8-2014

Hospital Competitive Strategies and Performance Outcomes

Wei Wu
University of Tennessee - Knoxville, wwu3@vols.utk.edu

To the Graduate Council:

I am submitting herewith a dissertation written by Wei Wu entitled "Hospital Competitive Strategies and Performance Outcomes." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Management Science.

Bogdan C. Bichescu, Major Professor

We have read this dissertation and recommend its acceptance:

Randy V. Bradley, Charles Noon, Russell Zaretzki

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Hospital Competitive Strategies and Performance Outcomes

A Dissertation Presented for the

Doctor of Philosophy

Degree

The University of Tennessee, Knoxville

Wei Wu

August 2014

To my family, and all the people who helped me:

Thank you very much for all your love and support

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Abstract

Hospitals are under increasing pressure to improve performance and healthcare outcomes. The existing literature does not point to a clear conclusion on whether competition can help address the performance challenges of hospitals which lead to improvements in clinical outcomes. Prior research on the effects of hospital competitive strategies usually focuses on one strategy or one type of outcome at a time. As such, there is a dearth of systematical studies on different hospital competitive strategies and their consequent performance outcomes.

The main objective of this dissertation is to examine several hospital competitive strategies and quantitatively validate the implications of each strategy relative to commonly used operational, financial, and clinical metrics of hospital performance. This study leverages prior research on competition in healthcare and other industries. It proposes a framework for hospital competition, which consists of three distinct competitive strategies: i) competing on quality, ii) competing on process execution, and iii) competing on service diversification.

By utilizing hospital-level secondary data sources spanning 2004 to 2011, this dissertation analyzes empirically the performance outcomes of hospitals adopting different competitive strategies in California. The first part of the dissertation employs a set of widely recognized quality awards to identify hospitals which excel in providing quality care. A sample-control matched study is conducted to quantify the benefits associated with competing on quality and winning a quality award. The second part of the dissertation uses difference-in-differences models to

study the impact of competing on process execution, as measured by operational measures such as length of stay and cost per discharge. The third part utilizes Data Envelopment Analysis (DEA) to investigate the ramifications of competing on service diversification. It also verifies the robustness of results pertaining to competitions on quality and process execution obtained earlier in the dissertation based on linear regression models.

This dissertation represents one of the first efforts to estimate quantitatively the implications of competitive positioning strategies on hospital performance. The results can provide guidance for theory and practice with respect to the strategy that leads to highest improvement in hospital efficiency, as a function of a hospital's unique set of characteristics.

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Chapter 1

Introduction

The healthcare industry has been undergoing significant growth and transformation in the last several years. As of 2011, the U.S. healthcare costs have increased to 17.9 percent of the U.S. gross domestic product (GDP), and are projected to reach 20 percent of GDP by 2021 (CMS, 2012). Meanwhile, the healthcare industry has experienced significant changes in patient demand, financing, and quality standards, which have contributed to the growth of health expenses, the need for restructuring, and public concern about health issues (Eiriz et al., 2010). Such changes require stakeholders to reevaluate and rethink the different strategies adopted by healthcare providers in order to improve the efficiency and effectiveness of healthcare services and, thus, performance (Federal Trade Commission, 2004).

Hospitals represent the central part of the healthcare system, and the place where most value is actually delivered. As payers seek to control the escalation in healthcare expenditures, hospitals are facing increasing pressure on their bottom lines due to decreasing reimbursements from insurance companies, rising costs due to stricter pay-for-performance guidelines and increasing competition from specialized free-standing facilities (Tiwari and Heese, 2009). As such, there is considerable interest among researchers to identify hospital strategies that can improve the effectiveness of care at the patient level and efficiency at the organizational level.

Hospitals, however, are very complex organizations. In addition to their complex social structures and external interdependencies, they also coordinate the activities of a diverse workforce and many are in fact uniquely positioned to implement solutions that might lead to better care. It is therefore important to understand the relationship between their different competitive strategies and the possible consequent outcomes. Related literature has shown that these different strategies interact with hospitals' unique characteristics leading to different changes in a variety of hospital performance measures (Li et al., 2002; Minkman et al., 2007; Tiwari and Heese, 2009). However, existing literature on the relationship between hospital competitive strategies and performance outcomes exhibits inconsistent results, making management and policy decisions a difficult endeavor. Thus, a better understanding of this interaction between hospital competitive strategies and performance outcomes would put hospitals in a better position to optimize their activities and align themselves with desired changes.

1.1 Hospital Competition Overview

Competition arises when two or more parties act independently to secure their own resources from a limited pool of sources. In a normal market, competition drives relentless improvements in quality and cost (Porter, 2006). However, the unique features of healthcare markets have made hospital competition different from competition in other markets. In hospital markets, the first complicating factor is quality. Usually when consumers choose between competing products, they know those products' true value and can evaluate their levels of quality. It is assumed that health-care consumers act similarly, balancing price and quality; though, in fact most consumers are willing to pay even more to maximize quality, since the restoration of health as quickly as possible with as little pain as possible is highly valued. One problem in healthcare, however, is that consumers face a great deal of uncertainty both about the product itself (i.e., should a particular procedure even be performed) and about the quality of the service (i.e., will the procedure be carried out in the best possible way) (Thomson, 1994). Even healthcare professionals disagree on how to measure quality, i.e., whether it should reflect structural measures (varying with the relative state-of-the-art of the hospital); process measures (analyses of the procedures themselves); or outcome statistics (rates of mortality, readmission, etc.) (Robinson, 1988). Thus, a common response of providers has been attempting to send quality signals to the market, as an approach that might create a stronger sense of certainty in consumers' minds and differentiate that provider from its competitors.

The second complicating factor is the presence of health insurance. The separation of payers from consumers means that patients, as consumers, have been largely shielded from the cost consequences of their choices (Pope, 1989). When the decision to select a care provider is based on the services, amenities, and quality of the provider, one should expect that hospitals will compete for patients based on these factors. Instead of more competition leading to prices driven closer to marginal costs, more competition in the hospital market can lead to increased services, amenities, quality rivalry and higher prices (Morrisey, 2001). Meanwhile, the initial constraints on hospitals are the conscientious efforts by payers - the governments (through Medicare and Medicaid programs) and health insurers. Health maintenance organizations (HMOs) and preferred provider organizations (PPOs) have been taking steps to reduce what they pay for, or at least limit the increases in hospital costs. These concerns have prompted the move to proscriptive payments (a set fee for procedures within a diagnosis-related group) and preferred provider coverage (clients of a given plan being directed to specific hospitals in turn for reduced charges). Both concerns have forced hospitals to become increasingly conscious of their costs, especially fixed costs, but also their variable ones as well (Trinh and O'Connor, 2002). Thus, historically, payers have used selective contracting, pay-for-performance and other means to contain the rising costs of delivering care.

Third, hospital services are usually provided and consumed at the same location in a time-sensitive manner. It requires the hospital to deal with uncertain factors which are often outside of its control and there are few methods that can be adopted by hospitals to mitigate such exogenous impact, including operation scheduling, demand forecasting, revenue cycle optimization, etc (Mclaughlin and Hays, 2008). So far, it is still challenging to apply the manufacturing-driven operational principles to achieve better process execution, though the successful application of such principles would be highly desired.

Fourth, theoretical models show that where there is product differentiation (as in the hospital market), competition can lead to too little, too much, or just the right amount of quality or variety of services (Gaynor and Vogt, 2000). The services provided by a hospital are usually differentiated due to the hospital's location or different mission and objectives. Hospitals can be vertically differentiated by quality, and horizontally differentiated according to geographic location and the breadth of service lines. Also, there is a tradeoff between travel time and quality, as medical care is sought on an emergent basis, and this tradeoff gives hospitals market power. Thus, the development of a hospital service structure involves a broad variety of services. Many are essential but some are in a sense optional; for example, a given hospital could choose not to offer certain highly specialized procedures such as radiation therapy or organ transplants.

Fifth, the hospital itself can be another complicating factor. Many organizations are not-for-profit (Dranove and Satterthwaite, 2000), that is, they do not distribute profits to shareholders, but instead invest surpluses in the organization. As a consequence, non-profit hospitals are likely departing from traditional profit maximizing production choices and prices by spending profits to attain other objectives with a break-even constraint. These other objectives might include lower prices, education, charity care, higher quality services, higher wages, or 'dividends-in-kind' for the managers or trustees (Keeler et al., 1999).

As such, in this type of complex market, standard economic theory fails to provide strong guidance about the outcomes associated with different forms of hospital competition. Hospitals, as important intermediaries between payers and consumers, have to deal with increasing expectations from each side, while competing each other for scarce resources.

1.2 Study Objectives

Extant literature has provided theoretical reasons and some empirical evidence to support the notion that adopting different competitive strategies may impact hospital performance (Mukamel and Mushlin, 1998; Li et al., 2002; Pauly, 2004). However, findings from previous studies suggest that there is no clear conclusion on how hospitals can utilize different strategies to improve their performance and the extent to which these strategies can impact hospital performance. A systematic examination of hospital strategies based on actual industry data can shed light on the realized benefits of these competitive strategies. Hence this dissertation will leverage publicly available hospital data from secondary sources to investigate several competitive strategies by measuring their impact on clinical, financial, and operational measures of hospital performance.

This study will examine different hospital characteristics and analyze their impacts on hospital's selection of competitive strategies. Understanding these mechanisms for better outcomes at hospital level will help hospital management recognize the factors that are highly associated with the different competitive strategies. Additionally, this dissertation will help identify realistic performance improvement objectives that can be achieved by these strategies.

In order to realize these goals, this dissertation seeks to fill a gap in the literature by investigating the following research questions: *(i)* to what degree does a quality award impact hospital performance? *(ii)* to what degree does better process execution impact hospital performance? *(iii)* to what degree does service diversification impact hospital performance?, and *(iv)* which of the three strategies appear to maximize hospital efficiency?

1.3 Theoretical Competition Framework

Thomson (1994) provides a conceptual framework to examine the relationship between hospitals' characteristics and their competitive strategies. The framework proffers that quality of care, price, and range of services offered are three forms of competition hospitals may engage in. Butler and Leong (2000) further investigate hospital strategies from an operational perspective. They find that an emphasis on cost containment and service delivery consistently results in superior business performance. They suggest that quality programs are a necessary component, though not sufficient, while flexibility needs to be addressed to differentiate their services after hospitals develop sufficient expertise. In fact, price competition, cost containment, and efficient service delivery all require a major improvement in process execution. As such, this dissertation will focus on the three components of this framework to examine hospitals competitive strategies, as shown in Figure 1.1.

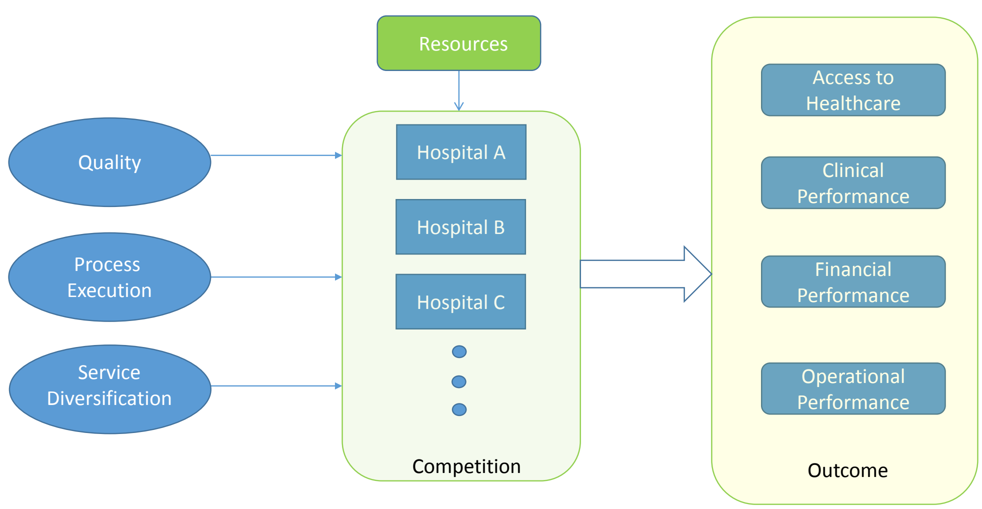

Figure 1.1: Competition Conceptual Framework

This approach is consistent with Porter's three generic strategies that are commonly used by businesses to achieve and maintain competitive advantage (Porter, 1980). The first strategy, competing on quality, is akin to meeting a narrow market scope, i.e., focusing on establishing leadership in a small, focused area, where hospitals can choose to become the leaders of specific complex treatments. The second strategy, competing on process execution, works well in a broad market scope, i.e., industry-wide leadership in cost. Hospitals choosing this strategy usually standardize their services and improve the efficiency to achieve cost leadership and fast turnover rate. The third strategy, competing on service diversification, also works in a broad market scope, since hospitals are able to develop unique sets of service lines to meet the unique needs of a diversified patient population.

The first part of this dissertation investigates the benefits of competing on quality of service. Hospitals compete on service quality to gain more patients, and to improve economies of scale and operational efficiency. In contrast to the extant literature, which relies on various quality indicators to rank hospital quality, a set of widely-recognized quality awards is employed to identify hospitals which excel in quality of care. An important finding of this work is that quality awards are associated with significant signaling effects. Using a matched-study design and regression analysis, this study finds that the sample of high quality hospitals exhibit significant increases in outpatient market share after winning quality awards, relative to local competitors with similar hospital characteristics that did not win a quality award. Moreover, hospitals winning quality awards benefit from higher levels of labor productivity and cost efficiency, while their total revenue and costs increase proportionally.

The second part of the dissertation examines the performance of hospitals which choose to compete on process execution. Hospitals often resort to such strategies in an effort to appeal to patients who are more cost sensitive or value timely and efficient service. At the same time, these are hospital characteristics regularly sought after by third-party payers. In this chapter, hospital-level data is used to quantify the impact of process execution. It turns out that hospitals with better process execution experience higher growth in inpatient market share. These providers also feature higher levels of labor utilization and higher bed turnover rates. In addition, the profitability of those hospitals has been improved, suggesting that these hospitals also become more cost effective while pursuing better process execution.

The third part of the dissertation utilizes Data Envelopment Analysis (DEA) to examine the benefits of service diversification. As a distinct non-parametric method, DEA can provide a robustness check on results pertaining to the other two competitive strategies in the framework, which are obtained using linear regression analysis. This method considers all available hospitals as a base for comparison. An efficiency score is then determined for each hospital by using linear programming techniques. This efficiency score is a measure of the efficiency of the hospital relative to all other hospitals in the analysis, and can be used to understand the relative impact of hospital competitive strategies, enabling a consistent comparison of the performance effects due to the different strategies. In addition, DEA provides further details on the dimensions that an inefficient hospital could improve on, e.g., by reducing inputs and/or by enlarging outputs. The findings of the DEA confirm earlier conclusions that competing on quality and/or competing on process execution are strategies with significant impact on hospital performance, whereas competing on service diversification tends to be effective when a hospital is experiencing changes in its case mix.

Chapter 2

Competing on Quality

2.1 Introduction

Hospital competition is generally perceived to be different from that observed in other industries due to its unique characteristics. The healthcare market is classified as a nonperfect competitive market because of uncertainty and information asymmetry (Cheng et al., 2006). Price competition is less common in health care than in other industries, and hospitals have historically competed on the basis of quality (Jacobs, 1974). Hospitals may improve quality to attract patients directly or indirectly, through their primary care physicians. Physicians may be quality sensitive, especially if the quality of hospital services is a substitute for their own time. To the extent that patients have health insurance, their concerns about the cost of high quality are attenuated. Thus, hospitals have to (indirectly) compete for patients by appealing (directly) to other entities, such as physicians and insurance companies, which in effect control the flow of patients to hospitals. Moreover, a unique characteristic of the healthcare industry is the prevalence of not-for-profit hospitals, which means that profit-driven activities are not as important as the quality of care to these hospitals. Therefore, hospital competition relies on reputation, and competition on the basis of quality is frequently addressed over price competition.

However, quality in healthcare is difficult to measure. Existent literature has mainly relied on quality indicators to measure hospital quality. This method can be undermined by the subjective selection bias of healthcare participants. For example, Shannon and Mitchell (2002) find that patients, nurses, and physicians viewed quality of care and patient satisfaction differently. As such, the direct use of an arbitrary set of quantitative quality indicators usually generates unwarranted results for the complex issue – hospital quality (Mutter et al., 2008).

Moreover, patients are often unable to make direct assessments of alternatives. Hospitals therefore often signal quality in various ways. For instance, hospitals can invest in advanced clinical technologies, focus on amenities and interpersonal qualities, improve staffing levels and staffing pattern (Thomson, 1994). Providing such goods and services in markets is to attempt to send "signals" to the market, which might create some "certainty" in consumer choice and differentiate that provider from its competitors.

Winning a quality award provides a clear signal that indicates a hospital's quality of care is, at a minimum, above average. There exists a wide variety of awards given to hospitals to recognize excellent performance in quality of care. For instance, Leapfrog Group Top Hospital Award recognizes physician staffing and safe practices. John M. Eisenberg Patient Safety and Quality Award emphasizes care coordination, reduction in disparities, and demonstrated results on publicly reported performance measures. These awards are provided through national or state quality measurement programs, which monitor hospitals quality data at regional, state and national levels. These quality awards are given to hospitals in recognition of their excellence in a variety of quality aspects relating to patient safety, clinical compliance, nurse staffing, and so on. The selection criteria incorporate a wide range of healthcare outcome measurements which are widely accepted in the medical community. And quality awards are given after the applicant typically goes through a multi-level evaluation process where a group of experts judge the applicants against the criteria, thereby ensuring award winners are among the best within the industry.

By focusing on quality awards winners, it is easier to avoid the biases associated with the arbitrary selection of individual quality indicators. In addition, many hospital administrators directly or indirectly use quality award criteria to define and benchmark their quality improvement and conduct internal self-assessments. To this extent, a clear signal that a hospital excels in quality is winning a quality award. As such, this study makes the case that quality awards are effective proxies for a hospital's focus on quality of care.

Existing research has already established the relationship between winning quality awards and performance measures such as price, cost, market share, and profitability in other industries (Hendricks and Singhal, 1997). Benefits, such as customer perceived quality and organizational structure, are also associated with winning quality awards (Kunst, 2000; Hendricks and Singhal, 2001).While award-winning organizations in other industries have garnered the interest of researchers (see, for example, Hendricks and Singhal 1997, 2001), limited evidence has been found that is associated with improved performance (Minkman et al., 2007). There still exists a dearth of research in healthcare that connects winning a quality award with hospital performance.

This study endeavors to provide the linkage between winning a quality award and hospital performance. It provides empirical evidence leveraging secondary data sources to formulate hypotheses that investigate whether the winning of quality awards, an indicator for higher quality, is linked to improvements in hospital market share, financial and operational performance. Using a matched-study design and regression analysis, this study finds that the sample of high quality hospitals exhibit significant increases in outpatient market share after winning quality awards, relative to local competitors with similar hospital characteristics that do not have any quality award. Moreover, hospitals winning quality awards benefit from higher levels of labor productivity and cost efficiency, as well as a stronger position in bargaining with payers and insurance providers. As one of the first studies to examine empirically the impact of quality awards on hospital performance, this study provides guidance to hospital managers seeking to apply for a quality award on what benefits to expect from winning such an award.

The remainder of this essay is organized as follows. In Section 2, a literature review is provided and related hypotheses are derived. In Section 3, the data and data process procedure are explained. The methodology and econometric models are presented in Section 4. The main results and findings are presented in Section 5. A discussion of the results will be presented in Section 6.

2.2 Hypothesis Development

2.2.1 Hospital Quality Awards

A set of seven quality awards are used to recognize hospitals that have outstanding quality of care. Six out of the seven quality awards are given at the national level, while one quality award is given in the state of California only. The chosen quality awards are among the most widely recognized in the nation, so they are effective in identifying those hospitals with truly excellent quality of care. Each award is being earned by a mere handful of hospitals, which indicates the award criteria are highly competitive and the awards are costly to get. The application process also demands significant hospital efforts and investment of resources and time.

Table 2.1: Summary of Selected Hospital Quality Awards

Name of Award	Focus
Leapfrog Group Top Hospital Nomination	Safety and Physician
John M. Eisenberg Patient Safety and Quality Award	Performance improvement
Premier Award for Quality	Medical procedures
NDNQI Award	Patient outcomes, nurse job satisfaction
Magnet Recognition Program	Quality patient care, nursing excellence
Baldridge National Quality Award	Patient-focused excellence, community health
California Awards for Performance Excellence	Continuous performance improvement

All the seven quality awards have a focus on hospital quality, though the actual measure may be different. Table 2.1 gives a glimpse of these widely recognized quality awards, and futher detailed descriptions of the award criteria are listed in Appendix A.1.

2.2.2 Hypothesis 1: Hospitals winning quality awards gain more market share

Hospitals have engaged in quality competition for a long time, and it has been a distinctive feature of local healthcare markets (Chirikos, 1992). Higher perceived quality care can be translated by hospitals into higher market share as well as other financial and operational benefits (Tomal, 1998). Although the quality awards selected in this study may emphasize different aspects of quality, the winning of a quality award is likely to convey clearly that the award-winning hospital excels in quality of care, since it is endorsed by the award givers. Evidence supporting the signaling effects of quality awards in other industries is provided in Hendricks and Singhal (1996).

Over time, there have been attempts at providing more information on hospital quality to physicians and the general public, through initiatives such as the Centers for Medicare & Medicaid Services Hospital Compare Project. This project aims to improve the level of transparency of hospital services and help patients develop a better understanding of how a hospital's level of quality compares to national averages. Although the mechanism through which information reporting affects hospital outcomes is still under debate (Dranove and Sfekas, 2008), such information reveals the actual performance of hospitals to the public, helping top performers build a solid reputation.

It is widely accepted that providing quality care improves hospital reputation and thus is positively associated with hospital market share. Luft et al. (1990) find that hospitals with poorer than expected outcomes attracted significantly fewer admissions. This result suggests that quality plays an important role in the choice of hospitals even before explicit data were widely available. Mukamel and Mushlin

(1998) confirm that hospitals and physicians with better outcomes experienced higher rates of growth in market share. They find that the magnitude of the association between reported mortality and market share varies geographically, and this association tends to decline over time, suggesting that it is primarily due to "new" information and that maintaining or improving market share requires hospitals to have a consistent focus on quality.

Therefore, while quality award-winning hospitals are among hospitals with better quality, the winning of a quality award is likely to have a positive impact on the market, and thus improve a hospital's market share. When the hospital market share is measured by inpatient discharges, it can be hypothesized that:

H1a: The winning of a quality award is associated with an increase in hospital inpatient market share

Due to the nature of hospital service, both inpatient and outpatient services are usually simultaneously provided to the market. However, the two markets have different characteristics. In the inpatient market, it is the physicians who usually make the decision of whether to admit a patient or not. However, the outpatient market is different in that it is usually the patient who has the freedom to choose the treatment facility. In addition, Windmeijer et al. (2005) shows that inpatient demand is less elastic than outpatient demand. Therefore, the mobility and elective features that characterize outpatient services may render a hospital's outpatient market share more sensitive to changes in reputation and quality of services. Based on these considerations, it can be further hypothesized that:

H1b: The winning of a quality award is associated with an increase in hospital outpatient market share

2.2.3 Hypothesis 2: Hospitals winning quality awards have better financial performance

A hospital's goal is usually to serve more patients and increase market share. As a consequence, financial indicators, such as total patient revenue, are valid proxies for the goals of hospitals, even though the majority of hospitals are non-profit organizations. These indicators can capture the growth of a hospital's business and are consistent with the mission of both for-profit and non-profit hospitals.

For a long time, patient revenue has been assumed to increase with the service volume (Avery and Schultz, 1972). Thomson (1994) argues that each element in the value-added processes of a hospital has a high fixed costs in terms of capital investment and salaried staff. In the end, these fixed costs can only be reduced by spreading them over more billable units (more procedures and/or more patients), in order to increase utilization rates by admitting more patients.

The level of quality of care is also highly correlated with the cost of the services offered (Friedman and Shortell, 1988). The current fee-for-service payment models have led to a proportional increase in both revenues and costs incurred in hospitals. Thus, if the award-winning hospitals improve their market share and are providing high quality services, it can be hypothesized that these hospitals are expected to achieve better financial performance, as measured by increased patient revenues.

H2a: Hospitals winning quality awards have greater increase in patient revenues

A hospital is a multiproduct firm, providing both inpatient and outpatient medical services. Within hospitals, there is a trend that an increasing number of procedures which were only available as inpatient services are now being offered on an outpatient basis by clinics and free-standing diagnostic facilities. Calem and Rizzo (1995) find that the concerns about rising health care costs have led to a shift toward prospective reimbursement systems with reductions in reimbursement levels, while advancements in medical technology have reduced the length of inpatient stays and enabled more procedures to be done on an outpatient basis. The fall in demand for inpatient care, together with the increased pressures for cost containment, has lead to changes in the competitive environment of hospitals.

In addition, the mobility and elective features of outpatient services have contributed to this industry shift. Physicians have more control on the number of patients they would like to admit for inpatient services, while they would be less likely to restrain the number of patients seeking treatments on an outpatient basis. As such, award winning hospitals would display both the general, industry-wide shift towards outpatient services as well as a potential additional inflow of outpatients attracted by a better quality reputation. In light of these arguments, it is reasonable to postulate that outpatient services can grow faster than inpatient services after the hospital wins a quality award.

H2b: Hospitals winning quality awards experience faster growth in outpatient revenue

It has become common for private and public payers to offer financial incentives to hospitals for improved clinical performance and service quality in an effort to accelerate quality improvement initiatives in hospitals. Eldenburg and Kallapur (1997) has shown that the quality-enhancing aspect of competition can also be amplified through these reimbursement schemes. The recently-adopted Hospital Value-Based Purchasing (VBP) program also shows that the Centers for Medicare & Medicaid Services (CMS) initiated a change in their payment approaches, rewarding hospitals for delivering services of higher quality and higher value, providing further proof that hospital quality is critical to insurers. The Patient Protection and Affordable Care Act (PPACA) also advocates reforms reducing costs and improve healthcare outcomes, shifting the system towards quality over quantity. Consistent with these considerations, it is expected that quality award winning hospitals, with higher payer-driven quality, would get higher reimbursement rate from third party payers for the incurred expenses.

H2c: Hospitals winning quality awards have a low allowance ratio

2.2.4 Hypothesis 3: Hospitals winning quality awards are more resource efficient

A number of previous studies have investigated the relationship between quality of care and operational efficiency. Blegen et al. (1995), for example, provides evidence that under the pressure from third party payers hospitals can reduce the costs associated with providing care while maintaining or improving the quality of care. Deily and McKay (2006) separate total hospital cost into two parts: cost that reflects the best use of resources under current circumstances and cost associated with waste or inefficiency. They finds a significant positive relationship between a hospital's level of clinical quality and the hospital's ability to manage costs efficiently. Competition can also play an important role in both increasing quality and reducing inefficiency. Hence, it posits that

H3a: Hospitals winning quality awards are more cost efficient, as indicated by a lower direct expenses ratio.

Valdmanis et al. (2008) find that quality of care could be correlated to labor efficiency, where low-quality hospitals have more inefficiency in labor inputs, while high-quality hospitals tend to be more efficient in utilizing labor inputs, thus achieving higher levels of labor productivity. Similar to what is hypothesized in H3a, health care providers with better quality of care can save efforts from unnecessary waste. As such, quality award winning hospitals exhibiting higher quality of care would benefit from higher labor efficiency, which leads to the following hypothesis:

H3b: Hospitals winning quality awards have higher levels of labor productivity.

2.3 Data and Variables

2.3.1 Data Collection

Consistent with the objective of this study, this study constructs a group of sample hospitals that have won quality awards between years 2005 and 2008. The list of award-winning hospitals is compiled from public information available on the websites of the organizations that give the awards. This study also uses news reports, industry publications, and online forums to insure a comprehensive coverage of awards. All documents pertaining to each award are carefully analyzed to ensure proper selection.

The secondary data for the hospitals in California are from the Office of Statewide Health Planning and Development (OSHPD) and the American Hospital Directory (AHD). The OSHPD provides annual financial reports, utilization reports, and patient discharge reports for all the hospitals in California. AHD provides annual clinical, operational, and financial performance data on more than 6,000 hospitals (both active and inactive). The collection of hospital information in the AHD database is derived from both public and private sources, including the cost reports compiled by the federal Centers for Medicare and Medicaid Services.

For each award winner, the year when the hospital won their first quality award is identified. This establishes the year when the winner has been recognized for its level of quality excellence. Since it typically takes hospitals at least several months to prepare and submit their award applications, it assumes that award winners had already established effective quality control procedures in the year of the quality award. However, the impact of quality awards on hospital performance is likely to be spread over a couple of years because of the evolutionary rather than revolutionary nature of the changes associated with winning a quality award (Garvin, 1991). Unfortunately, the literature does not provide much theoretical or empirical guidance on what should be the appropriate length of time period in examining these changes. The choice of the length of the time period is based on the time periods typically used in studies that examine the long-term performance of an organization. Consistent with similar studies on the quality of an organization (Ahire and Dreyfus, 2000), a 2-year period following the winning of first quality awards is chosen as the time period over which changes in hospital performance are measured. For example, the relevant time period would be from 2007 to 2009 for a quality award winning hospital that won its first award in 2007.

2.3.2 Sample & Control Selection

The first step in the empirical study is the identification of the sample group of hospitals in California that have won at least one quality award. This step identifies an initial set of 27 hospitals designated to receive awards between 2005 and 2008, the period of this analysis. The next step employs a matching procedure to identify similar control hospital for each of the sample hospitals.

An important consideration in the matching process is selecting a set of hospital characteristics that the sample and control hospitals will be matched on. The review of literature provides little guidance about the specific hospital variables that should be controlled for in the matching process. However, following recommendations for matching studies applied to public organizations (Barber and Lyon, 1996), this study controls for hospital size, defined by the number of beds, and hospital level patient severity, measured by the case mix index. In addition, this study also controls the competition to be in the same metropolitan statistical area (MSA), as most of the existing studies have measured competition based on market shares within a geographic defined hospital market (Gaynor and Haas-Wilson, 1999). In more detail, the specific steps of the matching process, which finds for each sample hospital the best control that satisfies the criteria listed above, are outlined below.

1) Step 1 - For each sample hospital, identify all other hospitals that are in the same MSA and of the same type as the sample hospital but have not yet received any of the selected quality awards.

2) Step 2 - For each sample hospital, select from the controls identified in Step 1 the hospitals with the same teaching status and profit status. If there is at least one control for the sample, then go to step 4.

3) Step 3 - Remove the constraint of teaching status and/or hospital type to find at least one possible control hospital for the sample hospital.

4) Step 4 - For each sample hospital matched against one control hospital, retain the only control hospital in the final selection. For each sample hospital matched against multiple controls, select from the set of identified controls the hospital with size and case-mix index values within 30% of the size and case-mix index values of the sample. If there are multiple controls available for the same sample hospital, then the threshold of 30% will be decreased to a low of 10% to find a unique control. If there are still multiple controls at 10% level, only one control will be selected randomly.

The above matching approach yields 27 matched pairs of sample and control hospitals. Table 2.2 provides a comparison of the main characteristics of sample and control hospitals after matching. Pairwise t-tests and Wilcoxon signed-rank tests for equality of the means and medians, respectively, indicate that sample and control hospitals are statistically indifferent on a wide range of characteristics, including clinical measures (e.g., mortality and case-mix index), operational measures (e.g., adjusted discharges per bed), and financial measures (e.g., ROA) . It seems that sample and control hospitals have very close match in all the metrics, even though only size and case mix index are strictly used.

2.4 Methodology

Many studies examining the potential impact of the existence (or non-existence) of a specific factor estimate the following Ordinary Least Squares (OLS) regression model:

$$\Delta y^i_{t,t+2} = X_i'\beta + \delta I_i + \epsilon_i, \tag{2.1}$$

Table 2.2: Summary Statistics for Sample and Control Hospitals

Specific	Mean			Median		
	Sample	Control	t-test	Sample	Control	Z-test
Size	353	289	0.235	286	297	0.5564
Case Mix Index	1.2605	1.1809	0.2701	1.17	1.17	0.4568
Teaching Hospitals				29.63%	25.93%	0.7719
For-profit Hospitals				0%	0%	1
Hospital Based Physician	258	269	0.898	108	144	0.4998
Paid Hours	3460972	2500325	0.109	2470958	2725803	0.3326
Bed Utilization	0.8046	0.8165	0.7868	0.8087	0.8362	0.387
Mortality	0.029	0.0314	0.7868	0.035	0.0335	0.7831
Length of Stay	10.188	5.5184	0.3261	5.675	4.8697	0.1414
Service Mix	114	107	0.486	117	116	0.4209
Patient Mix	0.415	0.3791	0.4469	0.3772	0.3478	0.4781
Visit Mix	0.5211	0.4505	0.2131	0.5198	0.4838	0.1637
Adjusted Discharges/Bed	81.45	82.68	0.9260	71.15	77.58	0.4001
ROA	0.1752	0.1582	0.6921	0.1401	0.1178	0.6491

where y_i represents a measure of hospital performance and I_i is a binary variable which takes a value of 1 if hospital i has an award and a value of 0 otherwise. The remaining explanatory variable X_i captures other hospital characteristics (e.g., size, CMI) that could potentially affect performance. A significant positive coefficient δ for I_i in the above model is generally interpreted as evidence in support of the existence of a performance improvement associated with the presence of an award. Equation 3.1 represents an application of the "treatment effects" model, which aims to evaluate the effect associated with a particular treatment (defined broadly to include any choice or decision; see, for example, Greene 2007).

To test H1a, the first OLS regression model is as follows:

$$\Delta IPMS_i = \alpha_{i0} + \alpha_{i1}T_i + \alpha_{i2}Size_i + \alpha_{i3}CMI_i + \alpha_{i4}Teach_i + \alpha_{i5}Type_i + \alpha_{i6}HHI_i + \epsilon_i. \tag{2.2}$$

where $\Delta IPMS = IPMS_{r+2}/IPMS_r$ represents the relative change in inpatient market share in the 2-year period following the winning of a quality award at year r. The treatment indicator T is a binary variable which has value 1 if the hospital is a sample hospital and 0 otherwise. This study also controls for other hospital characteristics such as size (*Size*), measured by the number of beds, case mix index (*CMI*), teaching status (*Teach*), coded as 1 if a teaching facility and 0 otherwise, hospital type (*Type*), coded as 1 if a general medical hospital and 0 otherwise, and HHI represents the level of market competition.

To test other hypotheses, similar OLS regression models are used, which include the control variables enumerated in Model 2.2, but differ with respect to the dependent variables. The resulting models are as follows.

The model for H1b is :

$$\Delta OPMS_i = \alpha_{i0} + \alpha_{i1} T_i + \alpha_{i2} Size_i + \alpha_{i3} CMI_i + \alpha_{i4} Teach_i + \alpha_{i5} Type_i + \alpha_{i6} HHI_i + \epsilon_i. \tag{2.3}$$

where $\Delta OPMS = OPMS_{r+2}/OPMS_r$ represents the relative change in outpatient market share in the 2-year period following the winning of a quality award at year r.

The model for H2a is :

$$\Delta PtRev_i = \alpha_{i0} + \alpha_{i1} T_i + \alpha_{i2} Size_i + \alpha_{i3} CMI_i + \alpha_{i4} Teach_i + \alpha_{i5} Type_i + \alpha_{i6} HHI_i + \epsilon_i. \tag{2.4}$$

where $\Delta PtRev = PtRev_{r+2}/PtRev_r$ represents the relative change in patient revenue in the 2-year period following the winning of a quality award at year r.

The model for H2b is :

$$\Delta IPR_i = \alpha_{i0} + \alpha_{i1} T_i + \alpha_{i2} Size_i + \alpha_{i3} CMI_i + \alpha_{i4} Teach_i + \alpha_{i5} Type_i + \alpha_{i6} HHI_i + \epsilon_i. \tag{2.5}$$

where $\Delta IPR = IPR_{r+2}/IPR_r$ represents the relative change in inpatient revenue to total revenue ratio in the 2-year period following the winning of a quality award at year r.

The model for H2c is :

$$\Delta AR_i = \alpha_{i0} + \alpha_{i1}T_i + \alpha_{i2}Size_i + \alpha_{i3}CMI_i + \alpha_{i4}Teach_i + \alpha_{i5}Type_i + \alpha_{i6}HHI_i + \epsilon_i. \tag{2.6}$$

where $\Delta AR = AR_{r+2}/AR_r$ represents the relative change in allowance ratio in the 2-year period following the winning of a quality award at year r. The higher this ratio, the more discounts provided by the hospital to the payers.

The model for H3a is :

$$\Delta DExp_i = \alpha_{i0} + \alpha_{i1}T_i + \alpha_{i2}Size_i + \alpha_{i3}CMI_i + \alpha_{i4}Teach_i + \alpha_{i5}Type_i + \alpha_{i6}HHI_i + \epsilon_i. \tag{2.7}$$

where $\Delta DExp = DExp_{r+2}/DExp_r$ represents the relative change in direct expense ratio in the 2-year period following the winning of a quality award at year r.

The model for H3b is :

$$\Delta LCR_i = \alpha_{i0} + \alpha_{i1}T_i + \alpha_{i2}Size_i + \alpha_{i3}CMI_i + \alpha_{i4}Teach_i + \alpha_{i5}Type_i + \alpha_{i6}HHI_i + \epsilon_i. \tag{2.8}$$

where $\Delta LCR = LCR_{r+2}/LCR_r$ represents the relative change in labor cost ratio in the 2-year period following the winning of a quality award at year r.

2.5 Results

This section presents the results of applying the regression models described in Section 2.4 to estimate the association between winning a quality award and hospital operational performance, as discussed in Section 2.2. A set of linear regression models is employed to estimate the association between the hospital performance and the treatment effect of winning awards as well as various hospital characteristics indicators, based on the set of 27 matched pairs. The ordinary least squares results for all hypotheses are shown in this section and tests for multicollinearity in the regression models presented in this study show variance inflation factor values lower than 5 for all predictor variables. These values are below the threshold of 10, indicating that these results are not likely to be biased by multicollinearity issues (Greene, 2007).

The first analysis corresponds to a test of Hypothesis H1a, which posits that winning quality awards will be associated with increased hospital inpatient market share. Table 2.3 illustrates the application of regression model and includes the cumulative effects of the two-year period after the hospital won awards. This analysis does not find a statistically significant correlation between inpatient market share and winning a quality award ($p > 0.1$). As such, the result does not support Hypothesis H1a.

Table 2.3: Test Results for Inpatient Market Share Change

Variable	Estimate	Standard Error	t-Statistics	Prob.
Intercept	1.0378	0.0883	11.76	$<.0001$
T	0.0029	0.0261	0.11	0.9113
Teach	-0.0015	0.0352	-0.04	0.9665
Type	-0.0539	0.0377	-1.43	0.1593
CMI	-0.0010	0.0570	-0.02	0.9858
Size	0.0000	0.0001	0.41	0.6805
HHI	-0.0275	0.0828	-0.33	0.7416

The second set of analyses correspond to a test of Hypothesis H1b, which states that winning quality awards is associated with an increase in outpatient market share. Table 2.4 shows the association between winning quality awards and outpatient market share change. This model shows that the treatment effect is positively associated with a 10.48% increase in outpatient market share in the two-year period after the sample hospital won quality awards. And this result is statistically significant at $p < 0.05$. Thus, the analysis provides evidence in support of Hypothesis H1b.

Table 2.5 contains the results of investigation concerning Hypothesis H2a, which posits a positive association between the winning of awards and patient revenue, as measured by the cumulative change in net patient revenue, after controlling for

Table 2.4: Test Results for Outpatient Market Share Change

Variable	Estimate	Standard Error	t-Statistics	Prob.
Intercept	1.1272	0.1389	8.12	<.0001
T	0.1048	0.0411	2.55	0.0141
Teach	-0.0305	0.0555	-0.55	0.5854
Type	0.0241	0.0593	0.41	0.6859
CMI	-0.1661	0.0897	-1.85	0.0703
Size	0.0001	0.0001	0.50	0.6199
HHI	0.1835	0.1302	1.41	0.1655

several hospital characteristics. This result shows the treatment effect is positively associated with net patient revenue at $p < 0.01$ level. In the two-year period, the sample hospitals on average gain 10.14% more revenue than the control hospitals. This result offers support for Hypothesis H2a.

Table 2.5: Test Results for Net Patient Revenue

Variable	Estimate	Standard Error	t-Statistics	Prob.
Intercept	1.0840	0.0934	11.61	<.0001
T	0.1014	0.0280	3.62	0.0008
Teach	0.0458	0.0369	1.24	0.2223
Type	0.0264	0.0410	0.64	0.5235
CMI	-0.0539	0.0598	-0.90	0.3725
Size	0.0001	0.0001	0.70	0.4851
HHI	0.1841	0.0867	2.12	0.0396

Table 2.6 presents the change in inpatient revenue to total revenue ratio in the two-year period after winning quality awards. This result demonstrates that sample hospitals experience an average decrease of 3.27% in the ratio of the inpatient revenue to total revenue after winning quality awards, which is statistically significant as $p = 0.0187$. This result implies that relative to their counterparts, sample hospitals' outpatient services are relatively growing faster than their inpatient services. Hence, this evidence supports Hypothesis H2b.

The next set of analyses concerns Hypothesis H2c, which explores the relationship between winning quality awards and the hospital allowance ratio. The results indicate that the sample hospitals have allowance ratios that are almost unchanged in the

Table 2.6: Test Results for Inpatient Revenue Ratio

Variable	Estimate	Standard Error	t-Statistics	Prob.
Intercept	0.9923	0.0446	22.25	<.0001
T	-0.0327	0.0134	-2.45	0.0187
Teach	-0.0011	0.0176	-0.06	0.9488
Type	-0.0628	0.0196	-3.21	0.0026
CMI	0.0370	0.0286	1.29	0.2024
Size	0.0001	0.0000	1.26	0.2132
HHI	-0.1049	0.0414	-2.54	0.0150

two-year period following the winning of a quality award, while control hospitals experience an increase in the allowance ratio. Thus, Table 2.7 shows a 2.8% relative decrease for the sample hospitals, comparing to the control hospitals, in the allowance ratio ($p \leq 0.1$). This result confirms Hypothesis H2c that sample hospitals are able to obtain a better reimburse rate with third-party payers, as they are offering less write-offs and discounts.

Table 2.7: Test Results for Allowance Ratio

Variable	Estimate	Standard Error	t-Statistics	Prob.
Intercept	1.1000	0.0545	20.20	<.0001
T	-0.0280	0.0163	-1.72	0.0934
Teach	-0.0327	0.0215	-1.52	0.1368
Type	-0.0194	0.0239	-0.81	0.4218
CMI	0.0008	0.0349	0.02	0.9818
Size	-0.0001	0.0001	-1.03	0.3086
HHI	-0.0769	0.0506	-1.52	0.1356

Table 2.8 provide the results in the change in ambulatory direct expenses ratio for the award winning hospitals. In the two-year period following the winning of a quality award, the ambulatory direct expenses ratio decreases by 8.3% on average for the sample hospitals comparing with the control hospitals. This finding provides supports to Hypothesis H3a.

Table 2.9 shows the labor productivity measured by the total payroll cost to net patient revenue. The result points to an improvement for sample hospitals in the two-year period, as there is 6.37% drop across the sample hospitals relative to the control

Table 2.8: Test Results for Ambulatory Direct Expenses Ratio

Variable	Estimate	Standard Error	t-Statistics	Prob.
Intercept	0.9569	0.1773	5.40	<.0001
T	-0.0830	0.0508	-1.63	0.1004
Teach	0.0181	0.0663	0.27	0.7862
Type	0.0187	0.0770	0.24	0.8093
CMI	-0.0589	0.1084	-0.54	0.5900
Size	0.0001	0.0002	0.47	0.6379
HHI	0.2239	0.1564	1.43	0.1602

hospitals. This statistically significant result (with $p = 0.0736$) provides support to the Hypothesis H3b.

Table 2.9: Test Results for Payroll Cost Ratio

Variable	Estimate	Standard Error	t-Statistics	Prob.
Intercept	1.2744	0.1159	11.00	<.0001
T	-0.0637	0.0347	-1.83	0.0736
Teach	-0.0802	0.0458	-1.75	0.0877
Type	-0.0575	0.0509	-1.13	0.2647
CMI	-0.0912	0.0743	-1.23	0.2259
Size	0.0000	0.0001	-0.01	0.9955
HHI	-0.0850	0.1076	-0.79	0.4339

2.6 Robustness Checks

In order to examine the robustness of the above results, a series of robustness tests have been performed to validate the findings. The first test is to see whether each hypothesis holds with the direct comparison between sample and control hospitals. Two kinds of tests are included: one is the t-test for the mean difference, and the other is the Wilcoxon signed-rank test for the median difference.

Table 2.10 shows that the differences between sample hospitals and control hospitals are highly significant, and they are in line with the results obtained in models presented in Section 2.5.

The matching procedure is applied within each MSA, and the regression analysis in Section 2.5 may have residuals not independent within each MSA. Therefore, a

Table 2.10: Robustness Tests using t-test and Wilcoxon signed-rank test

Variables	Mean		Median	
	Sample-Control	P.V. (t-test)	Sample-Control	P.V. (rank test)
Inpatient Market Share	0.0052	0.8342	-0.0020	0.1754
Outpatient Market Share	0.0980	0.0198	0.0697	0.0062
Net Patient Revenue	0.0985	0.0012	0.0558	0.0002
Inpatient Revenue Ratio	-0.0244	0.1043	-0.0195	0.065
Allowance Ratio	-0.0300	0.0662	-0.0247	0.0194
Ambulatory Direct Expense Ratio	-0.0828	0.0930	-0.0507	0.0551
Payroll Cost Ratio	-0.0699	0.0467	-0.0570	0.0175

robust regression has been conducted to take the MSA difference into consideration. SAS proc genmod is used to model such correlated data, which allows the hospitals to be clustered into MSAs and that they may be correlated within MSA, but would be independent between MSAs.

Table 2.11: Robustness check for Competing on Process Execution

Variables Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Intercept	1.0378***	1.1272***	1.084***	0.9923***	1.1***	0.9569***	1.2744***
T	0.0029	0.1048**	0.1014***	-0.0327**	-0.028*	-0.083*	-0.0637**
Teach	-0.0015	-0.0305	0.0458	-0.0011	-0.0327*	0.0181	-0.0802
Type	-0.0539**	0.0241	0.0264	-0.0628***	-0.0194	0.0187	-0.0575*
CMI	-0.001	-0.1661**	-0.0539	0.037***	0.0008	-0.0589	-0.0912
Size	0	0.0001	0.0001	0.0001	-0.0001	0.0001	0
HHI	-0.0275	0.1835	0.1841*	-0.1049***	-0.0769**	0.2239	-0.085

Table 2.11 shows the regression with robust error, the estimate of the coefficients are very similar to the results in Section 2.5. Although the standard errors may be larger in this analysis, all the seven models have similar significance for the awards treatment variable.

2.7 Discussion

The results point to evidence supporting all of the hypotheses proposed in this study, except for the hypothesized association between inpatient market share and winning a quality award.

It is interesting to notice that the outpatient market share increases significantly for quality award-winning hospitals, while for the same hospitals, there are few changes in the inpatient market share. This findings appear to diverge from those studies focussing on the patients of specific hospital procedures (Luft et al., 1990; Mukamel and Mushlin, 1998). However, hospitals commonly provide both inpatient and outpatient services to their serving communities. These different services are usually sharing the same resources in hospital's settings. The utilization of the two services are not identical. For example, Robinson (1996) points to the rise of outpatient and subacute care in California hospitals between 1983 and 1993. Technology and cost reimbursement policy are the main drivers for such trend (Eldenburg and Kallapur, 1997). Moreover, Windmeijer et al. (2005) shows that inpatient demand has less elasticity than the outpatient demand. Courtemanche and Plotzke (2010) use the entry of ambulatory surgical centers to detect the market impacts. They find it is more apparent for the outpatient volume than for the inpatient volume. As such, a plausible explanation can be that the patients' freedom of choice accounts for the changes in outpatient service, while it is the hospital physicians who make the final decision on whether or not to admit a patient for inpatient treatment. Thus, it is more likely to observe the changes in hospital outpatient market share than in hospital inpatient market share.

Given a higher market share, one would expect an increase in revenue and profit. However, hospitals are not improving their profitability. This phenomenon might be consistent with their mission, as all the sample and control hospitals in the study are not-for-profit organizations. Also, while outpatient services may have a higher margin, a significant change in overall hospital profitability has not been found. It may be because the increased outpatient services do not represent a large enough proportion of the total revenues. After further examination of the mix of patients, this study could not find any significant changes in profitability related to the winning of quality awards. This suggests that award-winning hospitals are not able to attract a different mix of patients.

Another interesting finding is that lower write-offs are associated with award-winning hospitals. It reflects a better payer mix with lower discounts, and/or better coding of cases. Insurance companies are more likely to pay higher rates to the award winning hospitals to reflect the lower risks of poor clinical outcomes. At the same time, patients might be willing to pay higher premiums for the opportunity to be treated by physicians affiliated with an award-winning hospital.

Considering that inpatients and outpatients share some of the same resources, it is difficult to properly estimate the increase in resource utilization due to the increase in market share for outpatient services. However, a larger patient population should lead to improved economies of scale and, thus, improved cost efficiency in the form of ambulatory direct expenses ratio and resource effectiveness in the form of labor productivity have been found in this analyses. Given that inpatient market share hasn't changed that much and an outpatient visit is relatively short, the detected modest improvement in resource efficiency is still a significant indication of the potential for operational benefits related to the quality award winning hospitals.

Chapter 3

Competing on Process Execution

3.1 Introduction

As an aging population drives healthcare demand higher, and the healthcare industry shifts to patient-centered care, hospitals are now consuming more resources to meet the continuously increasing demand. The pressure from payers and governments for reductions in costs without compromising healthcare quality has pushed hospitals to renewed attempts to control the spiraling costs and to improve healthcare outcomes. The enactment of the Patient Protection and Affordable Care Act (PPACA, 2010) is expected to reduce the per capita cost of care for patient populations and improve healthcare outcomes by shifting the focus towards quality over quantity through increased competition, improved regulation, and better-aligned incentives to streamline the delivery of healthcare. However, there exists evidence suggesting that the U.S. health system is not efficient (Institute of Medicine, 2001). Costs vary widely across geographic areas, but the differences are not associated with more reliable delivery of evidence-based care or better health outcomes (Fisher and Wennberg, 2003). International comparisons are also often used to question the efficiency of the U.S. health system (Hussey et al., 2009; Barthold et al., 2013). These concerns have created tremendous pressure on hospitals to pursue performance improvement initiatives, while operating in a highly competitive environment. As a result, hospitals have to compete with each other not only to seize scarce resources, but also to deliver care in a timely and cost efficient manner.

As hospitals face the increasingly complex challenges mentioned above, there is much to be gained by applying the rich knowledge developed in the field of operations management. Thus, a long-standing focus of the research on operations management in healthcare has been on process improvement (Harrington, 1991; Cook, 1996; Tucker, 2004; Jack and Powers, 2009). A process usually refers to a set of activities or tasks that produce a result of value to customers (Ittner and Larcker, 1997). Process improvement requires the successful application of techniques to measure and control the desired performance and outcomes, and it involves a number of common elements, such as: process focus, information utilization, customer/supplier relations, human resource management, etc. (Ittner and Larcker, 1997). Process execution further demands a systematic view and consideration of process improvement efforts for the entire organization (Spanyi, 2006). Prior research in manufacturing and other industries has shown that lower production costs, higher and faster throughput, on-time delivery of finished goods, and even better product quality are usual benefits resulting from successful implementations of process execution initiatives (Goyal and Deshmukh, 1992; Fullerton et al., 2003). Such benefits enable an organization to build and maintain distinct competitive advantages, even in a fiercely competitive market. For instance, lower costs afford higher pricing power for products and services sold (Miles and Snow, 1978; Porter, 1980); on-time, fast delivery defines an organization's ability to meet customers' needs and helps build a reputation for customer service (Skinner, 1974; Hayes and Wheelwright, 1984). Moreover, a focus on process improvement can enable firms to deliver (same level or better) quality more cost effectively through increased resource productivity or lower costs (Fullerton and Mcwatters, 2001; Fullerton et al., 2003; Flynn et al., 2013).

Considering the benefits resulting from improved process execution as documented in other industries, it can be expected that healthcare can derive similar advantages from a focus on process execution. However, while healthcare has seen a vigorous application of process improvement concepts and techniques (Li et al., 2002), most of the operations oriented studies focus narrowly on issues relating to hospital cost containment (Thakur et al., 1986), capacity planning (Buler et al., 1996), or personnel scheduling (Heineke, 1995) and do not investigate the wider, organizational-level ramifications of process improvement. As such, few references exist where a hospital's operations strategy is carefully examined and explicitly correlated with hospital-wide performance outcomes. Only recently, have researchers started to investigate the relationship between the level of operational focus and hospital performance outcomes (McDermott and Stock, 2011; Kc and Terwiesch, 2011; Clark and Huckman, 2012). These papers construct their focus measures based on hospital capacity or patients volume, and then correlate this focus measure with hospital performance measures such as length of stay, cost, and mortality. Although these studies find some support for the benefit of operational focus at different hospital levels to one or two dimensions of hospital performance, a general understanding of the benefits associated with process improvement still lacks empirical support.

In this chapter, cost per discharge (CPD) and length of stay (LOS) are used as proxies to measure a hospital's level of process improvement, which are two prevailing performance indicators in the healthcare literature (Hussey et al., 2009). This kind of objective measures overcomes the difficulty of directly measuring the level of process improvement from surveys which has been addressed in extant literature (Fullerton et al., 2003). The objective of this study is thus to investigate the relationship between improvements in hospital operations and other performance measures. Specifically, this study uses longitudinal secondary data to examine hospital performance based on several financial and operational metrics while controlling for clinical outcomes. By using secondary data, this study is free of the drawbacks related to survey design and primary data. The longitudinal study draws a clear picture on how process improvement can impact hospital performance. The model using CPD and LOS together simultaneously measures hospital process improvement in a more precise way.

The remainder of this essay is organized as follows. In Section 2, a literature review is provided and related hypotheses are derived. In Section 3, the data and data collection procedures are explained. The methodology and econometric models are presented in Section 4. The main results and findings are presented in Section 5. A discussion of the results is presented in Section 6.

3.2 Hypothesis Development

Like other multidivisional firms, hospital systems can facilitate scale and scope economies on the production side by eliminating duplicative equipment, reducing administrative costs, and more efficiently managing labor and supply inventories (Hill and Hoskisson, 1987). While hospitals are striving for economies of scale, the investment is fixed and large in amount. So hospitals usually seek to improve the economies of scale by serving a greater number of patients and increasing the service volume. Unfortunately, over the past decades, even as an aging population is consuming more health services, about 10% of US community hospitals have closed due to low occupancy rates and poor financial performance (Li et al., 2002). The remaining hospitals strive to find their way to survive, or even thrive, in the competitive healthcare market.

Given such competitive pressures, hospitals have turned to process improvement initiatives, such as lean healthcare, six sigma, process standardization, etc. These process improvement initiatives are believed to improve throughput ratio and cost savings (de Souza, 2009), which are essential for establishing a market stronghold that can help hospitals compete for patients. It allows hospitals to attract more business from insurance companies by accepting lower payment. This strategy is also strengthen by the prevailing selective contracting (Zwanziger et al., 2000), which results in affiliating with HMOs (Trinh and Begun, 1999) and pricing aggressively with deeper discounts (Kralewski et al., 1992).

Thus, hospitals have had to reconfigure their operation processes to meet demand while containing costs. As an important competitive strategy, it is widely accepted that an improved execution of hospital processes will help hospitals achieve these goals and gain more market shares by offering lower cost services (Trinh and O'Connor, 2002). Thus, it is expected that hospitals with better process execution will experience an increase in their market share, as hypothesized below:

H1: Better process execution will be associated with increased hospital market share.

Process improvement can result from different operational initiatives such as just-in-time execution (JIT) (Blackburn, 1991), focused factory (Schneider et al., 2008), etc. In the context of manufacturing and service industries, the main purpose for process improvement is to "increase profits by reducing costs through completely eliminating waste." (Monden, 1998). So the profitability has been improved through increased turnover ratio and/or improved return on sales (Kinney and Wempe, 2002). Hospitals face the same revenues and cost problems, though hospitals can be divided as for-profit and not-for-profit due to their distinguishing financial goals. It is as difficult for a not-for-profit hospital to break even as it is for a for-profit hospital to make a reasonable return on its investment.

Previous studies have attempted to identify relationships between operational strategies and financial performance. For example, Cleverley (1990) finds that hospitals which have lower gross service prices have a better financial performance. Cleverley (1992) further demonstrates that cost leadership is the most important strategy that results in better hospital financial performance measured by return on investment. As such, hospitals in pursuit of process execution excellence are expected to gain better financial performance as hypothesized below:

H2: Hospitals with better process execution have improved profitability.

The most consistent benefits promoting the adoption of process improvement initiatives found in the manufacturing industry are a reduction in inventory levels and/or an increase in inventory turns (Fullerton et al., 2003). Although reducing inventories may not be the primary purpose for enhancing process execution, it is a natural consequence of process improvement (Green et al., 1992). With work-in-process inventories kept at a minimum, production can respond more quickly to errors and changes in demand. Throughput time is reduced along with non-value-added (NVA) activities such as wait, move, and inspection time, which can comprise up to 95% of product costs (Foster and Horngren, 1987).

In a hospital context, a number of studies have investigated various sources of operational inefficiency and identified areas where hospitals can improve (Chen et al., 2005; Hollingsworth, 2008). This prior research makes use of frontier efficiency measurements to define hospital efficiency, but do not provide details about the quantitative benefits associated with longitudinal improvements in process execution. Limited evidence supports the association between hospital process improvement and operational performance measures such as productivity and utilization. For instance, Burns et al. (1994) find that providers serving a higher market share appear to be more efficient. Hospital managers will also maximize inpatient discharges and outpatient visits in order to minimize inputs in FTEs (Wang et al., 1999).

If a hospital with better process execution manages to exhibit excellence in delivering care to a greater number of patients, as hypothesized in H1, it would lead to that hospital's processes becoming both more efficient in time and more effective in cost. As such, it is reasonable to hypothesize that hospitals with better process execution have better operational performance, as measured by bed utilization and labor productivity.

H3a: Hospitals with better process execution have better labor productivity.

H3b: Hospitals with better process execution have higher levels of bed utilization.

3.3 Data and Variables

3.3.1 Data Collection

The secondary data released by the Office of Statewide Health Planning and Development (OSHPD) constitutes the main data source. It contains annual financial reports, utilization reports, and patient discharge reports for all the hospitals in California. The American Hospital Directory (AHD) provides annual clinical, operational, and financial performance data of those California hospitals. The collection of hospital information in the AHD database is derived from both public and private sources, including the cost reports compiled by the federal Centers for Medicare and Medicaid Services.

This study employs a longitudinal approach using a panel design. It facilitates a 5-year time window from 2005 to 2009 as the study period. But in order to calculate a 2-year cumulative change, the data is collected from 2005 to 2011. During this period, about 308 general medical/surgical hospitals are identified, which generally provide comparable service lines. The data set is also cross-sectional, which implies wide-scale heterogeneity in hospital characteristics, such as location, teaching status, and profit status.

3.3.2 Study Variables

Dependent Variables

The dependent variables capture several dimensions of changes in hospitals' performance so that each hypothesis proposed in section 3.2 can be examined. All these changes are measured by a two-year cumulative difference within the study period between 2005 and 2009. The choice of the study period and lag time for the calculation of changes seems to be arbitrary, since the literature does not provide much theoretical or empirical guidance on what should be the appropriate length of time period in examining these changes. But the choice of this length of the time period is based on the time periods typically used in studies that examine the long-term performance of an organization, such as Alexander et al. (1996); Ahire and Dreyfus (2000); Hendricks and Singhal (2003).

To measure market share, a variety of measures has been developed in the literature. Generally these measures can be classified as capacity-based and volume-based. The prevailing capacity-based measure mainly uses the number of beds as the proxy for market share (Eastaugh, 1984). The majority of volume-based measures are based on variables such as the number of patients (Erickson and Finkler, 1985), defined by either admissions or discharges, and the number of inpatient days Hsieh et al. (2010). In this paper, we are using hospital discharges to define hospital patient market share. This approach is consistent with the method used by the Agency for Healthcare Research and Quality (AHRQ) in the hospital market structure files.

There are many ways to define profitability in the literature. In this paper, profitability is defined by the ratio of total operating revenue to total operating expenses. This is a common measure of hospital profitability in the extant literature (Snail and Robinson, 1998). This measure is able to handle the cases when net income is negative.

In addition, labor productivity is defined by the number of discharges per productive hour, and bed utilization is measured by total discharges per staffed bed in a year. This kind of operational efficiency measures are common in the extant literature, as illustrated by Li and Benton (1996); Mobley (1998); Wang et al. (1999).

Independent Variables

Consistent with the objectives of this study, cost per discharge and length of stay are used as proxies for the level of hospital process execution. These cost and efficiency metrics are commonly used as operational performance measures (Robinson and Luft, 1985; Gittell et al., 2000; Ashby et al., 2000; McDermott and Stock, 2007; McCue, 2007).

Cost per discharge is a consistent measure of the effectiveness of services a hospital provides and is vulnerable to the waste and errors associated with the process. Since process improvement is defined by measures in the inpatient service, it should be adjusted to take account of the outpatient service in a hospital. The common adjustment is based on the ratio of inpatient revenue to total hospital revenue (Carey, 1994). To measure hospital overall performance and incorporate the difference of inpatient and outpatient services, this adjustment is being done by using hospital inpatient and outpatient revenue ratio.

Length of stay is a compound measure for the efficiency of a hospital and is widely used in the healthcare literature, as summarized by (Rapoport et al., 2003). To maintain quality standards, a hospital has to treat patients for at least a certain amount of time. The longer the treatment takes, the more resources are consumed for the patient. Thus, without degenerating the quality of care, there is a minimum length of stay corresponding to the severity and comorbidities that patients may present. To compensate for such patient severity, the case mix index is usually used to adjust the length of stay. So under this circumstances, length of stay is a comparable measure of hospital efficiency.

Table 3.1 provides statistics on the selected general hospitals over common hospital characteristic control variables.

Table 3.1: Summary Statistics for All Hospitals

Years	All Hospitals	
2005-2009	Mean	Median
Staffed Bed	183.02	150.00
Case Mix Index	1.17	1.10
Length of Stay	8.42	4.81
Adjusted LOS	7.57	4.23
Service Mix	43.03	39.68
Cost Per Discharge	$39,037.31	$24,625.28
Mortality	2.95%	2.16%
3rd Party Payer Ratio	33.84%	31.71%
Supply Cost Ratio	13.20%	12.98%
Labor Cost Ratio	40.07%	40.50%
Total Observations	1760	1760

3.4 Methodology

The analysis methodology relies on a difference-in-differences estimation (Greene, 2007), whereby the impact of process execution on hospital performance is measured as a double difference, one over time (i.e., between t and $t{+}2$) and one across hospitals. In general, regression models are formulated as the following form:

$$\Delta y^i_{t,t+2} = \alpha + \beta X^i_t + \gamma Z^i_{t,t+2} + \delta_1 LOS^i_{t-1,t+1} + \delta_2 CPD^i_{t-1,t+1} + \epsilon^i, \qquad (3.1)$$

where $\Delta y^i_{t,t+2}$ represents a two-year cumulative difference in a certain measure of hospital performance, X^i_t and $Z^i_{t,t+2}$ are vectors of control variables, with X^i_t capturing various hospital characteristics (e.g., staffed beds, teaching status) measured at the base year t, and $Z^i_{t,t+2}$ representing two-year accumulated changes in several dynamic hospital characteristics (e.g., Case Mix, Service Mix, Mortality). In addition, $LOS^i_{t-1,t+1}$ and $CPD^i_{t-1,t+1}$ are independent variables representing changes in Length of Stay (LOS) and Cost Per Discharge (CPD), respectively. They are binary variables taking value 1 if hospital i has above median change in that measure and value 0 otherwise. Such dichotomous variables are regularly used in the literature, such as Hannan et al. (2002); Kc and Terwiesch (2011). The benefit of using this binary encoding is that it provides a more sTable measure of change, since the continuous measure would be sensitive to outliers. It also facilitates an easier interpretation of the precess execution. Thus, a significant coefficient δ for these independent variables is generally interpreted as evidence in support of the association between performance outcomes and the proxies of process execution, while the magnitude of the coefficient would be indicative of the performance change experienced by the hospitals with above-median improvements in process execution. In equation 3.1, X is used to control for potential systematic differences among hospitals characteristics that usually do not change over time, while Z seeks to control for dynamic changes in hospital characteristics that may confound the impact of process execution on hospital performance.

To test H1, equation 3.1 has been expanded to formulate the first OLS regression model, where, for ease of exposition, hospital subscript i has been omitted:

$$\begin{aligned}\Delta IPMS_{t,t+2} \;=\;& \alpha_0 + \alpha_1 StfBed_t + \alpha_2 PrfStat_t + \alpha_3 TchStat_t + \alpha_4 HHI_t + \alpha_5 Year_t \\ & + \gamma_1 CMI^i_{t,t+2} + \gamma_2 SrvMix^i_{t,t+2} + \gamma_3 Mort^i_{t,t+2} \\ & + \delta_1 LOS^i_{t-1,t+1} + \delta_2 CPD^i_{t-1,t+1} + \epsilon. \qquad (3.2)\end{aligned}$$

$\Delta IPMS$ represents the cumulative change in inpatient market share during a two-year period. To address the size and scale issue in hospitals, relative measures are used to calculate $\Delta IPMS$, i.e., $\Delta IPMS_{t,t+2} = IPMS_{t+2}/IPMS_t$. This relative measure is applied to all cumulative changes tested in this study. $StfBed$ is the number of staffed beds. $PrfStat$ is a hospital's profit status, taking value 0 for non-profit hospitals, and value 1 for for-profit hospitals. $TchStat$ is a hospital's teaching status, and has value 0 for non-teaching hospitals, and value 1 for teaching hospitals. HHI represents the level of market competition, measured by the Herfindahl index. $Year$ is a nominal indicator, indicating different years. CMI represents the change in case mix index, $SrvMix$ represents the change in service mix, and $Mort$ represents the change in hospital mortality between t and $t+2$.

To test hypotheses H2-H3a/b, OLS regression models that include the control variables enumerated in equation 3.2 are used. The dependent variables in those models are profitability ($PRFT$), defined as operating revenue divided by operating expenses; productivity ($PRDC$), defined as discharges per productive hour; bed utilization ($BDUT$), defined as total discharges per staffed bed.

3.5 Results

3.5.1 Model Estimation

The results of applying the set of regression models described in Section 3.4 are presented in this section, in order to explain the association between better process execution and hospital performance, as hypothesized in Section 3.2. Table 3.2 shows the results for all four hypothesized models.

Table 3.2: Test Results for Competing on Process Execution

Variables	Market Share	Profitability	Productivity	Utilization
HHI	0.0105	0.0185	0.0061	-0.0135
StfBed	0.0001	0	0	0
SRVMIX	-0.0096	-0.0012	0.0162*	-0.0032
MORT	-0.0201	-0.0086*	-0.0007	-0.0737**
CMI	-0.4443***	0.0383	-0.4776***	0.0449
LOS	-0.0197	-0.0071	-0.0371***	-0.1125***
CPD	-0.0632***	-0.0171***	-0.0359***	-0.0095
Other Controls	Yes	Yes	Yes	Yes
F	4.6	4.58	6.82	3.33
R^2	0.0645	0.0694	0.1029	0.0476

Note: *, **, *** stand for statistical significance at 10%, 5%, 1% respectively.

The first analysis corresponds to a test of Hypothesis H1, which posits that better hospital process execution will be associated with increased hospital inpatient market share. According to the result included in the Market Share column of Table 3.2, the correlation between inpatient market share and the process execution proxy, cost per discharge, has been found statistically significant. Cost per discharge is negatively associated with hospital inpatient market share ($\delta_2 = -0.0632, p < 0.01$). The association between length of stay and hospital inpatient market share is not statistically significant ($p > 0.10$). The cumulative change of case mix index is negatively associated with hospital inpatient market share, i.e., $\gamma_1 = -0.4443$, significant at the 1% level. This cumulative change in case mix index is based on a continuous measure, which is different from the binary change of the cost per discharge or length of stay. So the changes in case mix index have different scope in the effect size, comparing to the changes in process execution proxies. In summary, an above median increase in the cost per discharge would negatively impact hospital inpatient market share which does provide evidence in support of Hypothesis H1.

The Profitability column of Table 3.2 contains the results of the investigation concerning Hypothesis H2, which states that better process execution is associated with an increase in hospital profitability. There is a negative association between profitability and cost per discharge ($\delta_2 = -0.0171, p < 0.01$). Again, length of stay does not play a significant role here, as $\delta_1 = -0.0071, p > 0.1$. This result indicates that better process execution in terms of reduced cost per discharge is associated with improved hospital profitability, thus lending support to Hypothesis H2.

The Productivity column in Table 3.2 corresponds to a test of Hypothesis H3, which posits a correlation between process execution and labor productivity. Labor productivity is measured by the number of discharges per labor hour. So this result shows that as lagged length of stay becomes shorter, the number of discharges per hour increases with $\delta_1 = -0.0371, p < 0.01$. This relationship is similar for cost per discharge, as hospitals with lower lagged cost per discharge gain higher productivity in the following year, with $\delta_2 = -0.0359, p < 0.01$. The amount of change in the case mix index also has a negative impact on the number of discharges per labor hour, i.e., the higher case mix, the lower labor productivity in terms of discharges per labor hour. This result offers support for Hypothesis H3.

The Utilization column of Table 3.2 provides result on bed utilization, measured by discharges per bed. Bed productivity is found to be negatively associated with length of stay $\delta_1 = -0.1125, p < 0.01$, but insensitive to cost per discharge $\delta_2 = -0.0095, p > 0.10$. This finding provides support to Hypothesis H4, indicating that better process execution in terms of shorter length of stay would improve bed productivity.

3.5.2 Robustness Checks

This section plans to investigate whether the results presented above still hold when different approaches are used to represent hospital dynamics in process execution.

A first approach consists of using a different set of ordinal variables. In this case, the original binary encoding indicating an improvement (0) or a deterioration (1) in process execution outcomes is now replaced with an approach where a value of -1 is used to indicate a decrease, a 0 to indicate no change, and a 1 to indicate an increase, respectively, in the process execution proxies. The results associated with this analysis are shown in Table 3.3.

Table 3.3: Robustness check for Competing on Process Execution

Variables	Market Share	Profitability	Productivity	Utilization
HHI	0.0054	0.0183	0.0074	-0.018
StfBed	0.0001	0	0	0
SRVMIX	-0.0106	-0.0015	0.0151	-0.0067
MORT	-0.0218	-0.0082	0.001	-0.0739**
CMI	-0.4104***	0.0332	-0.5291***	0.0795
LOS	0.0004	-0.0057*	-0.0327***	-0.0462**
CPD	-0.0436***	-0.0092***	-0.014**	-0.0262
Other Control	Y	Y	Y	Y
F	2.91	4.23	9.79	2.1
R^2	0.0464	0.0661	0.1009	0.0340

Note: *, **, *** stand for statistical significance at 10%, 5%, 1% respectively.

The results shown in Table 3.3 are very similar to earlier findings presented in Table 3.2. Cost Per Discharge is negatively correlated with inpatient market share, profitability, and productivity, while length of stay is negatively correlated with productivity and bed utilization. This is consistent with the results obtained from previous analysis. The only change is the significance of the association between length of stay and profitability, since this relationship was negative but not significant in the previous model. These results confirm that the use of categorical variables to represent process execution leads to robust findings, which supports all proposed hypotheses.

The second robustness check includes hospital's initial status on the two process execution proxies as additional control variables. At each base year, hospital's initial status on length of stay (LOSB) is coded as 0, if it is less than the median LOS of all the hospitals; otherwise, LOSB is 1, indicating a higher LOS at base year. Similarly, hospital's initial status on cost per discharge (CPDB) is coded as 0, if it is less than the median CPD of all the hospitals; otherwise, CPDB is 1, indicating a higher CPD at base year.

Table 3.4: Robustness check includes initial status

Variables	Market Share	Profitability	Productivity	Utilization
HHI	-0.0046	0.0179	0.0013	-0.0269
StfBed	0.0001	0	0	0
SRVMIX	-0.0084	-0.0015	0.0144	-0.0108
MORT	-0.0208	-0.0087*	-0.0013	-0.0723**
CMI	-0.4044***	0.0356	-0.4929***	0.0382
LOS	-0.005	-0.0059	-0.0394***	-0.1037***
CPD	-0.0616***	-0.0171***	-0.0343***	-0.0385
LOSB	-0.0010	0.0038	0.0134	0.034
CPDB	0.004	0.0021	0.0183	0.0578
Other Control	Y	Y	Y	Y
F	2.64	3.89	8.08	2.24
R^2	0.0467	0.0673	0.1322	0.0399

Note: *, **, *** stand for statistical significance at 10%, 5%, 1% respectively.

Table 3.4 shows the results for the four models. All the model variable estimates remain largely unchanged. The two newly added initial status variables are not statistically significant in the models. It means that the performance improvement tested in this study are mostly attributed to hospitals' changes in their process execution instead of the hospitals' initial status, as measured by the two process execution proxies. In other words, no matter what a hospital's process execution initial status is, the hospital would derive the same benefit from improvements in process execution.

The third approach entails the use of hierarchical regression models including the original continuous independent variables to perform another set of robustness checks. The ordinary least squares regression results for all hypotheses are shown in Table

3.5. Tests for multicollinearity in the regression models presented in this Table show variance inflation factor values lower than 3 for all predictor variables. These values are much less than the threshold of 10, indicating that these results are not likely to be biased by multicollinearity issues (Greene, 2007; Hair et al., 2010).

Table 3.5: Continuous Variable Tests for Competing on Process Execution

Variables	Market Share	Profitability	Productivity	Utilization
LOS	-0.0808*	-0.0433***	-0.2707***	-0.1589**
CPD	-0.1182***	-0.0561***	-0.0103	-0.1315**
LOS	0.0716	0.0158	-0.3096***	-0.0645
CPD	-0.1534***	-0.0638***	0.0685***	-0.0998
LOS	-0.0712	0.0378	-0.0878	-0.189
CPD	-0.2278***	-0.0524***	0.2194***	-0.1647*
Interaction	0.041**	-0.0063	-0.136***	0.0358
Other Controls	Y	Y	Y	Y

Note: *, **, *** stand for statistical significance at 10%, 5%, 1% respectively.

Table 3.5 shows that when the two process execution proxies are included separately in a model, there is significant correlation between them and the dependent variables, except that the lagged change of cost per discharge lacks a significant correlation with labor productivity. When both variables are included in the same regression model, cost per discharge seems to be a stronger factor, regardless of whether an interaction between the two variables is added or not, because in most cases the effect of length of stay vanishes in the presence of cost per discharge. Although the correlation matrix of all the variables indicates that the largest correlation is much less than 0.2, it looks like directly using the original continuous changes of these two process execution indicators would lead to biased results, leading to confounding especially in the tests for productivity and utilization.

Due to the use of relative measures, the data tested in these models may be skewed and the sample size may not be large enough. In this case, the approximation provided by the central limit theorem might not be good enough to guarantee normality. As such, the logarithmic transformation is applied to create a rank-preserving transformation of the data in the relative measures. This data transformation technique is commonly used to stabilize variance, make the data more normal distribution-like, and improve the validity of measures of association (see, for example, Greene 2007).

Table 3.6: Robustness check for logarithmic transformed data

Variables	Market Share	Profitability	Productivity	Utilization
HHI	0.0586	0.0204	0.0029	0.0295
StfBed	0.0002***	0	0	0.0001
LG-SRVMIX	-0.0176	-0.0042	0.0365	-0.0305
LG-MORT	-0.0999***	-0.0062	-0.0181	-0.1354***
LG-CMI	-0.5883***	0.048	-0.6948***	-0.3779**
LG-LOS	-0.119**	-0.0171	-0.3146***	-0.3389***
LG-CPD	-0.2559***	-0.0854***	-0.0162	-0.1096*
Other Control	Y	Y	Y	Y
F	7.28	5.05	9.8	5.71
R^2	0.1087	0.078	0.1424	0.0873

Note: *, **, *** stand for statistical significance at 10%, 5%, 1% respectively.

Table 3.6 shows that after applying the logarithmic transformation, the results obtained are very similar to earlier findings in Section 3.5, and the level of statistical significance has been improved for all 4 models.

3.5.3 Post-hoc Analysis

Based on the main results and findings discussed above, it is obvious that changes in case mix index can play an important role on hospital performance and, therefore, it is important to control for CMI in the analyses. Moreover, it can be surmised that dynamics in CMI could moderate the impact of process execution on hospital performance. For example, the performance ramifications of a decreasing cost per discharge could be different when a hospital is experiencing an increase in CMI from when a hospital is faced with a decrease in CMI (potentially due to shifts in patient population, or changes in the hospital's service mix offering, etc). Thus, to better understand the role played by CMI on the main findings of this chapter, a post-hoc analysis is conducted to investigate the implications of a two-year increase and decrease in CMI. Several scenarios are examined, as a function of the specific output metric considered. In each case, statistical tests are performed to determine whether the hypothesized results still hold under different CMI dynamics.

Table 3.7: Inpatient Market Share with Different CMI

CMI Decrease	N	Mean	Std Dev	Std Err	Minimum	Maximum	P-Value
No PE Improvement	305	0.9987	0.3708	0.0212	0.173	5.0484	-
LOS Reduction	140	0.9738	0.1868	0.0158	0.00208	1.7278	0.453
CPD Reduction	248	1.1188	1.1452	0.0727	0.167	17.8893	0.0851
Both Improvements	204	1.0664	0.3362	0.0235	0.2929	3.6824	0.0366
CMI Increase	N	Mean	Std Dev	Std Err	Minimum	Maximum	P-Value
No PE Improvement	218	0.9492	0.265	0.018	0.0695	2.3089	-
LOS Reduction	202	0.9947	0.2832	0.0199	0.1373	3.1141	0.0892
CPD Reduction	121	1.0498	0.3753	0.0341	0.0136	3.8952	0.0043
Both Improvements	279	1.0548	0.3197	0.0191	0.1856	4.9254	0.0001

Table 3.7 shows the results of the post-hoc analysis on inpatient market share. It seems that improving only the length of stay does not help the hospital gain market share when the hospital is experiencing a decrease in CMI. However, improvements in cost per discharge or in both length of stay and cost per discharge do lead to statistically significant improvements in hospital inpatient market share no matter whether CMI is decreasing or increasing. When a hospital has an increasing CMI, the complicated cases will demand more resources, therefore, reducing length of stay would help the hospital release resources quickly and thus serve more patients. When a hospital has a decreasing CMI, the patients in the hospital have already been less acute, which means that length of stay is expected to be shorter. Hence, in this case, further improvement in length of stay will be less likely to improve the hospital's ability to treat more patients.

Table 3.8 shows quite a different impact on hospital profitability, whereby improving only length of stay or improving only cost per discharge does not help the hospital improve profitability when CMI is increasing. It is very likely that a hospital with higher CMI already has improved profitability. So further performance improvement requires simultaneous enhancement in both cost and throughput.

Table 3.8: Profitability with Different CMI

CMI Decrease	N	Mean	Std Dev	Std Err	Minimum	Maximum	P-Value
No PE Improvement	304	0.9923	0.078	0.00447	0.5625	1.1968	-
LOS Reduction	139	1.0055	0.0723	0.00614	0.7965	1.287	0.0927
CPD Reduction	247	1.0328	0.2173	0.0138	0.5804	4.1483	0.0027
Both Improvements	202	1.018	0.0796	0.0056	0.7327	1.3365	0.0003
CMI Increase	N	Mean	Std Dev	Std Err	Minimum	Maximum	P-Value
No PE Improvement	217	1.0117	0.1401	0.00951	0.4538	1.9463	-
LOS Reduction	200	1.0078	0.0985	0.00697	0.537	1.4223	0.7437
CPD Reduction	119	1.0227	0.1072	0.00982	0.7393	1.5078	0.458
Both Improvements	276	1.0338	0.1017	0.00612	0.6784	1.8941	0.0435

However, when CMI is decreasing, there are many possible ways for the hospital to improve. Thus, improvement on one or two process execution proxies does help hospitals to improve their profitability when case mix is decreasing.

Table 3.9: Discharges Per Productive Hour with Different CMI

CMI Decrease	N	Mean	Std Dev	Std Err	Minimum	Maximum	P-Value
No PE Improvement	275	0.9608	0.1628	0.00982	0.3543	1.9197	-
LOS Reduction	129	0.9982	0.1712	0.0151	0.4126	2.2909	0.0353
CPD Reduction	217	0.9966	0.1636	0.0111	0.571	2.1523	0.0163
Both Improvements	184	1.0367	0.1816	0.0134	0.4313	2.2511	0.0001
CMI Increase	N	Mean	Std Dev	Std Err	Minimum	Maximum	P-Value
No PE Improvement	170	0.9253	0.1569	0.012	0.2215	1.5402	-
LOS Reduction	134	0.9621	0.2018	0.0174	0.5033	2.8667	0.0747
CPD Reduction	92	0.9578	0.1169	0.0122	0.6308	1.3855	0.0832
Both Improvements	162	0.9594	0.1397	0.011	0.4404	1.387	0.0377

Table 3.9 shows that improving any of the process execution proxies will directly help the hospital improve efficiency as measured by discharges per productive hour, no matter whether CMI is increasing or decreasing.

Table 3.10 shows that when CMI is decreasing, improvements in only one of the two process execution proxies will not be sufficient to significantly help the hospital improve discharges per bed. In this case, a hospital may have enough resources available already, therefore a minor improvement in one of the execution proxies would not have an impact on bed utilization. When CMI is increasing, improvement

Table 3.10: Bed Utilization with Different CMI

CMI Decrease	N	Mean	Std Dev	Std Err	Minimum	Maximum	P-Value
No PE Improvement	305	1.0621	0.3996	0.0229	0.2349	4.1275	-
LOS Reduction	140	1.1012	0.4002	0.0338	0.07	3.4437	0.3388
CPD Reduction	248	1.1244	0.5824	0.037	0.2207	7.4237	0.1379
Both Improvements	204	1.1357	0.4394	0.0308	0.187	4.5922	0.0511
CMI Increase	**N**	**Mean**	**Std Dev**	**Std Err**	**Minimum**	**Maximum**	**P-Value**
No PE Improvement	218	1.0152	0.3389	0.023	0.0898	3.1643	-
LOS Reduction	202	1.1654	0.7138	0.0502	0.142	9.6374	0.0056
CPD Reduction	121	1.1093	0.7465	0.0679	0.0169	8.0676	0.1127
Both Improvements	279	1.1197	0.5199	0.0311	0.1859	7.5995	0.0104

in length of stay with or without an associated improvement in cost per discharge would help a hospital gain more discharges per bed under such resource demanding cases.

In general, although the case mix index seems to play an important role in the original model and tests, the post-hoc analysis clearly indicates that improving the two process execution proxies together helps the hospital improve performance regardless of the dynamics in CMI.

3.5.4 Case Study

To glean a more refined understanding of the implications of process execution on hospital performance, a separate investigation is conducted for several hospitals that had strong gains in performance associated with process execution under several different scenarios.

At a first glance, there are many hospitals (over 200) achieving a decrease in their cost per discharge concurrently with lower case mix index and/or lower length of stay. By further constraining the changes in both case mix index and length of stay to be consistently decreasing in a 2-year rolling window, a set of 6 hospitals is identified. These hospitals consistently decrease their cost per discharge, length of stay and case mix index simultaneously. These hospitals are small in size, as most of them have less than 100 staffed beds, and they are operated by local districts. These hospitals have fewer service lines provided to their communities, since their volume-based top 10 DRG procedures constitute over two thirds of their inpatient services. Therefore, it seems that these hospitals tend to concentrate on a few common care services for lower severity patients. This shift in their services is also associated with growth in their inpatient market share, while no significant changes in clinical quality are observed, as indicated by hospital mortality and 30-day readmission rate.

As a comparison, another set of hospitals is selected, which have increased case mix index and a longer length of stay. Among this set, there are 6 hospitals which meet these criteria and also consistently increase their cost per discharge. In general, these hospitals are medium hospitals which have a little more than 100 staffed beds. These hospitals also have fewer service lines provided to their communities, as their volume-based top 10 DRG procedures also constitute over two thirds of their inpatient services. Such high concentration accompanied by the increase in both case mix index and length of stay clearly indicates a focus on certain services area in these hospitals. But in the study period, there is no significant improvement in their clinical outcomes as measured by hospital mortality, while the 30-day readmission rate may be improved slightly.

The final benchmark set consists of 5 hospitals which have higher case mix index and longer length of stay, but their cost per discharge is decreasing. These hospital are larger in size, as the average size is about 200 staffed beds. Few changes in their service mix and clinical quality have been observed. But it is very interesting to note that these hospitals are treating higher severity patients with longer length of stay, while decreasing average cost per discharge and increasing the market share for their inpatient services. The review of their mission statements shows that one of these hospitals manifests their focus on "providing appropriate and efficient care in a timely and effective manner". This statement attests to the hospital's focus on maintaining and improving process execution standards, and it confirms the implications of this study that effective process execution can lead to better hospital performance even in a context of higher patient risk and severity. As such, the example of this hospital underscores that by improving process execution, more can be done in hospital with currently available resources.

3.6 Discussion

Based on the above results, this study has provided evidence that competing on process execution is beneficial to hospital performance outcomes. First, better process execution is associated with higher hospital inpatient market share. For example, having a lower cost per discharge not only generates above average returns, but gives a hospital a defense mechanism against competitors, as third-party payers and cost-sensitive patients would favor cost-efficient hospitals given the comparable outcomes. With better process execution, hospitals can offer lower patient waiting times, i.e., patients are expected to wait less for a bed or an operating room to become available, or wait less during peak hours as more medical staff would be available to handle the surge in demand. All these elements can lead to a lower length of stay and higher patient satisfaction. This improvement in length of stay releases medical resources faster, which in return increases a hospital's ability to accommodate more patients.

Second, better process execution leads to improved profitability. When a hospital is able to reduce waste and unnecessary expenditures in its operations, it is very likely that the hospital gains a higher operating margin since usually the payers benefit less from the reduction than the hospital does. Consistent with the increase in market share, hospitals with better process execution are in a position to accumulate a surplus from effective and efficient operations, as the increase of operating revenue will outpace the increase in operating expenses.

The third finding indicates that better process execution is associated with improved labor productivity, as measured by an increase in the number of discharges per labor hour. Since better process execution is defined by lower length of stay and lower costs per discharge, hospitals with these features have on average faster throughput time as indicated by shorter length of stay. Again, as the market share is increasing, the lower cost per discharge is also followed by increased service volume. Thus, with shorter patients' length of stay and larger number of patients, better process execution leads to larger number of discharges per labor hour. As such, better process execution is followed by an increase in hospital labor productivity. An intriguing factor in this analysis is the case mix index. This factor is an important measure of the complexity of hospital's patient profile. It is obvious that a higher case mix index would demand more labor input, and productivity measured by the labor input would become lower given an increase in case mix index.

The last investigation points out that better process execution improves hospital bed utilization, which is measured by discharges per bed. This result indicates that lower length of stay plays an important role in improving the number of discharges per bed. Expeditious treatment helps release resources in a shorter time, and thus enables hospitals to serve more patients in a given period of time. With such increased capacity of serving more patients by more efficiently utilizing the resources, a hospital with better process execution would benefit from the increased patients volume and thus have higher discharges per bed.

Chapter 4

Using Data Envelopment Analysis to Examine Hospital Strategic Efficiency

4.1 Introduction to DEA

Two hospital competitive strategies have been separately discussed in depth in previous chapters. Multiple regression analysis has been employed to investigate the extent to which these hospital strategies are correlated with desired outcomes. Considering this modeling choice, the results obtained are unavoidably subject to the limitations specific to regression analysis. One such limitation is that the estimated equation represents an average effect, as opposed to the best-practice input-output relationship. It is reasonable to assume that hospitals that would be considered as ”outliers” in regression could actually point to instances of higher efficiency, in the sense that, for a given set of inputs, a particular organization produces more outputs. Moreover, ordinary regression method often cannot clearly distinguish these outliers, as it is difficult to determine whether it is due to the systematic variation or statistical noise (Chirikos and Sear, 2000; Ferrari, 2006). In an industry such as healthcare, where inefficiencies are thought to be widespread, this methodological limitation can hinder the effectiveness of statistical inferences for decision making. In addition, when several possible strategies are presented to decision makers, it might be useful to quantify the extent to which each strategy would affect organizational performance and determine the specific course of action which maximizes a set of performance metrics.

Data envelopment analysis (DEA) is a nonparametric method which measures the relative efficiency of a set of similar decision making units (DMUs), by maximizing the weighted output/input ratio of each DMU, subject to the condition that this ratio can never exceed the unity for any DMU included in the same analysis (Charnes et al., 1978). The DMUs can be different organizations, or different units within an organization, but should have enough similarity to form the basis for comparison. An important outcome of DEA is a piecewise liner efficient frontier, which is composed of all the efficient DMUs. DEA can help inefficient organizations, which are not on the efficient frontier, determine precisely the gap relative to the best performers and identify the proportional reduction in input levels and/or proportional improvement in output levels that could be achieved as the organizations ascend to the efficient frontier. Another important advantage of DEA is the ability to incorporate simultaneously multiple inputs and outputs by using linear programming techniques without a pre-specified linear relationship between inputs and outputs.

Although the term DEA was introduced by Charnes et al. (1978), the idea was actually first proposed by Farrell (1957). Since Sherman (1984) first applied DEA to measure the efficiency of health-care organizations, DEA has been adopted as a useful analytical technique for comparing the relative efficiency of hospitals on the basis of multiple inputs and outputs. Numerous studies demonstrate the usefulness of DEA for measuring the efficiency in healthcare (Hollingsworth, 2008; Roh and Jung, 2010). Extant studies are mainly using decision making units (DMUs) at three levels: organizational (such as hospitals), program-specific (such as outpatient surgery), and individual (such as physicians) (Roh and Jung, 2010).

This study will use the DMUs at the hospital level and the remainder of this chapter is organized as follows. In Section 2, background of competing on service diversification is discussed. Section 3 discusses the DEA methodology in detail, and relevant information on data and variables is presented. Section 4 explains the results from DEA analysis. A discussion of the results will be presented in Section 5.

4.2 Background of Competing on Service Diversification

There is a fundamental aspect of competition: hospitals will constantly evolve and adapt to innovative products and services with features demanded by patients and their physicians (Gaynor and Vogt, 2000). The underlying force behind hospital competition is patient preferences. Heterogeneity in patient preferences leads hospitals to differentiate along both clinical and nonclinical dimensions(Lindrooth, 2008). With respect to nonclinical competition, U.S. hospitals usually offer private and semi-private rooms with televisions and private phones. Many hospitals offer features such as upscale lobbies and waiting rooms. These amenities are a result of hospitals responses to patient preferences that value nonclinical attributes. With respect to clinical competition, hospitals usually have two choices. One is to focus on a small set of highly specialized procedures, such as Coronary Artery Bypass Grafting (CABG), providing both increased capacity and improved outcomes (Marcin et al., 2008). The other is to offer a unique set of related services, which enables a hospital to differentiate itself from competitors (Lindrooth, 2008). For instance, offering a neonatal intensive care unit (NICU) may give a hospital competitive advantages over another hospital in the same market for labor and delivery. A pregnant woman may strictly prefer to deliver her baby at a hospital with an on-site NICU, while another may value hotel-like surroundings more than an on-site NICU, and thus chooses a hospital offering hotel-like facilities for a birth expected to be uncomplicated.

In order to meet customers' diversified demands, there are several means for hospitals to change their service diversification (Trinh and O'Connor, 2002), such as service overhauls and redesign, elimination of low-demand services, etc. These strategies are generally viewed favorably because they should strengthen hospital business by protecting market share, containing costs, and enhancing operational efficiency. These differentiation strategies lead to market power, and there is a strong incentive to satisfy heterogeneous consumer preferences (Lindrooth, 2008).

However, there is a dearth of research in the literature on the realized benefits at the hospital level related to service diversification. Recent literature mostly concentrates on studying the benefits of providing a limited set of focused services. Mixed effects have been found on quality and operational performance (Kc and Terwiesch, 2011; McDermott and Stock, 2011; Clark and Huckman, 2012). Although service diversification has been found to be an important strategy due to its positive effects on economies of scope, economizing on operational costs, and risk control (Clement, 1987; Snail and Robinson, 1998), little attention has been paid to the realized benefits resulting from the increasing level of service variety. This study seeks to examine the association between the change in a hospital's level of service variety and the hospital's level of DEA efficiency, so that it provides empirical evidence on how service diversification can impact hospital efficiency performance, as measured by market share, as well as other clinical, financial and operational aspects.

4.3 Methodology

4.3.1 Modeling Approaches

Two main DEA models have gained popularity in the literature. One is the CCR DEA model, which is named for Charnes et al. (1978), and the other is the BCC DEA model, named for Banker R.D. and Cooper (1984). The CCR model proposed by Charnes et al. (1978) is input-oriented DEA method, which defines efficiency as a ratio of weighted sum of outputs to a weighted sum of inputs, and calculates the weights structure by means of mathematical programming. The CCR DEA model presumes the frontier surface in pursuing the maximum possible proportional reduction in input, with output to be held constant for each DMU. This model, known as the constant return to scale (CRS) model, assumes efficiency for the DMU as the weighted linear combination of its outputs divided by the weighted linear combination of its inputs, subject to the constraint that the efficiency is between 0 and 1 for each DMU. The BCC model proposed by Banker R.D. and Cooper (1984) extends the CCR DEA model to account for variable return to scale (VRS) situations. When all DMUs do not operate at optimal scale, the use of CRS specifications results in measures of technical efficiency that are confounded by scale efficiencies. The BCC DEA model assumes the efficiency can change according to different scale of input and output, while CCR DEA model is based on a constant relationship between inputs and outputs regardless of the scale. Thus, the BCC model enables the measurement of both technical efficiency and scale efficiency (Roh and Jung, 2010).

There are two kinds of orientation in DEA analysis: input-oriented and output-oriented. An output orientation assumes that DMUs have direct control over their outputs, while an input orientation assumes little control over outputs produced. Because hospitals cannot directly control the health of the community, it is more appropriate to concentrate on the inputs where there is more opportunity to reduce excess consumption (Harris et al., 2000). Since output-oriented DEA is also the dual problem of input-oriented DEA, the input-oriented DEA model is utilized throughout this chapter to ensure the coherence. And the ordinary input-oriented CCR model is as below:

$$\begin{aligned}
Minimize \quad & \theta_0 - \epsilon \left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+ \right) \\
s.t. \quad & \sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta_0 x_{i0}, \quad i = 1, \ldots, m \\
& \sum_{j=1}^{n} \lambda_j y_{rj} - s_i^+ = y_{r0}, \quad r = 1, \ldots, s \\
& \lambda_j \geq 0 \quad j = 1, \ldots, n,
\end{aligned} \tag{4.1}$$

where y_{rj} is the r-th output of DMU_j, and x_{ij} is the i-th input of DMU_j. λ_j is weight for the corresponding j-th DMU. s_i^- and s_i^+ represent input and output slack. ϵ in the objective function is called the non-Archimedean, which is defined as infinitely small, or less than any real positive number respectively. This calculation gives out the efficient score θ_0 for the focal DMU_0.

The input-oriented BCC model has one more constraint for λ_j, and it is listed below:

$$\begin{aligned}
Minimize \quad & \theta_0 - \epsilon \left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+ \right) \\
s.t. \quad & \sum_{j=1}^{n} \lambda_j x_{ij} + s_i^- = \theta_0 x_{i0}, \quad i = 1, \ldots, m \\
& \sum_{j=1}^{n} \lambda_j y_{rj} - s_i^+ = y_{r0}, \quad r = 1, \ldots, s \\
& \sum_{j=1}^{n} \lambda_j = 1, \quad j = 1, \ldots, n, \\
& \lambda_j \geq 0, \quad j = 1, \ldots, n,
\end{aligned} \tag{4.2}$$

Without this additional constraint, the original CCR model will assume constant return to scale and thus the estimated summation of weights $\sum_{j=1}^{n} \lambda_j$ can indicate increasing return to scale ($\sum_{j=1}^{n} \lambda_j < 1$), constant return to scale ($\sum_{j=1}^{n} \lambda_j = 1$), and decreasing return to scale ($\sum_{j=1}^{n} \lambda_j > 1$).

4.3.2 Data Set

Similar to the previous chapters, the analysis in this chapter leverages data from the Office of Statewide Health Planning and Development (OSHPD) in California. Because DEA analysis requires data for actual input and output metrics instead of data on cumulative changes, the study period ranges from 2005 to 2011. Given a preference for homogeneous DMUs, the hospitals included in this DEA investigation are general medical/surgical hospitals only. The data set includes about 300 hospital observations for each of the years captured in the study period.

Considering that the computation of efficiency scores under DEA is highly sensitive to the selection of appropriate inputs and outputs, based on a literature search of previous DEA investigations in hospitals, four input variables are selected to represent measures of hospital resource consumption. In DEA, the assumption is that the more of these inputs are consumed, the higher the costs incurred. Thus an increase in inputs is associated with an expectation of higher outputs. Similarly, there are three output variables selected for the DEA model. All these output variables are generally desirable to hospitals, which means that a hospital would be in favor of increasing such outputs, given a fixed set of inputs. The following subsections present detailed explanations of each of the input and output metrics included.

4.3.3 Input Variables

The first proposed input variable is the number of hospital beds. Larger hospitals (i.e., with larger numbers of beds) spend more on capital investments, consume more resources, and thus expect to realize economies of scale more easily than hospitals with fewer beds. Ozcan and Luke (1993) shows that the size of a hospital measured by number of beds is a good estimate of a hospital's level of capital investment.

As hospitals require significant capital investments, this input variable is crucial for capturing the association between hospital size and hospital output capacity. Note that the literature mentions several alternative approaches for counting a hospital's number of beds, such as operational beds Ozcan and Luke (1993), licensed beds Ozcan and Bannick (1994), and staffed beds Nayar and Ozcan (2008), etc. In this chapter, staffed beds (StfBed) will be utilized to measure the hospital size.

The second input variable is the number of services offered (NSrv). The OSHPD database currently identifies up to 216 services and educational programs offered by a hospital. The database provides coding that indicates whether these services are available in the hospital directly or, through agreements, at other hospitals. The key to the count is to identify whether the services are offered by the hospital, thus suggesting that appropriate investments in facilities, equipment, appropriately-skilled personnel, resources, etc., are in place to support those services (Ozcan, 2008). A binary indicator is used to indicate whether a hospital is offering a service. The hospital receives value 1, implying that the service is offered; otherwise, the value for that hospital and service is 0. The number of services is also a proxy for capital investment, as dedicated resources are required for each service, and the more services a hospital provides, the higher the incurred cost.

The third input variable is represented by operating expenses (OE). OE represent the total dollar expenditures corresponding to all direct costs. The use of this metric as an input is common in the hospital DEA literature (Chilingerian and Sherman, 1990; Ozcan and Luke, 1993; Ozcan, 2008), since it directly reflects the amount of resources consumed as input to provide support for hospital care-giving activities.

The fourth input variable considered in this study is the total productive hours (PdHr) of all hospital personnel. This input includes all the labor hours from physicians, nurses, technicians, etc., as long as they are directly related to revenue producing activities. This variable is very similar to the labor FTEs commonly being used in literature (Chilingerian and Sherman, 1990; Ozcan and Luke, 1993; Ozcan, 2008), since it can be easily converted to FTEs by dividing 2,080 working hours in a year. This variable is intended to reflect the volume and range of work undertaken by healthcare professionals in hospitals.

4.3.4 Output Variables

The first two output variables are most common in the literature on DEA applications to hospitals (Chilingerian and Sherman, 1990; Ozcan and Luke, 1993; Ozcan, 2008). They are total inpatient discharges (TDisc) and total outpatient visits (TVist), which measure the major outputs of a general hospital. The volume of inpatient services can be easily determined from either admissions or discharges. However, each patient may present different comorbidities, demanding different amounts and types of resources. In order to account for this diversity in health service demand, the aforementioned patient volume metrics should be adjusted for the severity of a hospital's patient population. The case mix index (CMI) has been traditionally used to represent patient severity (Hadley et al., 1996; Huerta et al., 2008). CMI is calculated based on patient diagnostic related groups (DRGs), providing relative weight for the different acuity of the services provided by a hospital. For instance, if case mix for a hospital is 1.3, it means the hospital served 30% more acute patients than a standard hospital, which is assumed to have a case mix index value of 1. In accordance with previous chapters, the case-mix adjusted inpatient discharges is used as an output of inpatient service. The second output variable is outpatient visits. This variable is defined by the OSHPD database as the summation of a set of ambulatory and ancillary service activities, such as outpatient surgery, emergency visits, renal dialysis care visits, etc.

The third output variable is gross patient revenue (GPR). This is not a common output in DEA studies on hospitals, due to the fact that the majority of hospitals are not-for-profit organizations. However, no matter what a hospital's profit orientation is, for-profit or not, all hospitals face the same challenges in revenue and cost schedules. As such, it is as difficult for a not-for-profit hospital to break even as it is for a for-profit hospital to make a reasonable return on investment. More importantly, revenues are typically a crucial output metric for DEA studies in other service sectors (see Sarkis, 2000, for examples). In addition, not all patients arriving at the hospital require the same level of attention and care. Some come for minor treatment requiring an outpatient visit or a one-day stay, while others have to go through major medical or surgical procedures requiring multiple-day stays. Thus, patient volumes alone may not be an accurate measure of hospital outputs. In contrast, GPR better reflects all the chargeable activities accomplished in a hospital, from both volume and complexity perspectives. For these reasons, GPR is included as an output metric in this DEA study.

In summary, the DEA model proposed here combines input and output metrics that have been commonly used in prior DEA studies on healthcare, and represents a hospital's level of resource consumption and capital expenditures as well as financial and operational outcomes. Summary statistics on the input and output variables described above for all the hospitals included in this study are shown in Table 4.1. The results are based on yearly observations for each general medical/surgical hospital in CA from 2005 to 2011, and any missing value in the input or output variables leads to the elimination of that observation from analysis basis.

Table 4.1: Summary Table for Input and Output Variables

	Mean	s.d.	Minimum	Maximum
Input				
Staffed Bed (StfBed)	186	147.32	10	911
Number of Service (NSrv)	103	35.18	4	214
Operating Expenses (OE $M)	182.69	219.97	3.33	1827.00
Productive Hours (PrHr in 1000 Hrs)	1,295.27	1,408.05	24.58	12,603.30
Output				
Adjusted Discharges (TDisc)	11,375	10,870.09	19	71,583
Total Visits (TVist)	134,843	149,308.30	198	978,100
Gross Patient Revenue (GPR $M)	697.53	790.66	3.15	7,254.62

4.4 Summary of Findings

The following results are based on input-oriented BCC DEA models, which assume that hospitals have direct control on their inputs. The CCR model is not selected, because it assumes constant returns to scale. It means that the DMUs are able to linearly scale the inputs and outputs without increasing or decreasing efficiency. This is a very strong assumption, which may not hold in hospital environment. For instance, a strategy works well in a small size hospital may not be applicable to a large size hospital for the same proportional scaled outcome. Instead, the BCC model takes organizational scalability into consideration. This approach enables the comparison of hospital performance by building a benchmark to evaluate different hospital competitive strategies. Once the model is solved for each DMU, the obtained efficiency score can be correlated with each strategy to understand their systematic impacts.

4.4.1 Efficiency scores

Table 4.2 shows yearly hospital efficiency scores between 2005 and 2011. On average, about 15% of all hospitals could be considered efficient in any given year, except in 2007, when the proportion of efficient hospitals drops dramatically to 3.72%. Figure 4.1 shows this dramatic change in 2007.

Table 4.2: Efficiency Scores by Year

	2005	2006	2007	2008	2009	2010	2011
Inefficient Hospitals	239	247	285	251	247	233	231
Mean	0.7761	0.7701	0.2321	0.7406	0.7633	0.7851	0.7854
S.D.	0.1266	0.1293	0.1768	0.1333	0.1335	0.1269	0.1273
Min	0.4022	0.3190	0.0583	0.3090	0.3104	0.3255	0.3128
Max	0.9964	0.9966	0.9846	0.9849	0.9963	0.9971	0.9983
Efficient Hospitals	58	49	11	45	49	60	59
% Efficient	19.53%	16.55%	3.72%	15.20%	16.55%	20.48%	20.34%
Total	297	296	296	296	296	293	290

Figure 4.1: Efficiency Scores Drop in 2007

The first set of DEA results focus on analyzing the efficiency of hospitals that won quality awards during the period from 2005 to 2009. Table 4.3 shows efficiency scores for award-winning hospitals and the trend in their efficiency scores several years after winning a quality award. It can be noted that on the base year, when the quality award is given, award-winning hospitals exhibit lower than average efficiency. The standard deviation of award winning hospitals' efficiency scores are much larger than the average, which means some award winning hospitals have extreme low efficiency scores. The situation remains unchanged even one year after winning a quality award. However, two years after winning a quality award, award-winning hospitals display a leap in their performance, as indicated by their increased average efficiency score. Within three years after winning a quality award, award-winning hospitals improve their efficiency even further and achieve significant higher scores than their counterparts which do not win a quality award. The trend is also shown in Figure 4.2. This difference has been confirmed as statistically significant in both t-tests for the equality of means and Wilcoxon rank-sum tests for the equality of medians.

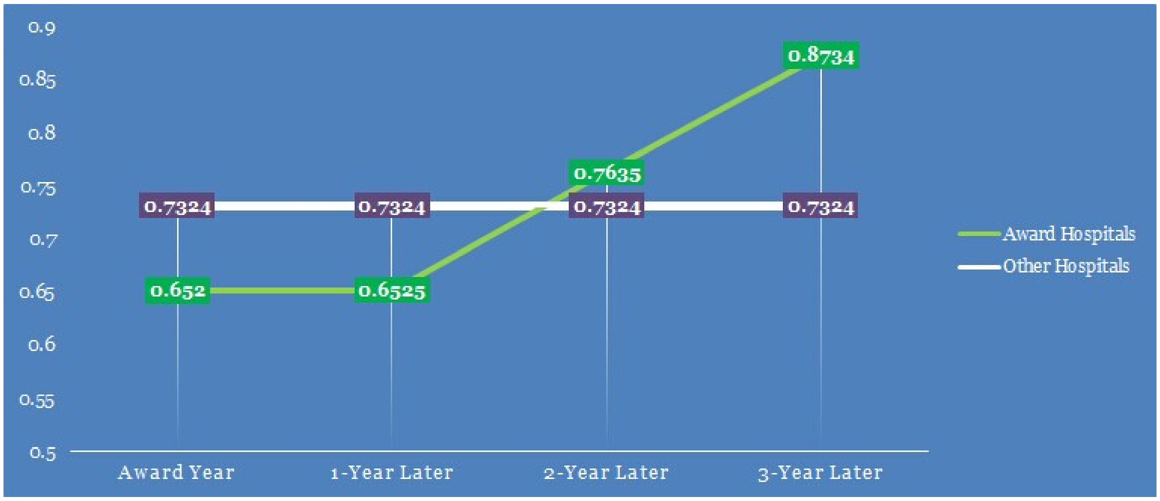

Figure 4.2: Efficiency Score Trend of Award Winning Hospitals

As such, this result is very similar to what has been obtained in Chapter 2, since these quality awards considered here are exactly the same awards described in Chapter 2. This result indicates that award-winning hospitals gain significant efficiency in their operations after winning quality awards.

Table 4.3: Efficiency Scores for Award-winning Hospitals

Hospital Observations	N Obs	Mean	Std Dev	Minimum	Maximum
No Award	1951	0.7324	0.2474	0.0594	1
Award-Winning	29	0.6520	0.3726	0.0670	1
1-Year After Award	29	0.6525	0.3526	0.0583	1
2-Year After Award	29	0.7635	0.2910	0.1135	1
3-Year After Award	26	0.8734	0.1316	0.6209	1

The next set of results are centered on the implications of a strategic focus on process execution on hospital efficiency. Note that, similar to Section 3.5, the two proxies used to identify hospitals with effective process execution are length of stay and cost per discharge. If both metrics are lower than median in a given year (which becomes the base year), the hospital is identified as having better process execution and coded as 0. If both length of stay and cost per discharge are higher than median in a given year, the hospital is identified as having worse process execution and coded as 1. This enables a direct comparison of efficiency scores between the two groups of hospitals and Table 4.4 presents the results of this evaluation. Thus, according to Table 4.4, hospitals with better process execution do exhibit significantly higher efficiency scores than hospitals with worse process execution, as indicated by a p-value lower than 0.01.

Table 4.4: Efficiency Scores for Hospitals Process Execution

Base Year Rank	N	Mean	Std Dev	Std Err	Minimum	Maximum
Better Process Execution	343	0.7472	0.2954	0.0159	0.0615	1
Worse Process Execution	342	0.6474	0.2458	0.0133	0.0583	1
Diff (0-1)		0.0997	0.2718	0.0208		

To further study the impact of a focus on process execution, another set of tests is performed on hospitals with/without significant improvement in the two metrics used to define process execution. Thus, if both length of stay and cost per discharge have a higher than average improvement over a two-year period, the hospital is identified as a hospital with improving process execution and coded as 0. If, however, both length of stay and cost per discharge have a lower than average improvement over a two-year period, the hospital is identified as a hospital with declining process execution and coded as 1. Again, this approach enables a direct comparison between the two hospital groups on their efficiency scores, as shown in Table 4.5.

Table 4.5 shows that over a period of up to two years from the base year, there is no significant difference in efficiency between hospitals with improving process execution and hospitals with declining process execution. However, with a one year lag effect on the process execution, a significant improvement in efficiency scores can be observed on the third year (p-value of 0.02). This result is consistent with previous findings in Section 3.5, where the 1-year lagged process execution cumulative changes in a 2-year period have been found to be significantly correlated with hospital performance improvement.

In the investigation for the third operational strategy, hospital's level of service variety needs to be defined to measure a hospital's focal service set. For focus hospitals, they tend to limit the number of services provided, and improve the

Table 4.5: Efficiency Scores for Hospitals with Improving Process Execution

Base Year	N	Mean	Std Dev	Std Err	Minimum	Maximum
Improving Process Execution	410	0.6722	0.2705	0.0134	0.0609	1
Declining Process Execution	410	0.7017	0.2766	0.0137	0.0594	1
Diff (0-1)		-0.0295	0.2736	0.0191		
1 Year After	N	Mean	Std Dev	Std Err	Minimum	Maximum
Improving Process Execution	363	0.6952	0.2696	0.0141	0.0664	1
Declining Process Execution	409	0.6981	0.2704	0.0134	0.0583	1
Diff (0-1)		-0.00289	0.27	0.0195		
2 Year After	N	Mean	Std Dev	Std Err	Minimum	Maximum
Improving Process Execution	363	0.6961	0.2925	0.0154	0.0609	1
Declining Process Execution	406	0.6829	0.2678	0.0133	0.0583	1
Diff (0-1)		0.0132	0.2797	0.0202		
3 Year After	N	Mean	Std Dev	Std Err	Minimum	Maximum
Improving Process Execution	296	0.8123	0.1488	0.00865	0.3128	1
Declining Process Execution	326	0.7843	0.1555	0.00861	0.309	1
Diff (0-1)		0.028	0.1523	0.0122		

service volume which means they prefer to provide services for patients' common needs. For diversification hospitals, they would like to diversify their services, offering more services which could serve patients unique demands. To study the impact of such service diversification/focus, the Saidin index is utilized to calculate a weighted summation for the services offered by a hospital. The weight is based on the number of services and the diversification of each service. It results that a higher weight is assigned to the service that is less popular in the hospital serving community. This approach of measuring service diversification is consistent with prior studies such as Harris et al. (2000).

After obtaining the service data for departments of every hospital, a service diversification indicator can be calculated by using the different weight of each service. The calculation is listed below, which is referred as the Saidin Index by Blank and Hulst (2009):

$$SDI = 1 - \sum_i w_i p_i, \tag{4.3}$$

where p_i is the binary variable, indicating the presence of service i, as 1 means the service is directly provided in a hospital unit and 0 means such service is not provided within the hospital. w_i is weight defined as 1 minus the ratio of the number of hospitals providing service i to the total number of hospitals. It is 0 if all the hospitals have the same service i. This Saidin index is not typically used to measure diversification, but it can effectively capture both service innovation and diversification, since it assigns more weights to service which is not common provided by all the hospitals.

Table 4.6: Efficiency Scores for Focused vs. Diversified Hospitals

Base Year Rank	N	Mean	Std Dev	Std Err	Minimum	Maximum
Focus	738	0.7163	0.2463	0.0091	0.0749	1
Diversification	735	0.6727	0.2979	0.0110	0.0583	1
Diff (0-1)		0.0435	0.2733	0.0142		

On a given year (base year), if the Saidin index defined service mix is lower than average, the hospital is identified as a focused hospital and coded as 0. If the Saidin index defined service mix is higher than average, the hospital is identified as a diversified hospital and coded as 1. Table 4.6 shows that hospitals competing on common services, i.e., are focused, have higher efficiency scores than diversified hospitals. The p-value of the t-test is less than 0.01. In other words, general hospitals providing diversified service tend to have lower efficiency scores.

To further explore how the impact of service diversification is moderated by changes in case mix index, a set of tests for different combinations of the two variables is performed.

Table 4.7 shows that when the case mix index is decreasing over a two-year period, the efficiency scores of focused and diversified hospitals are both improving, and the difference becomes smaller over time and not significantly different after three years, as indicated by a p-value of 0.26. Similarly, when CMI is increasing over a two-year period, Table 4.8 shows that both focus and diversification strategies lead to improved efficiency scores. In this case, a focus strategy seems to be better off, considering that over a three-year period focused hospitals gain significantly higher efficiency scores

Table 4.7: Efficiency Scores for Hospitals with Decreasing CMI

Base Year	N	Mean	Std Dev	Std Err	Minimum	Maximum
Focus	387	0.7284	0.2686	0.0137	0.0808	1
Diversification	303	0.6729	0.2952	0.0170	0.0594	1
Diff (0-1)		0.0555	0.2806	0.0215		
1 Year After	**N**	**Mean**	**Std Dev**	**Std Err**	**Minimum**	**Maximum**
Focus	267	0.8294	0.1558	0.0095	0.1522	1
Diversification	248	0.8004	0.1479	0.0094	0.4528	1
Diff (0-1)		0.0289	0.1521	0.0134		
2 Year After	**N**	**Mean**	**Std Dev**	**Std Err**	**Minimum**	**Maximum**
Focus	194	0.8375	0.1477	0.0106	0.3104	1
Diversification	191	0.7854	0.1943	0.0141	0.0609	1
Diff (0-1)		0.0521	0.1724	0.0176		
3 Year After	**N**	**Mean**	**Std Dev**	**Std Err**	**Minimum**	**Maximum**
Focus	131	0.8440	0.1432	0.0125	0.3128	1
Diversification	132	0.8241	0.1448	0.0126	0.4095	1
Diff (0-1)		0.0199	0.1440	0.0178		

Table 4.8: Efficiency Scores for Hospitals with Increasing CMI

Base Year	N	Mean	Std Dev	Std Err	Minimum	Maximum
Focus	346	0.7001	0.2719	0.0146	0.0670	1
Diversification	330	0.6735	0.2863	0.0158	0.0583	1
Diff (0-1)		0.0266	0.2790	0.0215		
1 Year After	**N**	**Mean**	**Std Dev**	**Std Err**	**Minimum**	**Maximum**
Focus	239	0.8000	0.1565	0.0101	0.0851	1
Diversification	261	0.7939	0.1624	0.0101	0.0845	1
Diff (0-1)		0.0061	0.1596	0.0143		
2 Year After	**N**	**Mean**	**Std Dev**	**Std Err**	**Minimum**	**Maximum**
Focus	187	0.8194	0.1504	0.0110	0.0851	1
Diversification	195	0.7700	0.2053	0.0147	0.1044	1
Diff (0-1)		0.0494	0.1805	0.0185		
3 Year After	**N**	**Mean**	**Std Dev**	**Std Err**	**Minimum**	**Maximum**
Focus	127	0.8489	0.1301	0.0115	0.4440	1
Diversification	138	0.7944	0.1512	0.0129	0.4361	1
Diff (0-1)		0.0545	0.1415	0.0174		

than what diversified hospitals gain, statistically significant at the 0.01 level. This result supports that service diversification can be a beneficial strategy to hospitals which are seeking of tapping into new patient groups and thus mitigating the costs and risks of treating high severity patients.

4.4.2 Slack Analysis

DEA can not only identify which DMUs are relatively inefficient, but also reveal what can be done, based on slack analysis, for those inefficient units to become efficient. Basically, slack analysis indicates by what amount hospitals can decrease the inputs and/or increase the outputs to reduce the discrepancy of their efficiency scores to the efficient frontier. The slack of inputs is referred to as "excess" and the slack of outputs is called "shortage" (Ozcan, 2008).

Table 4.9: Slack Analysis by Year

Year	StfBed	NSrV	OE	PdHr	TDisc	TVist	GPR	# DMUs
2005	115(38.72%)	79 (26.60%)	26 (8.75%)	108(36.36%)	16 (5.39%)	36 (12.12%)	43 (14.48%)	297
2006	99(33.45%)	106(35.81%)	27 (9.12%)	148(50.00%)	18 (6.08%)	20 (6.76%)	36 (12.16%)	296
2007	65(21.96%)	23 (7.77%)	192(64.86%)	284(95.95%)	256(86.49%)	199(67.23%)	272(91.89%)	296
2008	106(35.81%)	63 (21.28%)	42 (14.19%)	118(39.86%)	25 (8.45%)	47 (15.88%)	73 (24.66%)	296
2009	117(39.53%)	59 (19.93%)	38 (12.84%)	127(42.91%)	18 (6.08%)	53 (17.91%)	99 (33.45%)	296
2010	89 (30.38%)	89 (30.38%)	31 (10.58%)	112(38.23%)	16 (5.46%)	49 (16.72%)	51 (17.41%)	293
2011	91 (31.38%)	84 (28.97%)	34 (11.72%)	73 (25.17%)	15 (5.17%)	26 (8.97%)	54 (18.62%)	290

Table 4.10: Slack Analysis for Award-Winning Hospitals

Year	StfBed	NSrV	OE	PdHr	TDisc	TVist	GPR	# DMUs
Winning Award	6 (20.69%)	7 (24.14%)	9 (31.03%)	12 (41.38%)	9 (31.03%)	6 (20.69%)	10 (34.48%)	29
1-year after	4 (13.79%)	5 (17.24%)	10 (34.48%)	16 (55.17%)	9 (31.03%)	6 (20.69%)	12 (41.38%)	29
2-year after	8 (27.59%)	8 (27.59%)	8 (27.59%)	12 (41.38%)	3 (10.34%)	4 (13.79%)	8 (27.59%)	29
3-year after	8 (30.77%)	7 (26.92%)	3 (11.54%)	6 (23.08%)	1 (3.85%)	0 (0%)	6 (23.08%)	26

Table 4.9 shows the number of hospitals that are inefficient and need to improve their slack for every year in the study period. For instance, hospitals that are inefficient with respect to the operating expenses input should improve their cost per discharge, thus in favor of competing on process execution. Over 20% hospitals need to lower the number of services offered, and thus focus on fewer services. About one third of all the hospitals have slack on the number of staffed beds, and two thirds of all the hospitals have slack on total productive hours. From the output perspective, some hospitals need to increase the number of inpatient discharges and outpatient visits. As such, about 10% hospitals should improve discharges, and possibly decrease length-of-stay, assuming all the other inputs remain constantly. It also suggests that these hospitals should adopt a competitive strategy of improving process execution.

For award-winning hospitals, the slack analysis for each variable is presented in Table 4.10. It shows that these award-winning hospitals have a dramatic improvement in their outputs and efficiency. Almost all these hospitals have no slack in the patients volume measures after 2 years of winning a quality award. In addition, the direct cost related input measures, such as productive hours and operating expenses, have less slack as well.

The slack analysis in Table 4.11 also shows the same improvement for hospitals with better process execution that has been seen in previous efficiency scores in Table 4.5. It points to a significant improvement in efficiency over a period of three years.

The slack analysis in Table 4.12 supports earlier findings from the analysis of efficiency scores for focused and diversified hospitals, respectively. Thus, Table 4.12 shows that when the process execution focus is sustainable for more than three years, fewer hospitals in pursuit of such strategies have slack in their inputs and outputs.

Table 4.11: Slack Analysis for Hospitals Process Execution

Base Year	StfBed	NSrV	OE	PdHr	TDisc	TVist	GPR	# DMUs
Better PE	163 (39.76%)	83 (20.24%)	87 (21.22%)	243 (59.27%)	94 (22.93%)	94 (22.93%)	142 (34.63%)	410
Worse PE	128 (31.22%)	104 (25.37%)	93 (22.68%)	216 (52.68%)	91 (22.2%)	98 (23.9%)	153 (37.32%)	410
1 Year After	StfBed	NSrV	OE	PdHr	TDisc	TVist	GPR	# DMUs
Better PE	139 (38.29%)	87 (23.97%)	67 (18.46%)	216 (59.5%)	72 (19.83%)	94 (25.9%)	124 (34.16%)	363
Worse PE	124 (30.32%)	98 (23.96%)	91 (22.25%)	216 (52.81%)	96 (23.47%)	98 (23.96%)	151 (36.92%)	409
2 Year After	StfBed	NSrV	OE	PdHr	TDisc	TVist	GPR	# DMUs
Better PE	131 (36.09%)	79 (21.76%)	72 (19.83%)	201 (55.37%)	80 (22.04%)	99 (27.27%)	129 (35.54%)	363
Worse PE	135 (33.25%)	73 (17.98%)	97 (23.89%)	190 (46.8%)	99 (24.38%)	90 (22.17%)	151 (37.19%)	406
3 Year After	StfBed	NSrV	OE	PdHr	TDisc	TVist	GPR	# DMUs
Better PE	101 (34.12%)	85 (28.72%)	23 (7.77%)	122 (41.22%)	8 (2.7%)	52 (17.57%)	60 (20.27%)	296
Worse PE	117 (35.89%)	73 (22.39%)	50 (15.34%)	119 (36.5%)	31 (9.51%)	35 (10.74%)	89 (27.3%)	326

Table 4.12: Slack Analysis for Focused and Diversified Hospitals

Base Year After	StfBed	NSrV	OE	PdHr	TDisc	TVist	GPR	# DMUs
Focus	235 (32.06%)	170 (23.19%)	163 (22.24%)	388 (52.93%)	157 (21.42%)	187 (25.51%)	247 (33.7%)	733
Diversification	258 (35.44%)	159 (21.84%)	159 (21.84%)	388 (53.3%)	169 (23.21%)	162 (22.25%)	272 (37.36%)	728
1 Years After	**StfBed**	**NSrV**	**OE**	**PdHr**	**TDisc**	**TVist**	**GPR**	**# DMUs**
Focus	164 (30.26%)	118 (21.77%)	107 (19.74%)	278 (51.29%)	98 (18.08%)	131 (24.17%)	161 (29.7%)	542
Diversification	247 (33.98%)	177 (24.35%)	159 (21.87%)	398 (54.75%)	173 (23.8%)	167 (22.97%)	281 (38.65%)	727
2 Years After	**StfBed**	**NSrV**	**OE**	**PdHr**	**TDisc**	**TVist**	**GPR**	**# DMUs**
Focus	150 (27.88%)	102 (18.96%)	130 (24.16%)	278 (51.67%)	133 (24.72%)	161 (29.93%)	212 (39.41%)	538
Diversification	244 (33.75%)	164 (22.68%)	181 (25.03%)	355 (49.1%)	177 (24.48%)	169 (23.37%)	291 (40.25%)	723
3 Years After	**StfBed**	**NSrV**	**OE**	**PdHr**	**TDisc**	**TVist**	**GPR**	**# DMUs**
Focus	138 (31.87%)	97 (22.4%)	52 (12.01%)	170 (39.26%)	19 (4.39%)	73 (16.86%)	94 (21.71%)	433
Diversification	209 (36.28%)	155 (26.91%)	77 (13.37%)	205 (35.59%)	44 (7.64%)	75 (13.02%)	145 (25.17%)	576

4.5 Discussion

In this chapter, DEA has been utilized not only to perform a robustness examination of earlier findings in previous chapters , pertaining to the implications of competing on quality and process execution, respectively, but also to investigate the role that service diversification or focus can play on hospital efficiency. Moreover, this chapter also reveals how each strategy would impact specific input and output variables and highlights which operational strategies lead to highest improvements in hospital efficiency in different scenarios.

In general, the robustness examinations generate very similar results to what have been found by using regression analysis in earlier chapters . Analysis of the DEA results shows that winning a quality award (used here as a proxy for competing on quality) can lead to strong gains in hospital's desired outputs. This finding appears to provide evidence in support of the existence of a signaling effect associated with the winning of a quality award. Meanwhile, competing on process execution and competing on service diversification meet different hospital goals. For a general hospital, competing on process execution is always a good strategy. But when a hospital experiences a decrease in case mix index, diversifying to a unique set of uncommon services and providing more a variety of services would help such hospital gain efficiency.

Significant drops of hospital efficiency in 2007 have been detected for the majority of general hospitals by the DEA model. It seems to be caused by a sudden drop in the discharges and visits. Under such circumstance, the differences in the number of staffed beds and the number of services between efficient hospitals and inefficient hospitals may become smaller, but the majority of hospitals cannot achieve efficiency due to the sudden drops in their desired outputs.

Chapter 5

Conclusions

5.1 Summary of Findings

There is tremendous pressure on hospitals to improve performance and healthcare outcomes. In a context where hospitals strive to operate effectively and efficiently, this dissertation seeks to provide guidance to hospitals in need of adjusting their competitive strategy, by providing a detailed evaluation of the benefits associated with three distinct competitive strategic choices. Findings from the three studies quantify the implications of each competitive strategy, and facilitate meaningful qualitative analysis.

The first study of this dissertation focuses on the strategy of competing on quality. By using a set of quality awards as an indicator for superior healthcare quality, the findings provide evidence supporting the hypothesis that award-winning hospitals gain outpatient market share in a two-year period after winning a quality award. The award-winning hospitals also experience increasing revenue and costs, while little change is detected in their profitability. This result contrasts with findings from other industries, where profit maximization is the primary goal for most competitors and the likely motivation behind applying for a quality award (Hendricks and Singhal, 1997). However, since all of the award-winning hospitals investigated in this study are non-profit organizations, it is likely that profit maximization is not their primary goal. As such, it could be expected that a non-profit hospital will spend potential profits on non-profit generating activities, such as providing charity care, education services, better quality, etc., which are more consistent with the hospital's mission. Thus, while winning a quality award is not found to be associated with a statistically significant change in profitability, it is possible that the higher resulting revenues could afford award-winning hospitals better opportunities to fulfill their social mission.

The analysis of award-winning hospitals also uncovers evidence that these hospitals have decreasing inpatient revenue ratios, and better reimbursement rates in the two-year period after winning a quality award. In addition, winning a quality award is associated with hospital efficiency improvements in terms of lower direct expense ratios and lower labor cost ratios. These associated benefits of attracting new patients, achieving economies of scale, and signing more advantageous contracts with third party payers could play an important role on establishing and solidifying a hospital's competitive advantage. Thus this research is relevant to both care givers and award granters, as it provides guidance on what benefits to expect from winning such quality awards.

The second study in this dissertation examines an alternative competitive approach: improving process execution. The results suggest that by improving average cost per discharge and length of stay, which here are proxies for process execution, hospitals can gain significant inpatient market share. Hospitals with better process execution exhibit higher profitability in operations, most likely a result of the various process execution initiatives put in place by hospitals, such as waste-reduction and process-improvement programs. This strategy appears effective in helping hospitals contain costs and thus be more profitable. Moreover, such hospitals benefit from faster bed turnover and higher levels of labor productivity, as supported by improved discharges per bed and discharges per productive hour. All these benefits can be achieved while maintaining the level of clinical quality.

The third study uses DEA models first to examine the benefits of service diversification and second to compare the benefits associated with the above-mentioned three competitive strategies using a larger dataset that comprises all the general medical/surgical hospitals in California. The results show that there are significant changes in the hospital efficiency scores following their adoption of either of the three competitive strategies. Competing on quality is found to be a very strong competitive approach that leads to improvements in hospital efficiency and in desired outputs such as patient volume and revenue. Competing on process execution is associated with better efficiency for all general medical/surgical hospitals. A focus on process execution helps hospitals reduce waste in inputs and increase desired outputs. Competing on service diversification is found to be a very attractive strategy when a hospital is experiencing a decreasing CMI. When CMI is increasing, this strategy also helps hospitals improve efficiency though at a lower level than when competing on process execution. The results from the DEA confirm the findings from the previous two studies of this dissertation.

5.2 Managerial Implications

All three studies in this dissertation make use of real hospital datasets, spanning 2005 to 2011. The aforementioned findings demonstrate that each competitive strategy has its own strengths and weaknesses. Hospital management needs to carefully examine their unique characteristics and adopt their own set of competitive strategies that meet the hospital's ultimate goals.

The findings from this research provide useful insights into the consequences and performance impact of adopting different competitive strategies. For example, a hospital may adopt the quality competition strategy to improve its outpatient market share, while another hospital, which focuses on inpatient market share, needs to compete on process execution to gain more patients. Additionally, hospital management can provide different services to better serve their target patient segments, consistent with the hospital's goals and mission.

5.3 Contribution to the Literature

The three studies discussed in this dissertation are among the few that have used empirical data to systematically examine a competitive strategy framework that hospitals may utilize to compete. To study the consequent performance outcomes associated with different competitive strategies, all three studies are conducted in a comprehensive performance evaluation framework, which incorporates hospitals' performance in terms of clinical, financial, and operational measures, as well as with respect to market share.

The first study of this dissertation is among the first to utilize the winning of quality awards as a proxy for a hospital's excellence in quality of care, and examine the signaling effects of winning quality awards in the healthcare industry. This study contributes empirical findings to the existing literature on the quantitative impact of competing on quality.

The second study of this dissertation uses cost per discharge and length of stay as two important indicators to measure a hospital's focus on process execution. Many previous studies, especially those in manufacturing, demonstrate that better process execution could lead to cost reduction and fast delivery. But such a conclusion has not been clear in the healthcare industry. This study not only empirically validates the importance of these operational measures in a healthcare setting, but also examines the correlation between operational performance and other performance outcomes, such as access to healthcare and financial performance.

The final study of this dissertation explores the effect of hospital competition on service diversification and also examines the effectiveness of all three competitive strategies on all general medical/surgical hospitals in the state of California. In addition, this study successfully utilizes the Saidin index to measure a hospital's level of service variety, facilitating the understanding of hospital competition on service diversification. Unlike most recent studies which investigate service focus strategies, this study finds empirical support for service diversification, advocating that diversification could also be a beneficial strategy to hospitals seeking to tap into new patient groups and thus potentially mitigate the costs and risks of treating high severity patients. In addition, this study contributes to the existing literature by proposing DEA as an alternative methodology to check the robustness of results obtained using regression analysis. It shows that each of the three competitive strategies can help hospitals gain different types of competitive advantages.

Overall, the three studies differ in terms of the specific strategic orientation analyzed, the strategic proxies and type of control variables used, and the measured relationships. However, they all establish the important impact that choosing an appropriate strategic orientation can have on hospital performance outcomes.

5.4 Limitations and Future Research

Despite the significance of the findings, this research is subject to several limitations that create opportunities for future research. This research depends on secondary data and publicly available information. As such, this research was not able to exhaustively account for all potentially influential hospital characteristics. For instance, hospital leadership and culture could be factors that both drive and shape a hospital's competitive strategy and the associated performance outcomes.

Another limitation is that this research is confined to the state of California due to data availability. As state regulations and operational environments vary across different states, the findings of this research may or may not be applied to other states. As such, a recommendation for future research is the extension of the analysis to other states or the entire nation.

An additional limitation is related to the time period of this research. For instance, there exists a limited number of available quality awards, which constrains the size of the sample hospital set in the first study of this dissertation. As such, this study relies only on 6 years of data ranging from 2005 to 2010. Also, during the study period, the realized impact in different hospitals may still have different patterns, which can affect individual hospital performance. Thus, though the findings support the signaling effect of quality awards, it may result in a change of hospital performance sooner or later than two years.

Future study can examine the restructuring of hospital services, and understand how these strategies would impact individual units within a hospital. For instance, the resource allocation between inpatient and outpatient departments and their utilization could be an interesting topic. Moreover, there exist a variety of hospital performance measurements, future studies can explore other evidence of these competitive strategies affecting hospital performance. Further research on the hospital contract discount and allowance is also needed to better understand hospitals' reaction to insurance and reimbursement policy changes under the healthcare reform.

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Appendix

Appendix A

Appendix

A.1 Selected Quality Awards Criteria

1. Leapfrog Top Hospital *Estimate number of recipients in each year: 40 Nationwide*
On-site inspection: Yes

The Leapfrog Top Hospital award is given annually to the highest performing hospitals on the Leapfrog Hospital Survey. The award is given to hospitals that meet Leapfrog's standards for ICU Physcician Staffing and Safe Practices Score, as well as two of the Evidence Based Hospital Referral.

2. John M. Eisenberg Patient Safety and Quality Award
Estimate number of recipients in each year: 3 Nationwide
On-site inspection: Yes

John M. Eisenberg Patient Safety and Quality Award is selected by a panel that looks at applications from each hospital. The key factors of determining a winner are effective prioritization of performance improvement goals, well-designed and deployed "dashboard" to measure and manage whole system performance, commitment to transparency, data-driven improvement of national priorities with an emphasis on care coordination and disparities reduction, demonstrated results on public reported performance measures. The award is not given every year, and there have been no repeating winners of this award.

3. Premier Award for Quality

Estimate number of recipients in each year: 30 Nationwide

On-site inspection: No

Premier Award for Quality is decided on a number of factors. Cases that result in mortality, morbidity, and complications are compared with the length of stay for each patient. Theses process of care and the patient's starting condition are also factors. There are several winners nationwide each year, and each winner is based on their excellence with a certain medical procedure.

4. NDNQI Award

Estimate number of recipients in each year: 6 Nationwide

On-site inspection: No

The NDNQI Award for Outstanding Nursing Quality is a recognition program that identifies excellence in overall performance in nursing quality indicators. An analysis is done annually on participating NDNQI hospitals. The awards recognize six categories of hospitals based on hospitals performance: academic; teaching; community; rehabilitation; pediatric; and psychiatric. NDNQI Award winners usually demonstrate superior patient outcomes and high nurse job satisfaction on the 18 nursing-sensitive performance indicators tracked by NDNQI, such as hospital-acquired pressure ulcers, patient falls with injury, infections acquired as a result of hospitalization and nurse turnover. For any hospital to qualify for NDNQI award, they must report key indicators for 5 out of the previous 8 quarters, participate in at least 1 RN satisfaction survey, and report having more than 60 patients per day per quarter.

5. Magnet Recognition

Estimate number of recipients in each year: 50 Nationwide

On-site inspection: Yes

American Nurses Credentialing Center (ANCC) Magnet Recognition Program recognizes health care organizations for quality patient care, nursing excellence and innovations in professional nursing practice. Candidate hospitals must meet the organization eligibility requirements and system eligibility requirements, and have a site visit by the team of appraisers.

6. Malcolm Baldridge National Quality Award

Estimate number of recipients in each year: 2 hospitals Nationwide

On-site inspection: Yes

The Malcolm Baldrige National Quality Award (MBNQA) is presented annually by the President of the United States to organizations that demonstrate quality and performance excellence. Three awards may be given annually in each of six categories, including healthcare category. Malcolm Baldridge National Quality Award requires winning hospitals to display a high-performing, high integrity, ethical environment. To determine if this type of environment is sustained, a number of factors are evaluated, such as visionary leadership, patient-focused excellence, organizational and personal learning, valuing staff and partners, agility, focus on the future, managing for innovation, management by fact, social responsibility and community health, focus on results and creating value, systems on perspective, etc. It also requires of the Health Care Criteria for Performance Excellence embodied in seven categories, as follows: Leadership; Strategic Planning; Customer Focus; Measurement, Analysis & Knowledge Management; Workforce Focus; Operations Focus; Results.

7. California Awards for Performance Excellence

Estimate number of recipients in each year: 3 hospitals Statewide

On-site inspection: Yes

The California Awards for Performance Excellence (CAPE) Program exists to help California organizations continuously improve. It allows organizations to apply for state-level awards and to receive feedback about their current performance and their opportunities for improvement using the nationally recognized Malcolm Baldrige National Quality Award criteria.

Vita

Wei Wu is a Ph.D. candidate in the Management Science program at the University of Tennessee Knoxville. He entered Nankai University in 1999 after finishing his high school of science, and earned his bachelor degree with a major in Information Management & Information System in 2003. Then he was recommended to the master program in Management Science & Engineering at Sichuan University without the mandatory entrance exam. With his acquired bachelor's and master's degrees, Wei was admitted to the graduate program in the Department of Statistics, Operations, and Management Science at the University of Tennessee Knoxville in 2007. He was awarded full tuition waiver and teaching/research assistantship. He obtained a master degree in Management Science in the summer of 2009, and continued his PhD study in the same field after that. Wei completed his PhD degree in Management Science in the summer of 2014.