Essays on Healthcare Operations: Impacts of Focused Operations, Competition, Quality and Cost Efficiency of Hospitals

by

Junghoon Song

July 2018

A dissertation submitted to the
Faculty of the Graduate School of
the University at Buffalo, State University of New York
in partial fulfillment of the requirements for the
degree of Doctor of Philosophy

Department of Operations Management and Strategy
This dissertation is dedicated to:

my respected parents, Ho Kyung Song and Wee Sang Park,

my beloved wife, Juli Kim,

and my adorable son, Jinu.
Acknowledgement

I would like to express my sincere gratitude to my advisor, Dr. Nallan Suresh, for his valuable guidance and endless encouragement throughout the years of my doctoral studies. He shared his wisdom with me not only on the research but also the attitude and philosophy of being an academic. He also provided me huge support on my teaching career and job search which helped me tremendously.

I must extend my deepest appreciation to my co-advisor, Dr. Jurriaan de Jong. Meeting him is one of the luckiest events happened in my life. He heavily influenced me with his passion and enthusiasm on research and it shaped my way of coping with research. Without his supportive advice and guidance, I would not have been able to complete this dissertation.

Many thanks also go to the member of my dissertation committee, Dr. Yong Li. He has provided several helpful and critical comments regarding the development of my dissertation and it became a vital part of the finished product.

I would like to reiterate my gratitude to my family. Without their love and trust, I could not have achieved what I have done so far. Particularly, I would like to express my gratitude to my beloved wife, Juli, who has given me abiding support, encouragement, and love during the journey of my graduate studies.

Finally, I must acknowledge my colleagues in the School of Management, who took the long haul journey of doctoral program with me. We shared happiness and also frustration during the program and the memories with them have become a precious piece of my life.
Abstract

A wide range of operations management initiatives are currently being investigated and pursued in U.S. hospitals by both practitioners and academics (Kc and Terwiesch). Even as healthcare providers are being forced to drive down costs, maintaining acceptable levels of quality, while retaining cost efficiency continues to be a major challenge. The objective of this three-essay dissertation is to investigate the impacts of a focused factory approach to healthcare operations, the role of competition as a driver to adopting focused factory approach in healthcare on quality and cost efficiency of large U.S. hospitals, and provide insights on current practices and their efficacy.

The first essay investigates the impact of operational focus on quality of care in U.S hospitals, and the determinants of adopting focused operations. The relationship between increasing competition among hospitals and quality performance, and the degree of influence of regional competition on a hospital’s decision to implement a focused factory concept are examined in depth. The concept of a hospital as a ‘focused factory’ has drawn attention in recent years in healthcare management (Herzlinger, Huckman and Zinner, McDermott and Stock). The concept of a focused factory was first articulated in the seminal work of Skinner, in which it was argued that by reducing complexity, manufacturing plants can concentrate on a smaller number of tasks and be more effective and efficient. Specifically, it was argued that a “focused factory does a better job because repetition and concentration in one area allow its workforce and managers to become effective and experienced in the tasks required for success. A focused factory is more manageable and controllable than unfocused plants. Its problems are demanding but limited in scope”. A few studies have portrayed the impacts of the focused factory approach in healthcare environments, and they have reported that hospitals with more focused operations show improved operational performance (Clark and Huckman, Hyer et al.,
Kc and Terwiesch, McDermott and Stock). It is becoming apparent that hospitals benefit from economies of scale as they focus on fewer services, despite having to give up the advantages from economies of scope as they provide a narrower range of services.

It has also been observed that hospitals increasingly do tend to have more focused operations (Eastaugh, Goldberger and Nallamothu). While the focused factory concept in healthcare has begun to be investigated in recent years, existing studies typically focus on just one or a small number of performance outcomes. In our study, we provide a more nuanced understanding of the effects of focused operations on a broader spectrum of quality variables. This allows us to test in which specific area of quality performance the focused factory approach is most effective. In addition, while outcomes of the focused factory have received research attention, the antecedents of the focused factory approach in a healthcare environment have been studied to a much lesser extent.

Another area that is related to hospital performance is competition. The impact of competition on hospital performance has long been a point of discussion in medical and healthcare economics literature (Ginzberg, Miller, Mukamel et al., Porter and Teisberg, Rivers and Glover, Zwanziger and Melnick). The majority of past studies has focused on the impact of competition on cost, but not sufficiently on quality of care. As the object of competition shifts from price to non-price aspects (e.g. service availability, quality), we observe a nascent literature on competition in healthcare and its impact on quality performance. However, the results so far have not been consistent. For instance, Gaynor and Town ( find an association between competition and quality. In contrast, Ginzberg (1996) argues that the healthcare marketplace is different than other service industries, so that competition cannot necessarily be a driving force of quality improvement. Mukamel et al. (2001) do not find a significant association between hospital competition and risk-adjusted mortality.

While the literature on focused factory in healthcare has demonstrated consistent results on
improved quality of care, the impact of competition on quality is still not clear. Accordingly, in this essay, we explore competitive environment as a driving force of focused operations. Specifically, we test whether the focused factory approach is being used as a response to local competition. If so, it may serve to explain the increasing trend (Eastaugh, 2014) towards adoption of focused factory approach in healthcare. Using the Industrial Organization (IO) framework as the theoretical lens, we posit that a hospital’s decision to adopt focused operations is a part of its competitive response to regional competition.

The main data source for this first study is the Statewide Planning and Research Cooperative System (SPARCS) from the State of New York. We merge SPARCS inpatient discharge data with cost reports data collected by Centers for Medicare and Medicaid Services (CMS) for the time period of 2009 through 2014. Over 170 hospitals in New York State are included in the resulting data set.

The results of our longitudinal analyses show that focus in hospitals does help to improve the quality of care. Additionally, we find that competitive intensity is a strong antecedent of a hospital’s tendency to implement a focused factory concept. This essay makes several contributions to the literature. First, several focus and quality variables are tested to analyze the relationship between focus and quality in much more nuanced manner than in previous studies. Specifically, with two focus variables and three quality variables, we determine which dimension of the focused factory concept affects which specific aspect of hospital quality performance. Second, we investigate the relationship between the degree of regional hospital competition and the likelihood of implementing focused operations. The results show that competition has a significant influence on the movement toward a focused factory approach. This study serves to validate the tenets of the Industrial Organization (IO) framework. The study also provides managerial implications for augmenting the effects of focused operations on cost and quality outcomes.
The second essay explores the impact of hospital profile features on cost efficiency, and investigates specific relationships between cost efficiency and quality of care. In today’s healthcare industry, increasing expenses such as supply cost or administrative cost are subjecting hospitals to severe financial pressures (Himmelstein et al., 2014). With these internal and external pressures, hospitals are hard pressed to find ways to achieve both cost-efficiency and quality service. Despite these well-known concerns, there is, as yet, only limited research on these relationships.

Hospital operations are known to be very expensive and, typically, administrative costs alone take up a quarter of total hospital expenditures (Himmelstein et al., 2014). In addition, increasing supply and wage costs add up to make hospital operations financially challenging. In other words, hospitals need to maximize their outputs within budgets to stay cost efficient. This raises the basic question: how does a hospital provide high level of service quality while remaining cost-efficient? There are a number of studies on service quality and cost efficiency in operations management (OM) literature. Due to the growth and importance of service operations, many academic works on service quality have appeared in the literature. However, the majority of this research has focused on specific concepts and practices, and their impacts on operational performance based on narrowly defined problems, with an insufficient body of research as yet on the relationships and trade-offs between cost efficiency and service quality.

This second essay empirically addresses the following research questions: 1) How do teaching status and regional location affect the cost efficiency of hospitals? 2) What is the relationship between cost efficiency and service quality for hospitals? Is there a tradeoff? We first test if teaching affiliation and regional environment influence hospital cost efficiency, based on the data from New York State. Moreover, we examine if service quality and cost efficiency show trade-off or improve together in several conditions. To conduct the empirical analyses, Statewide Planning and Research Cooperative System (SPARCS) data is again
utilized. The dataset provides detailed admission information at the patient level for hospitals in New York State. In addition, cost data and administrative information for hospitals from was collected from Centers for Medicare & Medicaid Services (CMS). Service quality data was collected separately from New York State Health Department data archive.

This essay offers several new findings. First, it finds that teaching hospitals and urban hospitals are less cost efficient than non-teaching hospitals and rural hospitals. This finding suggests that teaching affiliation and the region in which a hospital locates do have relationship with cost efficiency. In addition, it reveals that urban-teaching hospitals may attract many patients with generally bigger size and cutting-edge technologies, but they fail to achieve cost efficiency with their operations. Second, the two-stage analyses show that it is possible to improve both cost efficiency and quality of care performance. The results also reveal that rural location without teaching affiliation appears to be the most favorable setting to improve both performances together.

The third essay provides a state-of-the-art survey of the literature on quality of care and cost efficiency of hospitals, given the fragmented nature of the studies conducted so far. Based on a critical appraisal of past literature, this essay attempts to clarify and identify the major gaps for future research. This review also integrates disparate studies in the fields of Operations Management, Economics and Medicine and suggests how future research can contribute to Healthcare Operations Management. This review concludes with how the future research in Healthcare Operations Management should be redirected to serve both researchers and practitioners.

**Keywords:** Healthcare operations, quality of care, cost efficiency, focused factory
Table of Contents

Dedication .................................................................................................................... ii
Acknowledgements ..................................................................................................... iii
Abstract ...................................................................................................................... iv
Table of Contents ...................................................................................................... ix
List of Tables and Figures ........................................................................................ xii

I. Essay One: Focused Factory and Competition in the Healthcare Industry ........... 1
   1.1 Introduction ....................................................................................................... 2
   1.2 Literature Review and Hypotheses Development ............................................ 4
       1.2.1 Focused factory ...................................................................................... 4
       1.2.2 Focused hospital ..................................................................................... 6
       1.2.3 Focus and improved quality ................................................................... 7
       1.2.4 Competition and focus ......................................................................... 8
   1.3 Data and Method ............................................................................................. 10
       1.3.1 Data source ............................................................................................ 10
       1.3.2 Quality variables .................................................................................. 11
       1.3.3 Focus variables .................................................................................... 12
       1.3.4 Control variables ................................................................................... 13
       1.3.5 Method ................................................................................................... 14
   1.4 Results and Discussion .................................................................................... 14
   1.5 Conclusion ....................................................................................................... 16
Appendix 1 ................................................................................................................ 26
II. Essay Two: Cost Efficiency and Quality in Hospitals: Bayesian Stochastic Cost Frontier Approach ................................................................. 34
   2.1 Introduction .............................................................................. 35
   2.2 Literature Review and Research Questions ............................... 37
      2.2.1 Cost Efficiency of Hospitals ............................................. 37
      2.2.2 Cost Efficiency and Quality Relationship ......................... 38
   2.3 Data and Sample ..................................................................... 40
      2.3.1 Quality variables ............................................................. 41
      2.3.2 Hospital profile and cost variables .................................... 42
   2.4 Empirical Analysis ................................................................. 42
   2.5 Discussion .............................................................................. 46
   2.6 Conclusion ............................................................................. 48
Appendix 3 ..................................................................................... 58
Appendix 4 ..................................................................................... 59
References ..................................................................................... 60

III. Essay Three: Healthcare Operations Management: A Literature Review and Directions for Future Research ...................................................... 62
   3.1 Introduction ............................................................................ 63
   3.2 Literature Review ................................................................. 63
      3.2.1 Focused operation .......................................................... 64
      3.2.2 Service quality ............................................................. 66
3.2.3 Patient safety ................................................................. 69

3.3 Conclusion and Future Research ............................................. 71

References .................................................................................. 77
List of Tables and Figures

Table 1.1 Sample hospital characteristics ............................................................... 19
Table 1.2 Definition of variables .............................................................................. 20
Table 1.3 Variable correlations .............................................................................. 21
Table 1.4 Regression results with mortality rates for selected procedures as the dependent variable ........................................................................................................ 22
Table 1.5 Regression results with mortality rates for selected conditions as the dependent variable ................................................................. 23
Table 1.6 Regression results with potentially preventable readmission rates as the dependent variable ................................................................. 24
Table 1.7 Regression results with focus variables as dependent variables ............... 25
Table 2.1 Data description ........................................................................................ 50
Table 2.2 Annual average wage rates by year ......................................................... 51
Table 2.3 First stage results ...................................................................................... 52
Table 2.4 Average cost efficiency by teaching affiliation and location .................... 53
Table 2.5 The effect of quality on cost efficiency in hospitals .................................... 54
Table 2.6 Regression results for teaching hospitals in urban area ............................ 55
Table 2.7 Regression results for non-teaching hospitals in urban area .......................... 56

Table 2.8 Regression results for non-teaching hospitals in rural area ............................ 57

Table 3.1 Description of reviewed articles ........................................................................ 74

Figure 3.1: Synthesized research framework .................................................................... 76
Essay One: Focused Factory and Competition in the Healthcare Industry

Abstract

This research empirically examines the impact of focus on quality of care for hospitals in New York State. We prepare focus variables and quality variables that portray different aspects of each concept, to investigate the relationship in depth. Additionally, drawing from the Industrial Organization framework, we explore whether regional competition drives hospitals towards focused operations. Our results show that focus in hospitals helps improving the quality of care, when the focus is on case-mix specialization. Furthermore, we find that competitive intensity is one of the drivers of focus in hospitals. Our findings provide academic contributions and managerial implications by offering a theoretical foundation and empirical evidence for the competition-focus-quality relationship and by investigating focus behavior in competitive healthcare environments.

Keywords: focus, healthcare, quality, competition, differentiation
1.1 Introduction

A wide range of quality improvement initiatives are pursued currently in hospitals by both practitioners and academics (Kc and Terwiesch). Even as healthcare providers are being forced to drive down costs, maintaining acceptable levels of quality continues to be an important challenge. In light of these objectives, the concept of ‘hospital as a focused factory’ has drawn attention in the academic healthcare management literature (Herzlinger, Huckman and Zinner, McDermott and Stock). The concept of focused factory is articulated in the seminal work of Skinner, in which it is argued that by reducing complexity, manufacturing plants can better concentrate on a smaller number of tasks and be more effective and efficient. Specifically, he argued: “The focused factory does a better job because repetition and concentration in one area allow its workforce and managers to become effective and experienced in the task required for success. The focused factory is more manageable and controllable than unfocused plants. Its problems are demanding but limited in scope”. A few studies portray the effect of the focused factory approach in healthcare environments, and they report that hospitals with more focused operations show increased operational performances (Clark and Huckman, Hyer, Wemmerlöv and Morris, Kc and Terwiesch, McDermott and Stock). Hospitals benefit from economies of scale as they focus on fewer services, but give up the advantages from economies of scope as they provide a narrower range of services.

In today's healthcare industry, hospitals increasingly have focused operations (Eastaugh, Goldberger and Nallamothu). While the focused factory concept in healthcare has been investigated in recent years, existing studies typically focus on just one or a small number of performance outcomes. In our study, we provide a more nuanced understanding of the effect of focused operations on a broad spectrum of quality variables. This allows us to test in which specific area of quality performance the focused factory approach is most effective. In addition,
while outcomes of the focused factory have received research attention, the antecedents of the focused factory approach, in particular in a healthcare environment, have been studied to a much lesser extent.

Another area that is related to hospital performance is competition. The impact of competition on hospital performance has long been a discussion in the medicine and healthcare economics literature (Ginzberg, Miller, Mukamel, Zwanziger and Tomaszewski, Porter and Teisberg, Rivers and Glover, Zwanziger and Melnick). The majority of past studies focus on the impact of competition on cost, not quality of care. As the object of competition shifts from price to non-price aspects (e.g. service availability, quality), we observe a nascent literature on competition in healthcare and its impact on quality performance. However, the results are not consistent. For instance, Gaynor and Town find an association between competition and quality. In contrast, Ginzberg (1996) argues that the healthcare marketplace is different than other service industries, so that competition cannot be a driving force of quality improvement. Mukamel et al. (2001) do not find a significant association between hospital competition and risk-adjusted mortality.

While the literature on focused factory in healthcare shares consistent results on increased quality of care, the impact of competition on quality is not clear in the literature. In this study, we explore competitive environment as a driving force of focused operations. Specifically, we test whether the focused factory approach is being used as a response to local competition. If so, it can serve to explain the increasing trend (Eastaugh, 2014) of focused factory in healthcare in recent years. In summary, in this study, we examine the relationship between hospital competition and quality performance, and the degree of influence of regional competition on a hospital’s decision to implement a focused factory concept.

Our main data source is the Statewide Planning and Research Cooperative System (SPARCS) from the State of New York. We merge SPARCS inpatient discharge data with cost
reports data collected by Centers for Medicare and Medicaid Services (CMS) for the time period of 2009 through 2014. Over 170 hospitals in New York State are included in the resulting data set.

The results of our longitudinal analyses show that focus in hospitals helps improving the quality of care. Additionally, we find that competitive intensity is a strong antecedent of a hospital’s tendency to implement a focused factory concept. Specifically, this paper makes several contributions to the literature. First, we prepare several focus and quality variables to analyze the relationship between focus and quality in a much more nuanced manner than in previous studies. Specifically, with two focus variables and three quality variables, we determine which dimension of the focused factory concept affects which specific aspect of hospital quality performance. Second, we investigate the relationship between the degree of regional hospital competition and the likelihood of implementing focused operations. While the effect of competition on hospital performance has received some research attention (Hyer, Wemmerlöv and Morris, Kc and Terwiesch, McDermott and Stock), the relationship between competition and a focused operations approach had yet to be investigated. With our results, we show that competition has significant influence on the movement toward a focused factory approach. Finally, we provide a theoretical explanation for competitive behavior of hospitals. Using the Industrial Organization (IO) framework as the theoretical lens, we claim that a hospital’s decision to have focused operations is a part of their competitive response to regional competition.

1.2 Literature Review and Hypotheses Development

1.2.1 Focused factory

The concept of focused factory is well-described in Skinner’s (1974) seminal paper. Skinner
argued that a focused factory can achieve competitive strength by focusing on the key manufacturing task which is essential to successfully compete in the market. The main point of the argument is that maintaining a small number of repetitive operations is considered a determinant of performance (Skinner, Skinner). The argument is consistent with well-known earlier work on specialization at the individual worker level (Smith, Taylor).

A number of subsequent researchers followed with empirical support for the advantages of focus, especially in manufacturing settings (Bozarth and Edwards, Brumme et al., Hayes and Wheelwright, Mukherjee et al., Vokurka and Davis). Bozarth and Edwards (1997) found evidence that a lack of focus in either the market requirements or manufacturing characteristics of a given plant is associated with poorer plant performance. Brumme et al. (2015) suggest that changes in focus can bring a strategic advantage. Hayes and Wheelwright (1984) showed a negative relationship between operating margin and the number of product lines. Mukherjee et al. (2000) examined whether production line labor productivity and conformance quality decline as the range of models and the heterogeneity of production volume increase. Their conclusion is aligned with the argument of other work stated above. Vokurka and Davis (2000) used survey data from managers of roughly 300 plants in multi-plant firms and found evidence of higher performance at focused plants.

In contrast, some researchers either questioned the effect of a focused factory approach on performance or tried to explain why large numbers of factories remain unfocused. Using plant-level data from the Census of Manufacturers, Brush and Karnani found that process focus—as measured by the absence of vertical integration—is negatively associated with labor productivity. In their analysis of 31 plants in the printed circuit board industry, Suarez et al. found that a broader product mix is not associated with decreased performance in terms of either cost or quality. Kekre and Srinivasan examined over 1,400 business units with similar results. Specifically, they found that business units with broader product lines are characterized
by larger market shares and higher profitability than more focused units. Further, they found that these benefits in overall performance do not come at the expense of higher production costs. Ketokivi and Jokinen concluded that focus is not a critical factor in firm performance, finding superior performance in both focused and unfocused plants, and argued that this may be the result of the particulars of the specific operating environments of the firms, as opposed to being driven by focus itself.

1.2.2 Focused hospital

Examinations of the effect of focus have likewise followed in the healthcare industry. McLaughlin et al. developed a framework that helps operations managers use focused strategy in service industries. The authors compared free-standing outpatient surgery centers to hospital-based surgery centers, using a large sample survey administered to physicians at both types of facilities. The respondents in this study perceived that free-standing centers perform better than hospital-based surgery centers in terms of low overhead cost and low infection rates. The researchers also found that performance differences between standalone and in-house units become diminished when the in-house units were managed more autonomously, which pointed to the importance of structural and infrastructural elements in focus. Huckman and Zinner (2008) explored the benefits of focus in the management of clinical trials. They not only investigated focus at the firm level but also at the divisional level to see if one is complementary with, or a substitute for the other. They concluded that clinical trials that were characterized by focus outperformed those without focus and that focus at the divisional level substituted for focus at the firm level. McDermott and Stock (2011) studied the effect of focus in general hospitals on cost efficiency using secondary data from New York State. They took the view of “focus as emphasis” rather than the view of “focus as narrowing” to examine the disproportionate emphasis on certain service lines.
1.2.3 Focus and improved quality

A number of studies have investigated how a focused factory approach in healthcare affects quality. With their case study on a trauma care unit, Hyer et al. (2009), studied the focus concept and its link to performance in healthcare. The authors observed no change in mortality but a slight improvement in length of stay. In terms of clinical quality, mortality was the only variable explored in the study. Kc and Terwiesch (2011) also investigated the effects of focus on performance, using cardiac patients’ data from California. Specifically, the authors analyzed the effect of focus at three different levels - firm, operating and process flow level. They found improved quality associated with increased focus at each of the three focus levels. However, the single quality measure used in this study was mortality rate. Clark and Huckman (2012) examined the relationship between hospitals’ specialization in cardiovascular care and clinical quality performance and found that focus is positively related with quality performance. Similar to Kc and Terwiesch (2011) and Hyer et al. (2009), the authors used risk-adjusted mortality rate as their only quality measurement.

We contribute to the literature on the effect of focus on quality performance in healthcare, by introducing three different measurements of quality; (1) mortality for selected procedures, (2) mortality for selected conditions and (3) potentially preventable readmission. Each of these three measurements represents a different aspect of hospital quality performance. Unlike prior focus studies, we emphasize for which aspect of quality performance the focus approach is most beneficial. Additionally, in contrast with the extant literature, our unit of analysis to test the effect of focused operations on performance is the hospital, rather than individual departments. This allows us to determine whether the strategic decision of taking a focused factory approach in certain areas of service is influential on the aggregate performance of the hospital. We formally hypothesize:
**H1A:** A hospital’s increased level of operational focus is associated with decreased mortality rates for selected procedures

**H1B:** A hospital’s increased level of operational focus is associated with decreased mortality rates for selected conditions

**H1C:** A hospital’s increased level of operational focus is associated with decreased readmission rates.

### 1.2.4 Competition and focus

We are interested in the relationship between competition and focus in healthcare, in particular competition as a potential determinant of implementing a focused factory approach. Previous studies in the health economics literature have investigated the relationship between competition and service quality (Gaynor, Gaynor and Town, Zwanziger and Melnick); between competition and pricing behavior of hospitals (Keeler et al.); and between competition and healthcare costs (Andritsos and Afraki, Kessler and McClellan, Zwanziger and Melnick). These studies in essence all investigated the impact of competition on hospital operational performance. However, none of these studies offered insights into how competition affects hospitals’ managerial decision making, with the exception of two studies. Calem and Rizzo ([suggest](#)) that hospitals compete for quality and that competition often leads to increased specialization. Using a Hotelling’s location model, the authors argued that hospitals have incentives to move toward greater specialization when competitive intensity is higher. Similarly, Liu ([claimed](#)) that hospitals choose specialization to compete with other regional hospitals under price regulation and the author concluded that competition introduces a centrifugal force in the specialization movement. While both studies above studied the relationship between competition and focus, they provide neither theoretical explanation nor empirical support. In
In this study, we hypothesize the competition-focus relationship with the theoretical lens of the IO framework and offer empirical evidence to support our argument.

Competition in healthcare is subject to several external factors, including economic and demographic trends, government regulation, and payment system (Devers et al.). Hospitals need to shape their competition strategies according to the changing environment to best leverage the resources they possess. However, what remains unchanged is that, to be competitive, hospitals tend to offer services that are desired by patients. We use the IO economics framework as a theoretical lens to apply on the matter. The IO framework was first developed by Mason and Bain (Bain) and further developed by a number of other researchers (Caves et al., Porter, Porter). The framework suggests that performance of organizations is determined by the structure of the industry in which an organization operates. The key characteristics of the industry structure that possibly affect an organization’s performance include the existence and value of barriers to entry, the existence and degree of differentiation in the industry, the number and relative size of organizations, and the elasticity of demand for the industry (Porter, 1980). The model claims that an organization should strive to set high barriers to entry, reduce the number of players in the industry, increase differentiation, or reduce demand elasticity to gain competitive performance. Among these aspects of industry structure, differentiation would be the most feasible approach for an individual organization to take as the others are hardly controllable. This raises the question what differentiation would entail for hospitals to compete in the healthcare market. The concept of the ‘focused factory’ can be seen as one of the choices for hospitals to differentiate themselves from other hospitals (Kesteloot and Voet, Luke). A hospital that offers a wide range of medical services, yet not all of them at a high quality level, may opt to focus on some and cease offering others to gain competitive advantage. On the other hand, a hospital would gain a competitive advantage by dropping medical services that are better served by its competition and by allocating more resources to
their best services (Eastaugh, Eastaugh). In sum, we argue that an increase in regional competition puts pressure on hospitals to differentiate themselves from other hospitals, leading to an increased tendency to implement a focused factory approach. Formally, we hypothesize:

**H2:** The level of competition among hospitals in the same geographic market is positively associated with the level of hospital focus

### 1.3 Data and Method

#### 1.3.1 Data source

Our dataset uses multiple secondary data sources. The main data source is the Statewide Planning and Research Cooperative System (SPARCS) from New York State Department of Health. We use SPARCS Hospital Inpatient Discharges data from 2009 through 2013. The SPARCS data is a comprehensive dataset which includes patient level detail on patient characteristics, diagnoses, services, and charges for hospitals in New York State. We obtain discharge data for calculating focus variables from this dataset. We next merge this data with CMS cost reports data for demographic information of each hospital, including number of beds, number of full-time employees, teaching affiliation, region or ownership status. We add case mix indexes provided by CMS to the dataset in order to control for weight of average diagnosis group (DRG) of each hospital. We further merge the dataset with quality of care data, released by New York State Department of Health. Table 1 describes the sample characteristics.

< Table 1 inserted here >

For calculating one of the focus measures and the competition intensity measure, we
use Hospital Referral Regions (HRR) data from Dartmouth Health Atlas (Kc and Terwiesch) for hospital market classification. HRR is defined as regional healthcare markets for tertiary medical service. According to Kilaru et al. (> patients are likely to stay within the HRR region for their medical care. Therefore, we choose HRR as our region boundary. New York State has 11 HRRs and no region has fewer than 6 hospitals.

1.3.2 Quality variables

We deploy three different quality of care variables. Risk-adjusted mortality rates have been used to measure hospital quality performance (Hyer et al. 2009; KC and Terwiesch 2011; Clark and Huckman 2012). Mostly, mortality rates from previous studies are based on discharged patients in a particular segment of the hospital (e.g., cardiology department) or certain procedure (e.g., coronary artery bypass grafting (CABG)). We adopt two different mortality rates developed by AHRQ; risk-adjusted mortality rates for selected procedures and risk-adjusted mortality rates for selected conditions. These hospital–level mortality rates are calculated as a weighted average of observed-to-expected ratios for mortality rates across multiple medical departments (See Appendices 1 and 2). With these measures, we are able to measure the effect of focus on performance with respect to procedures and conditions at the hospital level separately. The two mortality rates measure different aspects of quality performance. The mortality for selected procedures measures mortality rates for a specific set of treatments which hospitals provide, while mortality for selected conditions considers the type of illness a patient had when admitted.

The third quality variable we adopt is the Potentially Preventable Readmission rate (PPR) developed by 3M Health Information Systems. Hospital readmission rates have been widely used as an indicator of quality of care (Friedman and Basu) because hospital readmission potentially result from inadequate care such as incomplete treatment and poor
coordination of services (Goldfield et al.). However, not all readmissions are preventable even with careful treatment and inclusion of those necessary readmissions in the calculation of readmission rate may produce misleading information. PPRs are calculated with admissions that meet certain eligibility criteria to consider only preventable readmissions. Please see Goldfield, McCullough, Hughes, Tang, Eastman, Rawlins and Averill (for a detailed methodology) The rates were calculated using SPARCS data.

1.3.3 Focus variables

We measure hospital focus in two different ways. The first measure, $FOCUS_{HHI}$ is based on the Herfindahl-Hirschman Index (HHI) (Ding, Zwanziger et al.). This measure is calculated by summing the squares of discharge proportions in every major diagnostic category. Note that $p_{ij}$ is the proportion of treated patients in major diagnostic category $j$ of hospital $i$.

$$FOCUS_{HHI_i} = \sum_j (p_{ij})^2$$

Highly focused hospitals will have a value close to one (hospitals with only one major diagnostic category will have the value of one) and highly diversified hospitals will have a value close to zero.

The second focus measure is the Information Theory Index (ITI) (Eastaugh, Farley, Farley and Hogan, Lindlbauer and Schreyögg) adopted from the Information Systems literature. While this measure is similar to HHI, as both measures use the proportion of treated patients in each diagnostic category, ITI uses a baseline as a reference. This measures the extent to which hospitals are unusual or different compared to a baseline hospital. We use the New York State average as the baseline. $\theta_j>0$ represents the state’s average proportion for each major
diagnostic category \( j \)

\[
FOCUS_{JT} = \sum_j \ln\left( \frac{P_{ij}}{\theta_j} \right)
\]

The larger the value, the greater the difference from the baseline, and therefore the more focused the hospital is.

### 1.3.4 Control variables

A number of variables that may affect quality performance outcomes are controlled. Number of beds (BED) is used to control for size (Ding). We include a dummy location variable (REGION) to control for whether the hospital is located in an urban or a rural area (McDermott and Stock). Teaching affiliation (TA) and hospital control type (public or private) (CONTROL) are also controlled with dummy variables (McDermott and Stock). Ownership type (for-profit or not-for-profit) is not controlled as the number of not-for-profit hospitals is very small. We include case mix index (CMI) to control for heterogeneities in service complication for hospitals (Ding). Herfindahl-Hirschman Index (HHI), the proxy of market competition (HHI), is used as a control variable for the first part of our empirical analyses (Capkun et al.). HHI is calculated as follows:

\[
HHI = \sum \left( \frac{\text{Number of admitted patients in a hospital}}{\text{Number of admitted patients in the HSA}} \right)^2
\]

Table 2 and Table 3 describe definitions and statistics of the variables used.
1.3.5 Method

The econometric model used for the first part of the empirical analysis is presented below.

\[ Y_{it} = \alpha_0 + \beta_0 X_{it} + \beta_1 (BED_{it}) + \beta_2 (REGION_{it}) + \beta_3 (CONTROL_{it}) + \beta_4 (TA_{it}) + \beta_5 (CMI_{it}) + \beta_6 (HHI_{it}) + \mu_{it} + \varepsilon_{it} \]

where \( Y_{it} \) is the set of quality variables, \( X_{it} \) is the set of focus variables. \( \mu_{it} \) is the between-entity error and \( \varepsilon_{it} \) is the within-entity error. To choose the right model for our panel regression, we performed the Hausman test. The \( p \) value suggests that a random effects (RE) model is appropriate for our sample (\( p > .01 \)). Normality check was done using both graphical and numerical methods. Both scatterplot and Shapiro-Wilk test show that our dataset does not possess a normality issue. We also checked for possible multicollinearity issue with the variance inflation factor (VIF) test. We concluded multicollinearity is not present in our model as all VIFs are smaller than 10.

1.4 Results and Discussion

Hypothesis 1 posits that operational focus in hospitals is positively associated with quality of care. First, we test the relationship between focus and mortality rates with selected procedures (See Table 4). Model (1) shows the regression results with \( FOCUS\_HHI \) and Model (2) does with \( FOCUS\_ITI \). While both coefficients on the focus variables are negative, which indicates that an increased level of focus is associated with decreased level of mortality rates, neither of them is statistically significant (\( p > 0.10 \)). Therefore this result does not offer support for
Hypothesis 1A.

< Table 4 inserted here >

< Table 5 inserted here >

The second regression tests the effect of focus on the mortality rates for the selected conditions. The results are presented in Table 5. Both focus variables, $FOCUS_{HHI}$ and $FOCUS_{ITI}$, show negative signs and strong statistical significance. This indicates that a higher level of operational focus is associated with lower mortality rates for the selected procedures. These results support Hypothesis 1B.

< Table 6 inserted here >

Table 6 gives the results for the effect of operational focus on potentially preventable readmission rates. Both $FOCUS_{HHI}$ and $FOCUS_{ITI}$ give negative and statistically significant coefficient values. The results suggest that operational focus helps to improve preventable readmission rate. Hypothesis 1C is supported.

< Table 7 inserted here >

< Table 8 inserted here >

Next, we test the relationship between competition and focus. In Hypothesis 2 we suggested a positive relationship between hospital competition in geographic market and operational focus. Results are reported on Table 7. $HHI$ shows a negative and statistically significant
coefficient. The negative sign indicates that competitive intensity is positively associated with focus. In other words, hospitals are more likely to have focused operations in more competitive environment. While model 1 also shows a negative coefficient for HHI, the result is not statistically significant. Therefore, Hypothesis 2 is only partially supported.

The main findings of this study’s empirical test are three-fold. First, we find that focus is effective in improving mortality rates for selected conditions but not in improving mortality rates for selected conditions. In fact, several medical conditions require multiple steps of treatments and an illness can be caused by a number of different reasons. Our results indicate that operational focus is effective when its application is placed on a broader segment of medical operations (e.g. cardiology unit) than specific medical procedures.

Second, we find that operational focus in hospitals helps lowering readmission rates. Our readmission rate measurements include readmissions that are potentially preventable and that exclude medically necessary readmissions. Our results suggest that a focused operation helps reducing unnecessary readmissions thereby improving service quality provided to patients.

Finally, we find empirical support for the competition–focus relationship. Drawing from the IO framework, we hypothesized that regional competition drives hospitals to differentiate themselves through operational focus. We found a statistically significant result from one of our models to support this hypothesis.

1.5 Conclusion

This research investigates the relationship between focus and quality for hospitals in New York State. Our empirical results suggest that focused operations in hospitals have a positive effect on lowering mortality rates for selected conditions and readmission rates. However, medical
specialization emphasized focus does not seem to have a significant effect on quality. This result suggests that hospitals should focus their resources towards organizing a case-mix that best matches their specializations, rather than focusing on particular medical specialization for improving service quality provided to patients. Furthermore, we find that focused operations have a greater effect for selected conditions than procedures for improving mortality rates. Finally, we find empirical support for competition as a determinant of focus in hospitals.

This study offers several contributions to both academics and practitioners. First, with four different measurements of focus, we are able to shed light on various aspects of focus. Particularly, our findings indicate that quality performance is affected differently by a focused operation, depending on whether emphasis is placed on case-mix specialization or medical specialization. Second, we provide deliberate analyses with quality performance by using four different quality measurements. Specifically, our results reveal that focus is more effective when it is placed on a broader segment of medical operations rather than on specific procedures. This finding provides much needed nuance for hospital managers who are seeking to improve cost and quality performance through implementation of the focused factory concept. Finally, we find empirical support regarding competition as a determinant of focus in hospitals. This finding may in part explain the recent rise of specialized operations in hospitals in the United States. That is, hospitals compete with other regional hospitals and choose focused operations as their competitive edge.

Notwithstanding the contributions made to theory and practice, the limitations of this study present multiple opportunities for future research to validate and extend our work. First, this study is based on data collected for the New York hospitals. Future studies with data from different states can be done as we can reflect different characteristics of geographic regions to the study. Second, ongoing improvements in measuring quality in healthcare may benefit future research. The nature of the healthcare environment makes it challenging to
accurately measure service quality and therefore improvements in continuity or measurement accuracy can make a difference in future analyses.
Table 1.1: Sample hospital characteristics

<table>
<thead>
<tr>
<th>Hospital Characteristics</th>
<th>Number of hospitals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of control</td>
<td></td>
</tr>
<tr>
<td>Public</td>
<td>24</td>
</tr>
<tr>
<td>Private</td>
<td>131</td>
</tr>
<tr>
<td>Teaching affiliation</td>
<td></td>
</tr>
<tr>
<td>Teaching</td>
<td>87</td>
</tr>
<tr>
<td>None Teaching</td>
<td>65</td>
</tr>
<tr>
<td>Location</td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>125</td>
</tr>
<tr>
<td>Rural</td>
<td>27</td>
</tr>
</tbody>
</table>
Table 1.2 Definition of variables

<table>
<thead>
<tr>
<th>Control variables</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$BED_{it}$</td>
<td>Number of beds at each hospital</td>
</tr>
<tr>
<td>$FTE_{it}$</td>
<td>Number of full time equivalent employees at each hospital</td>
</tr>
<tr>
<td>$REGION_{it}$</td>
<td>Urban or rural location ($1=$Urban, $0=$Rural)</td>
</tr>
<tr>
<td>$CONTROL_{it}$</td>
<td>Type of control ($1=$Private, $0=$ Public)</td>
</tr>
<tr>
<td>$TA_{it}$</td>
<td>Teaching affiliation status ($1=$Teaching, $0=$None Teaching)</td>
</tr>
<tr>
<td>$CMI_{it}$</td>
<td>Case Mix Index</td>
</tr>
<tr>
<td>$HHI_{it}$</td>
<td>Competition measurement using Herfindahl-Hirschman Index</td>
</tr>
<tr>
<td>$YEAR_{it}$</td>
<td>Observation year</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Independent variables</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$FOCUS_{HHI_{it}}$</td>
<td>Focus measured using Herfindahl-Hirschman Index</td>
</tr>
<tr>
<td>$FOCUS_{ITI_{it}}$</td>
<td>Focus measured using Information Theory Index</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dependent variables</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>$MORTALITY_{A_{it}}$</td>
<td>Mortality for Selected Procedures</td>
</tr>
<tr>
<td>$MORTALITY_{B_{it}}$</td>
<td>Mortality for Selected Conditions</td>
</tr>
<tr>
<td>$PPR_{it}$</td>
<td>Inpatient Potentially Preventable Readmission (PPR) Rates</td>
</tr>
</tbody>
</table>
### Table 1.3 Variable correlations

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Sidev</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CONTROL</td>
<td>.869</td>
<td>.013</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>REGION</td>
<td>.821</td>
<td>.014</td>
<td>-.08*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>TA</td>
<td>.570</td>
<td>.019</td>
<td>-.20**</td>
<td>.44**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>BED</td>
<td>276.79</td>
<td>9.845</td>
<td>-.14**</td>
<td>.50**</td>
<td>.65**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>FTE</td>
<td>2214.94</td>
<td>99.915</td>
<td>-.18**</td>
<td>.46**</td>
<td>.71**</td>
<td>.92**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>CMI</td>
<td>1.399</td>
<td>.009</td>
<td>-.06</td>
<td>.43**</td>
<td>.59**</td>
<td>.73**</td>
<td>.74**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>HHI</td>
<td>.111</td>
<td>.003</td>
<td>-.04</td>
<td>-.21**</td>
<td>-.12**</td>
<td>-.11**</td>
<td>-.16**</td>
<td>-.05</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>FOCUS_HHI</td>
<td>.111</td>
<td>.003</td>
<td>.27**</td>
<td>-.15**</td>
<td>-.23**</td>
<td>-.37**</td>
<td>-.41**</td>
<td>-.19**</td>
<td>.09*</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>FOCUS_ITI</td>
<td>.246</td>
<td>.016</td>
<td>.06</td>
<td>-.10**</td>
<td>-.16**</td>
<td>-.41**</td>
<td>-.42**</td>
<td>-.21**</td>
<td>.07*</td>
<td>.69**</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>MORTALITY_A</td>
<td>.992</td>
<td>.003</td>
<td>-.08*</td>
<td>.02</td>
<td>.00</td>
<td>-.01</td>
<td>-.02</td>
<td>-.09*</td>
<td>.10**</td>
<td>-.08*</td>
<td>.04</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>MORTALITY_B</td>
<td>1.145</td>
<td>.008</td>
<td>.07</td>
<td>.04</td>
<td>-.00</td>
<td>-.03</td>
<td>-.07*</td>
<td>-.06</td>
<td>.04</td>
<td>.00</td>
<td>-.05</td>
<td>.15**</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>PPR</td>
<td>7.649</td>
<td>.045</td>
<td>-.05</td>
<td>.06</td>
<td>.09*</td>
<td>.07*</td>
<td>.05</td>
<td>-.05</td>
<td>-.12**</td>
<td>.10**</td>
<td>-.05</td>
<td>.12**</td>
<td>.14**</td>
</tr>
</tbody>
</table>

*p < 0.05; **p < 0.01
Table 1.4 Regression results with mortality rates for selected procedures as the dependent variable

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>Model (1)</th>
<th>Model (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.027*** (.019)</td>
<td>1.029*** (.019)</td>
</tr>
<tr>
<td>BED</td>
<td>-.001 (.001)</td>
<td>-.001 (.001)</td>
</tr>
<tr>
<td>CONTROL</td>
<td>-.001 (.008)</td>
<td>-.001 (.008)</td>
</tr>
<tr>
<td>REGION</td>
<td>.012 (.009)</td>
<td>.013 (.009)</td>
</tr>
<tr>
<td>TA</td>
<td>.008 (.008)</td>
<td>.009 (.008)</td>
</tr>
<tr>
<td>CMI</td>
<td>-.034** (.015)</td>
<td>-.038** (.015)</td>
</tr>
<tr>
<td>HHI</td>
<td>.071** (.0297)</td>
<td>.071** (.029)</td>
</tr>
<tr>
<td>YEAR</td>
<td>Included</td>
<td>Included</td>
</tr>
<tr>
<td>FOCUS_HHI</td>
<td>-.035 (.025)</td>
<td></td>
</tr>
<tr>
<td>FOCUS_ITI</td>
<td></td>
<td>-.006 (.005)</td>
</tr>
</tbody>
</table>

\[ R^2 \]

*     p < .10
**    p < .05
***   p < .01

22
Table 1.5 Regression results with mortality rates for selected conditions as the dependent variable

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>Model (1)</th>
<th>Model (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>1.178*** (.062)</td>
<td>1.189*** (.062)</td>
</tr>
<tr>
<td>BED</td>
<td>-.001 (.001)</td>
<td>-.001 (.001)</td>
</tr>
<tr>
<td>CONTROL</td>
<td>.055** (.026)</td>
<td>.057** (.028)</td>
</tr>
<tr>
<td>REGION</td>
<td>.033 (.028)</td>
<td>.037 (.028)</td>
</tr>
<tr>
<td>TA</td>
<td>.019 (.025)</td>
<td>.022 (.024)</td>
</tr>
<tr>
<td>CMI</td>
<td>-.093 (.048)</td>
<td>-.11** (.047)</td>
</tr>
<tr>
<td>HHI</td>
<td>.302*** (.09)</td>
<td>.298*** (.089)</td>
</tr>
<tr>
<td>YEAR</td>
<td>Included</td>
<td>Included</td>
</tr>
<tr>
<td>FOCUS_HHI</td>
<td>-.192** (.078)</td>
<td></td>
</tr>
<tr>
<td>FOCUS_ITI</td>
<td>.046</td>
<td>-.055*** (.018)</td>
</tr>
<tr>
<td>$R^2$</td>
<td></td>
<td>.052</td>
</tr>
</tbody>
</table>

* p < .10  
** p < .05  
*** p < .01
### Table 1.6 Regression results with potentially preventable readmission rates as the dependent variable

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>Model (1)</th>
<th>Model (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>8.513*** (.337)</td>
<td>8.641*** (.336)</td>
</tr>
<tr>
<td>BED</td>
<td>-.001 (.001)</td>
<td>-.001 (.001)</td>
</tr>
<tr>
<td>CONTROL</td>
<td>.004 (.149)</td>
<td>.024 (.149)</td>
</tr>
<tr>
<td>REGION</td>
<td>.186 (.148)</td>
<td>.221 (.148)</td>
</tr>
<tr>
<td>TA</td>
<td>.245* (.130)</td>
<td>.293** (.129)</td>
</tr>
<tr>
<td>CMI</td>
<td>-.620 (.267)</td>
<td>-.851*** (.261)</td>
</tr>
<tr>
<td>HHI</td>
<td>-.471 (.551)</td>
<td>-.501 (.549)</td>
</tr>
<tr>
<td>YEAR</td>
<td>Included</td>
<td>Included</td>
</tr>
<tr>
<td>FOCUS_HHI</td>
<td>-2.355*** (.440)</td>
<td></td>
</tr>
<tr>
<td>FOCUS_ITI</td>
<td></td>
<td>-.581*** (.101)</td>
</tr>
<tr>
<td>$R^2$</td>
<td>.064</td>
<td>.070</td>
</tr>
</tbody>
</table>

* p < .10  
** p < .05  
*** p < .01
### Table 1.7 Regression results with focus variables as dependent variables

<table>
<thead>
<tr>
<th>Coefficients</th>
<th>Model (1)</th>
<th>Model (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-.019 (.030)</td>
<td>.174 (.129)</td>
</tr>
<tr>
<td>BED</td>
<td>-.001*** (.001)</td>
<td>-.001*** (.001)</td>
</tr>
<tr>
<td>CONTROL</td>
<td>.030* (.013)</td>
<td>.142** (.056)</td>
</tr>
<tr>
<td>REGION</td>
<td>.026* (.013)</td>
<td>.167*** (.057)</td>
</tr>
<tr>
<td>TA</td>
<td>-.025** (.011)</td>
<td>-.024 (.049)</td>
</tr>
<tr>
<td>CMI</td>
<td>.107*** (.023)</td>
<td>.020 (.099)</td>
</tr>
<tr>
<td>YEAR</td>
<td>Included</td>
<td>Included</td>
</tr>
<tr>
<td>HHI</td>
<td>-.082 (.051)</td>
<td>-.380* (.219)</td>
</tr>
</tbody>
</table>

\[ R^2 \]

*  p < .10  
**  p < .05  
***  p < .01  

Model (1): FOCUS_HHI as DV  
Model (2): FOCUS_ITI as DV
Appendix 1. IQI90: Mortality for Selected Procedures

Mortality for selected procedures is calculated as the weighted average of the observed-to-expected ratios for the following components:

- Esophageal Resection Mortality Rate
- Pancreatic Resection Mortality Rate
- Abdominal Aortic Aneurism (AAA) Repair Mortality Rate
- Coronary Artery Bypass Graft (CABG) Mortality Rate
- Craniotomy Mortality Rate
- Hip Replacement Mortality Rate
- Percutaneous Coronary Intervention (PCI) Mortality Rate
- Carotid Endarterectomy Mortality Rate
Appendix 2. IQI91: Mortality for Selected Conditions

Mortality for selected conditions is calculated as the weighted average of the observed-to-expected ratios for the following components:

- Acute Myocardial Infarction (AMI) Mortality Rate
- Heart Failure Mortality Rate
- Acute Stroke Mortality Rate
- Gastrointestinal Hemorrhage Mortality Rate
- Hip Fracture Mortality Rate
- Pneumonia Mortality Rate
References


D.X. Ding. 2014. The effect of experience, ownership and focus on productive efficiency: A longitudinal


31
*Journal of medical systems.* 32(3) 193-199.


D.H. Taylor Jr, Whellan, D.J., Sloan, F.A. 1999. Effects of admission to a teaching hospital on the cost and


Essay Two: Cost Efficiency and Quality in Hospitals:

Bayesian Stochastic Cost Frontier Approach

Abstract
The second essay explores the impact of hospital profile features on cost efficiency and investigates specific relationships between cost efficiency and quality of care. It empirically addresses the following research questions: 1) What is the relationship between cost efficiency and service quality for hospitals? Is there a trade-off? 2) What factors influence the cost efficiency–service quality relationship? We first test whether teaching affiliation and regional environment influence hospital cost efficiency, based on the data from New York State. Moreover, we examine if service quality and cost efficiency show a trade-off or improvement together under several conditions. This essay offers numerous new findings. First, it finds that teaching and urban hospitals are less cost efficient than nonteaching and rural hospitals. This suggests that teaching affiliation and the region in which a hospital locates have a relationship with cost efficiency. In addition, it reveals that urban teaching hospitals may attract patients with their generally bigger size and cutting-edge technologies, but they fail to achieve operational cost efficiency. Second, the two-stage analyses show that it is possible to improve both cost efficiency and quality of care performance and it is dependent to hospital location and teaching affiliation. The results reveal that rural location without teaching affiliation appears to be the most favorable setting to improve both performances together.
Keywords: cost efficiency, quality of care, hospital profile,

2.1 Introduction

Today, increasing expenses, such as supply and administrative costs, are putting hospitals under financial pressure. Faced with competitive pressure, hospitals are unable to compromise the quality of patient care. With these pressures, hospitals seek to maintain both high level of cost efficiency and quality of care. Cost efficiency is achieved when a hospital produces the maximum amount of output from a given amount of cost input (Hollingsworth). Therefore, hospitals need to minimize unnecessary expenditure and optimally utilize resources to gain cost efficiency and provide satisfactory service to patients. Although we find studies on quality and cost efficiency of hospitals separately in the literature, there is limited research on the cost efficiency–quality of service relationship.

Running a hospital is costly. Typically, administrative costs consume a quarter of total hospital expenditures (Himmelstein et al., 2014). Increasing supply and wage costs add up to put the operations under financial pressure. However, many costs are not controllable; therefore, hospitals need to be cost efficient. In other words, hospitals need to minimize their operating cost with given necessary expenditures to stay cost efficient. How does a hospital provide a high level of service while remaining cost efficient?

There are numerous studies on service quality and cost efficiency in the operations management literature. As the importance of service operations has become more prominent, many academic works on service quality have appeared in the literature. However, most research has focused on each concept alone as the subject of operational performance improvement. Research needs to explore the relationship between cost efficiency and service quality.
In this study, we report results from an empirical investigation of the following questions: 
1) How do teaching status and regional location affect hospital cost efficiency?  
2) What is the relationship between hospital cost efficiency and service quality? Is there a trade-off?  
Moreover, we examined whether service quality and cost efficiency showed a trade-off or improvement together under several conditions.

To conduct our empirical analyses, we used Statewide Planning and Research Cooperative System (SPARCS) data. The data set provides detailed admission information at the patient level for hospitals in New York State. We also collected cost data and administrative information for hospitals from the Centers for Medicare & Medicaid Services (CMS). Service quality data was collected from the New York State Health Department data archive.

This essay offers several new findings. First, teaching and urban hospitals are less cost efficient than nonteaching and rural hospitals. This finding suggests that teaching affiliation and hospital location are related to cost efficiency. In addition, it reveals that urban teaching hospitals may attract patients because of their larger size and cutting-edge technologies, but they fail to achieve high cost efficiency within their operations. Second, the two-stage analyses show that it is possible to improve both cost efficiency and quality of care performance and it is contingent to hospital location and teaching affiliation. The results show that rural location without teaching affiliation appears to be the most favorable setting to improve both performances together.

The remainder of this paper is organized as follows: In the second section, we present the literature review and research questions. In the third section, we describe the data sources, variables employed, and the empirical design we used. In the fourth section, we report the results, and in the fifth, we provide discussion and implications from our findings. Finally, we conclude our study in the sixth section.
2.2 Literature Review and Research Questions

This section reviews the literature related to our research topic and shows how we develop our research questions. First, we reviewed studies on hospital cost efficiency; specifically, we examined what factors were considered and included in the analyses. Teaching affiliation and hospital location are used as hospital profile features. Second, we explored the cost efficiency and quality performance relationship studied in the past. This part of the review is focused on what the relationship looks like and what strengthens or mitigates the relationship.

2.2.1 Cost Efficiency of Hospitals

Hospital cost efficiency is influenced by several different factors such as organizational structure and government regulations. Accordingly, much of the literature has considered both external and internal factors. Rosko (claimed that external pressures and hospital cost inefficiency are correlated. The study showed that penetration of health maintenance organizations (HMOs) puts downward pressure on hospital cost inefficiency. However, increases in inefficiency were found with for-profit ownership status and Medicare share of admissions. Similarly, Li and Rosenman (asserted that hospitals with for-profit status and a higher proportion of Medicare patient days are more profitable. Results from Tiemann and Schreyögg (were slightly different. They found that public hospitals are more efficient than private nonprofit hospitals or for-profit hospitals, which are particularly associated with lower efficiency. Nevertheless, their assertion was weighted more on the finding that public hospitals show better efficiency performance than either form of private hospital. Regarding public hospitals versus private hospitals on cost efficiency, the results from the literature are mixed (Tiemann et al.). In contrast to the general belief that private hospitals are
more cost efficient because of the profit incentive, a number of studies have found that private ownership is not necessarily related with profitability (Tiemann and Schreyögg, Tiemann, Schreyögg and Busse). In addition to these factors, several other hospital characteristics, such as case-mix indices, location, and number of beds, have been studied (Carey, Li and Rosenman). However, results have not been in line with previous studies or are insufficient in number to reach consensus. This can be explained in several ways. First, the health-care industry and its administration are heavily influenced by government policy and relevant laws. Therefore, findings are sensitive to the source of data and its collection period. There are many studies that have used data from different countries or states in different periods, making it hard to generalize the findings. Second, findings from the literature are based on specific types of hospitals. For example, one study’s sample may consist of teaching hospitals in urban area and another may consist of only rural hospitals. Findings from analyses with a specific group of hospitals is only valid to the particular group and may not be generalized to other groups of hospitals.

2.2.2 Cost Efficiency and Quality Relationship

Hospitals provide health-care services to patients and get paid for the delivered services. Similar to other service industries, hospitals have operational costs. Accordingly, regardless of ownership status (e.g., for-profit or not-for-profit), cost management is important for financial health, and it is a big part of hospital management. Another important part of hospital management is quality control. In today’s health-care market, patients have access to a great quantity of information on service quality, especially from the Internet. Patients often choose the best hospital in the needed specialty. Therefore, providing high-quality service to patients is necessary for hospital survival in a competitive market. Successful management of both cost and
quality is essential.

Many academic works have addressed the importance of cost and quality management. Within the body of literature, a number of attempts have been made to determine the relationship between hospital cost and quality (Hvenegaard et al., Jha et al., Morey et al., Schreyögg and Stargardt, Venkataraman). Most studies have concluded that there is a trade-off between cost and quality. However, we want to look at cost efficiency rather than cost itself. Cost efficiency is simply defined as output, such as the number of discharges or the number of inpatient days, over cost input including capital and labor costs (Hollingsworth). Cost efficiency delivers more practical information than just cost. Cost efficiency shows the ability to produce certain amounts of service output with the given resources, whereas cost just indicates an amount of expenditures. In this research, we explore the paths where a hospital provides quality service while still staying cost efficient.

There is little prior research that investigated the cost efficiency-quality relationship. Nayar and Ozcan (examined the relationship between technical efficiency and quality performance using data envelopment analysis (DEA). They found that technically efficient hospitals also show good quality performance. The study by Nayar and Ozcan is different from our work in the first half of the equation; they took technical efficiency, which includes a broader range of inputs, for their analyses, where our focus is specifically directed at cost efficiency. Ferrier and Valdmanis (investigated efficiency performance of rural hospitals and its correlates. Their analyses showed that technical efficiency is positively related with quality, and allocative efficiency is negatively related with quality. Both technical and allocative efficiency are components of cost efficiency, according to the variable definition. Ferrier and Valdmanis interpreted these results by concluding that improving quality care requires many resources, but
the wrong mix of resources could drive down the quality performance. Although this research has similarities with ours, its sample was limited to rural hospitals, and the data is two decades old. Our sample includes both teaching and non-teaching hospitals in urban and rural areas to incorporate multiple groups of hospitals in the analysis. Based on the previous argument, we present our research questions here:

**RQ1**: What is the relationship between hospital cost efficiency and service quality? Is there a trade-off?

**RQ2**: What factors influence the cost efficiency–service quality relationship?

### 2.3 Data and Sample

Our data set uses multiple secondary data sources. The main data source is Statewide Planning and Research Cooperative System (SPARCS) from the New York State Department of Health. We use SPARCS hospital inpatient discharge data from 2009 through 2013. The SPARCS data is a comprehensive data set that includes patient-level detail on patient characteristics, diagnoses, services, and charges for New York State hospitals. We obtained from this data set the numbers of discharges and inpatient days. We merged this data with CMS cost report data for items such as operating cost, capital cost, wage cost, and demographic information for each hospital. We also merged the data set with quality of care data released by the New York State Department of Health. Table 2.1 describes the sample characteristics.

<Table 2.1 inserted here>
2.3.1 Quality variables

We deployed two different quality of care variables. Risk-adjusted mortality rates have been used to measure hospital quality performance (Clark & Huckman, 2012; Hyer et al., 2009; KC & Terwiesch, 2011). In general, mortality rates from previous studies have been based on discharged patients in a hospital segment (e.g., cardiology department) or from a certain procedure (e.g., coronary artery bypass grafting). We adopted two mortality rates developed by the Agency for Healthcare Research and Quality (AHRQ): risk-adjusted mortality rates for selected procedures and risk-adjusted mortality rates for selected conditions. These hospital-level mortality rates are composite measures and calculated as a weighted average of observed-to-expected ratios for mortality rates across multiple medical departments (see Appendices 3 and 4). The weighted average is based on the relative frequency of each component. With these measures, we can evaluate the relationship between cost efficiency and quality with respect to procedures and conditions at the hospital level separately.

The two mortality rates measured different aspects of quality performance. Mortality for selected procedures measured rates for a specific set of hospital-provided treatments provided by hospitals in the sample, whereas mortality for selected conditions considered the type of illness a patient had when admitted. Also, according to Ledneva, Sun, and Conroy (2015), the statewide value of mortality for selected procedures was lower than the national value, whereas mortality for selected conditions was higher during the same 5-year period we used for this study. We included both measures in our analyses to see if the different settings for the two measurements brought any impact to the results. Finally, as the measures contain information from multiple treatments and patient conditions, this method can better represent performance than can individual indicators, therefore making it easier to detect differences in quality.
2.3.2 Hospital profile and cost variables

We included a dummy location variable (UR) to control for whether the hospital was located in an urban or a rural area (McDermott and Stock). Teaching affiliation (TA) was also controlled with dummy variables (McDermott and Stock). Numbers of discharges and inpatient days were used to calculate the average cost efficiency.

2.4 Empirical Analysis

The objective of the analysis was twofold: 1) to find out whether cost efficiency and quality performance have a trade-off relationship or can be improved together, and 2) to investigate how different hospital profile features affect the cost efficiency – quality relationship. Therefore, the empirical analyses were two-staged. In the first step, we used a trans-log cost function with Bayesian cost frontier approach. The cost function is presented here:

\[
\ln OC = \beta_C + \sum_{i=1} \beta_i \ln P_i + \sum_{i=1} \gamma_i \ln Y_i + \frac{1}{2} \sum_{i=1} \sum_{j=1} \beta_{ij} \ln P_i \ln P_j + \frac{1}{2} \sum_{i=1} \sum_{j=1} \gamma_{ij} \ln Y_i \ln Y_j + \sum_{i=1} \sum_{j=1} \delta_{ij} \ln P_i \ln Y_j
\]

\[+ \delta_T T + \delta_{DU} dum_{UR} + \delta_{DTA} dum_{TA} + \nu_{it} + \mu_{it}\]

where \(\beta_C\) is constant, \(P_i = (WR, CP)\), and \(Y_i = (D, ID)\); and WR and CP are wage price and capital price, respectively. D and ID are the numbers of discharges and inpatient days. T is the time variable, and \(dum_{UR}\) and \(dum_{TA}\) are dummy variables for hospital region (urban or rural area) and teaching affiliation, respectively. Finally, \(\nu_{it}\) is an error term, and \(\mu_{it}\) is cost inefficiency.
Annual average wage (total wage cost divided by number of employees on payroll) was used for wage price. For the capital price, we used the 3-month treasury bill data and depreciation rate of medical equipment and instruments over the period of 2009 to 2013 obtained from the Bureau of Economic Analysis (BEA). The 3-month treasury bill rate was used for the capital opportunity cost, and BEA rates of depreciation were used for the depreciation rate. Then we added these to generate the total capital cost rate for each year. The calculated rates for the 5-year period are presented in Table 2.2.

< Table 2.2 is inserted here >

The proxy of capital price used for the first-stage analysis was obtained by the following process. First, we multiplied the total capital cost rate by the total capital expenditure of each hospital, then divided it by the number of hospital beds. Price of labor was approximated by the average annual salary of full-time-equivalent employees. We followed Rosko ( for the employment of both capital price and labor price.

For the first-stage analysis, we took the Bayesian approach with diffuse prior. We followed Zellner ( in undertaking t-statistics for testing the significance of regressors. The choice of prior for the inefficiency term was exponential distribution. The Gibbs sampling approach was used for the estimation, and the simulation number was 30,000. The results are reported in Table 2.3.

< Table 2.3 is inserted here >

As expected, we found positive, significant coefficient values from wage and capital prices. This intuitively indicates that operating costs increase as wage and capital prices increase. Additionally, we found negative, significant coefficient values from the teaching dummy and urban dummy. This tells us that teaching affiliation and urban location have a
negative impact on operating cost. This is an expected result, considering requirements such as
new technologies or additional human resources for teaching affiliation and expenses associated
with urban location. To investigate this further, we compared the average cost efficiency (ACE)
of each combination with teaching affiliation and hospital location to find out which of the two
factors shows the stronger impact on cost efficiency. We first calculated ACE with the whole
sample:

$$ACE = \frac{\sum_{i=1}^{\text{Exp}} \sum_{t=1}^{d} \text{Exp}(-\mu_{it})}{d}$$

Then we calculated the ACE for each of the four groups segregated with two
memberships: teaching affiliation and location. Table 2.4 reports the results.

With the two-by-two categorization, it is clear that teaching affiliation is negatively
associated with cost efficiency. For both urban and rural locations, nonteaching hospitals show
greater cost efficiency than teaching hospitals. However, the impact of location is not as strong
as location. Teaching hospitals in urban areas show greater cost efficiency than those in rural
areas, whereas nonteaching hospitals in rural areas show greater cost efficiency than those in
urban areas. Finally, nonteaching hospitals in rural areas show the greatest cost efficiency
among all groups.

The second-stage analysis was implemented to investigate the relationship between cost
efficiency and quality of care. Specifically, we wished to answer the questions of what the
relationship looks like and what variables drive the relationship in which direction. A Bayesian
regression approach was taken, and the equation used is presented here:

$$\ln CE = \beta_C + \beta_0IQI90 + \beta_1IQI91 + \beta_2dum_{UR} + \beta_3dum_{TA} + \beta_4 \ln(B) + \delta \tau + \nu_{it}$$

where \(CE = \text{cost efficiency, IQI90 is mortality rates for selected procedures, and IQI91 is}
mortality rates for selected conditions. Dummy variables for teaching affiliation and location were included as independent variables. As in the first-stage analysis, the prior choice was diffuse prior. The Gibbs sampling approach was used for the estimation, and the simulation number was 30,000.

< Table 2.5 is inserted here >

As the results show in Table 2.5, we did not find a significant relationship between cost efficiency and quality. Whereas the dummy variables showed negative, significant coefficient values, consistent with the first-stage results, the quality variables did not significantly impact cost efficiency. This may suggest that the hospital profile features of teaching affiliation and location may affect the cost efficiency–quality relationship. We sub-grouped the hospitals by teaching affiliation and location to see if we could find any significant cost efficiency–quality relationship. Among the four possible combinations, the group with teaching affiliation and rural location was excluded from the analysis due to small sample size (n = 3). Therefore, we considered the remaining three groups: 1) teaching hospitals in urban areas, 2) nonteaching hospitals in urban areas, and 3) nonteaching hospitals in rural areas. For this subgroup analysis, we used the following equation:

\[
\ln CE = \beta_c + \beta_0 IQI90 + \beta_1 IQI91 + \beta_B \ln(B) + \delta_T + \nu_{it}
\]

The Gibbs sampling approach was used for the estimation, and the simulation number was 30,000. The analysis results for the first group, teaching hospitals in urban areas, are presented in Table 2.6.

< Table 2.6 is inserted here >

We did not find statistically significant results for coefficients on both quality variables. Therefore, there is no significant relationship between cost efficiency and quality in this group.
Table 2.7 reports the results for the next group.

<Table 2.7 is inserted here >

Considering nonteaching hospitals in urban areas, we found a significant relationship with one of the quality variables: mortality rates for the selected conditions. This tells us that in this group of hospitals, cost efficiency is negatively associated with quality because a higher mortality rate means worse safety and therefore lower quality. Finally, Table 2.8 shows the results for nonteaching hospitals in rural areas.

< Table 2.8 is inserted here >

We found a statistically significant and negative coefficient value on one of the quality variables: mortality rate for the selected conditions. It indicates that quality of care is positively related with cost efficiency as the lower mortality rate means the higher quality. In other words, nonteaching hospitals in rural areas are best suited for improving cost efficiency and quality of care at the same time.

2.5 Discussion

Our results contribute to the literature with several findings. First, the first-stage results revealed that teaching affiliation and urban location are negatively related with cost efficiency. It is intuitive that teaching affiliation and urban location would cost more, considering the costs associated with teaching activities and maintaining facilities in urban areas. Specifically, teaching hospitals provide the means for medical education to students, interns, and residents, and the teaching activities require more resources, such as the latest technologies or human resources dedicated to education. Operating a hospital in an urban area is more expensive compared to one in a rural area due to higher spending on real estate and wages. Moreover, with
the ACE two-by-two analysis, we found that teaching affiliation is negatively associated with cost efficiency as well. Operating a teaching hospital is more expensive than a nonteaching hospital even after the adjustment for input cost items (capital and wages).

Second, we found that nonteaching affiliation with location in a rural area is the best setting to improve cost efficiency and quality together. The sub-analysis in the second stage showed that cost efficiency and mortality rates for selected conditions can be improved together in rural hospitals without teaching affiliation. In fact, 90% of rural hospitals in our sample were nonteaching hospitals; therefore, most rural hospitals in New York State are in a more favorable position to manage quality and efficiency at the same time. This finding brings significant contribution to the literature since majority of previous studies focused on effect of teaching mission or location on either of quality performance or cost. For example, Taylor Jr et al. (concluded that teaching affiliation is associated with better patient conditions and Theokary and Ren (2011) claimed that teaching intensity of a hospital influences the relationship between patient volume and process quality. Our results are different from previous findings since it finds the favorable teaching mission status and location to strengthen cost efficiency – quality relationship.

On the other hand, our results indicate that teaching hospitals in urban locations are not performing well in terms of cost efficiency. In general, teaching hospitals are in urban environments because it better serves the purpose of being a teaching institute. In our sample, only three out of 85 teaching hospitals were in a rural area. Therefore, it addresses the cost inefficiency issue of teaching affiliation. This can be explained by a few reasons. First, teaching affiliation entails costs. There are particular incremental costs, such as equipment or training costs, associated with the infrastructure and human resources needed to support teaching and research
activities that academic medical centers are supposed to perform. In addition, declining clinical reimbursements and government support for graduate medical education put downward pressure on the financial health of teaching hospitals (Rich et al.). Moreover, cost efficiency of insurance companies, medical supply providers, consultants, and pharmaceutical companies drive up hospital costs but do not help on the revenue side. It is clear that teaching hospitals need to create new revenue channels, cut costs, and find better use of resources to improve operational cost efficiency.

6. Conclusion

This essay examined the relationship between cost efficiency and quality of U.S. hospitals and further investigated what factors impact the relationship. Our results indicate that teaching affiliation is negatively associated with hospital cost efficiency. In addition, we find that rural location and absence of teaching affiliation are the favorable profile features for hospitals to improve cost efficiency and quality together.

While this essay offers a number of interesting findings, there are a few limitations. First, our analysis is based on a New York State sample. Although the state of New York houses a large number of hospitals with different characteristics, it is hard to generalize our findings to the nationwide level. Therefore, future researchers might analyze data from a different state, multiple states, or nationwide to test if our findings can be validated. Second, the limitations in data prevented us from incorporating more differences in cost efficiency and quality. Quality and cost variables with more diverse characteristics, such as patient satisfaction during care or detailed cost items associated with teaching affiliation or location,
would make the analysis more robust. Thus, as more data become available, additional research can be authored to provide new contributions on this topic.
## 2.1: Data description

<table>
<thead>
<tr>
<th>Hospital profile</th>
<th>Number of hospitals</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Teaching affiliation</strong></td>
<td></td>
</tr>
<tr>
<td>Teaching hospitals</td>
<td>85</td>
</tr>
<tr>
<td>Non-teaching hospitals</td>
<td>75</td>
</tr>
<tr>
<td><strong>Hospital location</strong></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>130</td>
</tr>
<tr>
<td>Rural</td>
<td>30</td>
</tr>
<tr>
<td><strong>Avg. number of beds</strong></td>
<td>250</td>
</tr>
<tr>
<td><strong>Avg. full-time equivalent employees</strong></td>
<td>1961</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>160</td>
</tr>
</tbody>
</table>
**Table 2.2: Annual Average Wage Rates by Year**

<table>
<thead>
<tr>
<th>Year</th>
<th>Rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>0.2992</td>
</tr>
<tr>
<td>2010</td>
<td>0.2892</td>
</tr>
<tr>
<td>2011</td>
<td>0.1892</td>
</tr>
<tr>
<td>2012</td>
<td>0.2092</td>
</tr>
<tr>
<td>2013</td>
<td>0.2292</td>
</tr>
</tbody>
</table>
Table 2.3: First stage results

<table>
<thead>
<tr>
<th></th>
<th>Means (beta)</th>
<th>Std. Dev.</th>
<th>NSE</th>
<th>T-statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-9.0189**</td>
<td>3.2865</td>
<td>0.0208</td>
<td>-2.5600</td>
</tr>
<tr>
<td>ln(WR)</td>
<td>1.7459***</td>
<td>0.6203</td>
<td>0.0039</td>
<td>2.6155</td>
</tr>
<tr>
<td>ln(CP)</td>
<td>0.8655*</td>
<td>0.5646</td>
<td>0.0036</td>
<td>1.4786</td>
</tr>
<tr>
<td>ln(D)</td>
<td>6.0252***</td>
<td>1.3973</td>
<td>0.0088</td>
<td>4.0669</td>
</tr>
<tr>
<td>ln(ID)</td>
<td>-4.0336***</td>
<td>1.1695</td>
<td>0.0074</td>
<td>-3.2658</td>
</tr>
<tr>
<td>0.5*ln(WR)ln(WR)</td>
<td>0.0168</td>
<td>0.0548</td>
<td>0.0003</td>
<td>0.2854</td>
</tr>
<tr>
<td>0.5*ln(WR)ln(CP)</td>
<td>-0.3020*</td>
<td>0.1802</td>
<td>0.0011</td>
<td>-1.6360</td>
</tr>
<tr>
<td>0.5*ln(CP)ln(CP)</td>
<td>0.0851***</td>
<td>0.031</td>
<td>0.0002</td>
<td>2.5898</td>
</tr>
<tr>
<td>0.5*ln(D)ln(D)</td>
<td>-0.5043*</td>
<td>0.275</td>
<td>0.0017</td>
<td>-1.7245</td>
</tr>
<tr>
<td>0.5*ln(D)ln(ID)</td>
<td>1.4101**</td>
<td>0.5187</td>
<td>0.0033</td>
<td>2.5511</td>
</tr>
<tr>
<td>0.5*ln(ID)ln(ID)</td>
<td>-0.7888***</td>
<td>0.2863</td>
<td>0.0018</td>
<td>-2.5709</td>
</tr>
<tr>
<td>ln(WR)ln(D)</td>
<td>-0.7672***</td>
<td>0.1913</td>
<td>0.0012</td>
<td>-3.7906</td>
</tr>
<tr>
<td>ln(WR)ln(ID)</td>
<td>0.6349***</td>
<td>0.1485</td>
<td>0.0009</td>
<td>4.1025</td>
</tr>
<tr>
<td>ln(CP)ln(D)</td>
<td>-0.4995***</td>
<td>0.1416</td>
<td>0.0009</td>
<td>-3.2716</td>
</tr>
<tr>
<td>ln(CP)ln(ID)</td>
<td>0.3605***</td>
<td>0.1232</td>
<td>0.0008</td>
<td>2.7118</td>
</tr>
<tr>
<td>Time variables</td>
<td>-0.0036</td>
<td>0.0101</td>
<td>0.0001</td>
<td>-0.3334</td>
</tr>
<tr>
<td>urban dummy</td>
<td>-0.0996**</td>
<td>0.0436</td>
<td>0.0003</td>
<td>-2.1127</td>
</tr>
<tr>
<td>teaching dummy</td>
<td>-0.3039***</td>
<td>0.0414</td>
<td>0.0003</td>
<td>-7.0091</td>
</tr>
<tr>
<td>h (error precision)</td>
<td>7.5691</td>
<td>0.4488</td>
<td>0.0028</td>
<td></td>
</tr>
</tbody>
</table>

BIC 0.3673  
R 0.7287

***significant at P>0.01
** significant at P>0.05
*significant at P>0.10
### Table 2.4: Average Cost Efficiency by Teaching Affiliation and Location

<table>
<thead>
<tr>
<th></th>
<th>Rural location</th>
<th>Urban location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-teaching affiliation</td>
<td>0.8676 (27)</td>
<td>0.8649 (48)</td>
</tr>
<tr>
<td>Teaching affiliation</td>
<td>0.8403 (3)</td>
<td>0.8586 (82)</td>
</tr>
</tbody>
</table>

*Number of hospitals in parenthesis*
Table 2.5: The effect of quality on cost efficiency in hospitals

<table>
<thead>
<tr>
<th></th>
<th>Means (beta)</th>
<th>Std. Dev.</th>
<th>NSE</th>
<th>T-statics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.1742***</td>
<td>0.0139</td>
<td>0.0001</td>
<td>-12.7266</td>
</tr>
<tr>
<td>IQI90</td>
<td>0.0108</td>
<td>0.0304</td>
<td>0.0002</td>
<td>0.3556</td>
</tr>
<tr>
<td>IQI91</td>
<td>-0.0102</td>
<td>0.0135</td>
<td>0.0001</td>
<td>-0.7595</td>
</tr>
<tr>
<td>ln(B)</td>
<td>0.0083**</td>
<td>0.0029</td>
<td>0.0000</td>
<td>2.9188</td>
</tr>
<tr>
<td>T(time)</td>
<td>-0.0005</td>
<td>0.0014</td>
<td>0.0000</td>
<td>-0.3619</td>
</tr>
<tr>
<td>dum_UR</td>
<td>-0.0097*</td>
<td>0.0058</td>
<td>0.0000</td>
<td>-1.6814</td>
</tr>
<tr>
<td>dum_TA</td>
<td>-0.0176***</td>
<td>0.0051</td>
<td>0.0000</td>
<td>-3.4329</td>
</tr>
<tr>
<td>h (error precision)</td>
<td>323.2768</td>
<td>16.1712</td>
<td>0.1023</td>
<td></td>
</tr>
<tr>
<td>BIC</td>
<td>0.0033</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>0.0221</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

***significant at P>0.01
** significant at P>0.05
*significant at P>0.10
Table 2.6: Regression results for teaching hospitals in urban area

<table>
<thead>
<tr>
<th></th>
<th>Means (beta)</th>
<th>Std. Dev.</th>
<th>NSE</th>
<th>T-statics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.2269***</td>
<td>0.0291</td>
<td>0.0002</td>
<td>-7.7770</td>
</tr>
<tr>
<td>IQI90</td>
<td>0.0126</td>
<td>0.0486</td>
<td>0.0003</td>
<td>0.2582</td>
</tr>
<tr>
<td>IQI91</td>
<td>-0.0299</td>
<td>0.0211</td>
<td>0.0001</td>
<td>-1.4268</td>
</tr>
<tr>
<td>ln(B)</td>
<td>0.0130**</td>
<td>0.0049</td>
<td>0.0000</td>
<td>2.6466</td>
</tr>
<tr>
<td>T(time)</td>
<td>-0.0002</td>
<td>0.0023</td>
<td>0.0000</td>
<td>-0.0780</td>
</tr>
<tr>
<td>h(error precision)</td>
<td>238.1540</td>
<td>16.6846</td>
<td>0.1055</td>
<td></td>
</tr>
<tr>
<td>BIC</td>
<td>0.0045</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>0.0207</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

***significant at P>0.01  
** significant at P>0.05  
*significant at P>0.10
Table 2.7: Regression results for non-teaching hospitals in urban area

<table>
<thead>
<tr>
<th></th>
<th>Means (beta)</th>
<th>Std. Dev.</th>
<th>NSE</th>
<th>T-statics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.1599***</td>
<td>0.0216</td>
<td>0.0001</td>
<td>-7.3489</td>
</tr>
<tr>
<td>IQI90</td>
<td>0.0066</td>
<td>0.0488</td>
<td>0.0003</td>
<td>0.1369</td>
</tr>
<tr>
<td>IQI91</td>
<td>0.0391*</td>
<td>0.0228</td>
<td>0.0001</td>
<td>1.7203</td>
</tr>
<tr>
<td>ln(B)</td>
<td>0.0022</td>
<td>0.0042</td>
<td>0.0000</td>
<td>0.5249</td>
</tr>
<tr>
<td>T(time)</td>
<td>-0.0011</td>
<td>0.0023</td>
<td>0.0000</td>
<td>-0.4839</td>
</tr>
<tr>
<td>h(error precision)</td>
<td>413.1991</td>
<td>38.0331</td>
<td>0.2405</td>
<td></td>
</tr>
</tbody>
</table>

**BIC**          | 0.0027       |           |       |           |
**R**            | 0.0146       |           |       |           |

*** significant at P>0.01
** significant at P>0.05
* significant at P>0.10
### Table 2.8: Regression results for non-teaching hospitals in rural area

<table>
<thead>
<tr>
<th></th>
<th>Means (beta)</th>
<th>Std. Dev.</th>
<th>NSE</th>
<th>T-statics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>-0.1733***</td>
<td>0.0186</td>
<td>0.0001</td>
<td>-9.4537</td>
</tr>
<tr>
<td>IQI90</td>
<td>0.0050</td>
<td>0.0464</td>
<td>0.0003</td>
<td>0.1075</td>
</tr>
<tr>
<td>IQI91</td>
<td>-0.0425**</td>
<td>0.0196</td>
<td>0.0001</td>
<td>-2.1725</td>
</tr>
<tr>
<td>ln(B)</td>
<td>0.0104</td>
<td>0.0040</td>
<td>0.0000</td>
<td>2.6274</td>
</tr>
<tr>
<td>T(time)</td>
<td>-0.0017</td>
<td>0.0020</td>
<td>0.0000</td>
<td>-0.8304</td>
</tr>
<tr>
<td>h(error precision)</td>
<td>959.3396</td>
<td>119.0967</td>
<td>0.7532</td>
<td></td>
</tr>
<tr>
<td>BIC</td>
<td>0.0012</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R</td>
<td>0.0849</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

***significant at P>0.01  
** significant at P>0.05  
*significant at P>0.10
Appendix 3. IQI90: Mortality for Selected Procedures

Mortality for selected procedures is calculated as the weighted average of the observed-to-expected ratios for the following components:

- Esophageal Resection Mortality Rate
- Pancreatic Resection Mortality Rate
- Abdominal Aortic Aneurism (AAA) Repair Mortality Rate
- Coronary Artery Bypass Graft (CABG) Mortality Rate
- Craniotomy Mortality Rate
- Hip Replacement Mortality Rate
- Percutaneous Coronary Intervention (PCI) Mortality Rate
- Carotid Endarterectomy Mortality Rate
Appendix 4. IQI91: Mortality for Selected Conditions

Mortality for selected conditions is calculated as the weighted average of the observed-to-expected ratios for the following components:

- Acute Myocardial Infarction (AMI) Mortality Rate
- Heart Failure Mortality Rate
- Acute Stroke Mortality Rate
- Gastrointestinal Hemorrhage Mortality Rate
- Hip Fracture Mortality Rate
- Pneumonia Mortality Rate
References


Abstract

This essay reviews the literature on three topics in health-care operations management: 1) focused operation, 2) service quality, and 3) patient safety. The objective of the literature review is to provide key findings from selected articles, highlight the research gap, and suggest areas for future research. Based on the identified research gap and needs from today’s health-care industry, we present a synthesized research framework for future research.

Keywords: focused operation, service quality, patient safety
3.1 Introduction

Health-care operations management (HOM) has become one of the major topics in the research field of operations management (OM). Research studies in the OM literature have addressed how to achieve effective, efficient delivery of health-care services by utilizing OM disciplines. Specifically, topics such as quality of care with hospital structure and practice, hospital efficiency, employee service scheduling for inpatients or outpatients, and hospital capacity requirements have appeared in the literature (Andritsos and Aflaki, Clark and Huckman, Ding, Ding, Huckman and Zinner, Hyer, Wemmerlöv and Morris).

The HOM literature also shows diversity in methodology. For topics such as appointment scheduling and emergency room wait time, mathematical modeling has been widely used. Many empirical studies with primary data collected by survey, interview, or secondary data at the state or national level appeared as more data has become available. Case studies are also found for in-depth analysis on certain health-care organization issues or accomplishments. In short, research methods employed in OM are also used to study HOM research topics.

The objective is to review the HOM body of literature with regard to three specific topics: 1) focused operation, 2) service quality, and 3) patient safety of health-care service providers. Whereas there are a range of HOM literature topics, we limit our review to these three topics.

3.2 Literature Review

This section provides the comprehensive review of selected articles on three topics; Focused Operation, Quality of Care and Patent Safety. Articles from peer-reviewed OM journals are
reviewed and with few exceptions, articles from last 10 years are selected for the review. For the topic of focused operations, keywords of focused factory, focused operations and focused healthcare are used for the search. Similarly, keywords of healthcare quality, service quality and quality of care are used for the topic of service quality and keywords of patient safety and medical errors are used for the topic of patent safety. A summary, research gap, and future research directions are briefly discussed at the end of each section.

3.2.1 Focused operation

Hospitals increasingly have evidenced a trend toward focused operations to improve their clinical and operational performance (Eastaugh, 2014; Goldberger & Nallamothu, 2010). Reflecting this trend, examinations of the effect of focus have followed in the HOM literature.

McLaughlin, Yang, and van Dierdonck (1995) developed a framework that helps operations managers use focused strategy in service industries. The authors compared freestanding outpatient surgery centers to hospital-based surgery centers, using a large sample survey administered to physicians at both types of facilities. Study respondents perceived that freestanding centers perform better than hospital-based surgery centers in terms of low overhead cost and infection rates. The researchers also found that performance differences between stand-alone and in-house units were diminished when the in-house units were autonomously managed, which pointed to the importance of structural and infrastructural elements in focus.

Huckman and Zinner (2008) explored the benefits of focus in clinical trial management. They investigated focus not only at the firm level but also at the divisional level to see if one is complementary with, or a substitute for, the other. They concluded that clinical trials that were
characterized by focus outperformed those without focus, and that focus at the divisional level substituted for focus at the firm level.

McDermott and Stock (2011) studied the effect of focus in general hospitals on cost efficiency using secondary data from New York State. They took the view of “focus as emphasis” rather than “focus as narrowing” to examine the disproportionate emphasis on certain service lines. The authors concluded that hospitals need to have an emphasis on one line of service to produce cost-effective operations.

With a case study on a trauma care unit, Hyer et al. (2009) studied the focus concept and its link to health-care performance. They examined the effect of focus on operational, clinical, and financial outcomes measured with length of stay, mortality rate, and profitability. The authors observed no change in mortality but improvements in length of stay and profitability.

KC and Terwiesch (2011) also investigated the effects of focus on performance, using data from California cardiac patients. They analyzed the effect of focus at three different levels—firm, operating, and process flow. The authors found improved quality associated with increased focus at each of the three focus levels. They then analyzed the extent to which the greater operational performance was driven by excellence of focused operations or by strategically admitting a larger proportion of easy-to-treat patients. Their results revealed that the effect of focus disappears at the firm level after controlling for selective patient admissions. They still found a positive effect of focus at the operating unit level even after controlling for the selective admission effects.

Clark and Huckman (2012) examined the relationship between hospitals’ specialization in cardiovascular care and clinical quality performance and found that focus is positively related with quality performance. They also found that hospitals with higher specialization in related medical
segments show a greater marginal benefit than hospitals specializing in a focal segment. The authors described this phenomenon as complementarities in specialization across related areas.

The majority of studies have reached a consensus about the positive effect of focus on operational performance. The common finding is that hospital-focused operations enhance the quality of care and financial performance. In Essay 1, we found the consistent results on the effect of focused operation on quality performance. Moreover, our results show that regional competition is one of the determinants of focused operations in hospitals. With the findings from the literature and the Essay 1, we suggest the following research extension opportunities in this topic. First, one can explore how health-care organizations use focused operations to maximize focus strategy benefits. For example, a number of studies in the current literature have measured focus within different operational levels such as firm level or operating unit level. However, it is unclear when and how the different operational levels of focus impact hospital performance. Second, while we see a general consensus on the benefits of focus, the effect of diversification has received less attention. Studies on when and how to use either diversification or focus to improve operational performance with limited resources can offer insightful managerial implications for health-care industry decision making.

3.2.2 Service Quality

The report To Err Is Human: Building a Safer Health System from the Institute of Medicine (IOM) was published in 1999, the point where quality improvement in health-care service started receiving attention (Boyer, Gardner, & Schweikhart, 2012; Donaldson, Corrigan, & Kohn, 2000). Since then, OM researchers have studied a range of topics regarding quality improvement. The
research direction has focused on how to make changes that will lead to better patient service, system performance, and employee professional development.

Chandrasekaran, Senot, and Boyer (2012) examined the effect of process management on clinical and experiential quality. They claimed there is a trade-off between clinical and experiential quality as hospitals emphasize process management. Moreover, the authors further investigated how external and internal forces of hospitals impact the relationship. Their results showed that hospitals’ emphasis on process management is related with an increase in clinical quality but a decrease in experiential quality. They also found that external forces (state legislation) and internal forces (patient-centered leadership) have an impact on the relationship between process management and quality performance. Finally, they found from empirical evidence that the relationship between clinical quality and patient satisfaction is contingent on experiential quality.

Nair, Nicolae, and Narasimhan (2013) investigated the impact of clinical quality and clinical flexibility capabilities on length of stay and cost performance of a cardiology unit. They also examined whether the experiential quality enhances the impact of clinical quality and flexibility on operational performance. The results from the empirical analyses indicated that clinical quality and flexibility lead to a decrease in average length of stay and that clinical flexibility reduces average costs. Finally, they found evidence for the moderating effect of experiential quality on the clinical quality versus length of stay relationship and for a complementary role in the relationship between clinical flexibility and cost.

Theokary and Ren (2011) studied the relationships among patient volume, teaching mission, and process quality in U.S. hospitals. They hypothesized that teaching intensity of a hospital influences the relationship between patient volume and process quality. The results indicated that as hospital teaching intensity increases, greater patient volume is associated with decreased process
quality. Their findings suggest that hospitals need to reevaluate their facility location with regard to teaching intensity and the problem of lower quality performance associated with large teaching hospitals.

Andritsos and Tang (2014) examined the association between hospital process quality and reduced resource usage during care within a cardiac department. Their results suggest that higher process quality is associated with a reduction in resource usage. Moreover, the finding shows that the effect of process quality on reduction of resource usage is more pronounced when patients in the cardiac department are distributed across a wider range of medical conditions.

Research on quality of care can be divided into two categories: 1) effect of service quality on operational performance and 2) drivers of quality in health care. The focus is on how to improve service quality that leads to operational performance improvement. Service quality studied in the literature has showed several aspects of quality performance: the flow of process management, clinical performance, and the patient experience during treatment. For the methodology, our literature review reveals that most studies have used empirical analysis as the primary research methodology in the domain of quality.

Regarding opportunities for future research, one may study service quality of teaching hospitals. As Theokary and Ren (2011) pointed out, the issue of lower quality performance from teaching hospitals with high patient volume is a concern in today’s health-care industry. We also find a similar result as in Essay 2: Teaching affiliation is negatively associated with cost efficiency and unfavorable for improving cost efficiency and service quality performance together. Therefore, research on barriers associated with maintaining or improving high service quality may bring helpful managerial implications for industry professionals.
3.2.3. Patient Safety

Donaldson et al. (2000) defined patient safety as “the prevention of harm to patients.” While it can be regarded as a part of service quality, the emphasis placed on patient safety distinguishes it from other elements of service quality. Patient safety is achieved by a system of care delivery that (1) prevents medical errors, (2) learns from the errors, and (3) is built on a culture that prioritizes patient safety (Clancy, Farquhar, & Sharp, 2005; Erickson, Wolcott, Corrigan, & Aspden, 2003). OM researchers have approached patient safety from different angles. First, several studies have looked at the employee side of operations such as leadership style, perceptions of safety, and lean orientation (Dobrzykowski, McFadden, & Vonderembse, 2016; Gowen III, Mcfadden, Hoobler, & Tallon, 2006; Naveh, Katz-Navon, & Stern, 2005; Stern, Katz-Navon, & Naveh, 2008).

McFadden, Henagan, and Gowen III (2009) investigated leadership’s effect on patient safety, hypothesizing that improvement comes from a transformational leadership style. They found empirical support for this hypothesis, indicating that leadership forms a safety culture, leading to patient safety initiatives and improvements.

Naveh et al. (2005) had similar results. Their study introduced a new theory of safety climate, in identifying four dimensions: safety procedures’ suitability, safety information flow, managerial safety practices, and priority of safety. Empirical analysis found that perceived suitable safety procedures and frequent, clear information flow reduce treatment errors only when managers prioritize patient safety.

Stern et al. (2008) claimed that situational learning orientation interacts with autonomy and voice and that the interaction influences employee errors. Their analyses found that encouraging employee autonomy and voice strengthens the benefits of learning, leading to decreased treatment
errors. The results show that the level of situational learning orientation impacts the relationship between autonomy/voice and number of errors.

Dobrzykowski et al. (2016) examined the relationships among comprehensive lean orientation, internal integration, patient safety, and financial performance. With the theoretical lens of dynamic capabilities, they hypothesized that comprehensive lean orientation has a positive impact on patient safety. Using patient safety indicators from the CMS to measure patient safety, they found empirical results that supported the hypothesis.

Patient safety has been studied along with capacity management (KC & Terwiesch, 2009; Kuntz, Mennicken, & Scholtes, 2014). For example, KC and Terwiesch (2009) took note of hospital workload and studied the impact of workload on service time and patient safety. They found that increase in workload, or overwork, leads to a decrease in patient safety measured by mortality rate.

Kuntz et al. (2014) claimed that safety tipping points can be found with variable hospital utilization rates. With discharge records of 82,280 patients in 83 German hospitals, their empirical analysis showed that pooling the capacity of nearby hospitals brought down the mortality rate by 34%. This result reflects the reasoning that reduction in variability of demand can be achieved by pooling capacity, leading to greater patient safety.

Patient safety has been studied by various approaches in OM research. Several studies have claimed that initiative and perception of patient safety are the key drivers. With the exception of Kuntz et al. (2014), most studies have focused on hospital employees for managing patient safety. Accordingly, the literature has relied on the survey method to establish patient safety measurements. We see here a research gap that could lead to future research opportunities. First,
the relationship between hospital profile features and patient safety performance can be explored. Hospitals can be categorized by different characteristics such as teaching affiliation, location, or ownership type. While financial performance or other quality performance indicators have been considered in the literature, analysis of patient safety with hospital profile features such as ownership or teaching status has received less attention. Whether these features have a positive or negative impact on patient safety is another research opportunity.

Second, future research could bridge the issues of hospital operational structure and patient safety. The two distinct strategies discussed in the focused operation section, diversification or focus, could also be explored with regard to patient safety. One might study the following research questions: 1) Which diversification or focus strategy, under what circumstances, is more suitable for improving patient safety performance? 2) Does diversification or focus strategy form a culture of patient safety? Studies on these questions would provide another extension in the OM research on patient safety.

3.3 Conclusion and Future Research

This essay reviewed selected HOM articles on focused operations, service quality, and patient safety. Overall, we find that the literature has focused on how to achieve operational performance improvement and the environment that enables improvement. Empirical testing has been used as the main methodology in most research, and both primary and secondary data sources are commonly used. Table 3.1 presents topics, methodology used, and reviewed article sources.

| Table 3.1 inserted here |

The research gap and opportunities have been discussed for each topic. For the topic of
focused operation, we suggest 1) an examination of different organizational levels of focus and the strategy to maximize the benefits of focus and 2) a comparison and evaluation of two different strategies, diversification and focus. Regarding the service quality topic, we see research potential for 1) enablers and barriers associated with maintaining or improving high service quality in teaching hospitals and 2) standardization of treatment processes. Finally, the diversification and focus strategy on patient safety is again offered as a future research opportunity. With the research opportunities found, we present the synthesized research framework in Figure 3.1.

< Figure 3.1 inserted here >

The framework is an extension of this dissertation. First, it considers the directions of both focus and diversification. Whereas Essay 1 investigates the effect of focus on quality and the determinant of focus, the suggested framework also examines the potential benefits of diversification. The emphasis is placed on evaluation and comparison of two distinct strategies regarding the impact on patient safety performance. Second, the finding on teaching affiliation from Essay 2 is reflected in the framework. One of the major findings from Essay 2 is underperformance of teaching hospitals on cost efficiency and quality. The next step considered as an extension is whether teaching affiliation moderates the relationship between focus or diversification strategy and patient safety performance. This would involve an investigation of whether hospitals’ investments and usage of resources to maintain teaching affiliation influence hospitals’ capability for securing patient safety. Finally, process standardization is included to study if the effect of standardization represented by studies in the literature still holds with patient
safety performance. Lack of standardization is especially dangerous to patients; therefore, it is a significant factor in maintaining patient safety (Boyer & Pronovost, 2010). Inclusion of process standardization in future analyses will be another contribution to the literature.
<table>
<thead>
<tr>
<th>Topic</th>
<th>Research</th>
<th>Methodology</th>
<th>Journal</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>McLaughlin, Yang, and van Dierdonck (1995)</td>
<td>Theoretical/conceptual</td>
<td>Management Science</td>
</tr>
<tr>
<td></td>
<td>Kc and Terwiesch (2011)</td>
<td>Empirical</td>
<td>Management Science</td>
</tr>
<tr>
<td></td>
<td>Brumme et al. (2015)</td>
<td>Field/case study</td>
<td>Production and Operations Management</td>
</tr>
<tr>
<td></td>
<td>Tiwari and Heese (2009)</td>
<td>Modelling/analytical</td>
<td>Health Care Management Science</td>
</tr>
<tr>
<td></td>
<td>Theokary and Justin Ren (2011)</td>
<td>Empirical</td>
<td>Production and Operations Management</td>
</tr>
<tr>
<td></td>
<td>Naveh et al. (2005)</td>
<td>Empirical</td>
<td>Management Science</td>
</tr>
<tr>
<td>Authors</td>
<td>Type</td>
<td>Journal</td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>---------</td>
<td>-----------------------</td>
<td></td>
</tr>
<tr>
<td>Dobrzykowski et al. (2016)</td>
<td>Empirical</td>
<td>Decision Sciences</td>
<td></td>
</tr>
<tr>
<td>Kuntz et al. (2014)</td>
<td>Empirical</td>
<td>Management Science</td>
<td></td>
</tr>
</tbody>
</table>
Figure 3.1: Synthesized research framework

- Teaching Affiliation
- Diversified Operation
- Focused Operation
- Standardization of Process
- Patient Safety
References


