effect of the prospective payment, but the physicians are also concerned with the outcome of treatment provided during the inpatient admissions apart from the hospital profits.

Dranove (1987) also stated that the hospitals maximize the profits and could respond to supply-side cost sharing in PPS on admission decision making that affect the volume and severity of inpatient cases admitted.

Hodgkin and McGuire (1994) presented the model of hospital behavior as utility function of financial outcome and service supply responded to financial incentives. This model include the profits or net revenues and quality of care reflecting patient benefits in term of intensity of medical care in the hospital utility function and hospital volume was recognized as a function of the service intensity offered. It could be concluded that this model is a utility function of quantity (hospital volume), quality (service intensity) and profits or net revenue, called quantity-quality-net revenue maximizing model.

2.1.1.3 Public or government hospitals

There are no particular models of hospital behavior for public hospitals. Thus, all models of both for-profits and not-for-profits would be applied for public hospitals.

Public hospitals have non-profit objectives and non-distribution constraint so not to profit maximize. But, because they can utilize the net revenue for compensation pay and investment, so the net revenue could be included in the utility function of hospital behavior. For *quantity maximization*, although the managers and medical staffs are civil servants that get salaries and wages, but unlike not-for-profit that executive salaries are correlated with firm size (quantity provided), public hospitals have a mission to provide health care for the indigent in the community, thus they want to maximize the quantity of outputs to provide the community as many as possible to increase their prestige and presence in the community. They may also have incentives to minimize costs to increase the quantity of output. For *quality maximization*, both managers and medical staff want to expand the range of services to maximize quality of care to increase the status or prestige in the community.

For *the physician control model*, the doctors are the salary-based employees of public hospitals and have no stake for an increase in their productivity, thus they have no incentives to force managers to hire other factor inputs to increase their productivity and in turn increase compensation. In addition, for *the supplier-induced demand (SID) model*, the doctors have no incentives to induce more demand for unnecessary services because it causes higher burden and there are no compensations for productivity gains and contradicts with a desire to minimize costs of health care.

As mentioned above, the *quantity-quality-net revenue maximizing model* is the most appropriate models for public hospitals.

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2.1.2 Market structure of hospital industry and its determinants

As mentioned above, degree of the health care competitiveness in the marketplace is one of key factors that affect or determine the behavior of hospitals.

The structural competitiveness of an industry can be affected by a number of characteristics such as the intensity of actual competition and the magnitude of any barriers to entry that reflect the degree of potential competition.

2.1.2.1 Degree of actual competition

The degree of actual competition is determined by the number, type and size distribution of sellers and payers, the type of products offered and degree of information asymmetry between sellers and payers. (Santerre and Neun, 2000)

Sellers of health care products or health care providers vary in the service offered, ownership type and the size of service capacity in different countries. In the US most of hospitals are private not-for-profit. In contrast to Thailand the most one are public hospitals. Especially, in most rural areas there is only public hospital to provide health services and automatically have monopoly power.

Buyers of health care products can be the patients, third-party payers or both. In most developed countries third-party payers have a purchasing role instead of the patients. The third-party payment can be private insurance company, government agency or both depending on the services purchased and their beneficiaries. In reality, there are at most a few payers, so they have some oligopsony power.

Based on *type of product*, health care products are increasingly varying and complex goods and services and can be classified into several groups as follows: 1) primary care services including primary medical care, health promotion, disease prevention services and community health services; 2) ambulatory services; 3) hospital care services; 4) rehabilitation services and others. Also, they can be considered as public and private goods and services. Many services of primary care are often public services, but ambulatory and hospital services are private services.

Even the hospital care services that are private services can be classified into several services, for example, emergency cares, outpatient care, inpatient stay, ancillary care services, amenities including hotel services, catering and room services and et cetera.

Rice (1966) categorized several types of hospital outputs into medical and non-medical goods and services in terms of necessary treatments in medicine and general amenities respectively. Amenities are defined to be patient comforts and conveniences in receiving medical cares and seem to be seen as a class of final products. Thus, a profit-maximizing behavior could be pursued in the market for amenities that demand is price elastic, although output of amenities will be functionally related to necessary treatments. While necessary treatments are perceived to be intermediate products that are somewhat price inelastic of demand in their market. Thus hospitals are perceived to be as joint-producers, where demand of their products is related and interdependent and their market competitions are different.

However, each type of health care products has its own market structure power, and other characteristics. Health care services are known to have imperfect market and often face market failure in terms of market power, public services and externalities. Thus, government or not-for-profit institutions have a role to overcome these limitations. Nonetheless, some hospital services as private services could be assured through private insurers.

Imperfect consumer information (Information asymmetry) can lead to opportunistic behavior on the part of health care providers. They may raise price above and quality below the competitive level. The increased amount of consumer information my lead to lower prices and higher quality. (advertisement, brand names, trademarks, and client relationship – product differentiation)

2.1.2.2 Degree of potential competition (Barrier to entry)

Barrier to entry is a condition that makes long-run production costs of new firms higher than those borne by existing firms and allows existing firms to make more than normal economic profits.

For the new entrant, it is rather difficult to enter because of government restrictions in terms of license and certification, and high cost investment from economies of scale and learning curve effects. (Santerre and Neun, 2000)

Based on the number of competitors and barriers to entry, in most areas of developed countries like US and UK hospital service providers can be seen as oligopolistic and in developing countries as monopolistic.

In competitive market environment like US health care system, changes in payment mechanisms from cost-based payment to prospective payment system in 1983 of Medicare health insurance schemes can contain health care costs (Zwanziger and Melnick, 1988) and hospital service price inflation rate (Melnick et al., 1992; Robinson and Phibbs, 1989).

2.1.3 Government regulation (Public policy)

In the case of *price regulation*, government may establish a maximum price or reimbursement level. In that case the government sets a price ceiling for a health service, and providers are prohibited from charging a higher price to patients. Price ceiling may result in excess demand of health services or an unbundling of services (Morrisey et al., 1984). One controlled empirical study found that rate-setting programs (price regulation) decreased per capita health care costs (Lanning, Morrisey, and Ohsfeldt, 1991).

Some unintended outcomes resulting from price regulation may occur. Providers may reduce the quality of service in order to lower costs such as longer waiting time, shorter time spent with doctors during the actual visits and ethical issues that some doctors may accept illegal side payments from people who want to jump to the front of the waiting line. In addition, the doctors might not be concerned for urgency level of patients. However, the findings of empirical studies concerning quality of care have been mixed and more studies are needed to conclude. (Santerre and Neun, 2000)

2.1.4 Hospital payment systems and their effects on hospitals' incentives

Purchasing by contracting and payment mechanisms could be an instrument in relation to financial incentives for providers. Strategic purchasing needs to know the right health interventions to be purchased, the right health care providers to purchase from, the right payment mechanisms to be used, and appropriate and acceptable contracting arrangements. The purchaser plays a role in communicating the concepts and principles and negotiating with providers as to the expected quantity and quality of services, and the equitable access to the service outputs to be purchased and provided.

The provider payment system and its incentive is used as a tool for purchasers to affect provider behavior and be able to achieve the desired goals of health care delivery in terms of quality, efficiency and accessibility (Jegers et al., 2002). In other words, they offer incentives to providers to respond according to the four objectives as follows 1) to prevent health problems 2) to provide quality services in order to solve health problems 3) to respond to people's needs and expectations and 4) to contain and control health care costs (WHO, 2000).

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To meet the objectives above, the purchaser has to determine the proper unit of purchasing for several types of service outputs. Such units should have proper size and compatible with several types of providers from individual person to big hospitals in order to help the purchaser and the provider to accept the shared risk together. (WHO, 2000)

The payment system has a considerable impact on the behavior and performance of health care markets. The different payment mechanisms can provide the different incentives to health care providers and then influence on their behavior through service provision or supply and cost utilization management.

Consequently, the behavior of health care providers in turn affects the efficiency and performance individual providers, health care industry and health care market respectively.

Provider payment systems for health care services can be classified into several groups as follows. (Cutler, 2006; Duran et al., 2005; Ensor and Langenbrunner, 2002; Jegers et al., 2002; Maynard and Bloor, 2003)

1) Fixed budget system
2) Fee-for-service system (FFS)
3) Prospective Payment System (PPS)
4) Capitation system
5) Pay for Performance (P4P)

2.1.4.1 Fixed budget system

In this system providers get a lump sum of budget to treat the patients in a given time period. The budget does not depend on the number of patients, or services provided. It reflects the prospective and fixed characteristic. Providers cannot provide more service outputs to raise the revenue. It is the advantage of cost containment and control for payers.

Hospitals also can be paid for per period or one time of the year such as quarterly or half of a year. In this case, they receive a fixed income or budget for providing helath care in a specified period, mostly a year. It can be divided into *line item and global budget system.*

Line item budgeting is prospective and fixed aggregate budget payment for a given period. It focuses purchasing efforts on inputs and do not relate to the payment levels for the services provided. Budgets were given according to specific expense items such as salaries and wages, compensation, allowances, material, drug and medical supplies, and equipment with inflexible reallocation across the item groups.

This payment method is simple, easy to manage and have low administrative costs (Szende and Mogyorosy, 2004). Additionally, line item budgeting can be effective in containing costs. However, it may lead to underutilize necessary health services and tend to have previous levels of resource use. In other words, it had no financial incentives to influence the behavior in order to increase productivity and was unlikely to allow for flexible resource use in response to the population needs, to prevent the health problems of the insured and to correct existing spatial inequalities. Furthermore, providers familiar with the politicians usually negotiated advantages and relax their budget constraints rather than behave more efficiently. (Szende and Mogyorosy, 2004; Waters and Hussey, 2004)

A global budget is prospective and fixed aggregate payment. Although global budgets do not relate to the payment levels for the services provided as line item budgeting, a global budget allows for reallocating resource across service categories but line item budgets do not (Waters and Hussey, 2004).

A global budget can limit the price and the quality of the services provided. It can be applied to different population, the facilities providing the services and the services given by the healthcare providers (World Bank, 2004).

However, a global budget have advantages as follows: certain funding to both purchasers and providers, cost containment from an decrease in the overspending risk, easier and cheaper administration, transparency due to easy audit and accountable manner, decentralization and local autonomy, and responsibility for spending decisions. Consequently, they can be expected that the health care system would improve healthcare planning and service delivery. However, the issue to be concerned is the adverse reaction and moral hazard effects on the quality of health care services provided. (World Bank, 2004)

For the global budgeting to be effective it must be able to change behavior and responses of provider. So, it is necessary to consider the behavioral responses of provider in the process of the global budgeting and balance the risks and gains of a global budget.

The global budget is based on price and volume of the services. These services can be at any level according to degree of complexity and disaggregation of existing information such as facility, specialty/program and/or patient care level.

The hospital global budget could be set using the approaches including historical base, capitation, normative base, line item base and mixed. Whichever approach is used, it is necessary to include a method to adjust the budget for any difference between planned and actual services provided.

For the historic base, to quantify the budget, an average of 3 years data at the specialty level should be used to establish the price and volume of services (World Bank, 2004). It is simple and stable. But if there is disproportionate distribution of resources and services, equity issues will exist.

In the capitation one, it is required that the population that providers serve and the services provided can be clearly defined. Then, factors that drive needs for those services are determined and used to calculate share of budget on cost weighted and pro-rata basis to relative needs. Finally, shared budget is allocated to eligible providers based on population covered. This would lead to more equitably distribute resources in the emerging and/or rural countries where there is disproportionate distribution of resources.

For the normative base, an external rate setting method is used to set a unit price for services mostly at the patient care level and applies it to the volume of services in order to calculate the budget.

The external price rate can force efficiency from providers. If it is too much, it will then lead to withdraw services and in turn real issues of unequal access.

In addition, the line item budget can be changed to a global budget by allocating line item expenditure to revised functional cost-center based structure.

2.1.4.2 Fee-For-Service system (FFS)

Fee-for-service (FFS) payment is based on units of services provided by health care providers to beneficiaries such as outpatient visits, inpatient stay, X-ray tests, laboratory services, health promotion, etc. The level of pay rate under FFS can be determined ex ante or ex post. The traditional FFS fee is an open-ended charged by the doctor based on the market competitiveness. Later, a set of standard fees for the service items is established from negotiation between purchasers and providers, called fee schedule. (Langenbrunner et al., 2005)

In current fee-for-service (FFS) systems, health care providers are paid based on a fee schedule and the number of services provided. The activities and services are separately specified and the fee or price of each item is known prospectively. FFS is based on the number of services provided, thus providers might increase their revenue by providing more services. (Jegers et al., 2002; Rice and Smith, 1999)

In general, FFS systems promote providers' internal efficiency. Although FFS systems have incentive to reduce costs per service, but to maximize the number of health care services delivered that increase the total cost of the system. In the same time, FFS also encourage the access of care resulting from producing more services. However, providers may tend to produce too much and unnecessary care, called supplier induced demand (SID). The responses in the short term to an increase in healthcare expenditure under fee-for-service are to set the ceiling for total spending on the supply side, and to promote cost sharing on the demand side to minimize moral hazard. However, if relative prices of service fees are not up-to-date this may lead to an inequitable resource allocation and fail to meet utmost social welfare. (Jegers et al., 2002; Langenbrunner et al., 2005; Rice and Smith, 1999)

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In the Western Europe health care systems especially social health insurance-based ones in Germany, France and Belgium, FFS system is used to reimburse for physician services. It is also paid for physiotherapy, speech training, dental services and nursing home care. (Jegers et al., 2002; Langenbrunner et al., 2005)

Civil Servant Medical Benefit System in Thailand also uses FFS system presently to reimburse outpatient services. It leads to continually increase in the health care expense of that scheme.

2.1.4.3 Prospective Payment System (PPS)

2.1.4.3.1 Per diem payment

The per diem payment system can largely vary and be retrospective or a prospective. In the prospective case, a price does not depend on the real costs and determined in advance by the regulatory authority. In the retrospective case, the reimbursement depends on the actual hospital costs. Thus, the per diem price is a payment method to cover the prior costs of the hospital, not a unit of reimbursement. (Jegers et al., 2002)

Incentives for providers are to decrease the costs per day of hospital stay. Like FFS, per diem payment can encourage overproduction of services. In this system, physicians can influence hospital reimbursement because they make decision on the length of stay of patients and thus the hospital income via their admission and discharge decision making. (Jegers et al., 2002; Langenbrunner et al., 2005)

Per diem payment is usually used as the basic payment method for facilities. Per diem payment and per case payment were the popular approach in the transition period changing from FFS system. Both of them usually developed together because they needed not much data and capacity to implement but they could also promote greater productivity and generate increased revenues. Nowadays some Central and East Europe countries use adjusted per diem payment to reimburse hospital inpatient care. (Langenbrunner et al., 2005)

2.1.4.3.2 Per case payment (DRG-based payment)

In this system, providers are paid according to the type and volume of cases treated. The units of per case payment are usually the number of inpatient cases with certain adjustments, for example, patient age, patient diagnosis, ward types, length of stay and et cetera. (Szende and Mogyorosy, 2004)

The payment per case is determined in a prospective way, irrespective of the real costs of the patient. Unit of this payment become bundles of services set for definable and measurable clinical episodes, such as outpatient visits, ambulatory surgery and typically inpatient stay. (Langenbrunner et al., 2005)

The best known method to classify inpatient cases is the diagnosis-related groups (DRG) system. Different DRGs are built up according to the homogeneity of the resource use and clinical characteristics, such as diagnosis, treatment and procedure, age and sex. This case-based system can be thought of as a prospective and intermediate product of variable and fixed cost systems. (Jegers et al., 2002)

If this payment method is applied correctly, control cost containment and efficiency improvement can be achieved resulting from removal the incentives to over-provide services. (Langenbrunner et al., 2005)

This per case payment method is mainly used to reimburse for hospital inpatient services in most countries in Central and East Europe, while in Western Europe DRG-based payment combined with global budgets is implemented. (Langenbrunner et al., 2005) In addition, DRG-based system is also used for hospital inpatient services in Medicare programs in the US. (Santerre and Neun, 2000)

2.1.4.4 Per capita payment (Capitation System)

Capitation payment make providers become risk pooling or budget holding organizations (Gravelle, 1999; Wilton and Smith, 1998). It is at the heart of aligning incentives between providers and purchasers. (Sekhri, 2000)

The concept of budget holding model is that budgets are funded to providers by purchaser in advance for purchasing predetermined services for corresponding patient group, providers are responsible for spending on patient care, and surpluses may be kept for future investment or some other expenses for service provision. Consequently, those providers are encouraged or given an incentive to provide services at the lowest cost and thus lead to improving the overall efficiency improvement of the health system. In this system, The providers would compete for contracts with budget holding entity, and competition among budget holding entities would also compete for patient enrolment that result in balancing power among purchaser, provider and individual consumer. (Wilton and Smith, 1998)

Capitation is a fixed-rate payment method based on the number of beneficiary. The budget is paid to a provider responsible for healthcare service delivery to those enrollees. (WHO, 2000) Capitation payment is also a form of supply-side cost sharing in which physicians or healthcare providers receive the budget for each patient who enrolls with them and then agree to provide services in advance for the certain and predetermined period mostly a year under the terms and conditions in the contract. (Gravelle, 1999)

The total income for a provider depend on the number of people in the catchment are enrolled on the list, not related to the number of provided activities, services and office visits. (Jegers et al., 2002)

In this system the health care provider is funded prospectively and must operate within received budget which is not related to the provided activities. (Rice and Smith, 1999)

A key objective of the budget holding model is improvement of efficiency, however, quality improvement and consumer empowerment are also prioritized. (Wilton and Smith, 1998)

The provider does not get more earnings when providing more services to patients, whereas under per case payment system providers are reimbursed each time a patient is hospitalized. Providers tended to decrease the costs incurred for the patient treatment, for example by not providing unnecessary or highly expensive care. Also, health prevention and promotion services might be provided more if these lead to reduce the future costs of treatment. (Jegers et al., 2002)

It offers potentially strong incentives for prevention if the contract is long enough that that preventive intervention would affect cost control and the providers can benefit from the surplus (WHO, 2000), otherwise they might provide less services or postpone treatment to save costs and not invest in prevention. The providers may increase the quality of care in order to have more enrollees and in turn receive additional revenue. (Aas, 1995)

However, capitation system may harm the access of care for vulnerable patient groups from risk selection by avoiding expected high cost or more severely patients or referring those patients to other providers. (Thorpe and Brecher, 1987)

The providers may tend to reduce the quantity or quality of health care offered and to restrict referrals and their costs. The prospective budget may be set lower than future expenditure forecasts to improve efficiency (Rice and Smith, 1999).

Capitation payments could prevent supplier-induced demand (SID) and decrease the moral hazard effect from overutilization of healthcare, whereas the providers may under-provide healthcare services due to no more earnings. (Léger, 2000)

Per capita payment is used for the GP fund holders based on the number of beneficiaries being enrolled. Capitation has incentives to reduce costs in a different way than fee-for-service or per case payments. (Jegers et al., 2002)

2.1.4.5 Pay for Performance (P4P)

Pay for performance is payment mechanism that intended to focus on quality improvement rather than cost control or productivity enhancement because previous mechanism like capitation system has the drawbacks about suboptimal quality of care. P4P mechanism use financial and non-financial incentives to reward or compensate health care providers if they meet the performance goals. Performance goals can include indicators of utilization management, clinical outcomes, or patient satisfaction, for example, the number of patients of emergency room, the readmission rate, the morbidity and mortality rate, percentage of patients with asthma receiving medication, and et cetera. (Freed and Uren, 2006)

Until now P4P programs are used increasingly to promote better health care performance in many countries. In the US Medicare and other programs pay providers according to measurable quality indicator (Rosenthal et al., 2004; Rosenthal et al., 2005). In the United Kingdom P4P programs give financial rewards to general practitioners who meet certain quality indicators (Doran et al., 2006).

P4P programs still are imperfect for rewarding the quality of specific services because of non-verifiability and multitasking problems (Baker, 1992; Holmstrom and Milgrom, 1991) and it is difficult to specify complete dimensions of performance measures in the contract. (Eggleston, 2005). There are varying dimensions of quality measures for health care services and precise metrics for quality effort are difficult to measure, so that some quality dimensions are measurable through performance indicators but other quality dimensions are not (Gravelle, Sutton, and Ma, 2008; Kaarboe and Siciliani, 2011). So, P4P programs can allocate distortedly resource to the measured areas or rewarded some services, but away from unmeasured areas or unrewarded and partially rewarded other services such as continuity and mental health, so the overall welfare effect is ambiguous (Eggleston, 2005; Smith and York, 2004). Thus, they will enhance quality in the measurable dimensions but will decrease quality for the unmeasurable dimensions (Roland, 2004; Whalley, Gravelle, and Sibbald, 2008).

From the details stated above, different payment mechanisms with services purchased and their incentive effects is summarized in the table below.

Table 3 Payment mechanisms with services purchased and their incentive effects

Payment Method	Services purchased	Incentive for provider (Performance)			
		Provision	Prevention	Cost control	Responsiveness
Line item budget	All services	--	+/-	+++	+/-
Global budget	All services	--	++	+++	+/-
Fee-for-service / Per diem	Physician services / Inpatient services	+++	+/-	---	+++
Per-case	Inpatient services	++	+/-	++	++
Capitation	Primary/Community	--	+++	+++	++

Comment: +++ very positive effect; ++ some positive effect; +/– little or no variable effect; – – some negative effect; – – – very negative effect

This system resulted in a decline in the admission rates and the average length of stay as the hospitals substituted less regulated outpatient care for inpatient care that caused increased outpatient visit rate but hospital staff ratio increased. (Santerre and Neun, 2000)

2.1.5 Previous studies on provider response and payment mechanisms

In the profit-maximizing monopoly market, like the case of Medicaid program, at the government-established price there is excess demand of health services and thus health service provider reduces the quality of health services. But, in the case of quantity/quality maximization model that there is trade-off or exchange between the quality and quantity of health care services in the utility function of decision makers given a break-even level of the profits, health care providers lowers cost by reducing the quality of services and increases quantity. In that condition, cost shifting may occur in that the health care providers may react by decreasing the regulated

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services and increasing the services in the unregulated market to offset the lower regulated price. However, the degree of cost shifting among health insurance schemes depends on the price elasticity of demand in the unregulated market. In addition, patient dumping that refers to the practice whereby some providers avoid providing services to severely ill and costly patients and instead dump them on the other providers may happen.

The following are the details of hospital response to each payment mechanisms.

Fee-for-service system / Per diem payment

Providers may tend to provided too much and unnecessary care, called supplier induced demand (SID) (Jegers et al., 2002).

In per diem payment system, physicians can influence on the amount of hospital revenue reimbursed because they make decision on the number of admissions, the length of patient stay or hospitalization and thus the hospital income via their admission and discharge decision making. (Langenbrunner et al., 2005)

Per case payment (DRG-based payment)

Economic theory suggests that hospitals may react to the fixed PPS price by seeking to increase admissions as a way to raise revenues. But the evidence is not shown that way.

Ellis and McGuire (1986) proposed provider behavior under prospective payment system (PPS). Although their approach considered the physicians as key decision maker, but benefits to patients and hospitals are incorporated as arguments in the physician’s utility functions as follows.

$U(\pi(q), B(q, s), s)$

where

$\pi(q)$ = hospital net revenue or profit

$B(q, s)$ = benefits to the patient

q = hospital level of services

s = physician inputs

Based on utility function, if physicians valuated hospital profits over benefits to patients, they can provide too few services under PPS. On the other hand, they can provide too many services under a cost-based reimbursement system. They also examined a mixed reimbursement system that hospitals are reimbursed partly prospectively and partly cost-based. This mixed system is shown to improve the efficiency of service provision, reduce unnecessarily admit, and reduce risk to providers whereas the other two systems are inferior.

Soderstrom (1993) studied the hospital behavior and response under Medicare prospective payment system in terms of incorrect admissions of patients and incorrect reporting of patient diagnoses and found that some managers tend to adopt these strategies.

Hodgkin and McGuire (1994) revealed that the number of admissions under Medicare actually be decreased by 11 percent during the first eight years under PPS, and a large portion of the decrease took place within the first two years.

Feinglass and Holloway (1991) attribute the decline to the implementation of utilization review programs that screen the use of inpatient medical services and to the switch to outpatient facilities as a result of the PPS. The switch to outpatient treatment is substantiated by the fact that hospital outpatient surgery for Medicare patients doubled between 1983 and 1985. This payment system also shortened the average length of stay for inpatient hospital visits. Estimates indicate that the average length of stay fell by 14.6 percent from 1982 to 1985.

Schwartz and Mendelson (1991) found that the decrease in the number of admissions and average length of stay caused a decrease in the overall number of inpatient days for Medicare clients by 20.7 percent from 1982 to 1988. The decline in inpatient days during the mid-1980s largely explains the decrease in the overall growth rate in Medicare hospital expenditures. However, the more recent increase in the overall growth rate in Medicare expenditures may also indicate that the cost savings resulting from fewer inpatient days have largely been exhausted.

The PPS also had a significantly negative impact on the overall financial condition of hospitals. Financial impacts are to be expected, since the hospitals are no longer able to bill Medicare for medical services on essentially a cost plus basis.

Fisher (1992) examined the financial performance of over 4,600 hospitals that were continuously involved with the PPS from 1985 through 1990. Overall, the proportion of hospitals that reported profits dropped marginally from 77.2 percent in 1985 to 72.4 percent in 1990. However, the proportion of hospitals that reported Medicare profits dropped more dramatically over the same period, from 84.5 percent in 1985 to 40.7 percent in 1990. Fisher also found a positive correlation between overall profitability and Medicare PPS inpatient net profits.

Dranove (1988) showed the evidence of cost shifting of hospitals in Illinois responding to considerable decrease in Medicaid payments in the early 1980s. Those hospitals' objective function includes hospital outputs and profits as arguments. Accordingly, they may respond to price cuts for Medicaid and Medicare patients by an increase in price for other patient groups such as private insurance patients, out-of-pocket patients, et cetera. As the markets are more competitive, the cost shifting behavior will be died out.

Prospective Payment Assessment Commission report to Congress stated that financial losses in the hospitals occurred from Medicare and Medicaid be passed on to private payers in the form of higher prices.

Coulam and Gaumer (1991) showed that Medicare's prospective payment system (PPS) successfully restrained the rate of growth in Medicare outlays without adversely affecting quality of care.

Ellis (1998) showed that under PPS the providers favor low severity patients and avoid high severity ones in particular in case of dumping of high severity patients.

2.2 Production and Cost for Multiproduct Firms

2.2.1 Modeling the Structure of Production and Cost for Multiproduct Firms

In the past, the models for multiple products typically specify transformation functions with severe a priori restrictions on the structure of production and cost. Later, McFadden, Jacobsen, and Shephard have applied the principles of duality to multi-product cost functions corresponding to single-output production structures. This gives rise to the possibility of directly modeling the structure of cost for multiproduct firms without imposing a priori restrictions on the structure of production. Two a priori common restrictions on the structure of multiple-output production are homogeneity and separability.

Multiple-output production function or transformation function of input vector X into output vector Y can be shown by the general function

$$f(Y_1, Y_2, \dots, Y_m, X_1, X_2, \dots, X_n) = 0$$

If f has a strictly convex input property, a multiproduct cost function uniquely exists as below. (McFadden, 1970)

$$C = g(Y_1, Y_2, \ldots, Y_m, P_1, P_2, \ldots, P_n)$$

which is dual to the transformation function. A convex input structure for above transformation function is equivalent to corresponding cost function being homogeneous of degree one, non-decreasing, and concave in the factor prices *P*. The vector of first partial derivatives of *g* with respect to *P* is equal to the vector of cost minimizing factor inputs, known as Shephard's Lemma. (Hall, 1973)

Assuming the existence of an aggregator function *h*, the transformation function above can be written as separable transformation process as below.

$$F(h(Y_1, Y_2, \ldots, Y_m), X_1, X_2, \ldots, X_n) = 0 \quad and \quad \partial F/\partial h \neq 0$$

$$h(Y_1, Y_2, \ldots, Y_m) = f^*(X_1, X_2, \ldots, X_n)$$

The cost function corresponding to separable transformation function has the form

$$C = g(h(Y_1, Y_2, \ldots, Y_m), P_1, P_2, \ldots, P_n)$$

which is separable in outputs.

The restrictiveness of separability of the transformation function apparent from the cost function is that relative marginal costs with respect to output $\partial g/\partial Y_i$ / $\partial g/\partial Y_j$ are independent of the input prices.

It is also assumed to be homogeneous. It means that a proportionate increase in all inputs results in a proportionate increase in output. The single output production functions can be written

$$T = f(\lambda X_1, \lambda X_2, \ldots, \lambda X_n) = \lambda^r f(X_1, X_2, \ldots, X_n)$$

The following multiproduct generalization of homogeneity has been suggested by Lau (1972) as follow.

$$f(\lambda^r Y_1, \lambda^r Y_2, \ldots, \lambda^r Y_m, ; \lambda X_1, \lambda X_2, \ldots, \lambda X_n) = f(Y_1, Y_2, \ldots, Y_m; X_1, X_2, \ldots, X_n) = 0$$

$$g\ (\lambda^r Y, P) = min\ \Sigma P_i \lambda X_i = \lambda\ min\ \Sigma P_i X_i = \lambda\ g(Y, P)$$

Thus a transformation function is homogeneous of degree r if and only if the dual joint cost function is homogeneous of degree 1/r in outputs.

2.2.1.1 Flexible function forms

The flexible functional forms have advantages in that they don’t need *a priori* restrictions on the elasticities of factor substitution, and also allow the variable returns to scale for varying output levels. (Li and Rosenman, 2001)

Diewert (1971) showed flexibility in using the flexible functional forms for production and cost structure while maintaining classical restrictions, for example, certain regularity conditions.

Guilkey, Lovell, and Sickles (1983) studied and compared the performance of three flexible functional forms namely the generalized Leontief, generalized squared root quadratic and translog forms in single output production. It was found that their performances are widely different, relying on the data and the underlying technology.

Vita (1990) proposed that a flexible forms are most useful if the analysis focus on scale and scope economies or other issues for policy analysis, whereas *ad hoc* specifications are more advantageous for forecasting future costs.

2.2.1.2 Multiproduct cost function properties

Brown, Caves, and Christensen (1979) illustrated the econometric technique with the translog function to model the structure of cost and production for multiproduct firms.

Following McFadden, Jacobsen and Shephard that have applied the duality principles to derive multiproduct cost functions corresponding to multiproduct production structures, they demonstrated that two common restriction on the production structure namely homogeneity and separability can be relaxed by using flexible multiproduct or joint cost functions especially translog joint cost function.

The translog joint cost function for a *m* outputs and a *n* inputs is to be used and can be written

$$\ln C = \alpha_0 + \sum_{i=1}^{m} \alpha_i \ln Y_i + \sum_{j=1}^{n} \beta_i \ln P_j + \frac{1}{2}\sum_{i=1}^{m}\sum_{j=1}^{m} \delta_{ij} lnY_i lnY_j + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \gamma_{ij} lnP_i lnP_j + \sum_{i=1}^{m}\sum_{j=1}^{n} \rho_{ij} lnY_i lnP_j$$

where $\delta_{ij} = \delta_{ji}$ and $\gamma_{ij} = \gamma_{ji}$

The necessary and sufficient conditions for linear homogeneity in factor prices are as the following *m+n+1* linear restrictions.

$$\sum_{j=1}^{n} \beta_j = 1; \quad \sum_{i=1}^{n} \gamma_{ij} = 0 \qquad (j = 1,2,\dots,n)$$

$$\sum_{j=1}^{n} \rho_{ij} = 0 \qquad (i = 1,2,\dots,m)$$

For homogeneity of the structure of production to be satisfied, it is required that the joint cost function be homogeneous in outputs. The necessary and sufficient conditions for homogeneity in outputs are as the following linear restrictions:

$$\sum_{i=1}^{m} \delta_{ij} = 0 \quad (j = 1,2,\dots,m) \qquad \sum_{i=1}^{m} \rho_{ij} = 0 \quad (j = 1,2,\dots,n)$$

The degree of homogeneity of the translog joint cost function can be shown as $(\sum_{j=1}^{m} \alpha_i)^{-1}$

Separability requires that

$\partial/\partial \ln P_l((\partial \ln C/\partial \ln Y_i)/((\partial \ln C/\partial \ln Y_k)) = 0 \quad (i,k = 1,2,\dots,m),(l = 1,2,\dots,n)$

For the translog form this implies that

$\partial/\partial \ln P_l\{[\alpha_i + \sum_{j=1}^{m} \delta_{ij} \ln Y_j + \sum_{j=1}^{n} \rho_{ij} \ln P_j]/[\alpha_k + \sum_{j=1}^{m} \delta_{kj} \ln Y_j + \sum_{j=1}^{n} \rho_{kj} \ln P_j] = 0$

Separability holds if

$$\rho_{ij} = 0 \quad (i = 1,2,\dots,m),(j = 1,2,\dots,n)$$

Brown, et al. uses the Klein's cross section data from U.S. railroads to illustrate the importance of allowing flexibility in the transformation function. The outputs were freight (F) and passenger (P) services, and the inputs were capital (K), labor (L), and fuel (E, for energy).

For the translog joint cost function to have more information on production, a set of factor demand equations are derived by Shepherd's Lemma as below.

$$\partial \ln C/\partial \ln P_j = P_j/C \ \partial C/\partial P_j = P_j X_j/C = M_j,$$

$$M_j = \beta_i + \sum_{i=1}^{m} \rho_{ij} \ln Y_i + \sum_{i=1}^{n} \gamma_{ij} \ln P_i \qquad (j = 1,2,\dots,n).$$

The method of maximum likelihood is used to estimate the unknown parameters through the Zellner's two-step estimation procedure due to joint normal additive errors in the system of equations. (Christensen and Greene, 1976)

The maximum likelihood estimates of the unrestricted translog joint cost function including linear homogeneity in factor prices and four restricted specification are obtained and the general translog joint cost function is a statistically significant generalization of the restricted forms by likelihood ratio tests of the restrictions.

An estimate of marginal cost for each product can be derived by differentiating the fitted cost function with respect to that product and yielding the cost elasticities as below.

$$\partial lnC/\partial lnY_i = \alpha_i + \sum_{j=1}^{m} \delta_{ij} \ln Y_j + \sum_{j=1}^{n} \rho_{ij} \ln P_j \qquad (i = 1,2,\ldots,m)$$

These elasticity equations are transformed into marginal cost equations simply by multiplying by $\hat{C}/Y_i$ where $\hat{C}$ is the right hand side of joint cost function exponentiated to estimate the marginal cost of each product. In addition, the cost elasticity can be transformed into the scale economies as one minus the cost elasticity along an output ray.

$$SCE = 1 - \sum_{i=1}^{m} \partial lnC/\partial lnY_i$$

SCE is positive for scale economies and negative for scale diseconomies. The translog joint cost function allows varying scale economies with the levels of outputs and factor prices.

The results showed that a priori restrictions of homogeneity and separability can cause substantial errors in estimating marginal costs and scale economies. Therefore, multiproduct cost function with flexible functional form can best perform.

2.2.2 Hospital cost function

The hospitals typically produce several outputs using several inputs. Thus the production of hospitals is multiple output and multiple inputs in nature.

From a methodological perspective, the multiproduct nature of the hospital comes up with some problems. Researchers have attempted to capture or determine the relationship between hospital costs and multiple inputs and multiple outputs while they remain to keep the number of explanatory variables manageable.

2.2.2.1 Model specification

Breyer (1987)summarized two approaches of previous econometric studies of hospital costs.

The first is traditional or 'ad hoc' approach, which considers the hospital cost function as an additively separable linear function of the determinants of unit costs of output among hospitals with loss of flexibility.

Secondly, it is called the production theoretic approach, in which hospital cost equation is derived from microeconomic neoclassical production theory and imposes a priori restrictions on parameters. This is a new approach to hospital average total cost function accounting for the multi-product nature of hospital production. The multiproduct hospital cost function has been widely used to model the structure of hospital production.

Based on economic theory of production and cost, the cost function is assumed to be dual to the production function. Under duality theory the hospitals are minimizing the costs.

- A cost function determines the minimum cost of providing a given number of output using exogenous vector of input prices
- Under the concept of neoclassical cost function, two requirements for the specification of hospital cost equation needed to be met as follows:
  (1) Right hand side variables may include only output quantities and input prices.
  (2) The hospital cost function is non-decreasing and linearly homogeneous (of degree one) in the vector of factor prices. Linear homogeneity in factor prices reflects the existence of the duality relationship between cost and production. Duality theory shows a one-to-one relationship between the

production function and the corresponding minimum cost function. It means that all factor inputs can be determined at their cost-minimizing levels.

- Flexible functional forms are often used due to unknown true functional form and they are consistent with microeconomic neoclassical production theory. Because these forms represent a local second order Taylor approximation to any true differentiable function, thus they can be used to explain total hospital costs on multiple output quantities and input prices and also to prevent the misspecification problem and have attractive local properties by representing any production technologies in the area near or around the approximation point. (Vita, 1990; Carey, 1997; Smet, 2002)

The production theoretic approach required a large number of parameters be estimated, perhaps it needs the aggregation of heterogeneous outputs, so it is possible to obscure some important relationships between cost and output mix. Moreover, they have limitations on statistical inference, because their global properties are not enough to satisfy. (Vita, 1990)

The choice of approach usually depends on the research objective. The production theoretic approach is most useful to analyze the impact of policy and to understand hospital nature namely properties of hospital production and cost, for example, average and marginal cost analysis, scale and scope economies, while *ad hoc* specifications are more advantageous for forecasting future costs. (Vita, 1990)

Neoclassical cost function assumptions and properties

A priori restrictions under neoclassical production theory must be imposed on its first and second order parameter or derivatives such as continuity of outputs and input prices, linear homogeneity (of degree one) in input prices. The regularity conditions of well-behaved cost function should be 1) non-negative, real valued and non-decreasing for non-zero outputs 2) linearly homogeneous (of degree one) and concave in input prices (Scuffham et al., 1996: 78).

Assumptions:

- cost minimization
- exogeneity of hospital outputs and input prices

Properties:

- The equality conditions: continuity in both factor prices and outputs, homogeneity in both factor prices and outputs,
- The inequality conditions: monotonicity in both factor prices and outputs, concavity in factor prices
- Other restrictions namely homogeneity in outputs, non-jointness and separability could be checked as hypothesis testing.

Other multiproduct cost concepts are as follows:

- Input elasticities of substitution

  Short-run Allen partial elasticities of substitution

  - Symmetric cross-price and own-price substitution elasticities
  - Asymmetric partial elasticities of demand
- Marginal cost and Economies of scale

  The translog cost function allows *ray or overall scale economies* to vary with the level of all outputs and input prices.
- Economies of scope – long-run

  Weak cost complementarities (WCC) by Vita (1990: 17-18)

Recently, there are efforts balancing between the above two approaches by combining the advantages from each, called hybrid functional forms. They include output quantities and input prices and other explanatory variables. In theory, these explanatory variables do not determine the minimization of cost, but can explain and capture deviation of observed costs. The examples of these variables are the number of beds, case mix index, the number of admitting physicians, dummy variables indicating teaching status, ownership, hospital type, and et cetera. However, they remain to maintain the linear homogeneity assumption in factor prices. (Smet, 2002)

2.2.2.2 Long-run versus short-run equilibrium

Based on production theoretic approach, in the analysis of hospital cost behavior, it needs to explicitly assume the equilibrium state among hospital sample. It is appropriate to employ a long-run cost function if it is believed that the firms determine the cost-minimizing levels of all inputs, given output levels and factor prices. It means that total costs are a function of the quantities of the multiple outputs and multiple input prices including fixed and variable factor inputs. By contrast, short-run total cost functions should be used if one may believe that firms cannot quickly adjust all inputs especially fixed factor inputs in response to changes in output levels or factor prices because regulatory restrictions are not allowed for the adjustment of capital stocks. Thus, the firms would employ optimal (possibly minimal) quantities of the easily adjustable variable inputs namely labor and materials, given the existing, possibly non-optimal levels of the fixed inputs like capital stocks namely expensive equipment and buildings. (Vita, 1990; Smet, 2002)

Long-run total cost function

In the long run it is assumed that all hospitals have chosen or determined the cost-minimizing level of all factor inputs including fixed inputs. Thus, the total cost of hospital production is defined as a function of a vector of output levels and a vector of input prices.

$$C = C(Y, P)$$

As shown in the cost function, all prices for factors inputs including capital input price are included in the long-run total cost function.

Before choosing the appropriate form of the cost function, we should test for appropriateness of long-run cost function otherwise it might come up with misspecification of the cost function and in turn estimation bias and misleading conclusion. Unfortunately, capital prices are often not available and there are no explicit evidences that hospital operate in long-run equilibrium condition.

Therefore, the short-run variable cost function should be estimated (Vita, 1990: 3–4; Cowing & Holtmann, 1983: 638–639).

Short-run variable cost function

In the short run hospital managers and administrators are able to adjust the variable input factors in order to minimize costs for given exogenous output quantities and input prices, but they take a considerably longer time to adjust the level of fixed factors such as new ward, high technology medical equipment, etc.

Hospitals or health care facilities are assumed to minimize total variable costs given existing capital stock in order to meet the unexpected demand for hospital outputs under budget constraint.

The short-run variable cost function is a function of a vector of output levels, a vector of variable input prices, a vector of fixed input quantities and other relevant explanatory variables. (Cowing and Holtmann, 1983; Scott and Parkin, 1995; Scuffham et al., 1996)

$$C^v = C(Y, P^v, K)$$

where *Y* = a vector of outputs, P^v = a vector of variable input prices, *K* = a vector of fixed inputs

The short-run cost functions consist of two parts as variable costs and short-term fixed costs (Smet, 2002):

$$C^s(w^v, w^f, y, F, X) = C^v(w^v, y, F, X) + \sum_{i=1}^{k} w_i^f F_i$$

where w^v and w^f are vectors of the variable input prices and the fixed input prices respectively, y a vector of the outputs, F a vector of the fixed input quantities and X a vector of other explanatory variables. Total variable cost function $C^v(w^v, y, F, X)$ can be estimated by econometric analysis. A test for long-run equilibrium can be performed by using the envelope condition. This condition relates short- and long-run costs needs to be satisfied to ensure long-run cost minimization and is shown as:

$$\frac{\partial C^v(w^v, y, F, X)}{\partial F_i} = -w_i^f \quad \text{for all } i.$$

This condition can only be tested if reliable fixed input prices are available and imply that long-run cost minimization take effect when the variable cost saved by introducing the last unit of a fixed input is equal to the marginal input cost of that fixed-input unit. The case where $\partial C^v / \partial K$ is less than $-w_k$ (i.e. negative and greater in absolute value) and *K* is one fixed input called capital implies inadequate investment in capital. In the case of $\partial C^v / \partial K$ to be positive, it implies that such a fixed capital is excessive and a reduction in K would cause a decrease in fixed and variable costs.

2.2.2.3 Flexible functional forms in hospital cost functions

Flexible functional form is an local arbitrary approximation to any functional forms, thus it could represent any relationship between total costs, output quantities and input prices, whereas other functional forms, such as the additively separable, Cobb-Douglas (CD), and Constant Elasticity of Substitution (CES), restrict the nature of production in terms of returns to scale and cost curve shape and may bias parameter estimates of marginal costs and other features. However, the Cobb-Douglas functional form, which is popular functional form in empirical studies of hospital costs, is special case of or nested in the translog form. Thus, the F-statistic test of joint significance of all the higher-order terms is that of the Cobb-Douglas form as the null specification (Gaynor and Anderson, 1995; Scott and Parkin, 1995).

The estimation of hospital cost functions with flexible functional forms avoids the misspecification risk due to an incorrect and unknown functional form and accounts for the problems of over-restriction and allows for a more general model specification (Scott and Parkin, 1995; Scuffham et al., 1996: 76).

However, the flexibility gained by the higher order terms comes at the cost of the number of parameters to be estimated (Scott and Parkin, 1995). This affects the model specification of hospital output in that it necessitates to aggregate hospital outputs in some way in order to retain sufficient degrees of freedom.

General formula of flexible functional forms

$$g(C) = \alpha_0 + \sum_{i=1}^{n} \alpha_i f_i(x_i) + \tfrac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \beta_{ij} f_i(x_i) f_j(x_j) + \varepsilon$$

where

C = Total cost; $\beta_{ij} = \beta_{ji}$ for all i, j; and x_i = the explanatory variables

The most commonly used flexible functional forms for hospital variable cost function are the quadratic, the translog and the generalized translog function.

The quadratic cost function

$$C = \alpha_0 + \sum_{i=1}^{m} \alpha_i Y_i + \sum_{j=1}^{n} \beta_i P_i + \tfrac{1}{2} \sum_{i=1}^{m} \sum_{j=1}^{m} \delta_{ij} Y_i Y_j$$
$$+ \tfrac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} P_i P_j + \sum_{i=1}^{m} \sum_{j=1}^{n} \rho_{ij} Y_i P_j + \varepsilon$$
$$where \delta_{ij} = \delta_{ji} and \gamma_{ij} = \gamma_{ji}$$

The ordinary translog cost function (Brown et al., 1979)

$$\ln C = \alpha_0 + \sum_{i=1}^{m} \alpha_i \ln Y_i + \sum_{j=1}^{n} \beta_j \ln P_j + \tfrac{1}{2} \sum_{i=1}^{m} \sum_{j=1}^{m} \delta_{ij} \ln Y_i \ln Y_j$$
$$+ \tfrac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln P_i \ln P_j + \sum_{i=1}^{m} \sum_{j=1}^{n} \rho_{ij} \ln Y_i \ln P_j + \varepsilon$$

where $\delta_{ij} = \delta_{ji}$ and $\gamma_{ij} = \gamma_{ji}$

The parameters consist of one neutral scale parameter (α_0), m+n first order parameters (α_i, β_j) and (m+1)(m/2)+(n+1)(n/2)+mn second order parameters.

In logarithmic form Shepherd's Lemma, which derived factor demand from joint cost function, can be written:

$$\partial \ln C / \partial \ln P_j = (P_j / C)(\partial C / \partial P_j) = P_j X_j / C = S_j$$

where S_j is the share of input j in total cost.

Using Shephard’s lemma, the translog joint cost function can be logarithmically differentiated, yielding the following n cost share equations associated with each factor inputs.

$$S_j = \partial \ln C / \partial \ln P_j = \beta_j + \sum_{i=1}^{n} \gamma_{ij} \ln P_i + \sum_{i=1}^{m} \rho_{ij} \ln Y_i$$

Since the share equations must necessarily sum to unity, one share equation is deleted to avoid singularity. In addition, the data are mean-scaled, at the mean value for each variable the logarithm will equal zero, and the mean share of the factor will be equal to its own-price coefficient β_j.

The first-order parameters of input prices from normalization of the right-hand side variables have coefficient values equal to the cost elasticities at the means for the corresponding variables. It also means that each coefficient value is equal to the average cost share of that factor input. The own-price elasticity of the factor demands are calculated by $(\beta_{ii} + M_i^2 + M_i)/M_i$, where β_{ii} is the estimated parameter, and M_i is the cost share for input i (Vita, 1990).

The cost function above must be linearly homogeneous (of degree one) in input prices. Thus, a doubling of all variable input prices would exactly double total variable costs. The necessary and sufficient conditions for linear homogeneity in factor input prices are imposed by restricting the parameters in the system of equation. The m + n + 1 linear restrictions for linear homogeneity in factor input prices are as follows:

$$\sum_{j=1}^{n} \beta_j = 1; \quad \sum_{i=1}^{n} \gamma_{ij} = 0 \;\; (j = 1,2,\ldots,n); \quad \sum_{j=1}^{n} \rho_{ij} = 0 \;\; (i = 1,2,\ldots,m).$$

This decreases the number of free parameters equal to (m+n+1)(m+n)/2.

Homogeneity of the production structure requires that the joint cost function be homogeneous in outputs. With linear homogeneity in outputs imposed on the cost function, there are m+n-1 additional independent linear restrictions which are necessary and sufficient to make the cost function homogeneous in outputs.

$$\sum_{i=1}^{m} \alpha_i = 1; \sum_{i=1}^{m} \delta_{ij} = 0 \;\; (j = 1,2,\ldots,m); \quad \sum_{i=1}^{m} \rho_{ij} = 0 \;\; (j = 1,2,\ldots,n).$$

Only n - 1 of the conditions $\sum_i \rho_{ij} = 0$ are independent since $\sum_j \rho_{ij} = 0$ has already been imposed by linear homogeneity in factor prices. The degree of homogeneity of the joint cost function is equal to $(\sum_{i=1}^{m}\alpha_i)^{-1}$. Constant returns to scale results from the further restriction that $\sum_{i=1}^{m}\alpha_i = 1$.

Separability requires that

$$\partial / \partial \ln P_l((\partial C / \partial \ln Y_i)/(\partial C / \partial \ln Y_k)) = 0 \quad (i,k = 1,2,\ldots,m); \quad (l = 1,2,\ldots,n).$$

For the translog form this implies that

$$\partial / \partial \ln P_l\{[\alpha_i + \sum_{j=1}^{m}\delta_{ij}\ln Y_j + \sum_{j=1}^{n}\rho_{ij}\ln P_j]/[\alpha_k + \sum_{j=1}^{m}\delta_{kj}\ln Y_j + \sum_{j=1}^{n}\rho_{kj}\ln P_j]\} = 0$$

.According to input cost share equations, these imply $\alpha_i\rho_{kl} = \alpha_k\rho_{il}$ and $\rho_{il}\delta_{kj} = \rho_{kl}\delta_{ij}$ $(j = 1,2,\ldots,m)$.

Separability holds if

$\rho_{ij} = 0$ for all values of i and j $(i = 1,2,\ldots,m); (j = 1,2,\ldots,n)$.

This implies m(n-1) restrictions on the translog form, because there are m(n-1) free ρ_{ij}'s.

In case of zero values for some of explanatory variables, replacing the zero values with arbitrarily small positive numbers could be a solution (Cowing and Holtmann, 1983), but some empirical results obtained from this method are not stable depending on the value chosen for these numbers (Vita, 1990). The alternative is the Box-Cox transformation in the generalized translog cost function Short-run translog cost function equation is shown as below.

$$\ln C^v = \alpha_0 + \sum_{i=1}^{m}\alpha_i \ln Y_i + \sum_{j=1}^{n}\beta_j \ln P_j + \sum_{k=1}^{o}\gamma_k \ln K_k + \tfrac{1}{2}\sum_{i=1}^{m}\sum_{j=1}^{m}\alpha_{ij}\ln Y_i \ln Y_j$$
$$+ \tfrac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n}\beta_{ij}\ln P_i \ln P_j + \tfrac{1}{2}\sum_{i=1}^{o}\sum_{j=1}^{o}\gamma_{ij}\ln K_i \ln K_j + \sum_{i=1}^{m}\sum_{j=1}^{n}\rho_{ij}\ln Y_i \ln P_j$$
$$+ \sum_{i=1}^{m}\sum_{j=1}^{o}\delta_{ij}\ln Y_i \ln K_j + \sum_{i=1}^{n}\sum_{j=1}^{o}\varepsilon_{ij}\ln P_i \ln K_j$$

Alba (1995) described equality and inequality restrictions of translog multiproduct cost function to be satisfied in the estimation of translog cost function.

Equality conditions consisted of homogeneity of degree one in prices and continuity in both prices and outputs. While inequality restrictions are focused on

Continuity of the variable cost function in prices and outputs implies that the function is non-negative for all non-negative outputs and prices and for given levels of fixed inputs. Young's Theorem was used to provide sufficient conditions for continuity. This theorem postulated that If function is twice differentiable, then its cross partial derivatives are equal. It implies that the coefficients of the interactions between factor prices and between outputs are symmetric (symmetry restriction). Linearly homogeneity in factor prices is formally described as

$C^{v}(Y, \lambda P, K) \geq \lambda C^{v}(Y, P^{'}, K)$ for all $\lambda > 0$

In the case of the translog variable cost function, this has been to impose the following restrictions.

$$\sum_{j=1}^{n} \beta_j = 1; \quad \sum_{i=1}^{n} \beta_{ij} = 0 \ \ (j = 1,2,\ldots,n); \quad \sum_{j=1}^{n} \rho_{ij} = 0 \ \ (i = 1,2,\ldots,m).$$

Note that if the coefficients of the interaction terms are all equal to zero, the translog variable cost function takes on a Cobb-Douglas form.

A variable cost function that is monotonically non-decreasing in factor prices has the property that

$C^{v}(Y, P, K) \geq C^{v}(Y, P^{'}, K)$ for all $P \geq P^{'}$

This condition is equivalent to

$$\partial C^{v}(Y, P_j, K) / \partial P_j = (C^{v} / P_j)(\partial \ln C^{v} / \partial \ln P_j) = (C^{v} / P_j) S_j \geq 0$$

For the translog variable cost function, a necessary and sufficient condition to be monotonically non-decreasing in factor prices is that the cost share of the jth input in total variable costs is greater than zero.

$$S_j = \partial \ln C^{v} / \partial \ln P_j = \beta_j + \sum_{i=1}^{n} \beta_{ij} \ln P_i + \sum_{i=1}^{m} \rho_{ij} \ln Y_i + \sum_{i=1}^{o} \varepsilon_{ij} \ln K_i \geq 0$$

However, the translog variable cost function is expanded at the sample means, thus if the cost share equation is evaluated at the mean of the sample, the condition for monotonicity in prices of the translog cost function translates into the condition that the input price coefficients be greater than or equal to zero.

$$\beta_j \geq 0$$

Analogously, if the translog variable cost function is to be monotonically non-decreasing in outputs, then a necessary and sufficient condition, given the point of expansion of the function, is that the output coefficients be greater than or equal to zero.

$$\partial \ln C^v / \partial \ln Y_i = \alpha_i \geq 0$$

Concavity of the variable cost function in factor prices requires that the Hessian matrix of cross-price derivatives of the conditional demand functions be negative semidefinite $H_{pp} \leq 0$.

$$H_{PP} = \begin{bmatrix} \partial^2 C^v / \partial P_1^2 & & & \\ \partial^2 C^v / \partial P_1 \partial P_2 & \partial^2 C^v / \partial P_2^2 & & \\ \vdots & \vdots & \ddots & \\ \partial^2 C^v / \partial P_1 \partial P_n & \partial^2 C^v / \partial P_2 \partial P_n & \cdots & \partial^2 C^v / \partial P_n^2 \end{bmatrix} \leq 0$$

For the translog variable cost function, at the point of approximation the diagonal elements of the Hessian matrix can be expressed as

$$\partial^2 C^v / \partial P_j^2 = (C^v / P_j^2)(\beta_{jj} - \beta_j + \beta_j^2) \text{ for } j = 1,2,\ldots,n$$

and the off-diagonal elements can be given as

$$\partial^2 C^v / \partial P_i \partial P_j = (C^v / P_i P_j)(\beta_{ij} + \beta_i \beta_j) \text{ for } i \neq j$$

If it is supposed that $C^v > 0$ and $P_j > 0$ for all j, then the sign of each element in the Hessian matrix H_{PP} is determined solely by the terms inside the parenthesis in the equations above.

Let

$$H_{PP}^{*}=\begin{bmatrix}\beta_{11}-\beta_1+\beta_1^2 & & & \\ \beta_{12}+\beta_1\beta_2 & \beta_{22}-\beta_2+\beta_2^2 & & \\ \vdots & \vdots & \ddots & \\ \beta_{1n}+\beta_1\beta_n & \beta_{2n}+\beta_2\beta_n & \cdots & \beta_{nn}-\beta_n+\beta_n^2\end{bmatrix}$$

Then the Hessian matrix H_{PP} is negative semidefinite if and only if H_{PP}^{*} is negative semidefinite.

The usual way to estimate translog variable cost function is by using the procedure outlined by Zellner. Firstly, Shepherd's Lemma was conducted to obtain a set of j factor demand equations by differentiating with respect to factor prices in order to avoid multicollinearity problem resulting from OLS. Then the system of equations consisting of the j factor demand equations and the translog function can be estimated iteratively by Zellner's procedure with the restrictions of linear homogeneity in factor prices imposed. (Scott and Parkin, 1995).

In the recent studies multiproduct translog short-run or variable cost functions are widely used to model hospital production function.

The generalized (hybrid) translog cost function

This function is a modified translog function in the case where some certain output categories have zero values because the natural logarithm of zero is undefined. The way to handle zero output values is to use the Box-Cox transformation to those outputs in place of the natural logarithmic transformation. The Box-Cox transformation of output Yi is as $(Y_i^{\lambda}-1)/\lambda$, where λ is the Box-Cox parameter. As λ approaches zero, the Box-Cox transformation is closely equal to the natural logarithmic transformation. Vita (1990) stated that varying λ between 0.0001 and 0.1 slightly affect parameter estimates. The Box-Cox metric allows zero values of output and also contains the natural logarithm metric as a limiting case (Scott and Parkin, 1995). This function is defined as follow:

$$\ln C = \alpha_0 + \sum_{i=1}^{m} \alpha_i \left(\frac{Y_i^{\lambda} - 1}{\lambda} \right) + \sum_{j=1}^{n} \beta_i \ln P_i + \tfrac{1}{2} \sum_{i=1}^{m} \sum_{j=1}^{m} \delta_{ij} \left(\frac{Y_i^{\lambda} - 1}{\lambda} \right) \left(\frac{Y_j^{\lambda} - 1}{\lambda} \right)$$

$$+ \tfrac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \ln P_i \ln P_j + \sum_{i=1}^{m} \sum_{j=1}^{n} \rho_{ij} \left(\frac{Y_i^{\lambda} - 1}{\lambda} \right) \ln P_j + \varepsilon$$

$$where \delta_{ij} = \delta_{ji} and \gamma_{ij} = \gamma_{ji}$$

Local versus global properties of flexible functional forms

Limitation of flexible forms including estimated translog is that their global properties are less satisfactory. It means that they fail to represent the firm's technology for outputs located far from the approximation point of the function (Wales, 1977; Caves and Christensen, 1980 cited in Vita, 1990). Fortunately, those flexible forms are able to represent any arbitrary firm's technology at some base or in the neighborhood of the approximation point, called local properties with no needs to place prior restrictions on substitution and scale elasticity (Caves and Christensen, 1980: 422).

They often can predict costs only for a limited range of output levels. Thus it might be limited for some analysis. For example, it might not be reliable to estimate the degree of economies of scale and scope because such an analysis have to evaluate the cost function at output levels outside the neighborhood of the approximation point in particular at zero output level in order to calculating incremental costs. (Vita, 1990)

Most recent works in hospital production have taken the advantages of flexible form functions to represent a production function at any point of approximation (Conrad and Strauss, 1983; Cowing and Holtmann, 1983; Vita, 1990; Fournier and Mitchell, 1992; Li and Rosenman, 2001). The most popular flexible functional form in those empirical works has been the translog form.

Cowing and Holtmann (1983) explored the hospital cost relationship through the use of flexible functional forms such as transcendental logarithmic function. Flexible functional forms are able to represent any production and cost structure at some approximation point. They also calculate the scale and scope economies measures of multi-output production.

Vita (1990) estimated a multiproduct variable cost function using an eclectic approach that combine the ad hoc and production theoretic approaches. The generalized translog form was used for the model specification, which differs from the ordinary translog function by using the Box-Cox transformation to the output variables in place of the natural log transformation. It includes the variables of input prices, output quantities and other explanatory factors that are evident to affect hospital cost behavior and also imposes linear homogeneity on the input prices. The results showed reasonable estimates of the marginal costs of outputs when evaluated at or near the sample means of the explanatory variables, but not satisfactory when evaluated at points outside the area near or around (neighborhood) of the sample means.

Scott and Parkin (1995) estimated hospital cost functions based on the economic theory of production and costs and found that short-run variable cost function better represent the nature of hospital costs at a particular point in time.

A number of studies, for example, Cowing and Holtmann (1983), Conrad and Strauss (1983), Grannemann and Brown (1986), Vita (1990), Scott and Parkin (1995), and Scuffham, Devlin, and Jaforullah (1996), employed the translog variable cost function to explore the structure of production of the non-profit multi-product firms like hospitals because flexible forms are able to represent any underlying arbitrary production and cost structure at the chosen point of approximation.

2.2.2.4 Hospital cost function variables

2.2.2.4.1 Hospital output variables

Although some authors (Grossman, 1972; Breyer, 1987; and Ellis, 1992) stated that health stock could be regarded as the output of a hospital because the patients restored the health stock when they avail of hospital services, even it fall short in some cases, for example, cosmetic surgery or palliative care services. However, health status or stock is multi-faceted and it is difficult to define and measure. So, researcher have taken the measures of throughputs or intermediate outputs instead, for example, the number of inpatient cases treated, length of stay served, and the number of outpatient visitors.

In the multiproduct cost function studies, Caves et al. (1980) proposed the approach that includes two output indices of total volume and average length-of-haul.

Previous studies have categorized hospital output into inpatients and outpatients. Inpatients have been further categorized into various medical specialties or case mix groups (Grannemann et al, 1986; Vita, 1990; Scott and Parkin, 1995).

Cowing and Holtmann (1983) elaborated another choice of hospital outputs such as the number of inpatient days by hospital department and the number of emergency room visits.

Conrad and Strauss (1983) used the number of inpatient days by age group divided into child and non-child and mode of payment including Medicare and non-Medicare.

But aggregation of hospital outputs might give rise to the homogeneity problem and quality differences of those outputs. However, case mix index could be included in the model specification of the hospital cost function to alleviate that problem supported by Ellis (1992). In addition, Breyer (1987) suggest total DRG weighted inpatient discharge to be used as one measure of hospital outputs.

Zwanziger and Melnick (1988) used the number of inpatient discharges, average length of stay, and deflated outpatient revenue as the measures of hospital outputs.

Vita (1990) used two-indices approach for each of four inpatient output categories namely medical/surgical discharges, obstetric discharges, pediatric discharges, and all other discharges, one index measuring total discharges, the other measuring average length-of-stay for those discharge categories. The hospital outputs also include the number of outpatient and emergency room visits. The case mix index was included to control for any output heterogeneity that is not able to capture by this five- output classification scheme.

Fournier and Mitchell (1992) used the number of acute and intensive care inpatient admissions, labor and delivery (maternity) procedures, outpatient visits, emergency room visits, and surgery minutes as the five measures of hospital outputs.

Wouters (1993) suggested the number of outpatient visits and of inpatient admissions.

Scott and Parkin (1995) categorized hospital outputs into outpatients and inpatient services. The inpatient outputs consisted of the number of discharges and average length of stay for two groups of specialties namely acute surgical/medical and other specialties. The second-order parameter of the length of stay variable is restricted to equal zero in order to improve further the degrees of freedom. A third output is the number of outpatient, accident and emergency and day case attendances.

Gaynor and Anderson (1995) used the numbers of outpatient visits, actual inpatient admissions, forecasted inpatient admissions and the standard error of forecasted admissions as four measures of hospital outputs.

Dor and Farley (1996) used four payer-specific case mix-adjusted discharges and the number of outpatient visits as the five hospital outputs.

In addition, studies on case mix were also reviewed as follows.

Zwanziger and Melnick (1988) used two case mix measures namely the number of distinct DRGs and the hospital's DRG case mix index. The first reflects the fixed costs for service availability borne by the hospital for the ability to perform a given set of services whereas the DRG case mix indies is to capture the direct costs of the hospital's case mix. Although the case mix index does not reflect the additional cost of more rarely services provided, but may represent its total costs, so the number of DRGs is additionally used as an approximate measure of additional fixed costs.

Vita (1990) used Medicare case mix index to reflect service complexity.

Fournier and Mitchell (1992) used case mix indicators such as the percentage of patient days that are devoted to intensive care, and the percentage of Medicaid patients to control for hospital output heterogeneity because the case mix index fails to recognize patient heterogeneity within each DRG. The Medicaid variable is a rough indicator of the additional costs of servicing an indigent population.

Gaynor and Anderson (1995) used the Medicare case mix index to represent the overall hospital case mix. It is a proxy for complexity and severity of hospital services.

Issues on hospital output measurement

The treatment of output measurement is the most taxing methodological issue in setting of hospital cost analyses. (Barer, 1982: 53)

Barer (1982) proposed and empirically tested the extended method of hospital output standardization in terms of patient mix compared with Evans-Walker specification developed by Evans and Walker (1972) in modeling of the hospital cost structure to compare unit costs. Regarding the nature of hospital production, it should have two dimensions for cross section analysis, one accounting for inter-hospital variation in activity mix, the other for patient mix variance within those activities directly related to patient care. In addition, third dimension of standardization methods is added and related to the activity dimension and specific to time series analysis.

In the past studies, single index of services or a weighted combination of outputs has been used to represent the hospital outputs. This method assumed that the effect of cost determinants was both linear and additively separable.

Saathoff and Kurtz (1962) devised a weighted measure of service output called Saathoff and Kurtz index based on a time and motion study using adult and pediatric days, surgical and obstetric admissions, X-ray and diagnostic procedures, laboratory tests and tissue exams, and outpatient department outputs.

Cohen (1967) based the weight of output measure on unit cost of services divided by unit cost per patient day.

Farley and Hogan (1990) aggregated hospital output by using case mix measures for total hospital admissions.

Later, in order to accommodate the patient heterogeneity issues, some studies attempted to disaggregate single output into classes.

In the previous studies, there are several aspects in the classification of hospital outputs. Typically, they are mostly divided into outpatient and inpatient services. The measures of outpatient services could be either only the total number of outpatient or those divided into several subgroups such as emergency room visits, outpatient surgery cases and other residual cases. For inpatient services it could be either the number of inpatient discharges (admission) or that of inpatient days in that each of them might be divided based on diagnostic category, source of payment (Dor, 1989; Dor and Farey, 1996), et cetera. Based on diagnostic category these studies typically distinguish at least between medical, surgical, pediatric, and OB/GYN inpatients.

Cowing and Holtman (1983) used emergency room visits and annual patient days for the diagnostic categories of medical-surgical, maternity, pediatrics and other inpatient care as hospital output measures.

Conrad and Strauss (1983) used patient days for Medicare, non-Medicare and children as hospital output measures

Next, to control the differences in patient characteristics, severity of medical conditions and the intensity of medical services, two-dimensional approach was employed by incorporating additionally either the case mix adjustment in term of hospital or payer-specific case mix index (Zuckerman, Hadley, and Iezzoni, 1994) or the average length of stay (Scuffham et al., 1996).

From the fact that the early inpatient stay days incurred a disproportionately higher cost than the later days because the more intensive cares such as diagnostic tests and procedures, critical drug administration and possibly surgery and medical care in the ICU, usually take place more frequently in the early days than the later days, thus only patient days cannot completely capture the effects of inpatient care on hospital costs. Consequently, some studies used the average length of stay as hospital output additionally.

Fournier and Mitchell (1992) mentioned the shortcomings in some previous studies: 1) the use of patient days as units of hospital outputs, their treatment of zero outputs, and the failure to calculate t-statistics for economies of scale and scope estimates in Cowing and Holtmann (1983), 2) not compliant with the theory of cost and choose an ad hoc polynomial specification that clearly suffers from several limitations in Grannemann et al. (1986), and 3) the use of revenues to measure outpatient services in Zwanziger and Melnick (1988).

Scuffham et al. (1996) adopted two-dimensional output approach by measuring total admissions and average length of stay for the inpatient care. The translog variable cost function was employed.

In addition, two more specific problems about hospital output measurement to concern are as follows:

1) Endogeneity

Scott and Parkin (1995: 475) mentioned the assumptions of theoretical neoclassical cost function that the level of all outputs are determined exogenously, for instance, by the demand of the patients, so doctors are perfect agents for their patients. They have full information about their patients' needs, but the doctor's preferences are not considered as a determining factor when deciding optimal courses of treatment. The possibility of an incomplete agency relationship could deteriorate the exogeneity assumption of the outputs when the doctors used personal benefits and preferences as a factor for decision making.

Grannemann et al. (1986: 109) pointed that the coefficients of the hospital outputs will be biased if the hospital can influence the level of service outputs provided. For example, less costly hospitals respond by producing higher levels of service outputs and decrease the service intensity in order to raise the income. However, insurance coverage can weaken the relationship between the service prices charged and quantity demanded. In addition, since hospitals must necessarily serve patients' demands and needs (Cowing and Holtmann, 1983) and physicians operate as independent and demand-creating health care providers that are not under the decisions and control of the hospital management (Arrow, 1963; Smallwood & Smith, 1975). Therefore, the assumption of exogenous hospital outputs is reasonably acceptable (Smet, 2002).

Gaynor and Anderson (1995) employed an instrumental variable (IV) regression approach to correct the endogeneity problem of the admission and occupancy rate variables after using the test of Hausman (1978) and Wu (1973) to test for the exogeneity of output variables namely the number of admissions, the number of outpatient visits, the occupancy rate and the case mix index including all the higher order term. The county level socioeconomic and demographic variables were used as instrument variables because they could affect demand through the level of health or through market structure but do not affect its costs. Dor and Farley (1996) also use an instrumental-variable (IV) regression technique to estimate the cost function. They used the main payer-specific indices of charges, type and number of services offered, and hospital size as instrument variables.

2) Zero value outputs

Some hospitals provide zero output for certain service categories that cause the problem for the translog functional form because the natural logarithm of zero is undefined. To handle this problem, we can use one of three ways as follows (Scott and Parkin, 1995; Dor and Farey, 1996):

(1) remove all observations that have zero values in any output category. This method is feasible in the case of a large number of observations or in the case that there is a small number of zero output values or that outputs can be aggregated into fewer categories in order to eliminate some zero values.

(2) put small positive numbers in place of zero output values, for example, the value in between 0.0001 and 0.1 could be used. (Cowing and Holtman, 1983)

(3) uses the Box-Cox metrics to all outputs instead of the natural logarithmic transformation. (Caves et al., 1980) The result is called the generalized translog functional form.

2.2.2.4.2 Hospital input variables

Input price variables

Zwanziger and Melnick (1988) used labor and non-labor cost indices as the measures for the input prices. The non-labor one is for purchased supplies, fuel and utilities, capital costs, and miscellaneous. These measures were applied from California Weighted Hospital Input Price Index (CWHIPI) produced by California Health Facilities Commission (CHFC). The labor index was adjusted by hospital-specific labor wage rate index developed by the Health Care Financing Administration (HCFA) to determine payment rates for hospitals under the Medicare PPS. CWHIPI is the composite state-wide index that was calculated from disaggregated price indices for the inputs utilized by California hospitals and was weighted by the state-wide average proportion of total hospital expenditures. Thus, the labor index is hospital-specific whereas the non-labor one is not.

Vita (1990) used payroll data to compute five input prices as wage rates per hour for management and supervisory personnel, nursing personnel, non-physician medical practitioners and technicians, auxiliary personnel, all other personnel. The variation in input prices across hospitals reflects within-occupation heterogeneity.

Fournier and Mitchell (1992) defined four input prices; three measure labor-related costs while the fourth controls for the price of non-labor inputs consisting medical supplies and drugs, materials, utilities, and others. Labor prices are measured as the average annual salary per FTE employee in auxiliary/general, administration and nursing. Averages are taken within the relevant local area defined by the metropolitan statistical area (MSA). The price of non-labor inputs is assumed to be constant because hospitals can generally purchase these items at uniform prices. Thus, this price is taken as the numeraire for imposing the input homogeneity restrictions.

Alba (1995) derived the annual wage of a typical member of each labor category by using the wage bill of that category of labor divided by the number of full-time staff. The price of drugs and medical supply is really the ratio of expenditures on those items (including inventories) to the number of both in-patient discharges and outpatient visits.

Scott and Parkin (1995) assumed the same nursing, medical and other labor input prices for each hospital due to national wage setting, so the substitution of labor inputs are on the same basis across all hospitals and the input price variables drop out of the equation.

Gaynor and Anderson (1995) used reported monthly salaries and wages from payroll data per full time equivalent employees (FTE) as a proxy for hospital wages.

Dor and Farley (1996) calculated the wages as average annual compensation per full-time-equivalent employees (FTEs).

Issues on hospital input prices

The assumption of exogenous input prices is reasonable because input factor markets are nearly completely competitive and free from monopsonistic pressures (Smet, 2002).

The most prevalent problem for input prices is no reliable and valid data on input prices available. Usually, there are no valid and reliable data on labor and non-labor inputs for hospitals available on a national basis. (Dor and Farey, 1996)

Most studies used a vector of salaries and wages for factor inputs by type of labor, for example, administration, nursing, technical, and auxiliary personnel but excluded employee benefits due to data limitations and unavailability.

In case of no all factor prices, it might imply that either input prices has the same rates for all hospitals or that all hospitals operate under zero input substitution technology (Cowing and Holtmann, 1983: 638).

In case that one input price is not available, for example, prices for non-labor inputs such as drugs and other medical supplies are often not available. However, these prices tend to be the same across hospitals and then can be assumed to be constant across hospitals. By using this price as the implicit price numeraire in imposing the input price homogeneity condition, estimated parameter for the missing input price can be then obtained. (Cowing & Holtmann, 1983: 641)

In case that input prices are not interacted with output levels in the cost function analysis, by duality theory the production function that is associated with this cost function is homothetic. This means that the volumes or mix of outputs does not affect the cost-minimizing mix of inputs and the changes in input prices will affect cost estimates only by a scale factor and not change the relationship between marginal and average incremental cost and economies of scale. (Grannemann and Brown, 1986: 110)

Fixed input variables

The number of hospital beds (Vita, 1990) and admitting physicians (Cowing and Holtmann, 1983; Fournier and Mitchell, 1992; Alba, 1995; Gaynor and Anderson, 1995) are used as the proxy indicators for fixed inputs.

Cowing and Holtmann (1983) used the book value of buildings and equipment and the number of admitting physicians as the measures of fixed inputs.

Zwanziger and Melnick (1988) used the number of distinct DRGs to reflect the availability fixed costs.

Vita (1990) used the number of beds as a fixed input.

Fournier and Mitchell (1992) used the book value of capital and the number of admitting physicians as the measures of fixed inputs. The capital stock is defined as the total book value of land, land improvements, movable equipment and construction in progress less depreciation and disposals.

Alba (1995) used the number of beds is a proxy of the capital stock of hospitals.

Scott and Parkin (1995) used the number of staffed beds as a proxy for fixed inputs.

Gaynor and Anderson (1995) used the inverse of the occupancy rate and the number of inpatient beds as the measures of fixed inputs.

Dor and Farley (1996) used book value of capital assets as capital inputs.

Because the fixed inputs like capital stock are difficult to quickly adjust in response to changes in output levels, thus assuming fixed inputs as exogenous and estimating short-run variable cost function could cause simultaneous equations bias. The bias is likely to be great in a cross-section analysis due to correlation between fixed inputs and outputs. (Grannemann and Brown, 1986)

Control and other variables

Vita (1990) also included variables measuring multihospital system affiliation, case mix, and profit/not-for-profit status.

Fournier and Mitchell (1992) include yearly dummy variables to control for the effects of inflation and changes in the regulatory environment. In addition, they also construct a series of Herfindahl indices to capture the degree of competition among hospitals for inpatient admissions, specialized services such as maternity, general surgery, and diagnostic imaging, highly specialized services, such as radiation therapy. Dummy variables for four ownership categories such as not-for-profit, government, investor-owned independent and investor-owned chains was used because ownership may change the production technology of the hospital and thereby affected its operating efficiency. The number of FTE residents was used as the measure of teaching status.

Gaynor and Anderson (1995) used the ownership form of the hospital namely for-profit and public hospital and teaching status as control variables.

2.2.3 Panel data regression

In fact, the panel data is primarily motivated to solve the omitted variables problem. In particular, that omitted variable is time-constant. An unobserved, time-constant variable is called an unobserved effect in panel data analysis. In the different time periods for the same individual, the unobserved effect is often interpreted as capturing features of an individual, such as cognitive ability, motivation, or early training, that are given and do not change over time.

In addition to unobserved effect, there are many other names in applications such as unobserved component, latent variable, and unobserved heterogeneity are common. For individuals, it is sometimes called an individual effect or individual heterogeneity. Analogous terms could apply to families, firms, cities, and other cross-sectional units. (Woodridge, 2002)

Regarding a possible bias from omitting some unobserved variables that is assumed to be time-constant such as quality, managerial ability, patient severity, and et cetera, panel data frameworks help us account for the unobserved heterogeneity across hospitals. It allows the researcher to model the differences specific to individuals (Li and Rosenman, 2001).

Ignoring unobserved heterogeneity across firms or individual-specific effect may cause inefficient or inconsistent estimates. The Breusch and Pagan test is used to test whether or not there is the individual specific effect. If there is the individual specific effect, OLS is inefficient. The Breusch and Pagan test is a Lagrange Multiplier (LM) test for the random-effects model based on the ordinary-least-squares (OLS) residuals. The test statistic is

$$LM = \frac{nT}{2(T-1)}\left[\frac{\sum_{i=1}^{n}\left(\sum_{t=1}^{T} e_{it}\right)^{2}}{\sum_{i=1}^{n}\sum_{t=1}^{T} e_{it}^{2}} - 1\right]^{2}$$

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Two basic models have been developed to address the unobserved heterogeneity among individuals in panel data framework, one is the so-called fixed effects model, and the other is random effects (or error components) model. The former treats the individual-specific effect as a fixed parameter in the regression model while the latter specifies individual-specific constant terms as randomly distributed across cross-sectional units.

1) Fixed-effects model

This traditional model treats the individual-specific effect as a fixed parameter. It is also known as the within-groups estimator or the least-squares dummy variable model. This model transforms the data into deviations from individual means. It perform best on data sets containing a reasonably lengthy time series, since it is required for consistent estimation of the fixed effect that both time-series and cross-sectional dimensions go to infinity. The disadvantages are that time-invariant effects cannot be estimated, and that it does not predict for "average" hospitals or for those out of the sample.

2) Random-effects (or error components) model

This model treats the individual effect as a random component of the error term and the parameters are estimated by feasible general least squares (GLS). Because the individual effect is estimated as a distribution, predictions can be made for out-of-sample individuals. It is best suited to data sets containing large numbers of individuals and a short time series and consistent estimation of these models requires only that the cross-sectional dimension go to infinity.

The assumption of this approach is that the unobservable individual effect is uncorrelated with the observable determinants of behavior. In the case of hospitals this assumption is questionable, for example, managerial ability and quality could affect the length of stay. Correlation between the unobserved individual effect and the regressors can be tested by using the orthogonality test or the Hausman's specification test. (Hausman, 1978) The test is based on the statistic

$$W = (\beta 1 - \beta 2)'(M1 - M2)^{-1}(\beta 1 - \beta 2),$$

where β_1 are the parameter estimates and M_1 is the estimate for the covariance matrix from the OLS of the LSDV model while β_2 and M_2 are the corresponding estimates from the random-effects model. Under the null, the statistic *W* is asymptotically distributed as $\chi^2(K)$, where *K* is the number of parameters.

After testing, if it is showed that there is no correlation, both OLS in the least squares dummy variable (LSDV) model and GLS in the random effects model are consistent. If this is the case, OLS in LSDV is consistent, but generalized least square (GLS) estimates are inconsistent because the usual orthogonality assumption fails.

Cowing and Holtmann (1983) analyzed the impact of several of the primary hospital characteristics, which are the hospitals' diagnostic case mix, admitting physicians, size, and efficiency, on the short-run costs of hospitals within a theoretically consistent framework. A short-run multiproduct (variable) cost function is used for analysis and defined as:

$C^V = G(Y, p', K, A)$

where C^V is (minimal) short-run total variable costs; *Y* is a vector of outputs of patient services-emergency room care, medical-surgical care, pediatric care, maternity care and other care-measured in patient days; *p'* is a vector of six variable input prices for nursing labor, auxiliary labor, professional labor, administrative labor, general labor, and materials and supplies; *K* is a vector of fixed capital inputs, and *A* represents (fixed) admitting physician inputs assumed to be fixed in the short-run. This cost function assumes that hospitals minimize (variable) costs, given the stock of capital, the number of admitting physicians, exogenous input prices and patients' demands for hospital services.

They proposed the test for long-run equilibrium that follows directly from the following relationship between long-run and short-run costs. Long-run costs are given by:

$$C = C^V(Y, p', K, A) + p_K K + p_A A$$

where p_K is the rental or user cost of capital (services), p_A is the price of admitting physician services. Long-run cost minimization requires that the long-run cost be minimized in terms of *K* and *A*, the two choice variables, since *Y* and *p'* are assumed to be exogenous to the hospital and C^V has already been minimized (implicitly) in terms of *Y, p', K* and A. The conditions for long-run cost minimization are given by the envelope conditions.

$$\frac{\partial C^V}{\partial K} = -p_K, \frac{\partial C^V}{\partial A} = -p_A.$$

This condition implies that long-run cost minimization is accomplished when the variable cost saved by substituting the last unit of capital for variable inputs (capital gradient) is equal to the marginal input cost of that unit.

They are also concerned with the direct impact of providing certain diagnostic services, and hence different case mixes, on hospital costs and then considered the economies of scale and scope.

The econometric model was specified as the system of equations consisting of the variable cost function, plus five share equations, with additive error terms, and was estimated using maximum likelihood estimation.

$$\ln C^V = \alpha_0 + \sum_r \alpha_r \ln Y_r + {}^1\!/_2 \sum_r \sum_s \alpha_{rs} \ln Y_r \ln Y_s + \sum_i \beta_i lnp'_i + {}^1\!/_2 \sum_i \sum_j \beta_{ij}\, lnp'_i\, lnp'_j + \gamma_K lnK + \gamma_{KK}(lnK)^2 + \phi_A lnA + \phi_{AA}(lnA)^2 + \sum_r \sum_i \delta_{ri} \ln Y_r \ln p'_i + \sum_r \psi_r \ln Y_r lnK + \sum_r \theta_r \ln Y_r lnA + \sum_i \zeta_i lnp'_i lnK + \sum_i \pi_i lnp'_i lnA + \gamma_{KA} lnKlnA$$

where C^V is variable hospital costs; Y_r is a set of patient services-emergency room care, medical-surgical care, pediatric care, maternity care and other care-measured in patient days; *p'* is a set of six variable input prices for nursing labor, auxiliary labor, professional labor, administrative labor, general labor, and materials and supplies; K is a single measure of the fixed capital stock; and A is the number of admitting physicians in each hospital, assumed to be fixed in the short-run.

Moreover, the efficiency of the resulting estimates are enhanced when the relevant share equations are estimated simultaneously with the cost function. Using Shephard's lemma, the variable translog cost function can be logarithmically differentiated, yielding the cost shares associated with each variable input.

$$S_i^V = \frac{\partial lnC^V}{\partial lnp'} = \beta_i + \sum_j \beta_{ij} \ln p'_j + \sum_r \delta_{ri} \ln Y_r + \epsilon_i lnK + \pi_i lnA. \quad i = 1,2,\dots,6$$

The results showed that all five of the cost share intercepts or estimated mean cost shares associated with nursing, ancillary, professional, administrative and general labor are positive and highly significant. The output elasticities of four diagnostic categories, emergency room treatment, medical-surgical care, maternity care and other types of care are all positively related to total variable costs.
The elasticity for the capital stock variable is positive and highly significant. This not only implies that the "average" hospital is not in long-run equilibrium but it suggests that the "average" hospital has too much capital. The elasticity of hospital costs with

respect to the number of admitting physicians affiliated with the hospital is also positive. This finding is consistent with the notion that physicians over-use hospital service. It is also found that the proprietary hospitals have significantly lower costs than do non-profit hospitals. The dummy variable representing teaching activity at a hospital is not significant in the results.

Zwanziger and Melnick (1988) studied hospital competition using California data for the years of 1980-1985. They tested for the presence of hospital-specific effects in the residual. Finding a very high degree of intrahospital correlation, they applied a variance components model.

Gaynor and Anderson (1995) used panel data for 1983-1987 from American Hospital Association in a fixed-effects model in an analysis of the cost of empty hospital beds.

Carey (1997) used a hybrid semi-log cubic polynomial function to estimate a multiple-output hospital total variable cost function in the panel data framework from 1987-1991 compared with cross-section one. A correlated random effects model was applied to account for correlation between the unobservable differences among hospitals and their observable determinants of behavior.

Issues on estimation procedure for hospital cost function

The estimation of translog joint cost function using ordinary least squares (OLS) is likely to cause imprecise parameter estimates due to multicollinearity. To overcome this problem, Shephard's Lemma is employed to derive m factor share equations, of which m - 1 are independent and assumes price-taking behavior in factor markets. Dropping one factor share equation to avoid singular covariance matrix is the standard practice.

The system of translog joint cost function with cost shared equations are iteratively estimated by the Zellner (1962) procedure with the restrictions of linear homogeneity in factor prices imposed. These increase the information about the production structure without increasing the number of parameters. This additional information results in improved efficiency of estimation. (Brown et al., 1979; Scott and Parkin, 1995)It is assumed that the disturbances be correlated within each hospital because errors of one input will affect the cost shares of other inputs and total costs (Conrad and Strauss, 1983).

In addition, three more specific problems about estimation procedure to concern are as follows:

1) heteroskedasticity

Generally, Breusch and Pagan’s test statistic is use to test for heteroskedasticity. In case of non-normality, the Koenker’s robust version of the Breusch and Pagan’s Lagrange multiplier test for heteroskedasticity of an unknown form could be used (Gaynor and Anderson, 1995). If homoscedasticity is rejected, heteroskedasticity consistent standard errors were calculated using the White’s method. All test statistics were also calculated using the heteroskedasticity consistent estimate of the covariance matrix.

2) Simultaneity bias

Possible correlation between one or more of the explanatory variables and the error term in the regression could cause simultaneous equation bias.

For example, these correlations between the output variables and the error term in the hospital cost regression would occur if hospitals could determine their level of output. To explore and test the possibility of simultaneous equation bias, the F-test could be performed as post-estimation statistical test (Nakamura and Nakamura, 1981).

3) Unobserved individual heterogeneity

Unobserved service quality may affect the hospital cost and causes unobserved heterogeneity (Gertler, 1988; Gertler and Waldman, 1992). Evidently, it is likely that quality improvement is consistent with lower costs (Fleming, 1991; Binns, 1991 cited in Carey, 1997). These individual-hospital effects also include severity of patients admitted and managerial ability of hospital managers. The behavioral equations in the cross-sectional analysis suffer from omitted variables bias. (Carey, 1997)

Fleming (1991) studied the relationship between cost and quality of care and found that the mortality and readmission rates be significant determinants of hospital cost.

Gertler and Waldman (1992) developed an empirical model in which costs are adjusted for unobserved endogenous quality and applied it to a sample of long-term care facilities. The findings showed that quality is an important determinant of hospital costs. In addition, they also proposed that the cross-sectional data analysis is not good enough to control for individual hospital differences or individual specific effects that cause variation in costs and panel data model is an alternative approach that can cope with variation in cost due to quality or other unobservable differences among hospitals.

CHAPTER III
METHODOLOGY

3.1 Study design

This study is an empirical analysis using econometric technique for analyzing hospital data. The panel data model was employed for estimating behavioral, production and cost functions for multiproduct firms.

3.2 Scope of study

The target population of the study included the regional, general and community hospitals under Office of Permanent Secretary of Ministry of Public Health. The study focuses on changes in payment method and hospital behavior and response from 2005 to 2010.

3.3 Analytical framework

Based on economic theory, healthcare provider responses to payment system change are complex.

Standard profit maximization models would predict that competitive firms respond to less generous payments by reducing quantity supplied. Also they might reduce the cost of healthcare by decreasing the service intensity and quality of care.

In contrast, models of utility maximization posit that under less generous payment situation providers might shift to other more generously paid services. Another strategy is that they may indeed increase volume when hospitals can induce demand among their patients (McGuire and Pauly, 1991) and simultaneously reduce the cost of care by decreasing service intensity to compensate the losing revenue until the quality of care have adverse effect. They also might provide services to other patients paid by other payers.

The main healthcare providers in Thailand are public hospitals under Ministry of Public Health (MoPH), and in the urban area there are also be other public or private hospital providing profitable services. In country areas except Bangkok public hospitals are like monopolistic firms in particular community hospitals in rural areas, but general and regional hospitals for highly specialized services, which locate in the urban areas, might compete with the other public or private hospitals for general services. In addition, proportion of out-of-pocket patients that public hospitals can set prices is almost scant.

Thai hospitals especially public hospitals under MoPH and MoE expressed that UC scheme under global budget inadequately pay for the healthcare services to them. A less generous payment might bring about an income and a substitution effect.

Under the income effect, hospitals respond to income losses caused by inadequate payment by inducing demand, or increasing volume. The payers' market share is an important determinant of the income effect (McGuire and Pauly, 1991). Community hospitals where UCS patients constitute a larger share of total outpatient patients are likely to experience greater revenue threats from less generous payment. Such hospitals are more "exposed" to UCS patients relative to hospitals with lower UCS patient shares. Thus, they tend to increase those services. On the other hand, regional and general hospitals with lower shares of UCS patients tend to decrease such services. Some authors found that hospital might reduce service intensity to decrease in cost in response to public payment reduction. For example, the hospitals with higher public payer caseloads did not shift costs, but instead they reduced quality (service intensity) and were more likely to close (Dranove and White, 1998). With the introduction of managed care in the early 1990s, cost cutting was the dominant response to lower Medicare payments rather than cost shifting. In particular, nursing staff levels were reduced. Evidently, it is less likely that payment changes affected hospital size or diffusion of technology. (Cutler, 1995) The hospitals reduce service intensity in terms of length of stay in response to lower reimbursement from changes in Medicare or Medicaid charges and the proportion of costs unpaid (Friesner and Rosenman, 2002).

According to the substitution effect, inadequate payment reduces the return to inducement, and the hospitals substitute toward reducing quantity supplied, which decreases volume. If the income effect dominates the substitution effect, less generous payment then generates a downward-sloping hospital supply curve.

In the context of multiple payers as Thai health insurance, changes in payment by one payer, for example, UC scheme can affect the volume of services reimbursed by other payers. It is so-called a second substitution effect under which hospitals substitute away from UCS services and toward services paid by the other non-UCS payers (which now have a relatively higher return). The net effect on UCS volume is thus ambiguous; it depends on the relative sizes of the income and substitution effects. For services paid by the other payer, however, changes in payment from one payer would lead to an unambiguous increase in volume. This is because the positive income effect generated by the less generous payment is reinforced by the second substitution effect which leads hospitals to substitute toward other services.

This study focuses on changes in payment method by CSMBS and UCS health insurance in 2007 and 2008 as detailed below.

There are three specific changes in payment methods for hospital services. Firstly, for outpatient service under the CSMBS scheme, before 2007 the patients paid for services directly to hospitals and after change in 2007 instead the hospitals get money back from funding agency known as Department of Comptroller General instead of patients (direct disbursement).

For inpatient services there are two changes under CSMBS and UCS schemes in 2008. Under CSMBS scheme payment system changes from fee-for-service to DRG-based reimbursement. The other one, under UCS scheme an abrupt increase in budget allocation for inpatient services from 514 to 845 baht per capita (64% increase) and decrease in that for high-cost care and emergency services from 260 to 145 (44% decrease) was implemented.

3.4 Material and Method

Thai public hospitals behave like utility-maximizing firms. It assumes that the hospital managers attempt to maximize utility that is related to increased pay, perquisites, prestige, patronage and power (Reder, 1966; Lee, 1971; Santerre and Neun, 2000). Executive salary, fringe benefit and prestige are more strongly correlated with firm size or scale than profit. Hospital managers also obtain prestige from the quality of hospital care provided for the patient. They attempt to enhance status or prestige of their hospitals by expansion of the range of hospital services, investment in expensive and highly specialized equipment and facilities, and medical personnel especially specialist doctors in order to maximize utility (Lee, 1970). The hospitals might make unprofitable investments and maintain unprofitable services, as long as these services added prestige to the institution. It is likely to increase the production cost and move towards duplication of resources and overspecialization. Cross subsidization of money losing services most likely occurred. Also, there might be some slack in the administrative task.

In addition, the managers might behave as managerial expense preference. They might use their authority to serve their own self-interests by using revenue earned to increase discretionary expenditure. That is to increase compensation, expand the number of support staff for the purpose of enhancing power and prestige or offer more perquisites. This behavior might lead to inefficient resource allocation and usage without cost-minimizing behavior (Lee, 1971; Reder, 1965).

Thus, it is hypothesized that the public hospital managers seeks to raise the revenue to meet their utility by investing the specialized equipment and facilities, purchasing necessary specialized services in order to expand services and increase the quality of service for attracting the patients, paying the compensation to permanent employee and civil servant and even hiring new temporary employee.

In this study there are two main issues about changes in service provision and hospital cost behavior and response resource utilization as follows:

1) Changes in pattern of service provisions in response to payment method change. They consist of service intensity and volume response.
2) Changes in cost behavior and response in response to payment method changes before and after 2008

3.4.1 Service intensity response

Topic #1: Intensity Response of Thai Public Hospitals on Length of Stay to Payment System Change

A better understanding of how hospitals react to changes in reimbursement or payment mechanism is extremely important for improving access to quality hospital services. All hospitals, public or private, are expected to change the level and/or composition of production due to payment system reforms. This paper is an attempt to understand the responses of public hospitals in Thailand due to the introduction of DRG-based payments.

Hodgkin and McGuire (1994) showed the model of hospitals' volume and intensity response to payment change. The following are the basic equations of the model. The objective or utility function of hospital depends on profit or net revenue (π) and service intensity (I) given for their patients.

$$U = U(\pi, I) \quad (1.1)$$

$$\pi = R + Y - TC \quad (1.2)$$

$$R = pX \quad (1.3)$$

$$p = \alpha + \beta c \quad (1.4)$$

$$TC = cX \quad (1.5)$$

$$c = c(I),\ c' > 0 \quad (1.6)$$

$$X = X(I),\ X' > 0 \quad (1.7)$$

Net revenue (π) is the sum of patient revenues (R) and outside income (Y) less total costs (TC). Revenues are the product of the volume of admissions (X) and the price per admission (p). The price (p) is set as the sum of a fixed per-case payment (α) plus a share of actual cost (β). The family of payment systems given by equation $p = \alpha+\beta c$ includes prospective payment ($\alpha>0, \beta=0$) and cost-based reimbursement ($\alpha=0, \beta=1$), and can be used to represent mixed systems such as payment under Tax Equity and Fiscal Responsibility Act (TEFRA) ($\alpha>0, \beta>0$). Cost per discharge (c) is an increasing function of intensity. As indicated in Equation (1.7), intensity also could positively affect the volume of discharges because an increase in intensity attracts more patients to come.

Prospective Payment Advisory Commission (ProPAC) defined the service intensity as the number, variety and complexity of patient care resources or intermediate outputs employed in providing a patient care service. (ProPAC cited in Hodgkin and McGuire, 1994) Hodgkin and McGuire also defined that service intensity could be the number of medical services per admission including drugs, surgical procedure, x-ray and laboratory testing, technical sophistication or length of stay. Average cost per discharge is assumed to be constant with respect to changes in admission volume, varying only with intensity. If average price are adequate, it might increase the amount of treatment provided in order to increase the number of admissions because the hospital care about the quality in addition to the revenue.

Hospital service supply is characterized by an admission policy and a treatment policy. Both are affected by the payment system. (Ellis and McGuire, 1996) Treatment policy is assumed to be a function of payment system and influence the service intensity through moral hazard effect. Admission policy influences the severity of admissions through selection effect. Average severity of admissions is also a function of payment system change through the admission policy.

Ellis and McGuire (1996) described and analyzed three possible hospital responses to payment changes, namely 1) moral hazard effect of the response, i.e., when hospitals supply fewer services to a given type of patient; 2) selection effect, changing the average severity of patients admitted; 3) practice-style effect, i.e., changes in the share of patients treated in all hospitals in a market area.

The moral hazard effect of a payment system is the incentive to reduce care per episode to avoid financial losses from supply-side cost sharing. The moral hazard effect is always negative, and depends on the share of costs at the margin paid by the hospital. It does not depend on the overall profitability of the payment system or the level of payment in relation to cost. (Hodgkin and McGuire, 1994)

The moral hazard effect occurs when hospital respond to changes in payment incentives by changing the level of services per discharges for a given severity of admissions. It consisted of two components consisting of the marginal reimbursement incentives and the average reimbursement incentives. (Gilman, 2000) For the marginal payment incentive, the hospital may reduce the intensity of services to avoid covering a higher share of costs incurred. For the other one, average payment incentive, the hospital may lower the intensity to avoid getting negative net revenues or discourage the admission of unprofitable patients. (Cutler, 1995)

The selection effect occurs when hospital respond to changes in payment incentives by changing the average severity of patients in admission policy independent from any changes in treatment policy (Newhouse, 1989). Newhouse confirmed a selection effect from the findings that PPS inpatients began to appear in public hospitals that are last-resort hospitals.

However, when receiving a per episode payment, hospitals would have an incentive to discharge the patients, but rapid re-admissions resulted in no change in total inpatient days. (Norton et al., 2002)

In most studies the impact of Diagnosis related Group (DRG)-based prospective payment system on hospital resource use pay attention to the impact on treatment policy (the moral hazard effect) and admission policy (selection effect). (Gilman, 2000)

In this study the service intensity response of hospitals to payment change for CSMBS patients is represented by changes in the average length of stay (LOS). The average LOS at hospital is assumed to be a function of average severity of inpatients during admission and treatment policy.

3.4.1.1 Policy context

The healthcare expenditures of CSMBS health insurance scheme has continued to increase rapidly since its inception. In response to cost escalation, Department of Comptroller General (DCG), the financier of this scheme in charge of allocating the budget for health insurance for civil servants, changed its payment system twice in recent years: 1) In 2007, the change in the method of payment to the hospitals for outpatient services from payment in advance by patients to direct disbursement from DCG in order to better track the use of medications was implemented. 2) In 2008, the change in reimbursement system from fee-for-service (FFS) to per case or DRG-based prospective payment system (DRG-based PPS). The objective of changing this payment system for inpatient services is to eliminate marginal financial incentives for the provision of unnecessary services in order to control expenditures for the CSMBS system.

Change in payment system for inpatient services from fee-for-service to DRG-based payment for CSMBS beneficiaries is to reduce hospital revenue earnings, but there is no strong evidence that the DRG-based payment rate exceeds the cost of providing services for the specific DRGs if the pre-DRG practice pattern is followed. Thus, it might lead to a decrease in service intensity and in turn the quality of inpatient services. However, improper payment change could induce adverse effects on service provision through the intensity response by reduction in service intensity.

3.4.1.2 Objectives

1) To examine the overall intensity effect of payment system change on the average LOS for Civil Servant Medical Benefit System (CSMBS) patients.
2) To decompose the overall intensity effect of payment system change on the average LOS into the moral hazard, selection and practice-style effects.

3.4.1.3 Hypothesis

Payment system change from fee-for-service payment to DRG-based payment could negatively affect service intensity in term of the average length of stay. This change resembles change in payment from marginal payment incentives (fee-for-service or per diem payment) to average payment incentives (per episode/case payment) that could affect the intensity of inpatient services.

Such change in payment for CSMBS inpatient services could induce the moral hazard effect and selection effects due to reduced revenue earnings. It might reduce the length of stay, so the expected sign of payment change variable is negative.

3.4.1.4 Model specification and estimation

The step of empirical identification of those effects from payment system change that comes both from variation over time and across hospitals are as follows:

1) Estimating the overall effect on the average LOS of payment system change

In this study, we used Ellis and McGuire's model to decompose the overall effect of payment system change on the average LOS (ALOS). This model is used within a general model of hospital supply characterized by an admission and a treatment policy. Unfortunately, both elements of behavior and the severity of inpatients cannot be observed in the data, so we relate the observables to their underlying elements as follows.

$$N_j = N_j(A_j(R), T_j(R))$$

$$V_j = V_j(A_j(R))$$

$$LOS_j = L_j(V_j, T_j(R))$$

where

$N_j = the\ number\ of\ inpatient\ cases\ at\ hospital\ j$

$V_j = average\ severity\ of\ inpatient\ at\ hospital\ j$

$LOS_j = average\ length\ of\ stay\ at\ hospital\ j$

$R = reimbursement\ change$

The average length of stay across all hospitals, denoted by ALOS, is

$$ALOS = \sum_j S_j LOS_j$$

where

$S_j = hospital\ j's\ share\ of\ length\ of\ stay$

$LOS_j = average\ length\ of\ stay\ of\ hospital\ j$

The overall effect of payment system change on the average length of stay (ALOS) can be directly estimated by ***dALOS/dR***.

Based on those equations above, this overall effect can be decomposed into three components namely the moral hazard, selection and practice-style effects as equation below.

$$\frac{dALOS}{dR} = \left[\sum_j S_j \frac{\partial LOS_j}{\partial T_j}\frac{\partial T_j}{\partial R}\right] + \left[\sum_j S_j \frac{\partial LOS_j}{\partial V_j}\frac{\partial V_j}{\partial R}\right] + \left[\sum_j LOS_j \frac{\partial S_j}{\partial R}\right]$$

(moral hazard) (selection) (practice-style)

The moral hazard effect is the change in LOS due to the change in treatment policy, holding patient severity constant. This effect is estimated econometrically to be described below and weighted by the share of inpatient admission to determine the contribution to the total change in the ALOS.

By definition, there are no practice-style effects within a hospital and the practice-style effect can be directly estimated because LOS_j and $\partial S_j/\partial R$ are observable in that $\partial S_j/\partial R$ is the change in share of inpatients treated at hospital j due to the effect of the payment system change on j's and non-j hospital's admissions.

Lastly, the selection effect at each hospital can be estimated by the difference in pre- and post-LOS at that hospital after correcting for the moral hazard effect. The residuals after subtracting those effects from the overall effect on ALOS could be a general shift in the severity of inpatients or attributable to interaction terms of those effects.

2) Estimating the moral hazard effect of change in the average LOS

We employ econometric model at the hospital level to estimate moral hazard effect of payment system and use the average length of stay of each hospital as the proxy for the service intensity devoted to the patients on average by hospital i at time t. This average length of stay is assumed to be a function of yearly time trend, the case mix index, the change in reimbursement, hospital individual characteristics, and an error term.

Yearly time trend represents the possibility of changes in hospital style of practice over time period for the reasons other than payment system change.

Case mix index represents the complexity of treatments provided to inpatients based on patient severity and difference in diagnosis-related patient groups.

The change in reimbursement is dummy variable that measure the pure moral hazard effect on the length of stay and we allow the effect of reimbursement change to vary by type of hospital, namely regional, general and community hospitals.

Hospitals often have own individual clinical style of practice due to difference in the number and specialty of physicians and facilities, the goals and methods of treatment, rather than other characteristics that play a role in explaining variation in the length of stay such as quality of service, managerial ability and et cetera. Unfortunately, hospital individual characteristics cannot be observable.

The model specification used is shown as described below.

$$avloscs_{it} = \beta_0 + \beta_1 ytrend + \beta_2 adjrwuc + \delta_{21} h21 * s2008 + \delta_{22} h22 * s2008 + \delta_{23} h23 * s2008 + \alpha_i + \varepsilon_{it}$$

where

$\mathbf{avloscs_{it}}$ denotes the average length of stay (LOS) of CSMBS patients

ytrend denotes time to estimate yearly time trend, where time is from 1 to 6 (Year 2004 to Year 2010)

CMI denotes the complexity level of each predetermined DRG

h21, h22, h23 are dummy variables which take on a value of one representing regional, general and community hospitals respectively, and zero otherwise s2008 denotes a dummy variable that takes on a value of one representing payment change for inpatient admissions in 2008, and zero otherwise

α_i denotes hospital time-constant unobserved effects

ε denotes stochastic disturbance

The variable CMI is used to control for patient severity and differences in diagnosis-related disease groups that affect the average length of stays.

The unknown parameters namely δ_{11}, δ_{12} and δ_{13} measure the pure moral hazard effect of the payment system on the change in the average length of stay for regional, general and community hospital, holding hospital characteristics constant.

Another econometric problem is that the unobservable individual hospital specific effect may be correlated with observed variables and affect the average LOS. We address this problem by using a hospital-level fixed effect model to control for the unobserved individual hospital characteristics.

3) Estimating the selection and practice-style effects

The selection effect at each hospital can be estimated by the difference in average LOS between pre- and post-period at that hospital after correcting for the moral hazard effect.

The practice-style effect can be directly estimated from the final set of bracket $\left[\sum_j LOS_j \frac{\partial s_j}{\partial R}\right]$ in the formula of the total derivative of the payment system change on average length of stay as specified above.

3.4.2 Volume response

Topic #2: Volume Response of Thai Public Hospitals to the Introduction of DRG-based Payment System

A better understanding of how hospitals react to changes in reimbursement or payment mechanism is extremely important for improving access to quality hospital services. All hospitals, public or private, are expected to change the level and/or composition of production due to payment system reforms. This paper is an attempt to understand the responses of public hospitals in Thailand due to the introduction of DRG-based payments.

Hodgkin and McGuire (1994) showed the model of hospitals' volume and intensity response to payment change. The objective or utility function of hospital depends on profit or net revenue (π) and service intensity (I) given for their patients.

Hodgkin and McGuire (1994) proposed that the volume effect of a payment system happens through the effect of payment mechanism on incentives to attract/discourage admissions of various types of patients. The degree of incentive to attract or discourage certain types of patients depends on price/cost margin associated with the patient-type and/or medical conditions. Incentive to attract a patient type for admission will be higher if reimbursement or price exceeds the cost of providing the service package. When the price is less than cost, hospitals will tend to discourage admissions to improve their financial margin. Consistent with this expected behavior, they observed that the number of discharges at PPS (Prospective Payment System) facilities decreased, and that the market share of Medicare discharges at hospitals not paid by PPS increased.

Newhouse (1989) proposed the problem of access to care that patients may face after PPS was implemented. The predictably high-cost patients within DRG such as the more severely ill patients are less likely to admit. This process is referred to as dumping and its opposite as skimming. The more general term “selection” was used to refer to both dumping and skimming. The certain individual patients, who are identified during the course of the stay as likely to reduce the hospital’s operating margin, may be transferred from that hospital especially the last-resort hospital to other hospitals elsewhere because the reimbursement for the hospital services will not cover the costs incurred in treating those patients and then get financial loss.

Hadley, Zuckerman, and Feder (1989) investigated the role of fiscal pressure index in determining hospitals’ response to PPS incentives using hospital-level data. Fiscal pressure index is defined as an estimate of each hospital’s operating margin on Medicare inpatients if it did not change costs or volume from the previous year. They found that the least pressured hospitals have greatest decline in discharges (14.1%) than the most pressured hospitals (10.8%). Hadley et al. described that Medicare discharges were profitable in the sense of making a contribution to overhead cost or have positive contribution margin in which highly pressured hospitals needed the most and therefore they were less willing to transfer Medicare patients to their outpatient clinics, as the low-pressure hospitals were doing.

Dranove (1987) discussed about hospital admission decision that it depends on what they know about each individual patient’s case mix. If hospitals cannot predict individual patient costs upon admission, then they will compare the mean cost of treatment to the DRG price and admit either all or no patients in that DRG. If hospitals can predict individual costs, then in the short run they will selectively admit only those patients for whom the DRG price exceeds expected marginal cost. In the long run, however, hospitals must decide whether to maintain the staffing and technical expertise necessary to treat any patients within that DRG. They will once again base this decision on a comparison of the price and the mean costs of treating all patients within that DRG. There is some evidence that hospitals can predict 10-20% of the variation in hospital costs on the basis of characteristics observable upon admission, such as age and medical history.

3.4.2.1 Policy context

Health Insurance System for CSMBS beneficiaries

The healthcare expenditures of CSMBS insurance scheme has continued to increased rapidly since its inception. In response to cost escalation, the scheme changed its payment system twice in recent years: 1) In 2007 Department of Comptroller General, the entity in change of arranging funding for health insurance of civil servants, changed the method of payment for CSMBS outpatient services from reimbursement to disbursement in order to better track the use of medications. 2) In 2008, change in payment system from fee-for-service (FFS) to DRG-based payment for CSMBS inpatient services. The objective of changing the payment mechanism for inpatient services is to eliminate marginal financial incentives for the provision of unnecessary services in order to control expenditures for the CSMBS system.

Change in payment system from fee-for-service to DRG-based payment for CSMBS inpatients is likely to reduce hospital earnings, but it is not clear whether the DRG-based payment rate exceeds the cost of providing services for the specific DRGs if the pre-DRG practice pattern is followed. Thus, the volume effect of the change in payment system for CSMBS inpatients could be positive or negative depending upon the financial margin of the DRGs. It may lead to a decrease in the quantity of admissions and a shift from inpatient to outpatient services in an attempt to reduce cost. However, one year prior to the change in payment mechanism for inpatient services, the CSMBS funders (Department of Comptroller) changed the payment system for outpatient services as well, changing it from reimbursement to patients to direct disbursement to hospitals in order to control improper drug use. Therefore, an increase in the number of CSMBS outpatient services may have been affected by both the 2007 reform and 2008 changes in hospital reimbursement system.

Health care delivery network

Within hospital service network under the Office of Permanent Secretary (OPS) of Ministry of Public Health (MoPH), there are three main types of hospitals in ascending order namely 1) community hospitals responsible in primary and secondary medical service provision for the people in certain catchment area, 2) general hospitals responsible in specialized secondary medical service provision for people in the provincial area as the last-resort hospitals in that province, 3) regional hospital responsible for highly specialized tertiary medical service provision for people in the sub-region area consisting of 4-8 provinces as the last resort hospitals in that area.

Outpatient services

Different payment methods were used for different insurance schemes. Under CSMBS scheme before 2007 outpatient services were paid for to the hospitals by patients and they got money back later. For UCS scheme, the hospitals are funded by NHSO according to the number of beneficiaries in the catchment area and the beneficiaries could not select the hospitals for providing the services. For SSS scheme, the hospitals are paid by funding agency under Ministry of Labor according to the number of enrollees.

After change in payment for the CSMBS outpatient services the patient don't have to pay first, it leads to increased demand for CSMBS outpatient services and competing with the UCS and SSS ones. The hospitals have incentives to provide the CSMBS outpatient services for revenue earning, otherwise they incur more expenses from CSMBS and SSS outpatient service provision.

Inpatient services

Focusing on an inpatient services, there are also different payment methods among three main insurance schemes. Under the biggest health insurance fund known as universal coverage scheme (UCS), Thai public hospitals get paid for inpatient services from NHSO according to DRG-based relative weights.

Under civil servant medical benefit package scheme (CSMBS), before 2008 Department of Comptroller General paid the hospitals through fee-for-service payment. The hospitals had incentives to provide more inpatient services and stays than usual. Thus, the hospital expenditures for civil servants were continuously rising and uncontrolled. Later, in 2008 the DRG-based payment system for CSMBS inpatient services was introduced to control the hospital care costs. Thus, CSMBS payment is less generous for severe or high degree of relative weight inpatients.

Under social security scheme (SSS), the third scheme, the hospitals was funded for comprehensive hospital services through capitation-based payment including outpatient and inpatient services. However, high cost inpatient cares was extra paid for using DRG-based payment.

In addition, payment rates for inpatients among those insurance schemes were different. The hospitals earned 9,000 baht per unit of relative weights for UCS patients, but 12,000 baht for CSMBS patients. However, some certain services like cancer treatment, and et cetera for SSS patients was paid for 15,000 baht per unit of relative weights.

From mentioned above, the inpatient admissions with high relative weights might be shifted to other hospitals, those with low relative weights was selected instead. Accordingly, it is hypothesized that after 2008 public hospitals would provide inpatient services differently from before. In addition, the hospitals would provide more low relative weight DRG inpatients and shift high relative weight DRG inpatients to other hospitals.

3.4.2.2 Objectives

1) To examine the admission decision on service provision (change in hospital utilization) due to changes in payment system for Civil Servant Medical Benefit Scheme (CSMBS) patients.

2) To examine the shift from inpatient service to outpatient care for less severe patients.

3) To examine the transfer behavior due to change in payment system

3.4.2.3 Hypothesis

1) The proportion of CSMBS cases out of total admissions in the hospitals and the admission rates for CSMBS patients are expected to decrease due to changes in payment mechanism.
2) The payment system reforms are expected to shift less severe inpatients to outpatients in order to increase the revenue for the hospital.
3) The referred-out rate of CSMBS patients is expected to increase.

In this analysis, we will be examining the volume effects of changes in payment mechanism by analyzing how the quantity of CSMBS outpatient and inpatient services change after change to DRG-based payment. The empirical models are defined below and analyzed by using the hospital-level fixed effect model to control for the unobserved individual hospital characteristics.

3.4.2.4 Material and Method

The study was designed as pre-post analysis and panel data regression was employed. Two estimation method were conducted as follows:

1) Conventional method (Pre- and Post-period analysis without comparison group)
2) Difference-in-Difference method (with comparison group)

In the second method, before estimating the effect of the payment system change for CSMBS on service provision for CSMBS patients, it needs to know whether CSMBS payment system change have any effect on other insurance groups (SSS & UCS).

3.4.2.4.1 Model specification

Conventional analysis

The proportion of inpatient discharges out of total inpatients for UCS and SSS groups

$$pipvcs_{it} = \beta_0 + \beta_1 ytrend + \beta_2 bocr + \beta_3 adjrwcs + \delta_{21} h21 * s2008 + \delta_{22} h22 * s2008 + \delta_{23} h23 * s2008 + \alpha_i + \varepsilon_{it}$$

The admission rate for inpatients for UCS and SSS groups

$$admrcs_{it} = \beta_0 + \beta_1 ytrend + \beta_2 bocr + \delta_{21} h21 * s2008 + \delta_{22} h22 * s2008 + \delta_{23} h23 * s2008 + \alpha_i + \varepsilon_{it}$$

The proportion of outpatient visits out of total ones for UCS and SSS groups

$$popvcs_{it} = \beta_0 + \beta_1 ytrend + \delta_{11} h21 * s2007 + \delta_{12} h22 * s2007 + \delta_{13} h23 * s2007 + \delta_{21} h21 * s2008 + \delta_{22} h22 * s2008 + \delta_{23} h23 * s2008 + \alpha_i + \varepsilon_{it}$$

The rate of referred-out patients out of total discharges for UCS and SSS groups

$$refoutcsr_{it} = \beta_0 + \beta_1 ytrend + \beta_2 adjrwcs + \delta_{21} h21 * s2008 + \delta_{22} h22 * s2008 + \delta_{23} h23 * s2008 + \alpha_i + \varepsilon_{it}$$

where

$pipvcs_{it}$ denote the proportion of inpatient discharges out of total ones for CSMBS group

$admrcs_{it}$ denote the admission rate for CSMBS group

$popvcs_{it}$, denote the proportion of outpatient visits out of total outpatient visits for CSMBS group

$refoutcsr_{it}$ denote the rate of referred-out patients out of total inpatient cases for CSMBS group

ytrend denotes yearly time trend, where take on value from 1 to 6 (Year 2005 to 2010)

bocr denotes bed occupation rate of individual hospital

adjrwcs denote the average adjusted relative weights (RW) for CSMBS group

h21, h22, h23 denote dummy variables which take on a value of one representing regional, general and community hospitals respectively, and zero otherwise

s2007 denotes a dummy variable that takes on a value of one representing year of commencing OP disbursement in 2007 and after, and zero otherwise

s2008 denotes a dummy variable that takes on a value of one representing year of payment change for inpatient admissions in 2008 and after, and zero otherwise

α_i denotes hospital time-constant unobserved effects

ε denotes stochastic disturbance (the error term)

Difference-in-Difference method

1) To assess the cross-group effect of payment change towards other payment sources (UCS and SSS), the following models were used according to the dependent variables.

The proportion of inpatient discharges out of total inpatients for UCS and SSS groups

$$pipvuc_{it} = \beta_0 + \beta_1 ytrend + \beta_2 bocr + \beta_3 adjrwuc + \delta_{21} h21 * s2008 + \delta_{22} h22 * s2008 + \delta_{23} h23 * s2008 + \alpha_i + \varepsilon_{it}$$

$$pipvss_{it} = \beta_0 + \beta_1 ytrend + \beta_2 bocr + \beta_3 adjrwss + \delta_{21} h21 * s2008 + \delta_{22} h22 * s2008 + \delta_{23} h23 * s2008 + \alpha_i + \varepsilon_{it}$$

The admission rate for inpatients for UCS and SSS groups

$$admruc_{it} = \beta_0 + \beta_1 ytrend + \beta_2 bocr + \delta_{21} h21 * s2008 + \delta_{22} h22 * s2008 + \delta_{23} h23 * s2008 + \alpha_i + \varepsilon_{it}$$

$$admrss_{it} = \beta_0 + \beta_1 ytrend + \beta_2 bocr + \delta_{21} h21 * s2008 + \delta_{22} h22 * s2008 + \delta_{23} h23 * s2008 + \alpha_i + \varepsilon_{it}$$

The proportion of outpatient visits out of total ones for UCS and SSS groups

$$popvuc_{it} = \beta_0 + \beta_1 ytrend + \delta_{11} h21 * s2007 + \delta_{12} h22 * s2007 + \delta_{13} h23 * s2007 + \delta_{21} h21 * s2008 + \delta_{22} h22 * s2008 + \delta_{23} h23 * s2008 + \alpha_i + \varepsilon_{it}$$

$$popvss_{it} = \beta_0 + \beta_1 ytrend + \delta_{11} h21 * s2007 + \delta_{12} h22 * s2007 + \delta_{13} h23 * s2007 + \delta_{21} h21 * s2008 + \delta_{22} h22 * s2008 + \delta_{23} h23 * s2008 + \alpha_i + \varepsilon_{it}$$

The rate of referred-out patients out of total discharges for UCS and SSS groups

$$refoutucr_{it} = \beta_0 + \beta_1 ytrend + \beta_2 adjrwuc + \delta_{21} h21 * s2008 + \delta_{22} h22 * s2008 + \delta_{23} h23 * s2008 + \alpha_i + \varepsilon_{it}$$

$$refoutssr_{it} = \beta_0 + \beta_1 ytrend + \beta_2 adjrwss + \delta_{21} h21 * s2008 + \delta_{22} h22 * s2008 + \delta_{23} h23 * s2008 + \alpha_i + \varepsilon_{it}$$

where

$pipvuc_{it}, pipvss_{it}$ denote the proportion of inpatient discharges out of total ones for UCS and SSS groups

$admruc_{it}, admrss_{it}$ denote the admission rate for UCS and SSS groups

$popvuc_{it}, popvss_{it}$ denote the proportion of outpatient visits out of total outpatient visits for UCS and SSS groups

$refoutucr_{it}, refoutssr_{it}$ denote the rate of referred-out patients out of total inpatient cases for UCS and SSS groups

ytrend denotes yearly time trend, where take on value from 1 to 6 (Year 2005 to 2010)

bocr denotes bed occupation rate of individual hospital

adjrwuc, adjrwss denote the average adjusted relative weights (RW) for UCS and SSS groups

h21, h22, h23 denote dummy variables which take on a value of one representing regional, general and community hospitals respectively, and zero otherwise

s2007 denotes a dummy variable that takes on a value of one representing year of commencing OP disbursement in 2007 and after, and zero otherwise

s2008 denotes a dummy variable that takes on a value of one representing year of payment change for inpatient admissions in 2008 and after, and zero otherwise

$\boldsymbol{\alpha_i}$ denotes hospital time-constant unobserved effects

$\boldsymbol{\varepsilon}$ denotes stochastic disturbance (the error term)

2) To assess the effect of CSMBS payment change of inpatient admissions on service provisional behavior for CSMBS beneficiaries

Due to difference-in-difference estimation was employed to identify the effects of payment change on the volume of service provision CSMBS as a following model. The above models that assess the cross-effects were applied and three more variables regarding pre-post analysis using treatment and comparison group was added. In this case, CSMBS scheme serves as treatment group, while both UCS or SSS group are comparison groups.

$$y_{it} = \beta_0 + \beta_1 period + \beta_2 treatment + \beta_3 (period * treatment) + \boldsymbol{x}_{it} + \alpha_i + \varepsilon_{it}$$

where

$\boldsymbol{y_{it}}$ is dependent or LHS variable representing hospital service output for CSMBS beneficiaries

period is dummy variable that take on a value of one if year is after 2007 and zero otherwise

treatment is dummy variable that take on a value of one if payment source are CSMBS insurance scheme and zero otherwise

period*treatment is interaction variable between period and treatment variable => β_3 is the Difference-in-Difference estimator representing the effect of CSMBS payment change on the average length of stay compared with comparison group (either UCS or SSS group)

$\boldsymbol{x}_{it}$ is a vector of explanatory variables depending on dependent variables y_{it} in the same way as above equations

3.4.2.4.2 Estimation procedure

Due to unobserved individual characteristics or effects, for example, managerial ability, service quality and et cetera and because the explanatory variables generally depend on those unobserved effects, those unobserved effects need to be controlled for. In addition, it is likely that the correlation between output in current year and explanatory variables in other year will exist. It is proved by Breusch and Pagan Lagrangian multiplier test and Hausman's test that individual specific effect and correlation between that individual effect and the explanatory variables exist. Thus, fixed-effects panel data regression is to be proper technique to control for unobserved effect and that correlation and to estimate the effect of payment policy change on service provision behavior. For statistical inference, the assumptions under the fixed-effects panel data regression need to hold.

Fixed effects (FE) assumptions (Wooldridge, 2002)

Assumption I:

The first assumption is strict exogeneity of the explanatory variables conditional on unobserved effect. It can be stated in terms the error term as

$$E(u_{it}|\boldsymbol{x}_{i1}, \boldsymbol{x}_{i2}, \ldots, \boldsymbol{x}_{iT}, \alpha_i) = 0$$

It implies that the explanatory variables in each time period are uncorrelated with the error term in each time period as the following conditional expectation, called the zero correlation assumption.

$$E(x_{is}' u_{it}) = 0, \quad s, t = 1,2, \ldots, T$$

In addition, it also can be stated in terms of the LHS variables as

$$E(y_{it}|\boldsymbol{x}_{i1}, \boldsymbol{x}_{i2}, \ldots, \boldsymbol{x}_{iT}, \alpha_i) = \boldsymbol{x}_{it}\boldsymbol{\beta} + c_i$$

It means that, once $\boldsymbol{x}_{it}$ and c_i are controlled for, $\boldsymbol{x}_{is}$ have no partial effect on y_{it} for s ≠ t or there are no omitted lagged effects of explanatory variables.

Based on this assumption, it can be shown that FE estimators be consistent.

Assumption II

This rank condition is on the matrix of time-demeaned explanatory variables, called the no multicollinearity assumption and can be stated as

$$rank(\textstyle\sum_{t=1}^{T} E(\ddot{\boldsymbol{x}}_{it}' \ddot{\boldsymbol{x}}_{it})) = rank[E(\ddot{\mathbf{X}}_i' \ddot{\mathbf{X}}_i)] = K$$

Based on this assumption, $\hat{\beta}_{FE}$ can be shown to be unbiased conditional on $\boldsymbol{X}$. The next assumption ensures that FE is efficient.

Assumption III

$$E(\boldsymbol{u}_i \boldsymbol{u}_i' | \boldsymbol{x}_i, c_i) = \sigma_u^2 \mathbf{I}_T$$

This assumption implies that the error term u_{it} has a constant variance across t (homoscedasticity) and are serially uncorrelated. However, FE assumptions allow arbitrary correlation between c_i and $\boldsymbol{x}_{it}$ for all t.

In the case of this application, the balanced panel data model is likely that the error term in the same cross section is not independent or serially correlated, for instance, average adjusted relative weight this year is strongly related to that of next year ($E(u_{it}, u_{is}) \neq 0$). When constructing standard errors, it needs to take serial correlation into account by thinking of this as analogous to the heteroskedasticity problem. In addition, heteroskedasticity in the error terms is always a potential problem. It might have different variances in the error term among three types of hospitals. Breusch and Pagan's test statistic can be used to test for heteroskedasticity. For serial correlation in fixed effects estimation, it causes minor complication especially for short panel period. However, the robust variance matrix is valid in any case. In case of homoscedasticity and no serial correlation, the robust variance estimation does not affect the standard errors. (Wooldridge, 2002: 270, 276)

3.4.3 Hospital cost behavior and response

Topic #3: The effects of CSMBS DRG-based Payment change (Reimbursement Change) on Hospital Cost Behavior

3.4.3.1 Policy context

In an earlier period when hospitals were reimbursed on a retrospective cost basis, most of the available studies suggest that in relatively more competitive markets, hospitals used and invests more capital and equipment, perform more surgical procedures, provide significantly more expensive medical care and incur higher costs than hospitals in monopolistic markets. (Noether, 1988; Robinson and Luft, 1985)

In the past, competition among hospitals was based upon non-price considerations in terms of quality of care, service intensity and resource availability which tended to raise costs (Fournier and Mitchell, 1992).

Zwanziger and Melnick (1988) analyzed hospital cost data from California before and after the enactment of selective contracting legislation in 1982 and Medicare's prospective payment system in 1983. Their findings show that hospitals competed on the basis of quality and amenities prior to the adoption of this legislation, but afterwards emphasized price competition.

Since the recent changes in the reimbursement system appear to have altered hospital behavior, further investigation of this issue is clearly warranted (Robinson and Luft, 1988).

Policy questions

The question is how the hospital cost behavior is and they respond to if there is change in the reimbursement system while the hospitals cannot set prices for their own medical services?

Behavioral assumptions

Public hospitals cannot determine their overall output levels at which they satisfy the first order condition of profit maximization that marginal cost equal to marginal revenue, although the doctors could partly induce demand for some particular medical procedures, for example, caesarean section. They only respond to the demand for medical care in their catchment area. In addition, they cannot determine the ratio of relevant inputs as price ratio in order to minimize the hospital cost. This is because they must pay the input factor under the price regulation from central government.

However, the hospital can use the revenue surplus for any purposes, thus they have incentive to minimize hospital costs for maximum revenue surplus and tend to reduce the unnecessary expenses to save money.

3.4.3.2 Objectives

1) To examine cost-minimization behavior through hospital cost function.

2) To determine the effects of changes in reimbursement for Civil Servant Medical Benefit Scheme (CSMBS) inpatient services on hospital costs

3.4.3.3 Hypothesis

1) Thai public hospital behave on short-run cost minimization basis
2) There are negative effects of reimbursement change on hospital cost of CSMBS inpatient services in the time periods after change in reimbursement policy.

3.4.3.4 Material and Method

Short-run multiproduct variable cost function is employed to examine the hospital cost utilization for hospital services, cost-minimization behavior of hospitals, and the effect of reimbursement change on hospital costs for inpatient service by source of payment. The functional form used to estimate the short-run multiproduct cost function is transcendental logarithmic form (translog) due to no limitation of *priori* restriction and corresponding with available data.

3.4.3.4.1 Analytical framework

The process of hospital cost analysis consisted of two steps. The first is to construct well-behaved variable cost functions for two hospital samples. The second is to apply the constructed hospital cost function to examine cost-minimization behavior and determine the effects of hospital cost response to change in reimbursement policy.

3.4.3.4.2 Model specification

In the first step, based on the literature review of empirical studies of hospital cost analysis, short-run transcendental logarithmic (translog) variable cost function with input cost share equations was employed to evaluate hospital cost behavior and response.

The system of econometric equations is as follows:

$$\begin{aligned} ln\, C_{it}^{v} = \alpha_0 &+ \sum_{r} \alpha_r\, lnY_{rit} + {}^{1}/_{2} \sum_{r}\sum_{s} \alpha_{rs}\, lnY_{rit} lnY_{sit} + \sum_{m} \beta_m lnP_{mit} \\ &+ {}^{1}/_{2} \sum_{m}\sum_{n} \beta_{mn}\, P_{mit}\, P_{nit} + \gamma_K\, lnK_{it} + \gamma_{KK}\,(lnK_{it})^2 + \phi_A lnA_{it} \\ &+ \phi_{AA}\,(lnA_{it})^2 + \sum_{r}\sum_{m} \delta_{rm}\, lnY_{rit} P_{mit} + \sum_{r} \psi_r\, lnY_{rit} lnK_{it} \\ &+ \sum_{r} \theta_r\, lnY_{rit} lnA_{it} + \sum_{m} \epsilon_i\, P_{mit} lnK_{it} \\ &+ \sum_{m} \pi_i\, lnP_{mit} lnA_{it} + \gamma_{KA}\, lnK_{it} lnA_{it} + +\varepsilon_{it} \end{aligned}$$

with the relevant variable input cost share equations

$$S_{mit}^{V} = \frac{\partial lnC_{it}^{v}}{\partial lnP_{mit}} = \beta_{mit} + \sum_{n} \beta_{mn} \ln P_{nit} + \sum_{r} \delta_{rm} \ln Y_{rit} + \epsilon_m\, lnK_{it} + \pi_m\, lnA_{it} + \varepsilon_{it}$$

where

C^{V} is variable hospital costs;

Y is a set of hospital outputs including OP, IP and PP visits;

P is a set of variable input prices;

K is a single measure of the fixed capital stock; and

A is the number of admitting physicians, assumed to be fixed in the short-run

ε denotes stochastic disturbance

Variable construction

The variables used in the hospital variable cost function are discussed in details based on the models.

Dependent variable

Total operating costs was used as our measure of total variable cost. It includes the sum of hospital expenditures on salary and wages, compensation, and other personnel expenses, drug, medical supplies, office materials, medical device and instrument of value less than 5,000 baht, utilities, repairs and maintenance, and other expenses including transportation and communication and outsourcing expenses, but excluding the depreciation and amortization expenses.

The distribution of total operating costs is highly skewed. A small number of hospitals have very much operating expenses, so that the natural log of these expenses was used as dependent variable in the cost function.

Independent variables

Hospital output variables

Due to no data on specialty-categorized hospital outputs available, the number of outpatient visits, and the health promotion services, and case mix index-adjusted inpatient discharges are used as three measures of hospital outputs. Health promotion services include health services for antenatal care, well child care, family planning and other preventive services. The hospital's DRG case mix index for three main payer categories such as CSMBS, UCS and SSS from year 2007 to 2010 is used. The DRG case mix index is intended to represent the direct cost consequences of hospital's case mix measures.

Input price variables

Unfortunately, the hospital price index of labors, drugs and medical supplies and others in Thailand have not yet been established. However, in order to construct a well-behaved hospital cost function based on neoclassical production theory, the input prices is necessary to be incorporated in the hospital cost function. For this limitation to be addressed, two approaches could be done. The first is to create the indices to be a proxy of those prices The other is to assume either that these prices are invariant across the hospitals in their sample, or that variations in such costs are adequately controlled for by some variables. Because the hospital personnel mostly are civil servant and the labor wage rates are controlled by central government, thus the labor input price is assumed to be the same in all hospitals and have no spatial variation. In addition, non-labor inputs namely medical supplies, office materials, and utilities are not likely to vary regionally and are also assumed to be not spatially different. Thus, these prices serve as the implicit numeraire for the linear homogeneity restriction imposed, which in turn allows the parameters corresponding to this input category to be known from imposing the linear homogeneity restriction. In this study, both approaches were chosen and used at first. Three variable input price indices for labor, drug and medical supplies, and other input prices were calculated.

Fixed input variables

In this study, the number of beds and admitting physicians are used as the proxy of capital inputs. It is because registered database on physicians by specialty, equipment and buildings have not been established.

Payer mix

For each hospital to be analyzed, the percent of total outpatient visits, promotion and prevention visits and inpatient discharges adjusted with case mix index by the following payer categories was calculated and used: Universal Coverage Scheme (UCS), Social Security Scheme (SSS), and Civil Servant Medical Benefit Scheme (CSMBS). However, the values of case mix index by source of payment were available for year 2007 to 2010. The log transform of these variables was used.

Interaction terms

First order interaction between outputs, variable input prices, fixed inputs and yearly time trend were also included as suggested by standard translog cost functions.

Control and other variables

Yearly time trend variable is incorporated into the hospital cost functions to account for technical change.

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A summary of the variable definitions for the sample as a whole are presented in table 4.

Table 4 Model variables and definitions for hospital cost function

Variable name	Definition
Dependent variable	
lntvc53bms	Total operating costs per year excluding depreciation and amortization costs
Hospital outputs	
Lntopvms	Total number of outpatient visits per year
Lntppvms	Total number of promotion and prevention visits per year
Lntadjrwms	Total number of inpatient discharges per year multiplied by hospital case mix index
Variable input prices	
lntlc53bprcms	Labor price index calculated by total labor costs divided by total number of personnel
lntnlc53bprcms	Price index for non-labor expenses calculated by total non-labor costs excluding depreciation and amortization costs divided by the number of outpatient visits, promotion and prevention services and inpatient discharges
lndms53bprcms	Price index for drug and medical supplies expenses calculated by total drug and medical supplies cost divided by the number of outpatient visits, promotion and prevention services and inpatient discharges
lnotopc53bprcms	Price index for other expenses calculated by total other operating costs divided by the number of outpatient visits, promotion and prevention services and inpatient discharges
Fixed Inputs	
Lnbedms	The number of beds
lndoctorms	The number of doctors

Table 4 Model variables and definitions for hospital cost function (cont')

Variable name	Definition
Policy change variable (inpatient service index interacted with year dummies by source of payment)	
lnopvcspms*fyr	Proportion of CSMBS outpatient visits interacted with yearly dummy variables
lnopvucpms*fyr	Proportion of UCS outpatient visits interacted with yearly dummy variables
lnopvsspms*fyr	Proportion of SSS outpatient visits interacted with yearly dummy variables
lnppvcspms*fyr	Proportion of CSMBS promotion and prevention visits interacted with yearly dummy variables
lnppvucpms*fyr	Proportion of UCS promotion and prevention visits interacted with yearly dummy variables
lnppvsspms*fyr	Proportion of SSS promotion and prevention visits interacted with yearly dummy variables
lntadjrwpcsms*fyr	Proportion of CSMBS inpatient discharges multiplied by their case mix index interacted with yearly dummy variables
lntadjrwpucms*fyr	Proportion of UCS inpatient discharges multiplied by their case mix index interacted with yearly dummy variables
lntadjrwpssms*fyr	Proportion of SSS inpatient discharges multiplied by their case mix index interacted with yearly dummy variables

A dependent variable and all right-hand side variables excluding dummy variables were normalized (divided by their means) prior to logarithmic transformations.

For hospital cost function to be well-behaved, it must be linearly homogeneous, continuous and non-decreasing in both outputs and factor prices, and concave in factor prices. However, four models have been tested on trial, the fourth model is the best to represent the hospital cost structure and was employed in the further step.

Later, the properties of short-run cost minimization behavior have been checked such as inequality conditions of monotonically non-decreasing in both outputs and input prices and concavity in prices. The conditions of monotonically non-increasing and concavity in fixed input have also been tested as the properties of long-term cost minimization behavior.

In the second step the well-behaved hospital cost function was utilized to test the hypothesis of whether the policy change in reimbursement for inpatient services for CSMBS beneficiaries have affected the hospital cost or not. The sign and magnitude of coefficients of the first order interaction terms between the proportion of CSMBS inpatient service index and yearly dummy variables before and after the introduction of reimbursement change for inpatient services have been examined.

3.4.3.4.3 Estimation procedure

The value of the hospital variable cost as well as the explanatory variables were normalized by their sample means and transformed into logarithmic metrics before estimation.

First step

In the first step of constructing well-behaved hospital cost function, the hospital cost model IV was estimated with two method as follows.

1) The SUR regression technique (Zellner's Seemingly Unrelated Regression)

This technique is required for the system of hospital cost function with cost share equations (Bilodeau, Crémieux, and Ouellette, 2000).

$$
\begin{aligned}
ln\, C^{v} = \alpha_0 &+ \sum_{r} \alpha_r \, lnY_r + {}^1\!/_2 \sum_{r}\sum_{s} \alpha_{rs} \, lnY_r lnY_s + \sum_{m} \beta_m lnP_m \\
&+ {}^1\!/_2 \sum_{m}\sum_{n} \beta_{mn} \, P_m \, P_n + \gamma_K \, lnK + \gamma_{KK} (lnK)^2 + \phi_A lnA \\
&+ \phi_{AA} (lnA)^2 + \sum_{r}\sum_{m} \delta_{rm} \, lnY_r P_m + \sum_{r} \psi_r \, lnY_r lnK \\
&+ \sum_{r} \theta_r \, lnY_r lnA + \sum_{m} \epsilon_m lnP_m lnK + \sum_{m} \pi_m lnP_m lnA + \gamma_{KA} lnKlnA \\
&+ \mu_t t + \mu_{tt} t^2 + \sum_{r} \mu_{rt} lnY_y t + \sum_{m} \mu_{mt} lnP_m t + \mu_{Kt} lnKt + \mu_{At} lnAt \\
&+ \varepsilon_{it}
\end{aligned}
$$

with the relevant variable input cost share equations

$$
S_m^V = \frac{\partial lnC^v}{\partial lnP_m} = \beta_m + \sum_{n} \beta_{mn} \ln P_n + \sum_{r} \delta_{rm} \ln Y_r + \epsilon_m lnK + \pi_m lnA + \mu_{mt} t + \varepsilon_{it}
$$

2) Multiple regression analysis with random-effects or fixed-effects panel-data model was employed to estimate the translog variable cost function in order to address the hospital-specific fixed effects (Zwanziger and Melnick, 1988; Gaynor and Anderson, 1995; Dor and Farley, 1996).

$$
\begin{aligned}
ln\, C_{it}^{v} = \alpha_0 &+ \sum_{r} \alpha_r \, lnY_{rit} + {}^1\!/_2 \sum_{r}\sum_{s} \alpha_{rs} \, lnY_{rit} lnY_{sit} + \sum_{m} \beta_m lnP_{mit} \\
&+ {}^1\!/_2 \sum_{m}\sum_{n} \beta_{mn} \, P_{mit} \, P_{nit} + \gamma_K \, lnK_{it} + \gamma_{KK} (lnK_{it})^2 + \phi_A lnA_{it} \\
&+ \phi_{AA} (lnA_{it})^2 + \sum_{r}\sum_{m} \delta_{rm} \, lnY_{rit} P_{mit} + \sum_{r} \psi_r \, lnY_{rit} lnK_{it} \\
&+ \sum_{r} \theta_r \, lnY_{rit} lnA_{it} + \sum_{m} \epsilon_m lnP_{mit} lnK_{it} \\
&+ \sum_{m} \pi_m lnP_{mit} lnA_{it} + \gamma_{KA} \, lnK_{it} lnA_{it} + \mu_t t + \varepsilon_{it}
\end{aligned}
$$

For this method, Breusch and Pagan test was used to confirm the existence of individual specific effect. And Hausman test is also used to test for the orthogonality of the unobserved individual effects.

However, no matter which method was employed to estimate the translog hospital variable cost function, prior restrictions on certain parameters were imposed to ensure that the equality conditions namely, continuity in both input prices and outputs and linear homogeneity (of degree one) in input prices are satisfied.

Second step

In the second step of determining the effects of reimbursement change on inpatient service costs, the interaction term variables between the proportion of inpatient services in terms of total adjusted relative weights by source of payment and yearly dummy variables were included into the well-behaved hospital cost function constructed in the first step to evaluate the hospital response on inpatient service costs to change in reimbursement policy for CSMBS beneficiaries in 2008 (Zwanziger and Melnick, 1988).

Post-estimation hypothesis testing and interpretation

After the hospital cost models were fitted, the following tests were conducted in order to examine the multiproduct cost properties.

1. Hypothesis testing for regularity conditions of well-behave cost functions
   - Concavity in input factor prices: The Hessian matrix, for example, H_{PP} is negative semidefinite with negative eigenvalues, for example, h_1^P = -0.2
   - Convexity in fixed inputs: The Hessian matrix, for example, H_{kk} is positive semidefinite with positive eigenvalues, for example, h_1^k = 0.2

2. Hypothesis testing of restriction for multiproduct function

   - Non-jointness
   - Separability
   - Homogeneity
   - Cobb-Douglas functional form

3. Statistical interpretation and inference about hospital cost minimization behavior

3.1 Short-term cost minimization behavior

3.1.1 Monotonicity of cost function (non-decreasing) in factor prices and outputs

   - Output coefficient estimates => the output elasticities of costs -> marginal costs responding to an increase in outputs
   - Input price coefficient estimates => intercepts of the cost share equations => cost shares of inputs

3.1.2 Concavity in variable input prices

3.2 Long-term cost minimization behavior

3.2.1 Monotonicity of cost function (non-increasing) in fixed inputs

3.2.2 Concavity in fixed inputs

4. Statistical interpretation and inference about the effects on hospital cost response to inpatient service

3.4.3.4.3 Data source

The data for analysis were gathered from input - output table from relevant organization such as Bureau of Health administration, Health Insurance Group under MoPH, NHSO and HSRI. Panel data on healthcare utilization and financial data ranging from 2005 to 2010 was collected and explored, but data on adjusted relative weight by three main payers are available from 2007 to 2010.

The financial data was adjusted for inflation and transformed to be 2010 baht using GDP deflators for Thailand published by World Bank.

Due to no established input price index, price index for labor, drug and medical supplies and other variable input services was calculated in form of the average amount of money per unit. Labor price index was the amount of annual labor cost divided by total number of hospital personnel. Price index for drug and medical supplies and other operating service was the amount of annual hospital costs on those corresponding categories divided by hospital weighted output mix consisting of outpatient visits, promotion and prevention visits and inpatient discharges. The inpatient discharges was weighted by factor of 14 outpatient visits for community hospitals and factor of 18 outpatient visits for general and regional hospitals.

All data for total public hospitals have been collected and verified, a number of hospitals with incomplete data were removed. The table 5 below showed the number of hospitals with complete data by hospital types for further analysis.

Table 5 The number and percentage of hospital population and sample

Hospital types	No. of population*	No. of sample	Percentage
Regional	25	16	64.0
General	70	38	54.3
Community	724	385	53.2
Total	819	439	53.6

*year 2005 as base year

Table 6 below showed the hospital characteristics about the number of beds and hospital outputs of in-sample and out-of-sample hospitals by hospital types

Table 6 Overall characteristics of in-sample and out-of-sample hospitals

Hospital types	Regional hospitals		General hospitals		Community hospitals	
Variables	In	Out	In	Out	In	Out
Bed Numbers	729	665	357	326	47	41
OPV	457478	403872	240472	202688	81825	66381
IPD	49946	41369	23359	20767	4620	3783
Total LOS	247945	239278	109223	95278	13910	11404

Note: in = in-sample out = out-of-sample

As shown in the table above, the number of beds and the number of hospital outputs of in-sample hospitals are greater than those of out-of-sample hospitals on average. Thus, the findings from in-sample hospitals could more or less represent the characteristics of out-of-sample ones.

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CHAPTER IV

RESULTS

4.1 Service intensity and Volume response

4.1.1 Overall trends of hospital service outputs

The overall trends of hospital service outputs were shown in the table 7 below.

Table 7 Overall trend data of service output variables of hospital sample

Fiscal Year	2005	2006	2007	2008	2009	2010
OPV	110801	118160	125245	131191	141718	142530
PPV	22012	34252	32633	36745	38507	43960
IPD	7801	7921	8115	8317	8496	8391
Adjusted RW	0.66	0.66	0.66	0.63	0.66	0.66
Average LOS	3.23	3.24	3.21	3.20	3.22	3.27

As table 7 shown below, in the overall picture the values of hospital outputs namely the number of outpatient visits (OPV), promotion and prevention visits (PPV) and inpatient discharges (IPD) showed increasing trends over the period from 2005 to 2010, while the average values of adjusted relative weights (Adjusted RW) and average length of stay (Average LOS) are rather constant.

In the table 8 below those variables are shown across the time period from 2005 to 2010 by health insurance schemes.

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Table 8 Trend data of service output variables of hospital sample by health insurance schemes

Fiscal Year	2005	2006	2007	2008	2009	2010
CSMBS						
OPV	14964	16287	19148	21423	22294	22325
PPV	NA	3949	4243	5629	5602	5874
IPD	826	815	801	801	789	763
Adjusted RW	NA	NA	0.64	0.70	0.74	0.74
Average LOS	3.96	3.92	3.87	3.76	3.79	3.79
UCS						
OPV	74108	79211	82914	86305	94346	95649
PPV	14433	24770	23087	25580	26566	30237
IPD	5641	5765	5891	6103	6349	6313
Adjusted RW	NA	NA	0.67	0.62	0.66	0.66
Average LOS	3.22	3.20	3.20	3.20	3.22	3.25
SSS						
OPV	6325	7870	8179	8899	9470	9967
PPV	NA	1709	1617	1625	1764	2152
IPD	315	380	377	391	397	403
Adjusted RW	NA	NA	0.52	0.53	0.56	0.58
Average LOS	2.85	2.84	2.94	2.97	2.87	2.89

As can be seen, the number of outpatient visits (OPV) and promotion and prevention visits (PPV) for all health insurance scheme have the increasing trends, while the inpatient discharges for civil servant medical benefit scheme (CSMBS) showed decreasing trend, but increasing trends for universal coverage scheme (UCS) and social security scheme (SSS). For the average adjusted relative weight (adjusted RW), the findings showed the increasing trends for CSMBS and SSS, but rather decreasing trends for UCS. For the average length of stay (average LOS), the findings showed the decreasing trends for CSMBS, but rather constant for UCS and SSS.

The average length of stay was used as proxy for service intensity to examine the effects of payment system change on change in service provision. The table 9 below showed the trends of the average length of stay by the hospital types and the sources of payment over the time period from 2005 to 2010.

Table 9 Trend data of average length of stay of hospital sample by hospital types and insurance schemes

Hospital type	2005	2006	2007	2008	2009	2010
Regional						
CSMBS	6.22	6.24	6.15	5.80	5.86	5.77
UCS	5.38	5.21	5.16	4.91	4.87	4.88
SSS	4.87	4.61	4.68	4.73	4.67	4.47
General						
CSMBS	5.93	6.10	6.57	5.85	5.78	5.81
UCS	4.62	4.61	4.64	4.52	4.51	4.58
SSS	4.08	3.98	3.98	3.97	4.34	4.01
Community						
CSMBS	3.67	3.61	3.51	3.47	3.50	3.51
UCS	2.99	2.97	2.98	2.99	3.02	3.05
SSS	2.64	2.65	2.77	2.80	2.65	2.71

As shown in the table 8 above in the overall picture the trend of the average length of stay for CSMBS is decreasing. By the hospital types there are the same decreasing trends at all types of hospitals as the overall picture, but the community hospitals has less magnitude of effects than general and regional hospitals.

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In the same time, the average length of stay for UCS at the regional hospital type over time period is the same as that of CSMBS, while they are at steady state at the general and community hospitals. In addition, those for SSS at all types of hospital are also unchanged.

The proportion of inpatient discharges, the admission rates and the proportion of outpatient visits were used to examine changes in volume response on service provision.

The table 10 below showed the trend data of the proportion of inpatient discharges by the hospital types and insurance schemes over the time period from 2005 to 2010.

Table 10 Trend data of the proportion of inpatient discharges of hospital sample by hospital types and insurance schemes

Hospital type	2005	2006	2007	2008	2009	2010
Regional						
CSMBS	0.13	0.12	0.12	0.12	0.11	0.11
UCS	0.67	0.67	0.67	0.70	0.71	0.71
SSS	0.05	0.06	0.06	0.06	0.06	0.06
General						
CSMBS	0.14	0.14	0.13	0.12	0.12	0.12
UCS	0.68	0.68	0.67	0.66	0.69	0.69
SSS	0.05	0.06	0.06	0.06	0.06	0.06
Community						
CSMBS	0.08	0.08	0.08	0.07	0.07	0.07
UCS	0.78	0.78	0.79	0.79	0.79	0.80
SSS	0.03	0.03	0.03	0.04	0.04	0.04

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As shown in the table 8 above in the overall picture the trend of the number of inpatient cases for CSMBS is decreasing, but increasing for UCS and SSS. It is the same picture for the proportion of inpatient cases at all types of hospitals. As seen, the findings showed slightly decreasing trends of the proportion of inpatient cases for CSMBS at all types of hospitals, but slightly increasing trends for UCS and SSS at all types of hospitals.

The table 11 below showed the trend data of the admission rate by the hospital types and insurance schemes over the time period from 2005 to 2010.

Table 11 Trend data of the admission rate of hospital sample by hospital types and insurance schemes

Hospital type	2005	2006	2007	2008	2009	2010
Regional						
CSMBS	0.08	0.06	0.05	0.05	0.04	0.04
UCS	0.13	0.13	0.13	0.12	0.12	0.11
SSS	0.06	0.06	0.06	0.06	0.05	0.05
General						
CSMBS	0.07	0.06	0.05	0.05	0.04	0.04
UCS	0.11	0.11	0.10	0.10	0.10	0.10
SSS	0.07	0.07	0.06	0.06	0.05	0.05
Community						
CSMBS	0.05	0.05	0.04	0.04	0.03	0.03
UCS	0.06	0.05	0.05	0.05	0.05	0.05
SSS	0.06	0.05	0.04	0.04	0.04	0.03

For the admission rates, the findings showed decreasing trends for all insurance schemes in all types of hospitals.

The table 12 below showed the trend data of the proportion of outpatient visits by the hospital types and insurance schemes over the time period from 2005 to 2010.

Table 12 Trend data of the proportion of outpatient visits of hospital sample by hospital types and insurance schemes

Hospital type	2005	2006	2007	2008	2009	2010
Regional						
CSMBS	0.20	0.20	0.24	0.26	0.25	0.24
UCS	0.54	0.53	0.53	0.54	0.54	0.56
SSS	0.08	0.10	0.09	0.09	0.10	0.10
General						
CSMBS	0.20	0.20	0.22	0.23	0.23	0.23
UCS	0.59	0.59	0.57	0.56	0.56	0.57
SSS	0.08	0.09	0.09	0.09	0.09	0.09
Community						
CSMBS	0.10	0.10	0.11	0.11	0.11	0.11
UCS	0.75	0.75	0.74	0.74	0.74	0.74
SSS	0.04	0.05	0.05	0.05	0.05	0.05

As shown in the table 8 above in the overall picture the trends of the number of outpatient visits for all health insurance schemes are increasing. It is the same picture for the proportion of outpatient visits at all types of hospitals for CSBMS. The findings showed increasing trends for CSMBS in all types of hospitals, but rather constant or decreasing trends for UCS and SSS in all types of hospitals.

The table 13 below showed the trend data of the referred-out rate of patients by the hospital types and insurance schemes over the time period from 2005 to 2010.

Table 13 Trend data of the referred-out rate of patients of hospital sample by hospital types and insurance schemes

Hospital type	2005	2006	2007	2008	2009	2010
Regional						
CSMBS	0.040	0.039	0.048	0.046	0.049	0.057
UCS	0.072	0.073	0.083	0.085	0.091	0.095
SSS	0.060	0.064	0.084	0.087	0.095	0.097
General						
CSMBS	0.061	0.060	0.065	0.125	0.080	0.073
UCS	0.116	0.129	0.150	0.311	0.192	0.171
SSS	0.103	0.108	0.133	0.255	0.220	0.231
Community						
CSMBS	0.301	0.314	0.347	0.378	0.385	0.404
UCS	0.689	0.755	0.787	0.830	0.854	0.901
SSS	0.484	0.562	0.576	0.554	0.600	0.542

As seen, the findings showed increasing trends for all health insurance schemes at all types of hospitals.

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4.1.2 Service intensity response

4.1.2.1 The overall effect of the payment system

Sample means and standard deviations are shown in table 14 below for all groups of samples: the CSMBS, UC, SSS and other inpatients. All samples correspond to the sample from period 2005 through 2010. These means show that the overall average length of stay (LOS) in the CSMBS, UC, SSS and other samples are 5.08, 3.81, 3.75 and 3.71 days respectively. The findings also show that the average LOS in the CSMBS sample declined by 0.23 days between the pre- and post-periods, while the averages in all other samples slightly changed over the same period. Such finding could be taken as evidence that payment system change was responsible for the LOS change.

Table 14 Descriptive statistics of average length of stays (LOS) between pre- and post- period by insurance schemes (unit: days)

Variables	CSMBS patients		UCS patients		SSS patients		Other patients	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Average LOS	5.08	1.63	3.81	.05	3.75	.42	3.71	1.24
Average LOS pre-period	5.19	1.76	3.84	1.13	3.73	1.32	3.71	1.26
Average LOS post-period	4.96	1.47	3.79	.98	3.77	.51	3.70	1.22
Difference 'post-pre'	-0.23***		-0.05		0.04		-0.01	

Note: standard errors are in parenthesis *p-value < 0.1 **p-value < 0.05 ***p-value < 0.01

By decomposing the overall average LOS change into those of different levels of hospitals, the average LOS for regional, general and community hospitals decreased by 0.30, 0.29 and 0.15 days respectively as table 15 below.

Table 15 Overall intensity effect of payment change on the average length of stays (LOS) between the pre- and post-payment reform periods for CSMBS patients by hospital types (unit: days)

Hospital	Average LOS			Differences in
Type	Both periods	Pre-period	Post-period	the average LOS
Regional	5.92 (1.16)	6.07 (1.26)	5.77 (1.03)	-0.30**
General	5.82 (1.27)	5.96 (1.43)	5.67 (1.05)	-0.29***
Community	3.79 (1.37)	3.86 (1.51)	3.71 (1.20)	-0.15***
Total	5.08 (1.63)	5.19 (1.76)	4.96 (1.47)	-0.23

Note: standard errors are in parenthesis *p-value < 0.1 **p-value < 0.05 ***p-value < 0.01

4.1.2.2 Moral hazard effect in aggregate and by hospital type

A series of regressions were conducted to estimate the magnitude of the moral hazard effect and the results are presented in table 16 below. Column (1) presented the hospital fixed effect estimates of the overall reduction in average LOS by 0.22 days following the payment system change and this change is statistically significantly different from zero. Column (2) showed the higher and significant estimates of the reduction in LOS after controlling for the yearly time trend and hospital case mix index. Column (3) showed the estimates of moral hazard effect by hospital type. The payment system change had statistically significant effects on regional and general hospitals but the community hospitals. It reflects that the regional and general hospitals try to contain the cost after payment system change.

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Table 16 Regression results of estimating moral hazard effect

Models	Hospital fixed effect models		
	(1)	(2)	(3)
Post-period of CSMBS IP payment change	-0.22***	-0.31***	
	(0.03)	(0.06)	
Yearly time trend		-0.05*	-0.09**
		(0.03)	(0.03)
Hospital Case Mix Index		0.89***	1.35***
		(0.19)	(0.21)
Regional hospital * Post-period of CSMBS IP payment change			-0.49***
			(0.09)
General hospital * Post-period of CSMBS IP payment change			-0.56***
			(0.08)
Community hospital * Post-period of CSMBS IP payment change			0.01
			(0.08)
Intercept	5.20***	4.48***	4.10***
	(0.02)	(0.17)	(0.08)
N	2634	1664	1664
sigma_u	1.319	1.134	1.127
sigma_e	0.715	0.682	0.671
Rho	0.773	0.735	0.739

Note: standard errors are in parenthesis

*p-value < 0.1 **p-value < 0.05 ***p-value < 0.01

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4.1.2.3 Moral hazard, selection, and practice-style effects

After estimating the moral hazard effect, the selection and practice-style effects of the payment system change are calculated as shown in table 17 below.

Table 17 Decomposition of overall change in the average LOS into moral hazard, selection and practice style effects (unit: days)

Hospital	Average LOS		LOS	Moral	Selection	Practice-style
Type	Pre	Post	Change	Hazard	Effect	Effect
	(1)	(2)	(3)	(4)	(5)	(6)
Regional	6.07	5.77	-0.30	-0.49	0.19	
General	5.96	5.67	-0.29	-0.56	0.27	
Community	3.86	3.71	-0.15	0.0	0.15	
Total	5.19	4.96	-0.23	-0.33	0.08	0.02

The first two columns of the table show the average LOS at each of the three different types of hospitals and in total for all types before and after change in the payment system. The third column shows the difference between the first two rows, and represents the overall effect on LOS at each type of hospital. They show that the average LOS changed by – 0.30 days at the regional hospitals, – 0.29 days at the general hospitals, – 0.15 days at the community hospitals and – 0.23 days in overall.

Column (4) shows the estimated moral hazard effects according to the coefficients estimated by Model (3) in Table 3. The moral hazard effects are – 0.49 days at the regional hospitals, – 0.56 days at the general hospitals and there was no moral hazard effect for the community hospitals. The overall moral hazard effect is calculated as the sum of the shares of each hospital in the post period multiplied by the moral hazard effect for each hospital. It explains an overall reduction of – 0.33 days in the average LOS.

Column (5) is calculated as the difference between Columns (3) and (4) and represents the estimates of the selection effect at each hospital type. The selection effects are + 0.19 days at the regional hospitals, + 0.27 days at the general hospitals and + 0.15 days at the community hospitals. According to our estimates, the average severity of patients at all hospitals increased after the payment system change. The estimate of the overall selection effect is estimated after calculating the contribution of practice-style effects to the total change in column (6).

Column (6) presents the estimate of the aggregate practice-style effect, calculated following equation (3) above as the change in market shares of each of the three types of hospitals, multiplied by their average LOS in the pre period. Overall, an increase of 0.02 days is showed just because of the changes in market shares and finally the overall selection effect is + 0.08 days.

4.1.2.4 Discussion

Based on the Hodgkin and McGuire's model of hospital response above that the hospitals include the intensity into the objective function, Thai public hospitals would provide more and more hospital services as long as it does not negatively affect the net revenue or the price-cost margin is positive. From the findings of a decrease in average length of stays after payment system change in 2008 it could imply that a decrease in service intensity exists. Before payment system change all inpatient services provided for CSMBS patients can be reimbursed, so these CSMBS patients are prioritized for hospital admission based on several reasons compared with other patients, for example, the civil servant status, ability to pay for extra money for special room service, extra privileges and more net revenue from original drug prescription and more demanding ancillary services and et cetera. After change in payment system for CSMBS patients the hospitals received fixed per case reimbursement (prospective payment), the hospitals have less incentive to admit because they expected high cost of admission incurred from the reason mentioned above. They admitted only those patients they can predict the lower individual patient costs upon admission than expected revenue because they have acquainted with the CSMBS patients and also know about each individual patient’s case mix. So in case the hospitals cannot refuse admission, they would decrease service intensity to reduce average cost of inpatient admission.

Subsequently, the decomposition of overall change in the average LOS presents negative moral hazard effects in the regional and general hospitals and no effect for the community hospitals. It is likely because the hospital services in the regional and general hospitals are more intense than the community hospitals, so the community hospitals have no room enough to reduce the service intensity. In the same time all levels of hospitals have positive selection effects, the second one. It implies that all hospital levels seek to admit more severe patients and it is likely because they expected to earn the higher income and positive net revenue. This effect also causes the hospitals to gain the efficiency in that decision making for patient admissions are based on proper and necessary medical conditions than ever and thus the higher level of severity are apparent. For the last effect, the overall practice-style effect is positive resulting from higher share of inpatient admissions at the regional hospitals after payment system change while the two other levels have lower shares. It reflects that the regional hospitals are last-resort hospitals especially in the country side, even in the central region they cannot refer out to the tertiary level hospitals outside the Ministry of Public Health. Finally, in overall picture the hospitals provide less inpatient stay and admissions for CSMBS patients after payment system change from fee-for-service to DRG-based basis. These findings might reflect possibility of lower quality of inpatient services provided to the patients due to lower service intensity.

In conclusion, payment system change from fee-for-service to DRG-based basis for CSMBS inpatient services negatively affects the hospital service intensity in term of a reduction of 0.23 days in average length of stay for CSMBS inpatient admissions between pre- and post-payment period. It is significantly different from those of other health insurance schemes.

As a result of the decomposition of overall intensity effects, the negative moral hazard effect was found at the regional and general hospital levels. It is likely that basically they provide the high-cost highly specialized and complex medical services, thus it necessitates a decrease in the service intensity to contain cost. On the other hand, the findings show positive selection effects at all levels of hospitals reflecting positive behavior of an increase in hospital performance. The overall practice-style effect is also positive reflecting net positive effect on the average LOS of the changes in market shares over all hospital levels in the system.

4.1.3 Volume response

4.1.3.1 The overall results of pre-post conventional analysis

The hospital behavioral changes in outpatient and inpatient service provision including patient transfer were examined to reflect the volume effect of payment system change in 2008.

The proportion of outpatient visits was used as proxy variable for outpatient services and the proportion of CSMBS inpatient discharges out of total admissions and the admission rate for inpatient services. In addition, the referred out rate of CSMBS patients was used to assess the adverse effect of transfer behavior.

In overall picture, the proportion of CSMBS inpatient discharges out of total admissions, the admission rates for CSMBS patients, the proportion of CSMBS outpatient visits and the referred out rate of CSMBS patients between the pre- and post-payment reform periods are showed in table 18 according to hypothesis 1 to 3.

Table 18 Differences of hospital service outputs between pre- and post-period for CSMBS

Service provision	Percentage (%)
Proportion of CSMBS inpatient discharges	
- Pre-period (%)	8.61
- Post-period (%)	7.69
- Difference	-0.92***
Admission rate of CSMBS patients	
- Pre-period (%)	4.74
- Post-period (%)	3.45
- Difference	-1.29***
Proportion of CSMBS outpatient visits	
- Pre-period (%)	11.47
- Post-period (%)	12.7
- Difference	1.23***
Referred-out rate of CSMBS patients	
- Pre-period	28.8
- Post-period	35.1
- Difference	6.24***

*p-value < 0.1 **p-value < 0.05 ***p-value < 0.01

As shown in the table above, the statistically significant decrease in the proportion of inpatient discharges and the admission rate for CSMBS patients between pre- and post-period are found. On the contrary, the statistically significant increase in the proportion of CSMBS outpatient visits and the referred-out rate for CSMBS patients was found.

4.1.3.2 The results of pre-post conventional analysis by hospital types

A multiple regression analysis was conducted to estimate the volume effect of payment system change on the proportion of CSMBS inpatient admissions and the CSMBS admission rates based on hypothesis 1 by hospital types and the results are presented in table 19 below.

Table 19 Regression results on the proportion of CSMBS inpatient discharges and admission rates

Variables	The proportion of CSMBS IP discharges	Admission rates of CSMBS patients
Regional hospital * Post-period of	-0.007**	-0.023***
CSMBS IP payment change	(0.004)	(0.004)
General hospital type * Post-period	-0.015***	-0.016***
of CSMBS IP payment change	(0.002)	(0.003)
Community hospital * Post-period of	-0.009***	-0.012***
CSMBS IP payment change	(0.001)	(0.001)
Intercept	0.086***	0.047***
	(0.000)	(0.001)

Note: standard errors are in parenthesis *p-value < 0.1 **p-value < 0.05 ***p-value < 0.01

As table above shown, two dependent variable models presented the hospital fixed effect estimates of the reduction in the proportion of CSMBS inpatient discharges and the CSMBS admission rates following the payment system change in 2008 by hospital type. As a result, that change had statistically significant negative effects on the proportion of CSMBS inpatient discharges and admission rates for all types of hospitals.

In order to investigate whether there is a shift of service provision from less severely inpatient service to outpatient visits based on hypothesis 2 by hospital types, a multiple regression analysis was conducted and the results were shown in table 20 below.

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Table 20 Regression results on the proportion of CSMBS outpatient visits out of the total outpatient visits

Variable	The proportion of CSMBS OP visits	
	(1)	(2)
CSMBS OP disbursement year	0.01***	
	(0.001)	
Post-period of CSMBS IP payment	0.006***	
change	(0.001)	
Regional hospital * CSMBS OP		0.038***
disbursement year		(0.006)
General hospital * CSMBS OP		0.018***
disbursement year		(0.004)
Community hospital * CSMBS OP		0.008***
disbursement year		(0.001)
Regional hospital * Post-period of		0.007
CSMBS IP payment change		(0.006)
General hospital * Post-period of		0.009**
CSMBS IP payment change		(0.004)
Community hospital * Post-period of		0.005***
CSMBS IP payment change		(0.001)
	0.111***	0.111***
Intercept	(0.001)	(0.001)

Note: standard errors are in parenthesis *p-value < 0.1 **p-value < 0.05 ***p-value < 0.01

As table above illustrated, column (1) presented the hospital fixed effect estimates of the overall increase in the proportion of CSMBS outpatient visits following the payment system change in both 2007 and 2008 and these changes are statistically significantly different from zero. Column (2) showed the estimates of volume effect by hospital type. The payment system change in 2007 had statistically significant effects on the proportion of CSMBS outpatient visits for all types of hospitals. But the payment system change in 2008 had statistically significant effects on the proportion of CSMBS outpatient visits for only general and community hospitals. Comparing between two payment changes, the magnitude of volume effects of payment change in 2007 are higher than that in 2008.

Transfer behavior of public hospitals based on hypothesis 3 by hospital types was examined by a multiple regression analysis and the results were shown as table 21 below.

Table 21 Regression results on the referred-out rate of CSMBS patients

Variable	The referred-out rate of CSMBS patients	
	(1)	(2)
Post-period of CSMBS IP payment change	0.062***	
	(0.006)	
Regional hospital * Post-period of		0.008
CSMBS IP payment change		(0.035)
General hospital * Post-period of		0.031
CSMBS IP payment change		(0.023)
Community hospital * Post-period of		0.067***
CSMBS IP payment change		(0.007)
Intercept	0.288***	0.288***
	(0.004)	(0.004)

Note: standard errors are in parenthesis *p-value < 0.1 **p-value < 0.05 ***p-value < 0.01

Column (1) of two dependent variable models presented the hospital fixed effect estimates of the overall increases in the number of CSMBS patients referred out and the number of CSMBS patients referred in following the payment system change in 2008. These changes are statistically significantly different from zero. Column (2) showed the estimates of volume effect from transfer behavior of hospitals by hospital type. The payment system change in 2008 had statistically significant effects on the number of CSMBS patients referred out for all types of hospitals. In the same time the change in 2008 had statistically significant associated with the number of CSMBS patients referred in only for regional hospitals but not for general and community hospital. It indicates that only the regional hospitals are the last-resort hospitals.

4.1.3.3 Results of Difference-in-Difference estimation and panel data regression

4.1.3.3.1 The proportion of CSMBS inpatient discharges out of total inpatient discharges

Table 22 Regression results of the cross-group effects on the proportion of inpatient discharges

Variable	Model I (All hospitals)		Model II (by types)	
	UCS	SSS	UCS	SSS
Yearly trend	0.004**	0.000	0.004**	0.000
	(0.001)	(0.000)	(0.002)	(0.000)
Bed occupation rate	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Adjusted DRG Relative Weight	0.043**	-0.003	0.043	-0.002
	(0.014)	(0.002)	(0.024)	(0.002)
Post-period of CSMBS IP payment change	0.001 (0.004)	0.000 (0.001)		
Regional hospital * Post-period of CSMBS IP payment change			0.006 (0.015)	0.001 (0.002)
General hospital * Post-period of CSMBS IP payment change			-0.003 (0.009)	-0.005** (0.002)
Community hospital * Post-period of CSMBS IP payment change			0.001 (0.005)	0.000 (0.001)
Intercept	0.729***	0.039***	0.728***	0.039***
	(0.010)	(0.001)	(0.015)	(0.001)

Note * p<0.05; ** p<0.01; *** p<0.001 standard errors are in parenthesis

The table 22 above showed the fixed-effects panel data regression results on the cross-group effects of CSMBS payment policy change on the proportion of inpatient discharges for UCS and SSS insurance schemes.

As shown in table above, CSMBS payment change has no significant effects on the proportion of inpatient discharges for UCS and SSS inpatients for overall hospitals. CSMBS payment change also has no effect on the proportion of inpatient discharges for UCS inpatients in each type of hospitals, while it caused a decrease in the proportion of inpatient discharges only in the general hospital for SSS inpatients. It implied that when compared with SSS, it would underestimate the effects of CSBMS payment change on the proportion of inpatient discharges for CSMBS patients in the general hospital.

Although we used both UCS and SSS ones as comparison group in estimating the effects of CSBMS payment change on the proportion of inpatient discharges for CSMBS inpatients, we would focus on comparison with UCS. The table 23 and 24 below revealed the fixed-effects panel data regression results on the proportion of CSMBS inpatient discharges of model I for overall hospitals and those of model II by hospital types.

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Table 23 Regression results of direct effects on the proportion of CSMBS inpatient discharges compared with comparison group for overall hospitals

Independent Variables	Model I: All hospitals	
	CSMBS vs UCS	CSMBS vs SSS
Yearly trend	-0.003	-0.002**
	(0.002)	(0.001)
Bed occupation rate	0.000	0.000
	(0.000)	(0.000)
Adjusted DRG Relative Weight	0.170***	0.018***
	(0.014)	(0.004)
Treatment group	-0.682***	0.043***
	(0.005)	(0.002)
Post-period of CSMBS IP payment change	0.019***	0.003
	(0.005)	(0.002)
Treatment group * Post-period of CSMBS IP	-0.036***	-0.007***
payment change	(0.006)	(0.002)
Intercept	0.664***	0.034***
	(0.010)	(0.003)

Note * p<0.05; ** p<0.01; *** p<0.001   standard errors are in parenthesis

As shown in the table above, CSMBS payment change has significant negative effects on the proportion of inpatient discharges of own patients for overall hospitals when compared with UCS and SSS patients.

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Table 24 Regression results of direct effects on the proportion of CSMBS inpatient discharges compared with comparison group by hospital types

Independent Variables	Model II: By hospital types	
	CSMBS vs UCS	CSMBS vs SSS
Yearly trend	-0.001	-0.001*
	(0.002)	(0.001)
Bed occupation rate	0.000	0.000
	(0.000)	(0.000)
Adjusted DRG Relative Weight	0.101***	0.010*
	(0.016)	(0.004)
Regional hospital * Treatment group	-0.589***	0.057***
	(0.022)	(0.009)
Regional hospital * Post-period of CSMBS IP payment change	-0.007 (0.019)	0.003 (0.007)
Regional hospital * Treatment group * Post-period of CSMBS IP payment change	-0.024 (0.025)	-0.008 (0.010)
General hospital * Treatment group	-0.557***	0.061***
	(0.014)	(0.006)
General hospital * Post-period of CSMBS IP payment change	-0.005 (0.012)	-0.002 (0.005)
General hospital * Treatment group * Post-period of CSMBS IP payment change	-0.021 (0.016)	-0.005 (0.007)
Community hospital * Treatment group	-0.702***	0.042***
	(0.005)	(0.002)
Community hospital * Post-period of CSMBS IP payment change	0.017** (0.005)	0.004* (0.002)
Community hospital * Treatment group * Post-period of CSMBS IP payment change	-0.028*** (0.006)	-0.007*** (0.002)
Intercept	0.706***	0.037***
	(0.011)	(0.003)

Note * p<0.05; ** p<0.01; *** p<0.001 standard errors are in parenthesis

In addition, the findings show that CSMBS payment change negatively affected on the proportion of inpatient discharges only for community hospitals.

4.1.3.3.2 The admission rate of inpatient services

The table 25 below showed the fixed-effects panel data regression results on the cross-group effects of CSMBS payment policy change on the admission rate of inpatient services for UCS and SSS insurance schemes.

Table 25 Regression results of the cross-group effects on the CSMBS admission rates

Variable	Model I (All hospitals)		Model II (by types)	
	UCS	SSS	UCS	SSS
Yearly trend	-0.003***	-0.005***	-0.003***	-0.005***
	(0.000)	(0.001)	(0.000)	(0.001)
Bed occupation rate	0.000***	0.000*	0.000***	0.000*
	(0.000)	(0.000)	(0.000)	(0.000)
Post-period of CSMBS IP payment change	0.002*	0.005*		
	(0.001)	(0.002)		
Regional hospital * Post-period of CSMBS IP payment change			-0.001	0.010
			(0.002)	(0.006)
General hospital * Post-period of CSMBS IP payment change			0.003	0.005
			(0.002)	(0.004)
Community hospital * Post-period of CSMBS IP payment change			0.002*	0.005*
			(0.001)	(0.002)
Intercept	0.065***	0.058***	0.065***	0.058***
	(0.001)	(0.002)	(0.001)	(0.002)

Note * p<0.05; ** p<0.01; *** p<0.001 standard errors are in parenthesis

As shown in table above, in model I CSMBS payment change has significant positive effects on the admission rate of inpatient services of both UCS and SSS patients for overall hospitals. For model II, it showed that CSMBS payment change has such effect on the admission rate of inpatient services for UCS and SSS patients for only community hospitals. It implied that when compared with either UCS or SSS, it would overestimate the effects of CSBMS payment change on the admission rate of inpatient services for UCS and SSS patients only in the community hospitals.

We would use both UCS and SSS ones as comparison group in estimating the effects of CSBMS payment change on the admission rate of inpatient services for CSMBS inpatients. The table 26 and 27 below revealed the fixed-effects panel data regression results on the admission rate of inpatient services of model I for overall hospitals and those of model II by hospital types.

Table 26 Regression results of direct effects on the CSMBS admission rate compared with comparison group for overall hospitals

Independent Variables	Model I: All hospitals	
	CSMBS vs UCS	CSMBS vs SSS
Yearly trend	-0.004***	-0.005***
	(0.000)	(0.000)
Bed occupation rate	0.000***	0.000***
	(0.000)	(0.000)
Treatment group	-0.015***	-0.003**
	(0.001)	(0.001)
Post-period of CSMBS IP payment change	0.006***	0.005**
	(0.001)	(0.002)
Treatment group * Post-period of CSMBS IP payment change	-0.007***	-0.003
	(0.001)	(0.001)
Intercept	0.068***	0.058***
	(0.001)	(0.001)

Note * p<0.05; ** p<0.01; *** p<0.001 standard errors are in parenthesis

As shown in the table above, CSMBS payment change has significant negative effects on the admission rate of inpatient services of own patients for overall hospitals when compared with UCS, but has no effect when compared with SSS patients.

Table 27 Regression results of direct effects on the CSMBS admission rate compared with comparison group by hospital types

Independent Variables	Model II: By hospital types	
	CSMBS vs UCS	CSMBS vs SSS
Yearly trend	-0.004***	-0.005***
	(0.000)	(0.000)
Bed occupation rate	0.000***	0.000***
	(0.000)	(0.000)
Regional hospital * Treatment group	-0.062***	0.004
	(0.004)	(0.005)
Regional hospital * Post-period of CSMBS IP payment	0.003	0.011
change	(0.004)	(0.005)
Regional hospital * Treatment group * Post-period of	-0.014**	-0.018*
CSMBS IP payment change	(0.005)	(0.008)
General hospital * Treatment group	-0.048***	-0.005
	(0.002)	(0.003)
General hospital * Post-period of CSMBS IP payment	0.007**	0.005
change	(0.003)	(0.004)
General hospital * Treatment group * Post-period of	-0.011***	-0.006
CSMBS IP payment change	(0.003)	(0.005)
Community hospital * Treatment group	-0.010***	-0.003**
	(0.001)	(0.001)
Community hospital * Post-period of CSMBS IP	0.006***	0.005**
payment change	(0.001)	(0.002)
Community hospital * Treatment group * Post-period	-0.007***	-0.002
of CSMBS IP payment change	(0.001)	(0.002)
Intercept	0.068***	0.058***
	(0.001)	(0.001)

Note * p<0.05; ** p<0.01; *** p<0.001 standard errors are in parenthesis

Additionally, the findings show that CSMBS payment change negatively affected on the admission rate of inpatient services for regional and general hospitals. For community hospitals, the evidence is not clearly suggestive of negative effects because of overestimation bias.

4.1.3.3.3 The proportion of CSMBS outpatient visits out of total ones

The table 28 below showed the fixed-effects panel regression results on the cross-group effects of CSMBS payment policy change on the proportion of CSMBS outpatient visits for UCS and SSS insurance schemes.

Table 28 Regression results of the cross-group effects on the proportion of CSMBS outpatient visits

Variable	Model I (All hospitals)		Model II (by types)	
	UCS	SSS	UCS	SSS
Yearly trend	0.003**	0.002***	0.003**	0.002***
	(0.001)	(0.000)	(0.001)	(0.000)
CSMBS OP disbursement year	-0.010***	0.001		
	(0.003)	(0.001)		
Post-period of CSMBS IP payment change	-0.008**	-0.003***		
	(0.003)	(0.001)		
Regional hospital * CSMBS OP disbursement year			-0.013	0.000
			(0.011)	(0.003)
General hospital * CSMBS OP disbursement year			-0.024**	-0.001
			(0.007)	(0.002)
Community hospital * CSMBS OP disbursement year			-0.009**	0.001
			(0.003)	(0.001)
Regional hospital * Post-period of CSMBS IP payment change			0.010	-0.001
			(0.011)	(0.003)
General hospital * Post-period of CSMBS IP payment change			-0.013	0.000
			(0.007)	(0.002)
Community hospital * Post-period of CSMBS IP payment change			-0.009**	-0.003***
			(0.003)	(0.001)
Intercept	0.724***	0.045***	0.724***	0.045***
	(0.002)	(0.001)	(0.002)	(0.001)

Note * p<0.05; ** p<0.01; *** p<0.001   standard errors are in parenthesis

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As shown in table above, in model I CSMBS OP direct disbursement in 2007 has significantly negative effects on the proportion of CSMBS outpatient visits of both UCS and SSS patients for overall hospitals, while CSMBS IP payment change in 2008 has such effect on that of only UCS patients. For model II, the findings additionally show that CSMBS OP direct disbursement has negative effects on that of only UCS patients for general and community hospitals, while CSMBS payment change has negative effects on that of UCS and SSS patients for only community hospitals. It implied that when compared with either UCS or SSS, it would underestimate the effects of CSBMS payment change on the proportion of CSMBS outpatient visits for UCS and SSS patients only in the community hospitals.

We would use both UCS and SSS ones as comparison group in estimating the effects of CSBMS payment change on the proportion of CSMBS outpatient visits for CSMBS inpatients. The table 29 and 30 below revealed the fixed-effects panel data regression results on the proportion of CSMBS outpatient visits of model I for overall hospitals and those of model II by hospital types.

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Table 29 Regression results of direct effects on the proportion of CSMBS outpatient visits compared with comparison group for overall hospitals

Independent Variables	Model I: All hospitals	
	CSMBS vs UCS	CSMBS vs SSS
Yearly trend	0.001	0.001
	(0.002)	(0.001)
Treatment group	-0.617***	0.063***
	(0.004)	(0.002)
CSMBS OP disbursement year	-0.008	0.003
	(0.006)	(0.003)
Treatment group * CSMBS OP disbursement year	0.016*	0.006
	(0.007)	(0.003)
Post-period of CSMBS IP payment change	-0.005	0.000
	(0.006)	(0.003)
Treatment group * Post-period of CSMBS IP payment	0.008	0.004
change	(0.007)	(0.003)
Intercept	0.727***	0.047***
	(0.004)	(0.002)

Note: * p<0.05; ** p<0.01; *** p<0.001 standard errors are in parenthesis

As shown in the table above, CSMBS payment change has no effects on the proportion of CSMBS outpatient visits for overalls hospital when compared with UCS and SSS patients.

Table 30 Regression results of direct effects on the proportion of CSMBS outpatient visits compared with comparison group by hospital types

Independent Variables	Model II: By hospital types	
	CSMBS vs UCS	CSMBS vs SSS
Yearly trend	0.001	0.001
	(0.002)	(0.001)
Regional hospital * Treatment group	-0.335***	0.112***
	(0.019)	(0.009)
Regional hospital * CSMBS OP disbursement year	-0.01	0.002
	(0.023)	(0.011)
Regional hospital * Treatment group * CSMBS OP disbursement year	0.046	0.035*
	(0.032)	(0.015)
General hospital * Treatment group	-0.391***	0.117***
	(0.012)	(0.006)
General hospital * CSMBS OP disbursement year	-0.021	0.002
	(0.015)	(0.007)
General hospital * Treatment group * CSMBS OP disbursement year	0.038	0.015
	(0.021)	(0.010)
Community hospital * Treatment group	-0.651***	0.055***
	(0.004)	(0.002)
Community hospital * CSMBS OP disbursement year	-0.006	0.003
	(0.005)	(0.003)
Community hospital * Treatment group * CSMBS OP disbursement year	0.013	0.003
	(0.007)	(0.003)
Regional hospital * Post-period of CSMBS IP payment change	0.014	0.002
	(0.022)	(0.010)
Regional hospital * Treatment group * Post-period of CSMBS IP payment change	-0.009	0.003
	(0.030)	(0.015)
General hospital * Post-period of CSMBS IP payment change	-0.009	0.003
	(0.014)	(0.007)
General hospital * Treatment group * Post-period of CSMBS IP payment change	0.017	0.005
	(0.020)	(0.009)
Community hospital * Post-period of CSMBS IP payment change	-0.005	0.000
	(0.005)	(0.003)
Community hospital * Treatment group * Post-period of CSMBS IP payment change	0.008	0.004
	(0.006)	(0.003)
Intercept	0.727***	0.047***
	(0.003)	(0.002)

Note * p<0.05; ** p<0.01; *** p<0.001 standard errors are in parenthesis

Additionally, the findings show that CSMBS payment change has no effects on the proportion of CSMBS outpatient visits for all types of hospitals.

4.1.3.3.4 The rate of CSMBS referred-out patients

The table 31 below showed the fixed-effects panel regression results on the cross-group effects of CSMBS payment policy change on the referred-out rate of CSMBS patients for UCS and SSS insurance schemes.

Table 31 Regression results of the cross-group effects on the referred-out rate of CSMBS patients

Variable	Model I (All hospitals)		Model II (by types)	
	UCS	SSS	UCS	SSS
Yearly trend	0.024**	-0.009	0.023**	-0.009
	(0.008)	(0.011)	(0.008)	(0.011)
Adjusted DRG Relative Weight	-0.069	0.054	-0.052	0.031
	(0.082)	(0.081)	(0.135)	(0.082)
Post-period of CSMBS IP payment	0.024	0.005		
change	(0.021)	(0.028)		
Regional hospital * Post-period of			-0.017	0.023
CSMBS IP payment change			(0.085)	(0.093)
General hospital * Post-period of			0.039	0.116
CSMBS IP payment change			(0.052)	(0.063)
Community hospital * Post-period			0.026	-0.008
of CSMBS IP payment change			(0.027)	(0.029)
Intercept	0.668***	0.516***	0.657***	0.526***
	(0.056)	(0.051)	(0.086)	(0.052)

Note * p<0.05; ** p<0.01; *** p<0.001 standard errors are in parenthesis

As shown in table above, in both model I and II CSMBS payment change has no significant cross-effects on the rate of CSMBS referred-out patients of both UCS and SSS patients for both overall and all types of hospitals. Thus, when compared with either UCS or SSS, it would not either overestimate or underestimate the effects of CSBMS payment change on the rate of CSMBS referred-out patients for UCS and SSS patients.

We would use both UCS and SSS ones as comparison group in estimating the effects of CSBMS payment change on the rate of CSMBS referred-out patients for CSMBS inpatients. The table 29 and 30 below revealed the fixed-effects panel data regression results on the rate of CSMBS referred-out patients of model I for overall hospitals and those of model II by hospital types.

Table 32 Regression results of direct effects on the rate of CSMBS referred-out patients compared with comparison group for overall hospitals

Independent Variables	Model I: All hospitals	
	CSMBS vs UCS	CSMBS vs SSS
Year trend	0.009	-0.004
	(0.007)	(0.007)
Adjusted DRG Relative Weight	0.251***	0.128**
	(0.059)	(0.042)
Treatment group	-0.372***	-0.221***
	(0.020)	(0.019)
Post-period of CSMBS IP payment change	0.063**	-0.010
	(0.022)	(0.020)
Treatment group * Post-period of CSMBS IP payment change	-0.066**	0.044*
	(0.024)	(0.022)
Intercept	0.497***	0.460***
	(0.044)	(0.031)

Note * p<0.05; ** p<0.01; *** p<0.001 standard errors are in parenthesis

As shown in the table above, CSMBS payment change has significantly negative effects on the rate of CSMBS referred-out patients for overalls hospital when compared with UCS, but has opposite signs with SSS patients.

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Table 33 Regression results of direct effects on the referred-out rate of CSMBS patients compared with comparison group by hospital types

Independent Variables	Model II: By hospital types	
	CSMBS vs UCS	CSMBS vs SSS
Year trend	0.013	-0.003
	(0.007)	(0.007)
Adjusted DRG Relative Weight	0.062	0.095*
	(0.073)	(0.045)
Regional hospital * Treatment group	-0.056	-0.064
	(0.100)	(0.097)
Regional hospital * Post-period of CSMBS IP	-0.045	0.003
payment change	(0.085)	(0.080)
Regional hospital * Treatment group * Post-period	0.004	-0.022
of CSMBS IP payment change	(0.112)	(0.111)
General hospital * Treatment group	-0.097	-0.091
	(0.064)	(0.063)
General hospital * Post-period of CSMBS IP	0.034	0.096
payment change	(0.055)	(0.053)
General hospital * Treatment group * Post-period	-0.045	-0.082
of CSMBS IP payment change	(0.073)	(0.072)
Community hospital * Treatment group	-0.423***	-0.237***
	(0.021)	(0.021)
Community hospital * Post-period of CSMBS IP	0.054*	-0.022
payment change	(0.023)	(0.021)
Community hospital * Treatment group * Post-	-0.044	0.062**
period of CSMBS IP payment change	(0.026)	(0.023)
Intercept	0.611***	0.476***
	(0.050)	(0.032)

Note * p<0.05; ** p<0.01; *** p<0.001   standard errors are in parenthesis

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Additionally, the findings shown in table 33 above showed that CSMBS payment change has no significant effects on the rate of CSMBS referred-out patients for all types of hospitals when compared with UCS patients, while it has positively significant effect on that for only the community hospitals.

The regression results from Difference-in-Differentiation estimation are summarized into the tables below. Table 34 summarized the findings about cross-effects of CSMBS IP payment change on both the service output of UCS and SSS patients for service intensity and volume response.

Table 34 Summary of cross-effects of CSMBS IP payment change to service output of UCS and SSS patients

Cross-effects	Hospital Service Output for either UCS or SSS				
	Average LOS	IP proportion	Admission rate	OP proportion	Refer rate
Cross-Effects of CSMBS IP payment change to service output of UCS patients					
- Overall	-0.032	+0.001	+0.002*	-0.008**	+0.024
- Regional	-0.556***	+0.006	-0.001	+0.010	-0.017
- General	-0.254***	-0.003	+0.003	-0.013	+0.039
- Community	+0.079*	+0.001	+0.002*	-0.009**	+0.026
Cross-effects of CSMBS IP payment change to service output of SSS patients					
- Overall	+0.121	+0.000	+0.005*	-0.003***	+0.005
- Regional	-0.132	+0.001	+0.010	-0.001	+0.023
- General	+0.051	-0.005**	+0.005	+0.000	+0.116
- Community	+0.141*	+0.000	+0.005*	-0.003***	-0.008

Note * p<0.05; ** p<0.01; *** p<0.001 standard errors are in parenthesis

As shown, regarding the cross-effect of payment change of CSMBS inpatient services (CSMBS IP) to service outputs of other schemes namely UCS and SSS, the findings show that in overall picture that CSMBS payment change has no significant cross-effects on the average length of stay, the proportion of inpatient cases, and referred-out rate of two other schemes. On the contrary, CSMBS IP payment change has significantly positive cross-effects on the admission rate of inpatient services of both UCS and SSS patients, while has significantly negative effect on the proportion of the outpatient visits of both UCS and SSS patients.

By disaggregating the cross-effects of that payment change into each type of those hospitals, the findings showed that the cross-effects on the admission rate and the proportion of outpatient visits of UCS and SSS patients are only for community hospitals. Another interesting point about the cross-effects on the average length of stay is that CSMBS IP payment change has no significant cross-effect in overall hospitals, but has significant cross-effects in all types of those hospitals. The findings also showed the significantly negative cross-effects on the average length of stay for the UCS patients in the regional and general hospitals. In contrast to the community hospitals, the significantly positive cross-effects for UCS and SSS were found. It is also found that CSMBS payment change has negatively cross-effect on the proportion of inpatient cases for SSS patients in the general hospitals.

Table 35 below summarized the direct effects of payment change for CSMBS inpatient services on service outputs of CSMBS patients.

Table 35 Summary of direct effects of IP payment change to service output of CSMBS patients

Direct effects	Hospital service output for CSMBS				
	Average LOS	IP proportion	Admission rate	OP proportion	Refer rate
Direct effects of CSMBS IP payment change when compared with UCS					
- Overall	-0.336***	-0.036***	-0.007***	+0.008	-0.066**
- Regional	+0.305	-0.024	-0.014**	-0.009	+0.004
- General	-0.615***	-0.021	-0.011***	+0.013	-0.045
- Community	-0.446***	-0.028***	-0.007***	+0.008	-0.044
Direct effects of CSMBS IP payment change when compared with SSS					
- Overall	-0.290***	-0.007***	-0.003	+0.004	+0.044*
- Regional	-0.581	-0.008	-0.018*	+0.005	-0.022
- General	-1.038***	-0.005	-0.006	+0.003	-0.082
- Community	-0.194**	-0.007***	-0.002	+0.004	+0.062**

Note * p<0.05; ** p<0.01; *** p<0.001 standard errors are in parenthesis

As expected, it is likely that the average length of stay, the proportion of inpatient cases and the admission rate for CSMBS be decreased and that the proportion of outpatient visits and the referred-out rate for CSMBS be increased.

According to the findings on direct effects on the service outputs for CSMBS patients, in overall picture CSMBS IP payment change has significantly negative direct effects on the average length of stay, the proportion of inpatient cases and the admission rate, but has no effects on the proportion of outpatient visits, but ambiguous on the referred-out rate.

By disaggregating those direct effects of that payment change into each type of those hospitals, it is found that CSMBS payment change has negatively direct effects on the admission rate for the regional hospitals, while on both the average length of stay and admission rate of inpatient services for the general hospitals. For the community hospitals, CSMBS payment change had negatively direct effects on all inpatient service outputs namely the average length of stay, the proportion of inpatient cases and the admission rate and positively direct effects on the referred-out rate.

However, having no effects on the average length of stay in the regional hospitals might cause from the spillover or cross-effects on UCS patients as comparison group, so the result might be underestimated. Also, the effect on the proportion of inpatients cases in the general hospitals when compared with SSS group might be underestimated from the spillover effect in the same basis. For community hospitals, a positive cross-effect on the average length of stay for SSS group and a positive cross-effect on admission rate for UCS group could cause the findings for those outputs to be overestimated. However, CSMBS payment change for CSMBS patients in the community tended to have negative direct effects.

The comparison of results between conventional (pre-post analysis) and difference-in-difference estimation was shown in the table 36 below.

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Table 36 Results of conventional (pre-post analysis) and difference-in-difference estimation

Direct effects of CSMBS payment change	Estimation procedure	
	Conventional	Diff-in-Diff
Negative effects on average LOS (Service intensity)		
- Overall	√	√
- Regional	√	X
- General	√	√
- Community	√	√
Negative effects on IP proportion (Service volume)		
- Overall	√	√
- Regional	√	X
- General	√	X
- Community	√	√
Negative effects on admission rate (Service volume)		
- Overall	√	√
- Regional	√	√
- General	√	√
- Community	√	√
Positive effects on OP proportion (Service volume)		
- Overall	√	X
- Regional	X	X
- General	√	X
- Community	√	X
Positive effects on referred-out rate (Service volume)		
- Overall	√	√
- Regional	X	X
- General	X	X
- Community	√	√

Note √ statistically significant difference **X no** statistically significant difference

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As shown, in overall picture the results from difference-in-difference estimation are in line with those from conventional analysis, but not for the proportion of outpatient visits. For better inference, the evidences from difference-in-difference estimation have more advantages and account for the changes in service provision from time trends that conventional analysis cannot.

For the service intensity response, CSMBS payment change has negative effects on average length of stay for general and community hospitals

In the same time, CSMBS payment change has negative effects on volume response for all types of hospitals in terms of the admission rate and affects the proportion of inpatient cases and the referred-out rate only for community hospitals, but has no effects on the shift to the proportion of outpatient visits.

4.1.3.4 Discussion

As shown payment system change in 2008 from fee-for-service to DRG-based payment negatively affected volume response on inpatient service provision as expected in hypothesis 1 in terms of the proportion of CSMBS inpatient cases and admission rates. Based on the Hodgkin and McGuire’s hospital response concept, the hospitals would admit inpatients as long as price-cost margin is positive. Also, Dranove stated that hospitals’ admission decisions will depend on what they know about each individual patient’s case mix. In the Thai public hospital context, the doctors acquainted with the CSMBS patients and also knew about each individual patient’s case mix, thus they could predict the individual patient cost from characteristics observable upon admission, such as age and medical history. In addition, CSMBS inpatients usually incurred high cost due to higher demand for original drug prescription and more ancillary services namely highly specialized laboratory and radiology services. So, this finding could imply that the hospital expected the financial loss from inpatient service provision for CSMBS patients and responded via the decrease in inpatient admission. Consequently, a decrease in admission rate caused a decrease in the proportion of inpatient cases in all types of hospitals, although not significantly significant in regional and general hospitals. It is partly because they are the hospitals for referral and the ones of last resort in the provincial and regional hospital network of the Ministry of Public Health, so they cannot refuse admissions.

Evidently, payment system change for inpatient cases in 2008 had no significant effects on the proportion of CSMBS outpatient visits for all types of hospitals although they were slightly positive. It is possible that after change to OP direct disbursement in 2007 there was no room left to increase the additional outpatient visits for all types of hospitals after the change in 2008.

Under current situation, there are still no shifts from less severely inpatient services to the outpatient services as found in the study of Hadley, Zuckerman and Feder (1989) and Hodgkin and McGuire (1994). So, a decrease in admission rates would not be influenced from doctor's decision making towards a shift to outpatient visits as desired.

As to the referred-out rate of CSMBS patients that reflect patient rejection, the findings showed an increase at the community levels according to hypothesis 3. It corresponds with what Newhouse (1989) proposed that the individual patients who are identified during the course of the stay as likely to reduce the hospital's operating margin may be transferred from that hospital especially the last-resort hospitals and cared for elsewhere because the reimbursement that those hospitals receive do not cover the costs incurred in treating those patients. However, the degree of transfer does not depend on the proxy of fiscal pressure represented by the proportion of total relative weight of DRG provided for CSMBS inpatients as Hadley, Zuckerman and Feder (1989) described. It is probable that the proportion of total relative weight of DRG could not be the good proxy for fiscal pressure index. However, it did not harm the CSMBS patients

Due to data limitation this study could not evaluate the fiscal pressure of individual hospital that is one of critical driving forces to hospital behavior on service supply. If data are available, the relationship among payment system change, fiscal pressure and hospital behavior would be revealed and we would get insight about the effect of payment change on fiscal performance and in turn the consequence on hospital supply behavior.

It could be concluded that payment system change in 2008 for CSMBS inpatient services affected the volume response in service provision through admission decision resulting in a decrease in the admission rates at all types of hospitals and change transfer behavior through an increase in the referred-out rate of CSMBS patients with a decrease in the proportion of IP cases only at the community hospitals, but had no significant effects toward a shift from inpatient to outpatient services at all types of hospitals.

4.2 Hospital cost behavior and response

4.2.1 Descriptive statistics

The descriptive statistics of the variables of hospital cost function for hospital sample are shown as table 37 below.

Table 37 Descriptive statistics of the variables for hospital cost function

Variables	Mean	Std. Dev.	Min	Max
Total operating costs (million baht)	128	218	11.5	1,930
Total outpatient visits	128,274	115,906	8,334	874,147
Total promotion and prevention services	34,685	37,578	1,657	768,842
Total inpatient discharges	8,174	11,301	497	86,473
Hospital Case Mix Index	0.73	0.25	0.30	2.23
Average length of stay	3.23	0.84	1.84	7.42
Labor price index (thousand baht)	522.11	132.46	87.11	1,179.90
Price index for non-labor costs (baht)	329.37	204.29	11.50	2,754.01
Price index for drug and medical supplies (baht)	142.66	135.18	6.31	1,407.75
Price index for other operating costs (baht)	186.72	103.16	5.19	1,856.66
The number of beds	95.48	155.00	10	1,000
The number of doctors	12.42	23.82	0	200
Proportion of CSMBS outpatient visits	0.121	0.065	0.011	0.435
Proportion of CSMBS inpatient discharges	0.082	0.041	0.003	0.590

As seen, the ranges of data for hospital cost function variables are quite broad. However, some data in particular the number of doctors are zero in some hospitals, so before estimating the hospital cost function the data would be corrected for them.

4.2.2 Empirical results

4.2.2.1 First step of constructing well-behaved hospital cost function

In the first step of constructing well-behaved hospital cost function, the hospital sample was divided into two groups: 1) general and regional hospital group and 2) community hospital group.

In general the hospital cost model with panel data performs better than the one using OLS or maximum likelihood estimation techniques in the cross section analysis. After four specification models of hospital cost models with a number of hospital's output mix type were preliminary estimated and the estimated coefficients of output and variable input price parameters are firstly considered in terms of statistical significance and expected direction, the model IV and two types of hospital output mix better represent the structure of production and cost than others.

Two types of hospital output mix were used in the hospital cost functions in the model I and II respectively.

1) Three hospital outputs for Model I consisting of

1.1) outpatient visits,

1.2) promotion and prevention visits and

1.3) inpatient discharges multiplied with case mix index (called total adjusted relative weights)

2) Two hospital outputs for Model II consisting of

2.1) outpatient, promotion and prevention visits

2.2) inpatient discharges multiplied with case mix index (called total adjusted relative weights)

The regression results from two methods of estimation are as follows:

4.2.2.1.1 SUR regression results

The results of regression on hospital cost for those two hospital groups are shown in table 38 below.

Table 38 SUR regression results of unrestricted models for general/regional and community hospitals

SUR Models	General/Regional hospitals		Community hospitals	
Independent Variables	Model I	Model II	Model I	Model II
<u>*Hospital cost function equation*</u>				
Hospital outputs				
Outpatient visits	0.177*		0.348***	
	(0.069)		(0.022)	
Promotion and prevention visits	0.100**		0.086***	
	(0.031)		(0.012)	
Outpatient, promotion and prevention visits		0.275***		0.416***
		(0.063)		(0.020)
Total adjusted relative weights	0.280***	0.274***	0.282***	0.296***
	(0.051)	(0.048)	(0.017)	(0.017)
Variable input prices				
Labor price index	0.384***	0.397***	0.226***	0.228***
	(0.057)	(0.056)	(0.019)	(0.018)
Drug and medical supplies price index	0.363***	0.354***	0.388***	0.385***
	(0.041)	(0.040)	(0.017)	(0.017)
Other operating price index	0.254***	0.249***	0.385***	0.387***
	(0.035)	(0.034)	(0.014)	(0.013)
Fixed inputs				
Bed numbers	0.163*	0.172*	0.055***	0.052***
	(0.078)	(0.072)	(0.016)	(0.015)
Doctor numbers	0.034	0.035	0.050***	0.049***
	(0.060)	(0.058)	(0.013)	(0.012)
Yearly time trend	-0.024*	-0.021*	0.075***	0.072***
	(0.011)	(0.010)	(0.007)	(0.006)

This table shows only the coefficients of relevant variables. Legend: * p<0.05; ** p<0.01; *** p<0.001

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As shown in table above, the coefficients of first-order derivatives of all outputs for two hospital groups namely outpatient visits, promotion and prevention visits, outpatient promotion and prevention visits, and total adjusted relative weights in both two hospital cost function specifications are significantly positive. It implies that both hospital cost function specifications for two hospital groups are monotonically increasing in all outputs.

For the variable input prices, the coefficients of first-order derivatives of all variable input prices namely labor price index, price index for drug and medical supplies and other price index are also significantly positive, implying that both hospital cost function specifications for two hospital groups are monotonically increasing in all input prices.

For both the fixed inputs of the general and regional hospital group namely the number of beds and doctors, the coefficient of the number of beds is significantly positive, but that of the number of doctors is positive and not statistically significant. While both the number of beds and doctors of the community group are significantly positive. Non-decreasing and increasing monotonicity in fixed inputs for general and regional group and community group respectively are inconsistent with long-term cost minimization behavior, indicating overcapitalization.

To examine the short-run and long-run cost minimization behavior, testing for the concavity in variable input prices and convexity in fixed inputs are to be further conducted respectively.

To test for the concavity in variable input prices and convexity in fixed inputs of the cost function, the eigenvalues of the Hessian matrix of the hospital cost functions with respect to variable input prices and fixed input quantities were calculated.

Test for concavity in variable input prices

Apart from monotonicity of outputs and variable input prices, testing for concavity in variable input prices is necessary to examine short-run cost minimization behavior.

We find that all of the three eigenvalues of Hessian matrix associated with the variable input prices of both the hospital cost function specifications are negative for general and regional hospital group whereas two negative values and one zero for community group as follows:

General and regional hospitals

The hospital cost function model I

Hessian matrix for variable input prices

	c1	c2	c3
r1	-0.26547		
r2	-0.06106	-0.13943	
r3	0.124018	-0.03545	-0.12478

Eigenvalues

-0.01997	-0.16564	-0.34406

The hospital cost function model II

Hessian matrix for variable input prices

	c1	c2	c3
r1	-0.30026		
r2	-0.04211	-0.12976	
r3	0.121854	-0.03851	-0.12088

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Eigenvalues

-0.03028	-0.15693	-0.36369

Community hospitals

The hospital cost function model I

Hessian matrix for variable input prices

	c1	c2	c3
r1	-0.18742		
r2	0.168848	-0.15998	
r3	0.086556	-0.00037	-0.12856

Eigenvalues

0.020453	-0.13503	-0.36139

The hospital cost function model II

Hessian matrix for variable input prices

	c1	c2	c3
r1	-0.17142		
r2	0.165087	-0.15794	
r3	0.083802	-0.00565	-0.12771

Eigenvalues

0.021696	-0.12944	-0.34933

Test for convexity in fixed inputs

Apart from monotonicity of fixed inputs, the convexity of fixed inputs is necessary for testing for long-run cost minimization behavior though eigenvalue calculation. The two eigenvalues associated with two fixed input that should be significantly positive are one negative and one zero value for general and regional group, while both negative values for community hospital group as follows.

General and regional hospitals

The hospital cost function model I

Hessian matrix for fixed inputs

	c1	c2
r1	0.016296	
r2	-0.04088	-0.20459

Eigenvalues

0.023619 -0.21191

The hospital cost function model II

Hessian matrix for fixed inputs

	c1	c2
r1	-0.02667	
r2	-0.02398	-0.18923

Eigenvalues

-0.02321 -0.1927

Community hospitals

The hospital cost function model I

Hessian matrix for fixed inputs

	c1	c2
r1	-0.01491	
r2	0.002787	-0.04234

Eigenvalues

-0.01463 -0.04262

The hospital cost function model II

Hessian matrix for fixed inputs

	c1	c2
r1	-0.01147	
r2	0.002423	-0.04098

Eigenvalues

-0.01127 -0.04118

Table 39 below summarize the findings for the condition for short-run and long-run cost minimization behaviors of regional, general and community hospitals using SUR regression.

Table 39 SUR regression results for the condition for short-run and long-run cost minimization behaviors

SUR models	General/Regional		Community hospitals	
Cost minimization behavior	Model I	Model II	Model I	Model II
Short-run cost minimization				
Monotonicity of outputs	Increasing	Increasing	Increasing	Increasing
Monotonicity of variable input prices	Increasing	Increasing	Increasing	Increasing
Concavity in variable input prices				
- Eigenvalue I	Negative	Negative	Zero	Zero
- Eigenvalue II	Negative	Negative	Negative	Negative
- Eigenvalue III	Negative	Negative	Negative	Negative
Long-run cost minimization				
Monotonicity of fixed inputs				
- Bed number	Increasing	Increasing	Increasing	Increasing
- Doctor number	Not sig.	Not sig.	Increasing	Increasing
Concavity in fixed inputs				
- Eigenvalue I	Positive	negative	negative	negative
- Eigenvalue II	Negative	negative	negative	negative

As can be seen, the findings in the table above show that the assumptions of short-run cost minimization of both the hospital cost function specifications for both the general and regional hospital group and the community group cannot be

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rejected but those findings for both groups of hospitals are inconsistent with the properties of long-term cost minimization assumptions.

In addition, four restrictions on the structure of production and cost, which are relaxed by the use of a flexible multiproduct cost function, namely non-jointness, separability, linear homogeneity in outputs (constant returns to scale) and Cobb-Douglas functional form were analyzed as the hypothesis testing. Brown et al. (1979) indicated that the imposition of homogeneity in outputs and separability can greatly distort estimates of cost function and in turn marginal costs and scale economics. In this study all four restrictions were treated as testable hypotheses. The results of testing the hypotheses were shown in table 40 below.

Table 40 Test Statistics for restricted SUR Model I and II

Hospital types	General/Regional Hospitals			Community Hospitals		
SUR models	Test statistics	No of restrictions	p-value	Test statistics	No of restrictions	p-value
SUR model I						
Non-jointness	4.62	3	0.2016	4.19	3	0.2419
Separability	3.40	9	0.9463	30.42	9	0.0004
Linear homogeneity in outputs	327.03	10	0.0000	1413.48	10	0.0000
Cobb-Douglas form	190.99	44	0.0000	1043.63	44	0.0000
SUR Model II						
Non-jointness	0.69	1	0.4052	1.04	1	0.3069
Separability	0.88	6	0.9897	31.76	6	0.0000
Linear homogeneity in outputs	101.33	8	0.0000	523.73	8	0.0000
Cobb-Douglas form	159.15	28	0.0000	698.66	28	0.0000

Based on test statistics shown in table 3, two out of four restrictions namely linear homogeneity in outputs and Cobb-Douglas form for the general and regional hospital group are rejected, while all but non-jointness for community group are rejected. Thus the full generality of the unrestricted translog form no longer adequately represent the structure of production.

The table 41 below showed the results of testing between unrestricted and restricted models for structural properties of multiproduct cost functions using the likelihood ratio test.

Table 41 Test Statistics for restricted SUR Model I and II by Likelihood Ratio test

Hospital types	General/Regional Hospitals		Community Hospitals	
SUR models	Test statistics	p-value	Test statistics	p-value
SUR model I				
Non-jointness*	12.08	0.0005	116.59	0.0000
Separability	3.58	0.9370	30.92	0.0003
Linear homogeneity in outputs	201.59	0.0000	1440.37	0.0000
Cobb-Douglas form	166.13	0.0000	1277.97	0.0003
SUR Model II				
Non-jointness*	12.18	0.0005	107.83	0.0000
Separability	0.86	0.9904	35.30	0.0000
Linear homogeneity in outputs	201.67	0.0000	1244.63	0.0000
Cobb-Douglas form	163.08	0.0000	1216.96	0.0000

*Jointness assumption is nested in the non-jointness assumption

As can be seen, the results are the same as those tested using Wald test in the table 40.

Based on the results of testing monotonicity and curvature conditions, multiproduct production and cost concepts consisting of non-jointness, separability, linear homogeneity in outputs, and Cobb-Douglas functional form, the hospital cost function model I and II for both the hospital groups are theoretically satisfied and used as parametric methods in the evaluation of hospital response in the second step because the non-optimal long-run behavior does not preclude the use of parametric methods which requires only short-term cost minimization (Carey, 1997).

4.2.2.1.2 Panel data models

The random-effects and fixed-effects panel data model technique was used as the other technique to fit the hospital cost function models. At first a random-effects panel data technique was used and then the Breusch and Pagan Lagrangian multiplier test for random effects was applied to test the existence of the individual hospital-specific effects. The chi squared test statistics is reported. If null hypothesis of no random effects is rejected, it implies that the OLS technique might yield inconsistent results. Next, a fixed-effects panel data technique was used, and then the Hausman specification test was done to examine the presence of correlation between the individual hospital-specific effects and some regressors.

In the same way, the analysis was separately conducted into both hospital groups:

1) General and regional hospital group

2) Community hospital group.

General and regional hospitals

The table 42 below shows the results of random-effects and fixed-effects panel regression on hospital cost for the general and regional hospitals.

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Table 42 Random-effects and fixed-effects panel regression results of hospital cost function model I and II for general and regional hospitals

General and Regional Hospitals	Model I		Model II	
Independent Variables	Random-effects	Fixed-effects	Random-effects	Fixed-effects
Hospital outputs				
Outpatient visits	0.148***	0.115***		
	(0.040)	(0.027)		
Promotion and prevention visits	0.081***	0.069***		
	(0.018)	(0.012)		
Outpatient, promotion and prevention visits			0.225***	0.189***
			(0.033)	(0.026)
Total adjusted relative weights	0.237***	0.115***	0.175***	0.092***
	(0.033)	(0.023)	(0.028)	(0.022)
Variable input prices				
Labor price index	0.409***	0.430***	0.452***	0.445***
	(0.064)	(0.043)	(0.051)	(0.039)
Price index for drug and medical supplies costs	0.320***	0.278***	0.313***	0.279***
	(0.025)	(0.017)	(0.021)	(0.017)
Price index for other operating Costs	0.237***	0.214***	0.234***	0.209***
	(0.020)	(0.014)	(0.017)	(0.013)
Fixed inputs				
Bed numbers	0.131**	-0.002	0.114**	0.013
	(0.047)	(0.034)	(0.039)	(0.032)
Doctor numbers	0.126**	0.058*	0.112***	0.054*
	(0.040)	(0.028)	(0.034)	(0.027)
Yearly time trend	-0.024**	0.013*	-0.008	0.019**
	(0.009)	(0.006)	(0.007)	(0.006)

This table shows only the coefficients of relevant variables.* $p<0.05$; ** $p<0.01$; *** $p<0.001$

As a result, the test statistics of the Breusch and Pagan Lagrangian multiplier test and Hausman specification test were both significant and implied that the results in the columns of fixed-effects of each models are consistent.

As shown, although almost coefficient values of the fixed-effects models are less than those of random-effects ones, but are in the same direction. Except the coefficient of bed numbers of fixed-effects models are not significant and the coefficient values of yearly time trend variables of the fixed-effects model are of opposite direction compared with those of random-effects ones.

Focusing on the columns of fixed-effects models, monotonicity and curvature properties of short-run and long-run cost minimization assumptions for both the hospital cost models were tested for.

For the properties of short-run cost minimization assumptions such as non-decreasing monotonicity of outputs and variable input prices and concavity in variable input prices, in this step now the sign of first-order derivatives for all outputs and variable input prices are significantly positive as expected.

Test for concavity in variable input prices

Regarding the concavity of variable input prices, the Hessian matrix and eigenvalues are derived as follows:

The hospital cost function model I

Hessian matrix for variable input prices

	c1	c2	c3
r1	-.20278751		
r2	.10412152	-.10943304	
r3	.09866598	.00531152	-.1039775

Eigenvalues of Hessian matrix

-1.359e-14 -.1119007 -.30429735

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The hospital cost function model II

Hessian matrix for variable input prices

	c1	c2	c3
r1	-.2151519		
r2	.11822885	-.11747416	
r3	.09692305	-.00075469	-.09616836

Eigenvalues of Hessian matrix

-3.785e-15 -.10450644 -.32428798

According to the results above, the hospital cost function model I and II is satisfied for the short-run cost minimization assumptions.

Test for convexity in fixed inputs

For the properties of long-run cost minimization assumptions such as non-increasing monotonicity of fixed inputs and convexity in fixed inputs, the sign of first-order derivatives for nearly all fixed inputs are positive, even the coefficient value of the number of beds of model I is negative but not significant.

Regarding the convexity of fixed inputs, the Hessian matrix and eigenvalues are derived as follows:

The hospital cost function model I

Hessian matrix for fixed inputs

	c1	c2
r1	.15883628	
r2	-.09187838	-.01661484

Eigenvalues of Hessian matrix

.19814383 -.05592239

The hospital cost function model II

Hessian matrix for fixed inputs

	c1	c2
r1	.16187685	
r2	-.08320929	-.01763822

Eigenvalues of Hessian matrix

.19451294 -.05027432

The findings of eigenvalues are inconsistent with the long-run cost minimization assumptions, corresponding with the results obtained from SUR regression technique.

However, the fixed-effects hospital cost function model I and II would be used to further test for the multiproduct cost concepts.

Community hospitals

The table 43 below shows the results of random-effects and fixed-effects panel regression on hospital cost model I and II for the community hospitals.

As a result, the test statistics of the Breusch and Pagan Lagrangian multiplier test and Hausman specification test were both significant for both models and implied that the results in the columns of fixed-effects of each models are consistent.

Table 43 Random-effects and fixed-effects panel regression results of hospital cost function model I and II for community hospitals

Community Hospitals	Model I		Model II	
Independent Variables	Random-effects	Fixed-effects	Random-effects	Fixed-effects
Hospital outputs				
Outpatient visits	0.273***	0.195***		
	(0.014)	(0.012)		
Promotion and prevention visits	0.067***	0.065***		
	(0.007)	(0.006)		
Outpatient, promotion and			0.315***	0.252***
prevention visits			(0.013)	(0.011)
Total adjusted relative weights	0.221***	0.148***	0.227***	0.149***
	(0.011)	(0.010)	(0.011)	(0.009)
Variable input prices				
Labor price index	0.433***	0.443***	0.447***	0.452***
	(0.023)	(0.019)	(0.023)	(0.019)
Price index for drug and medical	0.199***	0.176***	0.199***	0.174***
supplies costs	(0.011)	(0.009)	(0.010)	(0.009)
Price index for other operating	0.309***	0.310***	0.303***	0.303***
Costs	(0.008)	(0.007)	(0.008)	(0.006)
Fixed inputs				
Bed numbers	0.024*	-0.008	0.026**	-0.007
	(0.010)	(0.008)	(0.009)	(0.008)
Doctor numbers	0.051***	0.031***	0.050***	0.029***
	(0.007)	(0.006)	(0.007)	(0.006)
Yearly time trend	0.032***	0.036***	0.032***	0.036***
	(0.005)	(0.004)	(0.004)	(0.004)

This table shows only the coefficients of relevant variables. * p<0.05; ** p<0.01; *** p<0.001

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As shown as the ones for general and regional hospital group, almost coefficient values of the fixed-effects models are less than those of random-effects ones, but are in the same direction. Except the coefficient of bed numbers of fixed-effects models are of opposite direction compared with those of random-effects ones, but not statistically significant.

Focusing on the columns of fixed-effects models, monotonicity and curvature properties of short-run and long-run cost minimization assumptions for both the hospital cost models were tested for.

For the properties of short-run cost minimization assumptions such as non-decreasing monotonicity of outputs and variable input prices and concavity in variable input prices, the sign of first-order derivatives for all outputs and variable input prices are significantly positive as expected.

Test for concavity in variable input prices

Regarding the concavity of variable input prices, the Hessian matrix and eigenvalues are derived as follows:

The hospital cost function model I

Hessian matrix for variable input prices

	c1	c2	c3
r1	-.26273811		
r2	.1302628	-.16410283	
r3	.13247531	.03384003	-.16631533

Eigenvalues

-7.216e-16 -.19903029 -.39412599

The hospital cost function model II

Hessian matrix for input prices

	c1	c2	c3
r1	-.33812238		
r2	.13396005	-.10308176	
r3	.20416233	-.03087829	-.17328403

Eigenvalues

9.173e-15	-.09826546	-.51622271

According to the results above, the hospital cost function both model I and II is satisfied for the short-run cost minimization assumptions. It differs from the results obtained from SUR regression technique that neither models are satisfied.

For the properties of long-run cost minimization assumptions such as non-increasing monotonicity and convexity in fixed inputs, the sign of first-order derivatives for the number of beds of both models are negative but not statistically significant, whereas the sign for the number of doctors of both models are significant positive.

Test for convexity in fixed inputs

Regarding the convexity of fixed inputs, the Hessian matrix and eigenvalues are derived as follows:

The hospital cost function model I

Hessian matrix for fixed inputs

	c1	c2
r1	-.06139796	
r2	-.00066577	-.0350594

Eigenvalues

-.03504258	-.06141478

The hospital cost function model II

Hessian matrix for fixed inputs

	c1	c2
r1	-.01536323	
r2	.00236867	-.02645449

Eigenvalues

-.01487855	-.02693917

The findings of eigenvalues are inconsistent with the long-run cost minimization assumptions, corresponding with the results obtained from SUR regression technique and the results for general and regional hospitals.

The fixed-effects hospital cost function model I and II for community hospitals would be used to further test for the multiproduct cost concepts.

Table 44 below summarize the findings for the condition for short-run and long-run cost minimization behaviors of regional, general and community hospitals using fixed-effects panel regression.

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Table 44 Regression results for the condition for short-run and long-run cost minimization behaviors

Fixed-effects panel regression models	General/Regional		Community hospitals	
Cost minimization behavior	Model I	Model II	Model I	Model II
Short-run cost minimization				
Monotonicity of outputs	Increasing	increasing	increasing	Increasing
Monotonicity of variable input prices	Increasing	increasing	increasing	Increasing
Concavity in variable input prices				
- Eigenvalue I	Negative	Negative	Negative	Zero
- Eigenvalue II	Negative	Negative	Negative	Negative
- Eigenvalue III	Negative	Negative	Negative	Negative
Long-run cost minimization				
Monotonicity of fixed inputs				
- Bed number	Not sig.	Not sig.	Not sig.	Not sig.
- Doctor number	Increasing	Increasing	Increasing	Increasing
Concavity in fixed inputs				
- Eigenvalue I	Positive	Positive	Negative	Negative
- Eigenvalue II	Negative	Negative	Negative	Negative

As can be seen, the findings from fixed-effects panel regressions in the table above show the same results as those from SUR regression in that the assumptions of short-run cost minimization of both the hospital cost function specifications for both the general and regional hospital group and the community group cannot be rejected but those findings for both groups of hospitals are inconsistent with the properties of long-term cost minimization assumptions.

The fitted models above were tested for multiproduct cost concepts by imposing the restrictions of non-jointness, separability, linear homogeneity in outputs or constant return to scale and Cobb-Douglas function form. The table 45 below shows the results of those testing.

Table 45 Test Statistics of restricted fixed-effects panel data model I and II

Hospital types	General/Regional Hospitals			Community Hospitals		
Panel Regression Models	Test statistics	No of restrictions	p-value	Test statistics	No of restrictions	p-value
<u>Fixed-effects model I</u>						
Non-jointness	2.20	3	0.0896	4.78	3	0.0026
Separability	5.01	6	0.0001	3.90	6	0.0007
Linear homogeneity in outputs	129.52	9	0.0000	95.62	9	0.0000
Cobb-Douglas form	9.84	36	0.0000	5.82	36	0.0000
<u>Fixed-effects model II</u>						
Non-jointness	4.89	1	0.0283	3.48	1	0.0622
Separability	12.74	4	0.0000	5.47	4	0.0002
Linear homogeneity in outputs	215.83	8	0.0000	605.88	8	0.0000
Cobb-Douglas form	12.52	28	0.0000	33.65	28	0.0000

As shown in the columns of the general and regional hospitals, the fixed-effects hospital cost model I and II are non-joint and joint respectively, whereas other properties such as separability, linear homogeneity in outputs and Cobb-Douglas function form of both model I and II are all rejected. This non-jointness restriction is required for use in the parametric methods in the next step.

For the community hospitals, hospital cost model I are satisfied without restriction, whereas non-joint restriction is required for hospital cost model II.

Based on the results of hypothesis testing in table 45 above, the restricted fixed-effects hospital cost model I for non-jointness property and unrestricted hospital cost model II could represent the structure of production and cost for general/regional hospitals and are able to be employed to determine the effects of change in reimbursement policy on hospital costs for CSMBS inpatient service index.

For the community hospitals, the unrestricted fixed-effects hospital cost model I and restricted hospital cost model II for non-jointness property could represent the structure of production and cost are able to be employed to determine the effects of change in reimbursement policy on hospital costs for CSMBS inpatient service index.

4.2.2.2 Second step of determining the effects of change in reimbursement on hospital costs of CSMBS inpatient services

For this step, the interaction term variables between the proportion of inpatient services in terms of total adjusted relative weights by source of payment and yearly dummy variables were included into the well-behaved hospital cost function constructed in the first step to evaluate the hospital response on inpatient service costs to change in reimbursement policy for CSMBS beneficiaries in 2008. The sources of payment include Civil Servant Medical Benefit Scheme (CSMBS), Universal Coverage Scheme (UCS), and Social Security Scheme (SSS). Seemingly unrelated regression (SUR) and fixed-effects panel regression were employed to estimate the hospital cost functions and determine those effects. After the model was fitted, the regularity conditions have been verified again to confirm the validity of estimated hospital cost function.

4.2.2.2.1 Using SUR regression technique

For general and regional hospitals, the non-jointness and separability restrictions were imposed in the estimation process for hospital cost model I and II and it showed that no estimated hospital cost models are valid. Furthermore, in case that those restrictions were relaxed and the coefficients of the interaction term variables of yearly time trend were set to zero, the estimated hospital cost models are still invalid.

For community hospitals, the non-jointness restrictions were imposed in the estimation process for hospital cost model I and II and it showed that both estimated hospital cost models are valid according to test statistics for concavity in variable input prices as follows.

The restricted SUR hospital cost function model I

Hessian matrix for variable input prices

	c1	c2	c3
r1	-.22457427		
r2	.08557771	-.16099724	
r3	.06446502	-.00837409	-.12977422

Eigenvalues

-.07705076	-.13457261	-.30372236

The restricted SUR hospital cost function model II

Hessian matrix for variable input prices

	c1	c2	c3
r1	-.223402		
r2	.09360649	-.16712491	
r3	.06416312	-.00311357	-.13402536

Eigenvalues

-.07165297	-.14312348	-.30977582

The restricted SUR hospital cost function model I

Hessian matrix for fixed inputs

	c1	c2
r1	-.0570062	
r2	.00316799	-.04744343

Eigenvalues

-.04648916 -.05796048

The restricted SUR hospital cost function model II

Hessian matrix for fixed inputs

	c1	c2
r1	-.04468317	
r2	.00340083	-.04932254

Eigenvalues

-.04288623 -.05111948

4.2.2.2.2 Using the fixed-effects panel data technique

For the general and regional hospitals, hospital cost model II is valid whereas hospital cost model I is invalid. In addition, both hospital cost models I and II for community hospitals are invalid according to test statistics for concavity in variable input prices as follows.

General and regional hospitals

The hospital cost function model I

Hessian matrix for variable input prices

	c1	c2	c3
r1	-.18607406		
r2	.08837372	-.0973843	
r3	.09770034	.00901057	-.10671091

Eigenvalues

6.318e-15 -.11067086 -.27949841

The hospital cost function model II

Hessian matrix for variable input prices

	c1	c2	c3
r1	-.17453066		
r2	.08626736	-.09269702	
r3	.0882633	.00642966	-.09469296

Eigenvalues

-9.122e-15	-.10010617	-.26181446

Community hospitals

The hospital cost function model I

Hessian matrix for variable input prices

	c1	c2	c3
r1	-.33073418		
r2	.11944025	-.07953953	
r3	.21129393	-.03990072	-.1713932

Eigenvalues

4.303e-16	-.070691	-.5109759

The hospital cost function model II

Hessian matrix for variable input prices

	c1	c2	c3
r1	-.32882912		
r2	.11641024	-.0774414	
r3	.21241887	-.03896885	-.17345003

Eigenvalues

2.226e-16	-.0701376	-.50958294

Final regression results of general and regional hospitals are obtained from fixed-effects panel regression technique whereas those of community hospitals are resulted from SUR regression technique as shown in table 46 below.

Table 46 Regression results on the effects of change in reimbursement policy for CSMBS inpatient services on hospital cost behavior

Hospital types	General/Regional	Community hospitals	
Variable	Model II	Model I	Model II
Hospital outputs			
Outpatient visits		0.461***	
		(0.049)	
Promotion and		0.117***	
prevention visits		(0.027)	
Outpatient,	0.266***		0.565***
promotion			
and prevention visits	(0.017)		(0.048)
Total adjusted	0.110***	0.187***	0.194***
relative			
Weights	(0.013)	(0.037)	(0.036)
Variable input price indices			
Labor price index	0.531***	0.290***	0.272***
	(0.013)	(0.044)	(0.043)
Drug and medical	0.267***	0.328***	0.347***
supplies price index	(0.010)	(0.037)	(0.036)
Other service price	0.203***	0.382***	0.382***
Index	(0.007)	(0.037)	(0.036)
Fixed inputs			
Bed numbers	-0.010	0.075*	0.064*
	(0.021)	(0.032)	(0.031)
Doctor numbers	0.056***	0.058*	0.058*
	(0.015)	(0.024)	(0.023)
Yearly time trend	-0.014***	0.133***	0.132***
	(0.001)	(0.028)	(0.028)

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Table 46 Regression results on the effects of change in reimbursement policy for CSMBS inpatient services on hospital cost behavior (cont'2)

Hospital types	General/Regional	Community hospitals	
Variable	Model II	Model I	Model II
CSMBS inpatient service proportions			
2007	0.005	-0.034**	-0.036**
	(0.008)	(0.011)	(0.011)
2008	0.000	-0.025*	-0.027*
	(0.010)	(0.011)	(0.011)
2009	0.013	-0.022	-0.030*
	(0.011)	(0.012)	(0.012)
2010	0.019	-0.032**	-0.039***
	(0.011)	(0.012)	(0.011)
UCS inpatient service proportions			
2007	0.014	0.022	0.015
	(0.022)	(0.048)	(0.046)
2008	-0.009	-0.055	-0.063
	(0.012)	(0.046)	(0.046)
2009	-0.004	0.032	0.020
	(0.020)	(0.040)	(0.039)
2010	0.029	-0.052	-0.072
	(0.022)	(0.044)	(0.042)
SSS inpatient service proportions			
2007	0.008	-0.012	-0.011
	(0.009)	(0.008)	(0.007)
2008	0.003	-0.011	-0.011
	(0.008)	(0.009)	(0.008)
2009	0.006	-0.007	-0.006
	(0.009)	(0.009)	(0.008)
2010	-0.006	-0.008	-0.011
	(0.009)	(0.009)	(0.009)

This table shows only the coefficients of relevant variables. Legend: * p<0.05; ** p<0.01; *** p<0.001

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As can be seen, the coefficients of output and variable input price parameters are all positive in line with the previous results in the first step for both hospital groups. For the fixed input parameters, the coefficients of the number of beds of general and regional hospitals are negative but not statistically significant, but the coefficient of the number of doctors is significantly positive. While both the coefficients of the number of beds and doctors that are estimated from SUR regression are significantly positive for the community hospitals. The findings are consistent with shortage of bed capacity in the general and regional hospitals and low bed occupancy rate in the community hospitals. Also, positive coefficients of the number of doctors indicate an increase in hospital costs that are consistent with an increase in compensation for all hospital types in 2008.

For the yearly time trend variable, its coefficient for general and regional hospitals is significantly negative reflecting that the technical change in those hospitals results in cost saving, whereas significantly positive in community hospitals indicating higher cost utilization. This finding is mostly due to higher proportionate increase in hospital labor costs than that of hospital outputs in the community hospitals and vice versa in general and regional hospitals.

As shown in the columns of the general and regional hospitals, the sign of coefficient of CSMBS inpatient service proportion of both hospital cost model I and II are positive and not statistically significant since 2008, not as expected. Hypothetically, it should be negative and statistically significant if hospitals attempted to contain costs by a decrease in unnecessary medical treatment. Not surprising, it is because rather than flat-rate payment based on relative weight of DRG, the additional revenues could be gained from other items excluding from DRG-based payment such as medical instruments and devices, some expensive medical supplies and et cetera. In addition, itemized costs incurred for out of pocket payment by the CSMBS patients are also offered such as special room, accommodation facilities and other amenities. While the effects on hospital costs for other sources of payment such as UCS and SSS schemes are not present due to no obvious reimbursement policy changes from those payers.

For the community hospitals, the effects of the change in reimbursement policy on hospital costs are significantly negative as expected. However, a decrease started from 2007, it might be the results from other cost containment measures from Department of Comptroller in the previous period before change in reimbursement, for example, prior control measure of usage for the original expensive medicine.

So far, the findings imply that the change in reimbursement for CSMBS inpatient services could take effect on the hospital costs only in the community hospitals, not in general and regional hospitals that better adjust for financial pressure from reimbursement policy change.

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4.2.3 Discussion

The findings that both general/regional hospitals and community hospitals are satisfied with short-run cost minimization behavior are consistent with the results of Bilodeau et al. (2000). They found that all short-term properties are verified in the public hospital in Quebec. Moreover, the sign of coefficients and eigenvalues associated with fixed input quantities are wrong, indicating non-optimal long term cost minimization. This is because the decision on allocation of physician, equipment and physical buildings are under control of central government/authority.

For the finding of no effects of change in reimbursement policy for CSMBS inpatient beneficiaries on hospital costs in the general and regional hospitals, it reflects partly that due to the inpatients in general and regional hospitals are rather severe and complex, although there are financial pressure from change in reimbursement, perhaps it is difficult to reduce service intensity that might affect the treatment outcome. For another reason regarding on treatment decision making of doctors it is desirable that doctors are indeed responsible to behave as perfect agents of their patients (Scott and Parkin, 1995) and neglect to financial pressure to the hospital. However, this change in reimbursement policy has not just introduced, the hospitals had the experience of the same change from Universal Coverage Scheme since 2001. As a result, the hospital could adjust their response to the second time of reimbursement policy change with no effects on hospital costs in the same picture of the findings for Universal Coverage Scheme.

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CHAPTER V
CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This study stemmed from policy questions of whether and how the public hospital under Office of Permanent Secretary, Ministry of Public Health that comprise the main part of all hospitals in Thailand behave on cost minimization basis and respond to change in payment system on the volume and service intensity of healthcare. The importance of these issues is that the effect on the volume the healthcare services might result in change in resource allocation in the healthcare system whereas the impact on service intensity could affect the quality of service and in turn treatment outcome of their patients. The objective of this study is to examine how they respond on the volume and intensity of service provision, whether and how cost minimization behaviors of public hospitals are present and the hospitals respond on the hospital costs.

This study used the hospital-level service utilization and financial data and employed the econometric techniques to achieve the objectives. Regarding the response to service provision the length of hospital stay was used as the proxy of service intensity of healthcare service and the healthcare utilization in terms of outpatient visits, the proportion of inpatient discharges admission rates and the number of referred out cases with multiple regression technique were used to examine change in the volume of healthcare services. On the other hand, the issues on hospital cost minimization behavior and response on hospital cost for inpatient services needed the development of well-behaved hospital cost function to determine the effects on hospital costs. The seemingly unrelated regression (SUR) and fixed-effects panel data models were used to construct the hospital cost functions and determine effects on hospital costs.

The analysis was divided into two or three hospital groups based on healthcare technology, severity and complexity of healthcare services, consisting of regional, general and community hospitals. All hospitals with complete panel data set from year 2005 to 2010 were used.

The results and conclusions are divided into two parts consisting of 1) service intensity and volume response and 2) hospital cost behavior and response.

5.1.1 Service intensity and volume response

The change in payment system from fee-for-service to DRG-based basis for CSMBS inpatient services had negative effects on the hospital service intensity in term of a reduction in average length of stay for CSMBS inpatient cases. The overall service intensity effects consisted of the negative moral hazard effect at the regional and general hospital levels, positive selection effects at all levels of hospitals and positive practice-style effect. It also had negative effects on the admission rate of CSBMBS patients at all types of hospitals and the proportion of inpatient cases at community hospitals. There were still no shifts from the inpatient admissions to outpatient visits in order to increase the hospital revenue. Finally, it promotes the transfer behavior that leads to the increase in the referred-out rate of CSMBS patients at the community hospitals.

5.1.2 Hospital cost behavior and response

For the effects of change in payment policy for CSMBS inpatient beneficiaries on hospital costs, there is no effects on hospital costs in the general and regional hospitals, but negatively affected on hospital costs in the community hospitals. The findings showed that both general/regional hospitals and community hospitals exhibit short-run cost minimization behavior with non-optimal long term cost minimization. This is partly because the decision on allocation of physician, equipment and physical buildings are under control of central government/authority.

However, no matter how the hospitals respond to change in payment policy, all levels of public hospitals in Thailand including community, general and regional hospitals still exhibit the short-run cost minimization behavior.

5.2 Recommendation

5.2.1 Recommendation for policy implementation

According to the findings from this study, although public hospitals in Thailand operate in the non-market environment, but it is apparent that public hospitals respond to change in payment policy both on volume and intensity of service provision and cost behavior depending on their own context. Such response could affect to health care system performance including quality and efficiency in any way.

Policy maker and high-level executive in particular healthcare purchaser should keep in mind on such response and continuously evaluate the possible effects and impacts of financial pressures exerting from payment mechanism and methods on the performance of health care provider especially the hospitals.

However, data and information system in the developing countries including Thailand usually are not well-established due to short fall of competence, vision and long-term investment. The performance measurement and evaluation system in terms of hospital efficiency, service quality or health outcome status should be established for policy formulation and evaluation process. Long term investment in healthcare information system should be prioritized. At least the following problems should be addressed, for example, no time-series patient-level hospital service utilization data available to evaluate the service intensity and quality, no well-established categorized data on medical specialty care to account for hospital out homogeneity, no ancillary service data such as high-technology laboratory and radiological service data to reflect actual magnitude of service intensity, no formal index for input price data, no registered data on quasi-fixed and fixed inputs stock such as personnel especially distribution of general practice and specialist doctor, expensive and high-technology equipment and buildings, too short time series database, and et cetera. Actually, healthcare purchasers could influence on this process through payment for hospital IT system investment rather than payment for data reporting performance.

Moreover, due to different response to policy change in different context of the various types of hospitals, purchasing and payment policy should be based on their own context, not "one-size fit all" policy. For example, under the Medicare health insurance plan hospital wage index and price index for non-labor input services based on different geographic location and region were established including particular payment for capital inputs. Thus different payments based on specialized medical care level, hospital performance in terms of quality and efficiency, geographic location, and et cetera should be considered for add-on payments rather than flat rates based on DRG relative weights.

5.2.2 Recommendation for further study

Empirical studies on some relevant policy issues related with healthcare organization provider and physician behavior, for example, effects on the quality of services, technical and allocative efficiency, productivity, economic implication on economies of scale and scope, the in-depth hospital cost behavior, and et cetera should be done on continuous basis.

For further study on healthcare organization behavior and response to be more sophisticated and in depth, the patient-level data collection and analysis should be conducted in the next step.

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APPENDIX

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Table A1 Full fixed-effects panel regression results of the hospital cost function estimation for general and regional hospitals

Variables	Model II
Hospital outputs	
Outpatient, promotion and prevention visits	0.266***
	(0.017)
Total adjusted relative weights	0.110***
	(0.013)
Variable input price indices	
Labor price index	0.531***
	(0.013)
Drug and medical supplies price index	0.267***
	(0.010)
Other service price index	0.203***
	(0.007)
Fixed inputs	
Bed numbers	-0.010
	(0.021)
Doctor numbers	0.056***
	(0.015)
Yearly time trend	-0.014***
	(0.001)
Squared and interaction terms	
Outpatient, promotion and prevention visits squared	0.079*
	(0.033)
Total adjusted relative weights squared	0.034
	(0.018)
Outpatient, promotion and prevention visits * Total adjusted relative weights	-0.103**
	(0.039)
Labor price index squared	0.075*
	(0.036)
Drug and medical supplies price index squared	0.103***
	(0.013)

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Table A1 Full fixed-effects panel regression results of the hospital cost function estimation for general and regional hospitals (cont'2)

Variables	Model II
Other price index squared	0.067***
	(0.010)
Labor price index * Drug and medical supplies price index	-0.055**
	(0.020)
Labor price index * Other price index	-0.019
	(0.019)
Drug and medical supplies price index * Other price index	-0.048**
	(0.017)
Bed numbers squared	0.012
	(0.034)
Doctor numbers squared	0.068*
	(0.031)
Bed numbers * Doctor numbers	-0.053
	(0.045)
Outpatient, promotion and prevention visits * Labor price index	-0.267***
	(0.043)
Outpatient, promotion and prevention visits * Drug and medical supplies price index	0.133***
	(0.030)
Outpatient, promotion and prevention visits * Other price index	0.134***
	(0.023)
Outpatient, promotion and prevention visits * Bed numbers	-0.136**
	(0.045)
Outpatient, promotion and prevention visits * Doctor numbers	0.038
	(0.046)
Total adjusted relative weights * Labor price index	0.049
	(0.034)
Total adjusted relative weights * Drug and medical supplies price index	-0.025
	(0.024)

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Table A1 Full fixed-effects panel regression results of the hospital cost function estimation for general and regional hospitals (cont'3)

Variables	Model II
Total adjusted relative weights * Other price index	-0.024
	(0.020)
Total adjusted relative weights * Bed numbers	0.084*
	(0.040)
Total adjusted relative weights * Doctor numbers	-0.062
	(0.033)
Labor price index * Bed numbers	0.049
	(0.049)
Labor price index * Doctor numbers	0.110*
	(0.044)
Drug and medical supplies price index * Bed numbers	-0.016
	(0.035)
Drug and medical supplies price index * Doctor numbers	-0.060*
	(0.030)
Other price index * Bed numbers	-0.034
	(0.026)
Other price index * Doctor numbers	-0.050*
	(0.023)
Interaction term between CSMBS outpatient, promotion and prevention visits proportion and yearly dummy variable	
2007	-0.001
	(0.013)
2008	-0.003
	(0.012)
2009	-0.007
	(0.015)
2010	-0.008
	(0.015)

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Table A1 Full fixed-effects panel regression results of the hospital cost function estimation for general and regional hospitals (cont'4)

Variables	Model II
Interaction term between UCS outpatient, promotion and prevention visits proportion and yearly dummy variable	
2007	-0.062
	(0.034)
2008	-0.005
	(0.029)
2009	0.034
	(0.033)
2010	-0.010
	(0.034)
Interaction term between SSS outpatient, promotion and prevention visits proportion and yearly dummy variable	
2007	-0.017
	(0.012)
2008	-0.002
	(0.013)
2009	-0.003
	(0.013)
2010	0.015
	(0.014)
Interaction term between CSMBS inpatient service proportion and yearly dummy variable	
2007	0.005
	(0.008)
2008	0.000
	(0.010)
2009	0.013
	(0.011)
2010	0.019
	(0.011)

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Table A1 Full fixed-effects panel regression results of the hospital cost function estimation for general and regional hospitals (cont'5)

Variables	Model II
Interaction term between UCS inpatient service proportion and yearly dummy variable	
2007	0.014
	(0.022)
2008	-0.009
	(0.012)
2009	-0.004
	(0.020)
2010	0.029
	(0.022)
Interaction term between SSS inpatient service proportion and yearly dummy variable	
2007	0.008
	(0.009)
2008	0.003
	(0.008)
2009	0.006
	(0.009)
2010	-0.006
	(0.009)
Intercept	-0.016
	(0.000)

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Table A2 Full SUR regression results of the hospital cost function estimation for community hospitals

Variables	Model I	Model II
Hospital cost function equation		
Hospital outputs		
Outpatient visits	0.461***	
	(0.049)	
Promotion and prevention visits	0.117***	
	(0.027)	
Outpatient, promotion and prevention visits		0.565***
		(0.048)
Total adjusted relative weights	0.187***	0.194***
	(0.037)	(0.036)
Variable input price indices		
Labor price index	0.290***	0.272***
	(0.044)	(0.043)
Drug and medical supplies price index	0.328***	0.347***
	(0.037)	(0.036)
Other service price index	0.382***	0.382***
	(0.037)	(0.036)
Fixed inputs		
Bed numbers	0.075*	0.064*
	(0.032)	(0.031)
Doctor numbers	0.058*	0.058*
	(0.024)	(0.023)
Yearly time trend	0.133***	0.132***
	(0.028)	(0.028)
Squared and interaction terms		
Outpatient visits squared	0.087***	
	(0.026)	
Promotion and prevention visits squared	0.047***	
	(0.007)	

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Table A2 Full SUR regression results of the hospital cost function estimation for community hospitals (cont'2)

Variables	Model I	Model II
Outpatient, promotion and prevention visits squared		0.121***
		(0.024)
Total adjusted relative weights squared	0.067***	0.066***
	(0.015)	(0.015)
Outpatient visits * Promotion and prevention visits	-0.014	
	(0.021)	
Outpatient visits * Total adjusted relative weights	-0.111***	
	(0.034)	
Promotion and prevention visits * Total adjusted relative	-0.040*	
weights	(0.016)	
Outpatient, promotion and prevention visits * Total		-0.157***
adjusted relative weights		(0.031)
Labor price index squared	-0.019	-0.026
	(0.046)	(0.045)
Drug and medical supplies price index squared	0.059***	0.059***
	(0.012)	(0.012)
Other price index squared	0.106***	0.102***
	(0.014)	(0.014)
Labor price index * Drug and medical supplies price index	-0.01	-0.001
	(0.034)	(0.033)
Labor price index * Other price index	-0.046	-0.039
	(0.040)	(0.038)
Drug and medical supplies price index * Other price index	-0.134***	-0.135***
	(0.019)	(0.019)
Bed numbers squared	0.012	0.015
	(0.009)	(0.009)
Doctor numbers squared	0.007***	0.006***
	(0.002)	(0.002)
Bed numbers * Doctor numbers	-0.001	0.000
	(0.009)	(0.009)

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Table A2 Full SUR regression results of the hospital cost function estimation for community hospitals (cont'3)

Variables	Model I	Model II
Outpatient visits * Labor price index	0.004	
	(0.051)	
Outpatient visits * Drug and medical supplies price index	0.012	
	(0.027)	
Outpatient visits * Other price index	0.080**	
	(0.026)	
Outpatient visits * Bed numbers	-0.01	
	(0.021)	
Outpatient visits * Doctor numbers	-0.005	
	(0.017)	
Promotion and prevention visits * Labor price index	-0.026	
	(0.029)	
Promotion and prevention visits * Drug and medical supplies price index	-0.005	
	(0.016)	
Promotion and prevention visits * Other price index	0.028	
	(0.015)	
Promotion and prevention visits * Bed numbers	0.019	
	(0.013)	
Promotion and prevention visits * Doctor numbers	-0.017	
	(0.009)	(0.000)
Outpatient, promotion and prevention visits * Labor price index		-0.048
		(0.052)
Outpatient, promotion and prevention visits * Drug and medical supplies price index		0.019
		(0.026)
Outpatient, promotion and prevention visits * Other price index		0.119***
		(0.026)
Outpatient, promotion and prevention visits * Bed numbers		0.008
		(0.019)

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Table A2 Full SUR regression results of the hospital cost function estimation for community hospitals (cont’4)

Variables	Model I	Model II
Outpatient, promotion and prevention visits * Doctor numbers		-0.021 (0.016)
Total adjusted relative weights * Labor price index	-0.003 (0.041)	0.012 (0.040)
Total adjusted relative weights * Drug and medical supplies price index	-0.014 (0.019)	-0.024 (0.019)
Total adjusted relative weights * Other price index	-0.029 (0.021)	-0.037 (0.020)
Total adjusted relative weights * Bed numbers	-0.03 (0.018)	-0.034* (0.017)
Total adjusted relative weights * Doctor numbers	-0.002 (0.015)	0.005 (0.013)
Labor price index * Bed numbers	-0.039 (0.030)	-0.036 (0.029)
Labor price index * Doctor numbers	0.061** (0.022)	0.063** (0.022)
Drug and medical supplies price index * Bed numbers	0.022 (0.016)	0.021 (0.015)
Drug and medical supplies price index * Doctor numbers	-0.002 (0.012)	-0.003 (0.012)
Other price index * Bed numbers	0.001 (0.019)	0.001 (0.019)
Other price index * Doctor numbers	-0.018 (0.011)	-0.018 (0.011)
Yearly time trend squared	-0.011*** (0.003)	-0.011*** (0.003)
Yearly time trend * Outpatient visits	-0.009 (0.010)	
Yearly time trend * Promotion and prevention visits	-0.004 (0.006)	

Table A2 Full SUR regression results of the hospital cost function estimation for community hospitals (cont'5)

Variables	Model I	Model II
Yearly time trend * Outpatient, promotion and prevention visits		-0.013
		(0.010)
Yearly time trend * Total adjusted relative weights	0.005	0.005
	(0.008)	(0.008)
Yearly time trend * Labor price index	-0.039***	-0.035***
	(0.010)	(0.010)
Yearly time trend * Drug and medical supplies price index	-0.009	-0.012
	(0.008)	(0.008)
Yearly time trend * Other price index	-0.004	-0.003
	(0.008)	(0.008)
Yearly time trend * Bed numbers	-0.004	-0.002
	(0.007)	(0.007)
Yearly time trend * Doctor numbers	-0.003	-0.003
	(0.005)	(0.005)
Interaction term between CSMBS outpatient visits proportion and yearly dummy variable		
2007	0.047***	
	(0.012)	
2008	0.028**	
	(0.009)	
2009	0.014	
	(0.011)	
2010	0.025	
	(0.015)	
Interaction term between UCS outpatient visits proportion and yearly dummy variable		
2007	-0.038	
	(0.052)	
2008	0.053	
	(0.049)	

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Table A2 Full SUR regression results of the hospital cost function estimation for community hospitals (cont'6)

Variables	Model I	Model II
2009	0.032	
	(0.052)	
2010	0.047	
	(0.051)	
Interaction term between SSS outpatient visits proportion and yearly dummy variable		
2007	0.034***	
	(0.010)	
2008	0.027**	
	(0.010)	
2009	0.019	
	(0.011)	
2010	0.034**	
	(0.011)	
Interaction term between CSMBS promotion and prevention visits proportion and yearly dummy variable		
2007	0.004	
	(0.008)	
2008	0.000	
	(0.008)	
2009	0.011	
	(0.009)	
2010	0.018	
	(0.009)	
Interaction term between UCS promotion and prevention visits proportion and yearly dummy variable		
2007	-0.003	
	(0.037)	
2008	-0.005	
	(0.040)	

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Table A2 Full SUR regression results of the hospital cost function estimation for community hospitals (cont'7)

Variables	Model I	Model II
2009	-0.019	
	(0.031)	
2010	0.018	
	(0.029)	
Interaction term between SSS promotion and prevention visits proportion and yearly dummy variable		
2007	-0.012	
	(0.007)	
2008	-0.006	
	(0.007)	
2009	-0.003	
	(0.008)	
2010	-0.015	
	(0.008)	
Interaction term between CSMBS outpatient, promotion and prevention visits proportion and yearly dummy variable		
2007		0.053***
		(0.013)
2008		0.034**
		(0.011)
2009		0.032*
		(0.013)
2010		0.050***
		(0.014)
Interaction term between UCS outpatient, promotion and prevention visits proportion and yearly dummy variable		
2007		-0.035
		(0.051)
2008		0.063
		(0.051)

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Table A2 Full SUR regression results of the hospital cost function estimation for community hospitals (cont'8)

Variables	Model I	Model II
2009		0.027
		(0.051)
2010		0.099*
		(0.050)
Interaction term between SSS outpatient, promotion and prevention visits proportion and yearly dummy variable		
2007		0.024*
		(0.009)
2008		0.022*
		(0.010)
2009		0.017
		(0.011)
2010		0.031**
		(0.011)
Interaction term between CSMBS inpatient service proportion and yearly dummy variable		
2007	-0.034**	-0.036**
	(0.011)	(0.011)
2008	-0.025*	-0.027*
	(0.011)	(0.011)
2009	-0.022	-0.030*
	(0.012)	(0.012)
2010	-0.032**	-0.039***
	(0.012)	(0.011)

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Table A2 Full SUR regression results of the hospital cost function estimation for community hospitals (cont'9)

Variables	Model I	Model II
Interaction term between UCS inpatient service proportion and yearly dummy variable		
2007	0.022	0.015
	(0.048)	(0.046)
2008	-0.055	-0.063
	(0.046)	(0.046)
2009	0.032	0.02
	(0.040)	(0.039)
2010	-0.052	-0.072
	(0.044)	(0.042)
Interaction term between SSS inpatient service proportion and yearly dummy variable		
2007	-0.012	-0.011
	(0.008)	(0.007)
2008	-0.011	-0.011
	(0.009)	(0.008)
2009	-0.007	-0.006
	(0.009)	(0.008)
2010	-0.008	-0.011
	(0.009)	(0.009)
Intercept	-0.343***	-0.340***
	(0.065)	(0.062)

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Table A2 Full SUR regression results of the hospital cost function estimation for community hospitals (cont'10)

Variables	Model I	Model II
<u>Labor cost share equation</u>		
Drug and medical supplies price index	0.018***	0.019***
	(0.003)	(0.003)
Other price index	-0.103***	-0.101***
	(0.004)	(0.004)
Outpatient visits	-0.016**	
	(0.005)	
Promotion and prevention visits	-0.022***	
	(0.003)	
Outpatient, promotion and prevention visits		-0.042***
		(0.005)
Total adjusted relative weights	-0.040***	-0.037***
	(0.004)	(0.004)
Bed numbers	0.018***	0.017***
	(0.003)	(0.003)
Doctor numbers	0.008***	0.008***
	(0.002)	(0.002)
Yearly time trend	0.021***	0.020***
	(0.001)	(0.001)
Intercept	0.461***	0.466***
	(0.007)	(0.007)

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Table A2 Full SUR regression results of the hospital cost function estimation for community hospitals (cont'11)

Variables	Model I	Model II
Drug and medical supplies cost share equation		
Labor price index	0.031***	0.030***
	(0.006)	(0.006)
Other price index	-0.043***	-0.044***
	(0.004)	(0.004)
Outpatient visits	0.000	
	(0.005)	
Promotion and prevention visits	0.003	
	(0.003)	
Outpatient, promotion and prevention visits		0.003
		(0.005)
Total adjusted relative weights	0.026***	0.026***
	(0.004)	(0.004)
Bed numbers	-0.003	-0.003
	(0.003)	(0.003)
Doctor numbers	0.002	0.002
	(0.002)	(0.002)
Yearly time trend	-0.019***	-0.019***
	(0.001)	(0.001)
Intercept	0.249***	0.248***
	(0.006)	(0.006)

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