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EVALUATING HOSPITAL POLICY AND PERFORMANCE: CONTRIBUTIONS FROM HOSPITAL POLICY AND PRODUCTIVITY RESEARCH

JOS L. T. BLANK
VIVIAN G. VALDMANIS
Editors

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PREFACE

Hospitals worldwide command the majority of any countries' health care budget. Reasons for these higher costs include the aging of the population requiring more intensive health care treatments provided in hospitals, the relatively high costs of labor in this labor intensive industry and payment systems that may encourage inefficient behavior on the part of hospital managers and physicians. Governments are seeking to instruments to mitigate this cost rise. Liberalizing hospital markets, deregulation, changing budget systems and changing ownership are only a few examples of attempts to make hospitals more efficient.

In this volume, a number of outstanding internationally known scholars in the field of productivity measurement and health economics provide the reader with an excellent insight in the complexity of the issue. They explain that there is no straightforward panacea or recipe for the issues addressed.

We hope that the book contributes to a better understanding of the problem and encourage policymakers to conduct proper academic research before implementing far-reaching reforms or policy measures. We would like to acknowledge all the authors for their excellent contributions. We would also like to thank Mark Newson of Elsevier and the Production Team at Macmillan India Limited for all their efforts in editing and correcting the text.

Jos L. T. Blank
Vivian G. Valdmanis
Editors

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ABSTRACTS

Chapter 1 discusses the objective of the book and presents an outline. It explains the relevance of the subject not only from a social point of view, but also for the economy as a whole. Hospitals worldwide command the majority of any countries' health care budget. Reasons for these higher costs include the aging of the population requiring more intensive health care treatments, the relatively high costs of labor in this labor-intensive industry and payment systems that may encourage inefficient behavior on the part of hospital managers and physicians. There is also a special role of technology in the hospital. It has been argued that advances in technology are one of the major reasons for hospital cost increases. Further Chapter 1 indicates that from international comparison we may conclude that large differences in hospital productivity exists. Chapter 1 presents an outline of the other chapters in the book, varying from issues dealing with privatizing, liberalizing, ownership, networks, budgeting, management skills, innovations and government facilitating research on productivity enhancement.

Productivity is an important variable in monitoring and benchmarking exercises. Chapter 2 discusses the basic accounting model as well as some measurement problems. Though this model is derived for production units operating in a market environment, with minor modifications it can serve for regulated environments such as the hospital industry. Chapter 2 proceeds by reviewing a number of methods for decomposing productivity change or difference.

Chapter 3 emphasizes that hospitals are complex service organizations that ultimately treat each patient one at a time. The complexity is of a type that makes modeling attempts to simplify the characterization of services be limited by fundamental tradeoffs that require careful attention to the context of the questions being asked by the researcher. In particular, there are a number of key tradeoffs that apply in particular hospital situations, including taking a patient focused vs. an organizational/service provision focus view of the hospital services, taking a cost/expenditure based focus vs. an outcome focus, and the level of aggregation for the analysis. These attributes are crucial and decisive in determining the course of measuring hospital productivity and they cannot be determined completely objectively.

As a result, high quality hospital productivity research must carefully state research objectives and questions and align the analytic choices to that context and communicate clearly to the communities consuming the research.

Chapter 4 discusses that hospital industry has become increasingly consolidated through the formation of multi-hospital health systems and networks and the legal merger of institutions under a single license. However, despite extensive structural consolidation and relationship development, service line integration within newly structured hospital organizations has lagged behind. In fact, hospitals that merge or affiliate with a system or network typically look no different after these actions in terms of their operations and services than they did before. This chapter examines what hospitals have accomplished through their efforts to structurally consolidate – what exactly changed about their operations, what were the barriers and facilitators to that change, and what ultimate effects consolidation had on hospital costs and financial performance. In addition, the chapter examines why we may be seeing increased service line integration in selected areas in the future.

Chapter 5 investigates how hospital affiliation in a multi-hospital system (contract managed, owned, sponsored), the number of hospitals in a system, HMO and PPO contracts, and other factors, impacts hospital cost efficiency. Separate stochastic cost frontiers were estimated for rural and urban hospitals. The data sample is a 1996 to 1999 panel of 248 U.S. Midwestern hospitals. Empirical results show that for urban hospitals on average, signing more HMO contracts, increasing the number of hospitals in the system, and membership in multiple organizations (alliance and system) compared to only membership in a system, contributes to improvements in cost efficiency. Signing more PPO contracts, system ownership and system contract management/sponsorship of hospitals did not contribute to improvements in cost efficiency. For rural hospitals, system ownership and system contract management/sponsorship of hospitals contributed to improvements in hospital cost efficiency. Increasing the number of hospitals in a system led to a small improvement in cost efficiency. Signing more HMO and PPO contracts, and membership in multiple organizations (system and alliance) compared to membership in only a system did not help enhance hospital cost efficiency.

Chapter 6 studies the relationship between technology and productivity of Dutch hospitals. In most studies technology change is measured by a proxy, namely a time trend. In practice however, innovations slowly spread over all hospitals and so different hospitals are operating under different technologies at the same point of time. In this study we explicitly inventory specific and well-known innovations in Dutch hospital industry in the past 10 years. These innovations are aggregated into a limited number of homogenous innovation clusters, which are measured by a set of technology index numbers. The index numbers are included in the cost function and the parameters are being estimated. The estimates show that some technologies affect cost in a positive way, whilst others affect cost in a negative way. The outcomes also show that technology change is non-neutral and output biased.

Chapter 7 begins with a consideration of the theories that seek to explain differences in performance associated with variations in the ownership of hospitals in the United States. This is followed by a review of the literature of empirical studies that have examined the impact of ownership on hospital efficiency. While this section emphasizes frontier studies, corroborating evidence from studies that used ordinary least squares (OLS) methods are also included. Our review found very mixed evidence about the impact of ownership status on efficiency. Next, we discuss the methods of the study. A panel of 869 hospitals that reported complete data from 1999 to 2002 was used. Stochastic frontier analysis (SFA), using a simultaneous estimation procedure for panel data, was employed. Choices regarding the form of the cost function, assumptions about the distribution of the error component that represents inefficiency, the appropriateness of using SFA vis-à-vis OLS, and the use of inefficiency effects variables were guided by the results of formal hypothesis tests. In the results section, we report that the mean estimated cost-inefficiency of for-profit hospitals was 8.6%. In contrast, the mean values for non-profit and government hospitals were 11.3% and 25.8%, respectively. This concurs with expectations derived from Property Rights Theory. Consistent with previous SFA studies, our results found that environmental factors, such as hospital competition, managed care penetration and public payer mix affect hospital cost-inefficiency.

Chapter 8 focuses on market concentration in hospital industry. Hospital markets have become highly concentrated due to increasing numbers of mergers and acquisitions. These consolidations in hospital markets may have anticompetitive or procompetitive effects due to increasing market power, economies of scale and scope and quality consequences. In this chapter, market competition and concentration and their antitrust implications in hospital markets are examined. After a brief summary of recent changes in hospital markets, the chapter focuses on the relevant economics literature on price, cost and quality consequences of market concentration, and their implications and connections with the merger guidelines and antitrust policies.

Chapter 9 sheds light on the welfare consequences of public hospitals. Public hospitals enhance social welfare by serving as "safety net" hospitals, providing trauma care, and training medical personnel. Nonetheless, critics of public hospitals argue that they are inefficient and that social welfare would be improved if public hospitals were closed and their workload transferred to private hospitals. Here we deal with the subject in two ways. First, we directly compare the efficiency and productivity of public vs. private hospitals. Second, we examine an indirect effect of public hospitals by comparing the performance of private hospitals operating in markets with and without a public hospital presence. The latter issue is important because public hospitals may generate a positive "spillover" for neighboring private hospitals through their provision of "social goods," which would lighten the burden for private hospitals particularly in terms of providing charity care. Finally, we examine whether the proportion of uninsured people in a community affects hospital productivity by diverting resources to uncompensated care. Data envelopment analysis (DEA) is used to measure efficiency and construct the Malmquist productivity index and its components in order to address the issues noted above. Using annual data covering general, acute care hospitals operating in major US urban areas over the period 1994–2002, we failed to find significant evidence of performance differences between public and private hospitals, suggesting that welfare would not be enhanced if hospital care were shifted from public to private providers. We also failed to find evidence of any positive spillovers associated with public hospitals – the performances of private hospitals with and without a public hospital presence were similar. Finally, with few exceptions, a higher proportion of uninsured people did not appear to have a significant effect on hospital productivity.

Chapter 10 discusses that since 1998, all major hospitals in Finland have been participating in a voluntary benchmarking project based on comprehensive and continuous data collection from patient records and cost accounts. The aim of this chapter is to describe how the national hospital benchmarking system (BMS) was implemented, focusing on the use of BMS for managerial purposes and its impact on hospital care productivity. Descriptions of the characteristics of different phases in the development and use of the BMS are provided. Finally, important issues and potential problems in the use of productivity and efficiency benchmarking are discussed and future solutions are suggested.

Chapter 11 examines the aim, structure, operation and health care efficiency-related activities of the Productivity Commission of Australia, and sheds light on how such a mechanism can influence broader policy and funding patterns. The benefits and constraints of the mechanism are considered, and the chapter concludes with a discussion of the potential use and impacts of such a mechanism in other countries.

The purpose of Chapter 12 is to find the optimal allocation of resources across two surgery strategies procedures. The two strategies are: immediately sequential cataract surgery which is defined as surgery on both eyes at once. The other strategy is dubbed delayed sequential cataract surgery, which entails surgery on one eye and then surgery on second eye 2–3 month later. The method used here includes two steps: measuring changes in health and daily life activities, i.e., estimating a capability index and second, finding the optimal allocation of resources across the two strategies, based on the estimated capability index and cost of treatment. In the capability approach health in terms of anatomic and mental conditions of the body is related to the patient's ability to pursue daily life activities, using an index approach. In contrast to many other approaches the success of a medical treatment includes both health and quality of life aspects. The index approach requires data on eye characteristics including visual acuity, left and right eye – contrast vision, and self assessed frequency of daily life activities related to vision. These daily life activities comprise the outcomes of the surgery such as reading, walking, watching television, as well as more subjective, self-assessed difficulties with daily life activities related to vision.

Even though hospitals do not operate in a competitive market, there are lessons to be learned from the economic literature to improve performance. In Chapter 13, we review the methodological approach described by Balk in Chapter 2 and the necessity of appropriate data from Burgess in Chapter 3. Echoing the concerns of Burgess, benchmarking promotes such data collection and utilization among policy makers and managers. Market factors such as hospital organization, market influences, and geographical location and ownership are also assessed revealing that there does not exist a single magic bullet that could eliminate or explain all deviations from optimizing hospital performance. We close this chapter with concluding remarks calling for not only economic indicators of performance but quality and access as well.

Jos L. T. Blank
Vivian G. Valdmanis

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PART I:
INTRODUCTORY AND METHODOLOGICAL ISSUES

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CHAPTER 1

PRODUCTIVITY IN HOSPITAL INDUSTRY

Jos L. T. Blank and Vivian G. Valdmanis

INTRODUCTION

Hospitals worldwide command the majority of any countries' health care budget. Reasons for these higher costs include the aging of the population requiring more intensive health care treatments provided in hospitals, the relatively high costs of labor in this labor intensive industry and payment systems that may encourage inefficient behavior on the part of hospital managers and physicians, that have not been fully mitigated via reforms and regulations.

It has been well documented that health care expenditures over a person's lifetime is greatest during the last two years of life. Much of this may be attributed to costly treatments in the hospital including the special role of technology. As Chernew, Fendrick, and Hirth (1997) argued, advances in technology is one of the major reasons for hospital cost increases because innovations are often more expensive and require more highly trained staff to operate and treat patients with the new technology. Conversely, advances in technology may also lead to lower *social* costs if utilizing it improves the health outcomes of patients. Therefore, hospital productivity analysis should include measures of health outcomes in conjunction with efficiency.

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Despite the notion that increased benefits arise given technological changes, costs and cost increases impact the overall economy. The central question therefore is how best to improve performance. Relying solely on market interventions is not a viable option since health care is an industry dominated by market failures including asymmetric information, licensing requirements, payment methods that exacerbate principal-agency issues, public as well as private ownership and the incompleteness of contracts.

These issues transcend international borders. For example, hospitals in the United States also face a myriad of varying conditions of reimbursement (a mix of public and private payment) as well as different ownership forms in which cases managers answer to different stakeholders and objectives. For example, in the United States, where there is no national health insurance, over 44 million citizens are without health care insurance and lack necessary primary and preventive care leading to more serious cases once admitted to the hospital. Also, since private health insurance is typically provided by employers, these additional costs translate to higher prices of the end product making them less competitive in a global economy. Hospital care in other countries may be either produced publicly, paid for publicly or both. However the different approaches to hospital care, the excess costs and inefficiency impose burdens on private, public, and social welfare.

One way to lower the burden on governmental budgets and private costs is to improve the performance of hospitals to lower total costs. Hence, to increase total efficiency is a first good step in any form of health/hospital care system. Before, these objectives can be met by measuring hospital productivity. However, given the idiosyncrasies of hospital care, methodological approaches require flexibility as well as meeting the economic assumptions of productivity. As background information, we first describe hospital care in an international context.

INTERNATIONAL COMPARISONS

There are several basic health care structures found across OECD countries. These include public reimbursement programs common in France, public contract systems which characterize the health care programs in The Netherlands and Germany and the public integrated system as found in most Nordic countries. National health insurance and public ownership of production is also found, most notably in the UK (Dervaux, Ferrier, Leleu, & Valdmanis, 2004). These varying systems may impact hospital productive behavior differently; therefore flexibility in analysis and identifying specific

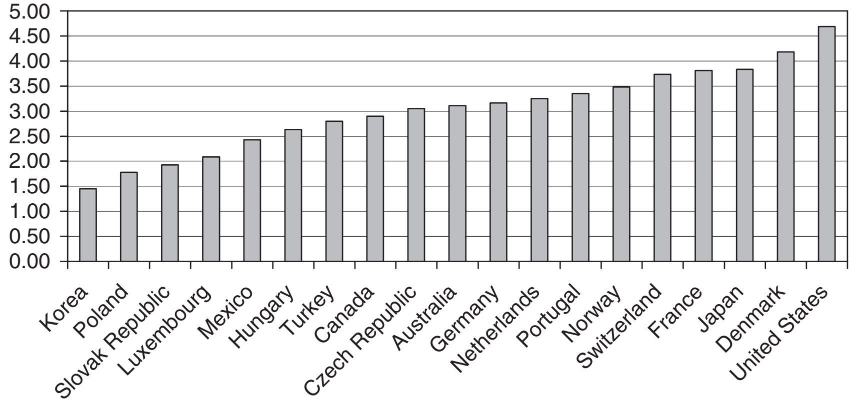

Fig. 1. Expenditures on Hospital Services in GDP (in %).

implications can aid policy-makers in forecasting possible responses to hospitals to economic changes either on the micro or macro level.

In this section we present some interesting figures on the relevance of the hospital industry in the national economy and on the ''productivity'' of the hospital industry. All figures are derived from the OECD-CD ''OECD Health Data 2006''.[1] In Fig. 1 we present expenditures on hospital services, corrected by the purchasing power parities, as a percentage of gross domestic product (GDP) in a number of OECD countries.

From Fig. 1 we notice that hospital industry is a substantial economic activity in the national economy. In the OECD-countries available in the dataset it varies from almost 1.5% in Korea to more than 4.5% in the United States. Another telling feature is that there appears to be a systematic relationship between country income and expenditures on hospital care. For example, Korea, Poland, and Mexico all spend below 2.0% of GDP on hospital expenditures whereas more than 3.5% of GDP is spend to hospital services in Switzerland, France, Japan, and Denmark.

In Figs. 2 and 3 we introduce two global productivity indexes, based on the number of discharges per US$ and the number of discharges per full-time equivalent employee (FTE). In Fig. 2, expenditures, the denominator of the productivity index, are corrected by the purchasing power parities. Since we use the US outcome as a reference, the productivity index for the United States is set at 100. An index of 150 implies that a country's productivity is 50% higher than in the United States. Notice that the set of countries is not identical due to missing data for some countries.

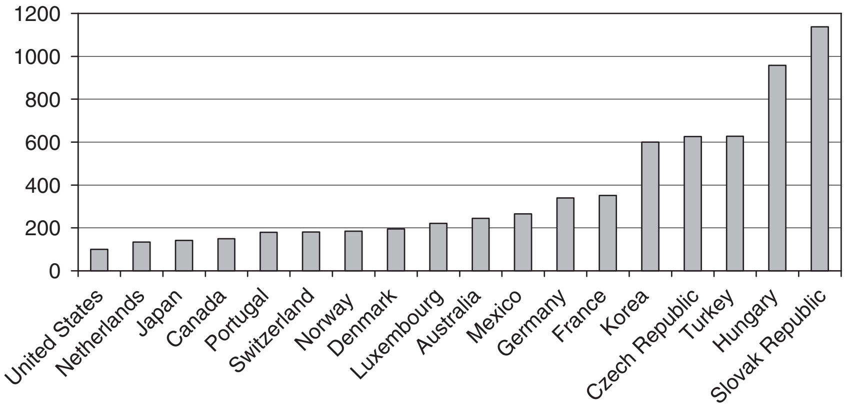

Fig. 2. Total Factor Productivity: Discharges per US$ Expenditures on Hospital Services (Index Number US = 100).

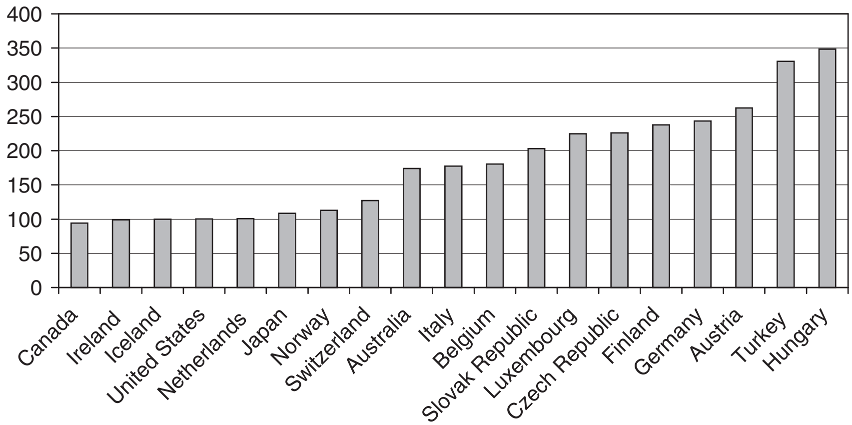

Fig. 3. Labor Productivity: Discharges per FTE Hospital Employment (Index Number US = 100).

From Fig. 2 we may conclude that lowest total factor productivity is found in the United States, the Netherlands, Japan, and Canada. Conversely, the highest productivity is found in Korea, Czech Republic, Turkey, Hungary, and Slovak Republic which in the case of the latter is more than ten times higher as compared to total factor productivity in the United States.

From Fig. 3 we see a similar pattern, although there are also some striking differences. The ranking has changed. Canada now shows the lowest productivity, whereas the United States is ranked fourth. We also notice that productivity differences, according to this labor productivity index, are much smaller than the total productivity differences in Fig. 2. Differences in labor wages and labor capital ratios may responsible for these discrepancies.

The simple question is where do these differences come from? Elaborating this central question may evoke other complex questions. Aside from artificial and technical explanations related to data and definition issues, there are a number of other explanations. The first group of explanations deals with the composition and quality of services delivery. Higher spending on hospital services could be an indicator for better health care outcomes; however, this direct association was disputed by the World Health Organization's study of national health as a function of expenditures (Evans, Tandon, Murray, & Lauer, 2001). Therefore, it is important to ask whether these resources are allocated and used efficiently.

Other factors also must be accounted for when assessing hospital efficiency at a national or macro level. For instance, an aging society requires other services than a younger society which may affect resource usage substantially. Questions on how to measure services are therefore extremely relevant. Furthermore, economic behavior is determined by all kinds of regulations and policy issues.

The transformation from resources into services is in general a complex issue. There is a technical component related to the transformation, but also an economic one. The technical component refers, for instance, to resources and services substitutability and returns to scale. Economic behavior and financial constraints are also important determinants of productivity. The response of hospitals to changes in resource prices, services prices, and budgets is also of great importance to productivity outcomes.

The productivity indexes from Figs. 2 and 3 are nothing more than a simple illustration and hide more than they reveal. It is the complex world behind these figures that are really interesting. Similar productivity differences as depicted in Fig. 3 can also be found using data on individual hospitals in a country.

ACADEMIC ISSUES

Hollingsworth (2003) reviewed the hospital efficiency and measurement literature and found growth of the number of referred and published papers focusing on hospital productivity. The predominant methodological approaches include data envelopment analysis (DEA) or stochastic frontier analysis (SFA). Both these methods are used to measure hospital efficiency and/or productivity to a best practice frontier. Hospitals "lying" interior to the frontier are considered inefficient or practicing lower levels of productivity. Since the mid-1980s, hospital performance measurement has increased both at the academic, policy-making, and managerial levels. In Chapter 2, Balk reviews the current approaches of how (hospital) productivity and efficiency are measured.

Comparing hospital costs alone does not fully describe the other objectives of hospital policy-making at the governmental or social levels. Quality of care and access to hospital services are also of interest to hospital researchers and policy-makers. One issue that dominates the literature is the measurement of hospitals outcomes. Often these data are not available, and researchers substitute measures of outcomes for measures of outputs. This approach recognizes the use of resources to produce a product, but methodological approaches need to be developed to address this shortcoming. Burgess addresses this shortcoming extensively in Chapter 3. One approach is to model case-mix severity exogenously (Ferrier & Valdmanis, 1996), or adjust outputs with case-mix severity indices (Grosskopf & Valdmanis, 1993).

Even though different countries have different hospital and/or health care systems, efficient performance meeting quality and access standards is one of the major ways to maximize the social welfare function. Dead weight loss via inefficient practices or losses due to non-productive behavior facilitates economic loss and a growth of unnecessary costs. These lost resources that could have been used elsewhere in society results in other societal goals not being achieved or higher tax burdens on society in general. If hospitals must bear the burden of charity care and other social responsibilities, does this hinder a hospital's ability to grow and advance technologically – a hallmark of the US hospital care system?

POLICY ISSUES

Analyzing hospitals cannot be simply addressed by economic models familiar in private markets. The United States stands out as the country that has pursued a market approach to hospital care rejecting nationalized systems pursued in other nations. Because of this market type approach, there are characteristics of the hospital sector that can serve as examples of policy changes in a variety of settings. To review, as of 2004, there are 4,919 community hospitals operating in the United States. Of these hospitals, there are several different ownership forms. Sixty percent of these hospitals are not-for-profit; 17% are investor-owned, for profit; with the remaining 23% comprised of state and local government hospitals (AHA, 2006). These hospitals are joined by federal hospitals, psychiatric, long-term care, and specialty hospitals that may also alter market conditions. Given the diversity present in the US and other hospital markets, it is incumbent that we accurately account for the issue of ownership on hospital productivity as well as effectively measure hospital services.

Despite the difference in hospital provision and production, there is a growing trend towards privatizing hospital care services in systems that are both predominantly private and public. It has been hypothesized that by using market mechanisms, hospitals are urged to compete among themselves on the basis of cost and quality. Contracts with insurance companies for their enrollees includes offering services at reduced prices as well as the implicit contracts with the US federal government for Medicare Patients via the prospective payment plan have been credited with slowing the growth of hospital costs.

Along with more competitive pressures on price comes deregulation which frees hospitals to become more innovative in treating patients with alternative types of care and patient follow-up. In either case, treating patients in the least costly appropriate alternative has implications on private and public finances. Other issues of deregulation includes easing of restrictions for the number of nurses treating patients as well as incorporating alternative providers such as nurse practitioners rather than resident physicians whose hours have been cut back by federal mandate in the United States. In Chapter 6 Blank analyzes the effects of innovations on productivity.

Competition is also waged on a yardstick or best practice basis which directly compares hospitals on their cost efficiency as well as quality maintenance. Carried out appropriately, competition may force hospital managers to utilize the most efficient care approach that is not based on an engineering standard, but on a measure that can be achieved as demonstrated by other hospitals in the market or industry.

Hospital competition used to be based on a non-price competition approach that focused on providing the most technically advanced equipment as well as the highest amenity levels irrespective of costs. This behavior was allowable since third party payers, especially in the United States, would pay on a retrospective cost-based payment scheme. Therefore, whatever the hospital charged, the third party payer would reimburse leading to highly inefficient hospital care and excessive costs. To combat this inefficient system, insurers and government sought out reimbursement schemes to reward hospitals for efficient behavior. One of the responses to a more market driven approach for hospitals is to consolidate or merge and share certain services that are highly costly but do not warrant duplication within a hospital market. Even though this type of merger can lead to monopoly power in the hospital industry these mergers could lower costs rather than increased costs as in the case of other industries. Mergers are particularly relevant in studying hospital productivity as changes in hospitals' structures can lead to higher levels of economies of scale and scope. Sharing services between two hospitals, particularly if demand in the market is not sufficient to warrant duplication of services is one way that mergers could be used to increase economies of scale and decrease average costs. This finding would depend on whether the production process is less costly or less inefficient if two or more goods are produced within a single firm; but diseconomies of scope exist if it is less costly/inefficient for two firms to produce the two goods separately. One way to maximize market shares and exploit economies of scale and scope is via mergers. Whereas horizontal concentration may lead to anti-competitive impacts via the increase in market share, pro-competitive impacts may arise via economies of scale. Recent developments in the US hospital market have renewed the interest in studying economies of scope.

Changes in hospitals such as mergers or conversions are often driven by economic factors. For example, it has been reported that in 60% of cases, conversions from not-for-profit status to for-profit status had beneficial effects in terms of financial viability (*A Guide to Communities Considering Hospital Conversion*, 1998). Financially viability may not be the only objective for community hospitals. In most communities in the United States, not-for-profit and public hospitals are governed by community-based boards that need to answer not only to the hospital but to the community as well – ensuring that costs are controlled but access to quality hospital care are maintained. Jointly studying competitiveness and market concentration, especially in the hospital market, identifies how policy-makers can assess hospital market changes and how resource allocation and production may be affected by changes. In Chapters 4 and 5 Bazzoli and Alam and Granderson pay attention to developments in scale and the consequences for hospital productivity, respectively. Bazzoli sets the stage for this discussion by describing and developing the current literature and implications of scale efficiency. Alam and Granderson takes the theory of scale and empirically measures the cost implications of scale inefficiency and market factors on a sample of US hospitals.

Irrespective of hospital system, the issue of hospital system, the issue of hospital ownership, and the motivations of hospital decision-makers on hospital policy are often used to explain these variations. Rosko and Mutter (Chapter 7) describe the property rights literature and use a sophisticated methodology to add to this literature as to which ownership form promotes efficiency. Sari (Chapter 8) takes a different approach to focus on market influences on hospital behavior, particularly hospital mergers, competition, efficiency, and quality. Another market issue regarding hospitals is the presence of a public hospital responsible for the community's uninsured and other social goods provision. In Chapter 9, Ferrier and Valdmanis explore the dynamic relationship among hospitals by ownership over time in several large urban US markets.

Maximizing efficiency and productivity in hospitals may include consolidation via systems and networks. In these cases, hospital systems typically own and operate a core set of hospitals offering a wide array of services and products. Whether these networks or system chains can exploit economies of scale and scope is debatable. One success, however, is the development of new market imperatives including the growth of capacity constraints within a hospital market. According to the AHA statistics for 2004, 54% of community hospitals are members of a system and 9% are members of a network.

With the growth of networks and chains has been the growth of specialty hospitals focusing primarily on psychiatric, cardiac, and orthopedic care. Coincidentally, these are the three most profitable areas of care for hospitals in general. The argument of specialization includes quality via experience and cost control. Whether these specialized hospitals add or detract from the social welfare functions general hospitals provide is subject to further debate.

It has long been argued that physicians are the driving forces behind hospital decision-making. Able to contract with several hospitals for admitting privileges, physicians could demand services from the hospitals for treatment and diagnosis as well as labor inputs to substitute for physicians' time. This so-called model of "a doctor's workshop" coined by Mark Pauly (1980) placed the blame for duplication of services and excessive costs at physicians. To combat this phenomenon, hospitals are increasingly limiting admitting privileges to physicians who will only admit patients to one hospital, purchase physician practices and other organizational forms that hire physicians on a salaried basis. The idea behind these changes in the organizational relationship is to bring physicians' objectives in line with the hospitals' goals of cost minimization and economic efficiency and productivity. Evaluating increases in hospital productivity can only be achieved by management involves data collection, public/private mechanisms, and the advancements in methodology to enhance measuring patient outcomes measurements. To meet these objectives, Linna (Chapter 10) describes in detail the enactment, implementation, use, and evaluation of benchmarking techniques in Finland. The focus of that chapter is identifying hospitals' management use of data in order to gauge hospital production and patient care. Expanding on the data collection approach, Bloom (Chapter 11) assesses successful approaches to improve efficiency in the "non-health" sector and their application to the health sector. Finally, in the advanced methods chapter (Chapter 12) Färe et al. demonstrate the linkages among organizational performance, clinical intervention, and patient outcomes as an example for future productivity analysis.

Even though hospitals, in general, perform the same types of activities, they may operate under different regulatory and legislative environments that may, as shown in section "academic issues", lead to large variations in productivity. To unravel these complex relations is therefore a challenging task and one of the objectives of this book.

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CHAPTER 2

MEASURING AND DECOMPOSING PRODUCTIVITY CHANGE: THE BASICS

Bert M. Balk

1. INTRODUCTION

There are two main dimensions in which the performance of a production unit can be assessed. The first is the dimension of time. The basic question here is: how is this or that production unit doing over time? Assessing a unit's performance over time is called monitoring. The second dimension is characterized by the question: how is this or that production unit doing relative to other, similar units? To answer this question one needs to specify the reference set of units and one needs sufficient information on each of the members of this set. This activity is usually called benchmarking. A combination of the two dimensions in the setting of a panel is also possible.

The specific performance measure of course depends on the purpose of the exercise. In a market environment, however, a suitable overall performance measure seems to be profit, here defined as a production unit's revenue minus its cost. An alternative measure is profitability, defined as a unit's revenue *divided* by its cost. As will appear later on in this chapter, the profitability measure is better suited for intertemporal and cross-sectional comparisons than the profit measure.

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Units operating in a non-market environment are characterized by the fact that their revenue cannot be calculated since there are no output prices. National accountants 'solve' this problem by imputing their revenue as being equal to their cost. Non-market production units thus have zero profit, whereas their profitability is by definition equal to 1.

An important component of profitability appears to be productivity. Indeed, as will be shown, the most encompassing measure of productivity change, total factor productivity (TFP) change, is nothing but the 'real' component of profitability change. Put otherwise, if there were no differentially changing prices then productivity change would coincide with profitability change. This is why productivity measurement is so important. There is a direct welfare implication here.

Any measurement exercise must start with setting up an adequate accounting model. In such a model one must specify the inputs and the outputs, the quantities and the prices which must be observed, and the various concepts that play a role, such as revenue, cost, and profit (ability). This will be the topic of Section 2.

Section 3 turns to the problem of decomposing any (nominal) revenue or cost change into the contributions of price change and quantity change.

After all this preliminary work, Section 4 defines TFP change as the 'real' component of profitability change.

In Section 5 we turn to the decomposition of productivity change. The old, neoclassical idea is that productivity change can be equated to technological change, which is why the two terms are frequently mixed. This, however, appears to hold only in an economically perfect world. In reality there are a number of other factors which contribute to productivity change, such as efficiency change, scale effects, and input- or output-mix change.

Section 6 reviews the main econometric methods that are used in productivity measurement, and Section 7 concludes.

2. THE BASIC ACCOUNTING MODEL

Basically, our accounting model is of surprising simplicity. Each production unit is considered as an input–output system. For the output side there is a common list of M commodities, and for the input side there is a similar list of N commodities. A commodity is here defined as a set of closely related items which, for the purpose of analysis, can be considered as 'equivalent,' either in the static sense of their quantities being additive or in the dynamic sense of displaying proportional price or quantity changes. Ideally then, for any accounting period considered (ex post), each commodity comes with a price and a quantity (and thus a value).

Unfortunately, reality is less simple. First of all, some units produce for the market whereas others do not. For the input side, however, this difference hardly matters.

The inputs are customarily classified according to the KLEMS format. The letter K denotes the class of owned capital assets. Commodities here are the assets, of various type and age, that are available at the start of the accounting period and, in deteriorated form (due to ageing, wear and tear), still available at the end of the period. Investment and desinvestment is assumed to happen in the split second between end of a period and start of the next. Examples include buildings and other structures, machinery, hospital equipment. Theory[1] implies that quantities are just the quantities of all these assets (thus representing the productive capital stock), whereas the relevant prices are the unit user costs (per type-age combination), constructed from imputed interest rates, depreciation profiles, (anticipated) revaluations, and tax rates. The sum of quantities times prices provides the capital input cost of a production unit.

The letter L denotes the class of labor inputs, that is, all the types of work that are important to distinguish, for instance according to educational attainment, gender, and experience (usually proxied by age). Quantities are measured as hours worked (or paid), and prices are wage rates per hour. Where applicable, imputations must be made for the work executed by self-employed persons (a. o. physicians). The sum of quantities times prices provides the labor input cost (or the labor bill, as it is sometimes called).

The classes K and L concern the so-called primary inputs. The letters E, M, and S denote three, disjunct sets of so-called intermediate inputs. First, the energy commodities consumed by a production unit: gas, electricity, and water. Second, all the materials consumed in the production process, which could be sub-divided into raw materials, semi-fabricates, and auxiliary products. Third, all the business services which are consumed for maintaining the production process. Though it is not at all a trivial task to define precisely all such inputs and to classify them, it can safely be assumed that at the end of each accounting period there is a quantity and a price associated with each input.

For each accounting period and each production unit, production cost is defined as the sum of primary and intermediate input cost.

The outputs are the commodities, goods and/or services, which are produced by the units. Though in some sectors definitional problems are formidable, as pointed out for the hospital industry by Burgess in Chapter 3, it can safely be assumed that for each accounting period there are data on quantities produced. For units operating on a market there are also prices. The sum of quantities times prices then provides the production revenue, and, apart from taxes on production, revenue minus cost yields profit.

For units that do not operate on a market there are no output prices. The national accountant's solution in such cases is to set revenue equal to cost. As a further step, output prices could be imputed, whereby the restriction that revenue equals cost implies that *relative* prices are sufficient. Such imputed prices should measure the relative importance of the various outputs. Eventually they could be set proportional to 1, meaning that all the outputs are considered as equally important.

Other points of attention include:

- Production and consumption in the economic sense (sales, purchases) is often correlated with physical production and consumption. When this is not so, the question arises how to deal with inventories of input or output commodities. This problem is especially important for units involved in wholesale or retail trade.[2]
- The production process sometimes leads to the production of undesirable commodities. How do we handle these? Should, for instance, pollution be considered as an output or an input? And what (shadow) prices should be placed on environmentally undesirable commodities? An issue that is especially relevant for the medical sector is the occurrence of waiting lists or malpractice.
- Some units produce unique commodities, that is, commodities made on demand. What sort of accounting rules must then be followed?
- How must outputs be valued whose production takes longer than the accounting period? Put otherwise, how must work-in-progress be valued?
- How must intangible capital assets be dealt with? Examples include software, organizational practices, skills, or other forms of 'knowledge capital'. There is a link here with the definition of the labor inputs.
- Services are hard to measure. It is not only difficult to define the units of measurement, but also to make a sharp distinction between price and quantity. Services cannot be kept in stock and have in a substantial number of cases a unique character.
- The universe of commodities at the input and output side of the production unit is not constant but changes continuously. Put otherwise, in a time-series context one must deal with new and disappearing goods and services (new diseases and new medical technology). This is especially

problematic when it comes to the decomposition of cost or revenue changes in price and quantity components.
- Many commodities, especially in the information and communication and medical technology area, undergo a process of more or less rapid quality change. Just comparing quantities and nominal prices through time then does not make much sense. It is usually felt that quality change, whether improvement or deterioration, belongs to the quantity component in a decomposition of revenue or cost change, but how this effect must be separated out exactly is a matter of great concern.

Assuming that, at least pragmatically, all the measurement problems can be solved, it is now time to introduce some notation to define the various concepts we are going to use. As stated, at the output side we have M commodities, each with their (imputed) price p_m^{it} and quantity y_m^{it}, where $m = 1, \ldots, M$, i denotes a production unit, and t denotes an accounting period. Similarly, at the input side we have N commodities, each with their price w_n^{it} and quantity x_n^{it}, where $n = 1, \ldots, N$. All prices are assumed to be positive and all quantities are assumed to be non-negative.

The production unit i's revenue, that is, the value of its gross output, during the accounting period t is

$$R^{it} \equiv p_1^{it} \cdot y_1^{it} + p_2^{it} \cdot y_2^{it} + \cdots + p_M^{it} \cdot y_M^{it} \tag{1}$$

whereas its production cost is given by

$$C^{it} \equiv w_1^{it} \cdot x_1^{it} + w_2^{it} \cdot x_2^{it} + \cdots + w_N^{it} \cdot x_N^{it} \tag{2}$$

The unit's profit (disregarding taxes on production) is then given by its revenue minus its cost, that is $R^{it} - C^{it}$. However, profit can be equal to zero, which is problematic when working with indices (ratios). It is therefore more convenient to use the concept of profitability. The unit's profitability is defined as its revenue divided by its cost, that is, R^{it}/C^{it}. Notice that profitability expressed as a percentage equals the ratio of profit to cost.

3. DECOMPOSING REVENUE AND COST CHANGE

The notation employed in the previous section permits us to monitor a number of different units over a number of different accounting periods.

What precisely do we want to see? In the intertemporal framework we want to see the evolution of revenue, cost, profit, or profitability. In the cross-section framework we want to see how units differ with respect to revenue, cost, profit, or profitability. In both frameworks the measures can be formulated in terms of ratios or differences. And, most important, we want to split any ratio or difference into a part due to prices and a part due to quantities. For example, when monitoring a single unit over time, we want to see whether its revenue change is caused by price change or by quantity change. Or, in case of a comparison of two units, we want to see whether their revenue difference is due to different prices or different quantities. Put otherwise, in either of these cases we want to see which part of the change or difference is 'monetary' (or price induced) and which part is 'real'.

In order to avoid that the reader must continuously switch between the two frameworks, in the remainder of this chapter the discussion will be cast in terms of intertemporal comparisons. Thus, we consider two periods, labelled $t = 0$ (which will be called the base period) and $t = 1$ (which will be called the comparison period), respectively.

Let us consider ratio type measures. We want to decompose the revenue ratio into two parts,[3]

$$\frac{R^1}{R^0} = P_0(p^1, y^1, p^0, y^0) Q_0(p^1, y^1, p^0, y^0) \tag{3}$$

of which the first part (P_0) measures the effect of differing prices and the second part (Q_0) measures the effect of differing quantities. The first part is called an output price index number. It is the outcome of a function $P_0(\cdot)$, called a price index, operating on the output prices and quantities of the two periods. The second part is called an output quantity index number. It is the outcome of a quantity index, that is a function $Q_0(\cdot)$, also operating on the output prices and quantities of the two periods.

Likewise, we want to decompose the cost ratio into two parts,

$$\frac{C^1}{C^0} = P_i(w^1, x^1, w^0, x^0) Q_i(w^1, x^1, w^0, x^0) \tag{4}$$

The first part at the right-hand side is an input price index number and the second an input quantity index number. The functional forms of the price and quantity indices used to get the decomposition of the revenue ratio, at the output side of the unit, might differ from the functional forms of the indices used to get the decomposition of the cost ratio, at the input side of the unit.

Which specific formula(s) should be selected for the price and quantity indices? There are several theoretical approaches available, the most important of which are the axiomatic approach and the economic approach.

The axiomatic approach, with roots in the second half of the 19th century, specifies requirements which the formulas should satisfy. These requirements are called axioms or tests and are usually stated in the form of functional equations. The general idea is that an index is some sort of average of commodity specific price or quantity changes. The basic theory for indices (ratio-type measures) can be found in the monograph by Eichhorn and Voeller (1976) and the review article by Balk (1995); see also Diewert (1992). The parallel theory for indicators (difference-type measures) was developed by Diewert (2005).

The economic approach, with roots in the first half of the 20th century, defines theoretically motivated price and quantity indices and combines assumptions on the behavior of the production unit (such as cost minimization, revenue maximization, or profit maximization) with assumptions on the prevailing production structure – defined by means of a production function, for instance – to obtain empirically applicable formulas. The basic theory for indices was surveyed by Balk (1998), and for indicators by Balk, Färe, and Grosskopf (2004).

Though both approaches lead to a preference for certain specific formulas, it is fair to say that they do not lead to the recommendation of a single formula that serves all imaginable purposes. If, in the axiomatic approach, the requirements are restricted to those that are more or less self-evident, then quite a number of formulas turn out to be satisfactory. On the other hand, every specific formula turns out to be characterized by at least one property that is not self-evident. With respect to the economic approach, it turns out that the assumptions needed to justify any specific formula are all more or less subject to argument. Put otherwise, available theory makes clear that the choice of a specific formula depends very much on the purpose one has in mind. Fortunately, however, it turns out that in the case of 'normal' and non-seasonal time-series data all preferred formulas approximate each other reasonably well, at least when 'not too distant' time periods are compared.

4. MEASURING PRODUCTIVITY CHANGE

We are now in a position to discuss what to understand by 'productivity' and 'productivity change'. There appear to be several measures, the most important of which will be reviewed in this section. The natural starting point is to consider the ratio of comparison period and base period profitability.

Using relations (3) and (4), this ratio can be decomposed as

$$\frac{R^1/C^1}{R^0/C^0} = \frac{R^1/R^0}{C^1/C^0} = \frac{P_0(p^1, y^1, p^0, y^0)}{P_i(w^1, x^1, w^0, x^0)} \frac{Q_0(p^1, y^1, p^0, y^0)}{Q_i(w^1, x^1, w^0, x^0)} \tag{5}$$

Thus, profitability change has a price and a quantity component. The index of total factor productivity (TFP), for period 1 relative to period 0, is now defined by

$$\mathrm{ITFP}(1, 0) \equiv \frac{Q_0(p^1, y^1, p^0, y^0)}{Q_1(w^1, x^1, w^0, x^0)} \tag{6}$$

which is the real or quantity component of the profitability ratio. Put otherwise, ITFP(1, 0) is the factor by which the output quantities on average have changed relative to the factor by which the input quantities on average have changed. If the ratio of these factors is larger (smaller) than 1, there is said to be productivity increase (decrease).

The wording used here suggests that a meaning can be attached to the term ‘productivity’ itself. Consider the purely hypothetical situation of a unit that employs a single input to produce a single output. Then the index of TFP reduces to

$$\mathrm{ITFP}(1, 0) = \frac{y^1/y^0}{x^1/x^0} = \frac{y^1/x^1}{y^0/x^0} \tag{7}$$

which has indeed the simple interpretation as a ratio of productivities. In the single-input/single-output case y^t/x^t is the output quantity produced per unit of input quantity, which is a natural measure of the productivity of the production process. In the multi-input/multi-output case, however, the term ‘productivity’ does not have such a natural meaning.

Using relation (5), the ITFP index can also be expressed as

$$\mathrm{ITFP}(1, 0) = \frac{R^1/C^1}{R^0/C^0} \frac{P_i(w^1, x^1, w^0, x^0)}{P_0(p^1, y^1, p^0, y^0)} \tag{8}$$

The right-hand side of this expression consists of two parts. The first part is the (nominal) profitability ratio. The second part is the ratio of an input price index number over an output price index number. Thus, if the profitability of the production unit were not changing over time, then TFP change could be measured by the ratio of an input price index number over an output price index number. Notice that constant profitability is not the same as constant profit.

It is also important to notice that expression (8) is only useful for production units operating on a market. For all non-market units the generic definition of TFP change is given by expression (6) in which, of course, output prices p^0, p^1 must be imputed.

5. DECOMPOSING PRODUCTIVITY CHANGE

Measuring productivity change over time or comparing productivity levels between entities starts with positing something that is stable and/or communal. We will call this the technology and suppose that it is shared by at least the set of units we wish to compare.

The classical approach was to represent the technology by a production function and to assume that all units are behaving optimally in some economic sense, that is, for instance, as being profit-maximizers. The progress of the last decades was brought about by recognizing the heterogeneity of reality, in the sense (i) that the technology is a set rather than a function and (ii) that units might behave non-optimally.

We will first illustrate the concept of TFP by a simple picture and then proceed to a discussion of the various factors which contribute to TFP change. We will thereby employ the various concepts defined in Sections 3 and 4.

The horizontal axis in Fig. 1 measures real input, whereas the vertical axis measures real output. Both are, by definition,[4] conditional on a certain normalization with respect to input-mix and output-mix, respectively. Put otherwise, the picture represents a single 'slice' of the full $(N+M)$-dimensional space of input and output quantities.

The technology of period t is to be thought of as the body of both tacit and explicit knowledge concerning products, processes, and organizational structures. Based on this body of knowledge there is a set of feasible combinations of input quantities and output quantities. In Fig. 1 this set is represented by the area bounded by the curved line and the horizontal axis. As depicted here, this set is assumed to exhibit some simple properties like free disposability of inputs and outputs. In reality, however, this set might have a less simple form.

The boundary of the technology set, that is the curved line itself, is called the frontier. This name is very appropriate, since beyond the frontier lie all those input–output combinations that are infeasible according to the technological state of affairs in period t.

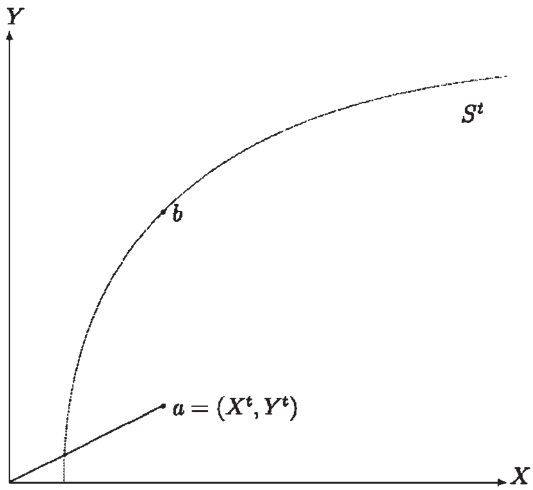

Fig. 1. Total Factor Productivity.

Each individual unit occupies a certain point within the technology set. Two examples have been drawn in the figure. The unit at point *a* uses real input X_t and produces real output Y_t. The TFP of this unit is then given by the ratio Y^t/X^t, which is just equal to the slope of the line connecting the origin *O* with the point *a*. Expanding real input X_t and real output Y_t with the same factor will leave TFP unchanged. Every other change in input or output quantities will in principle lead to TFP change. We will discuss now the various factors by which TFP can change.

As depicted, unit *a* is not particularly efficient. For instance, holding its real input X_t constant, the unit could expand its real output Y_t by a certain factor until it reaches the frontier. Or, holding its real output Y_t constant, it could contract its real input X_t by a certain factor until it reaches the frontier. Put otherwise, the unit can increase its (technical) efficiency by moving towards the frontier in the NW direction. This means that the slope of the line *Oa* increases, which is tantamount to saying that increasing efficiency means increasing TFP.

Consider now unit *b*. Since, as depicted, this unit is acting on the frontier, it is technically efficient. However, its TFP, that is, the slope of the line *Ob*, can still change by moving on the frontier. There appear to be two logically distinct types of movement here:

1. The first is a movement within the 'slice' of the quantity space as drawn in the picture, that is, a movement conditional on the unit's input- and

output-mix. In particular, the unit could move towards the point where the slope of *Ob* attains its maximal value. This point would be reached when the line *Ob* became tangential to the frontier. At that point the unit's TFP would be maximal. This is what we will call the *scale effect*. The scale effect depends of course on the curvature of the frontier. Imagine, for instance, that the frontier is a straight line originating at *O*. Then a movement of unit *b* along this line would not change its TFP. According to Diewert (2001), economies (internal) of scale can be due to (1) the existence of indivisibilities, (2) the existence of fixed costs, (3) certain laws of geometry or physics, or (4) certain laws of probability.

2. The unit can also move on the frontier by adapting its input- or output-mix. This type of movement can of course not be represented in our simple figure since it cuts across all dimensions of the quantity space. Adaptation of the unit's input-mix can, for instance, be caused by a relaxation of capacity restrictions. Also, by moving towards the point where the unit is considered to be economically optimal, that is, the point where the unit, given the prices of all the inputs and outputs, maximizes profit, causes the input- or output-mix to change. At such a point the unit is called *allocatively efficient*. A special phenomenon related to the output-mix and allocative efficiency is known as *economies of scope*. By specializing in a subset of outputs or, on the opposite, by producing outputs jointly efficiency may improve.

Finally, the frontier itself can change over time. This means that the technology set changes, and is therefore called technological change.[5] An outwardbound change of the frontier is usually associated with technological progress, whereas an inwardbound change is associated with technological regress (which can occur as a result of organizational change). These changes can be of local nature, which means that a certain region can exhibit progress while an other region can exhibit regress. Assuming that our unit continues to stay on the frontier, technological change brings about TFP change.

It may be clear that, in order to arrive at measurement, all these rather intuitive notions must be made precise. The instruments needed in the first place are provided by duality theory.[6] Starting with the notion of a technology set S^t, duality theory shows that there are a number of equivalent representations of such a set in the form of mathematical functions. The main distinction thereby is between distance functions and value functions. Distance functions act on (primal) quantity space and are unitless. Value functions act on (dual) price space and read in money units. Well known among the distance functions are the (radial) input- and output distance functions. Well known among the value functions are the cost, revenue, and profit functions.

We now review the most important specifications, without introducing too much mathematical detail. For this, the reader is referred to the appendix and the literature.[7]

We first discuss some output-oriented measures. The (direct) output distance function is most naturally defined by the largest factor by which the output quantities can be multiplied such that the resulting quantities are still producible by the input quantities. The inverse of this largest factor is called the output distance function. The (direct) revenue function is defined by the maximum revenue that can be obtained when output prices are given and the input quantities are fixed.

In some situations it is more appropriate to replace the condition of fixed input quantities by a budget constraint together with fixed input prices. Thus, the so-called indirect output distance function is defined by the largest factor by which the output quantities can be multiplied such that the resulting cost does not exceed a given budget. The inverse of this largest factor is called the (cost) indirect output distance function. Likewise, the indirect revenue function is defined by the maximum revenue that can be obtained when output prices are given and the input quantities are such that their cost does not exceed a certain budget. For the input orientation a similar set of measures exist.

Finally, the profit function is defined by the maximum profit that can be obtained when output prices and input prices are given. The fact that, without additional specifications, all these functions[8] represent the same technology enables the analyst to choose the analytical frame-work that fits (1) the behavioral objective that is assigned to or considered appropriate for the units studied and (2) the data available. For instance, suppose that the units studied can be considered to be competitive profit maximizers, but that, for some reason, the analyst has only data on input prices and output quantities. Then an analysis in terms of the cost function is still appropriate, since profit maximization implies cost minimization.

Of course, for non-market units the choice is usually limited to models without output prices. In a study of the Dutch general hospitals sector, however, Blank and Merkies (2004) used not only the direct but also the indirect cost function.

By using all these functions it is possible to replace the intuitive notions of technological change, technical efficiency change, allocative efficiency change, scale efficiency change, and input- or output-mix change by precisely formulated expressions which are adapted to the situation under study. Moreover, within the various frameworks it is possible to formulate hypotheses, for instance about the nature of technological change (as Hicks neutral, or input-, or output-biased) or about the scale properties of a technology (constant or variable returns to scale).

The first question we want to address, however, is how these theoretical measures relate to the conventional, data-driven measures as discussed in Section 4. This is one of the main subjects of Balk's (1998) monograph. The results appear to be limited in scope.

One of the basic theoretical measures is what came to be called, due to Caves, Christensen, and Diewert (1982), the (primal) Malmquist productivity index.[9] Depending on the situation studied, this index is defined as a function of (direct or indirect, input or output) distance functions. In the case of direct input distance functions the geometric average version reads

$$M_i(x^1, y^1, x^0, y^0) \equiv \left[\frac{D_i^0(x^0, y^0)}{D_i^0(x^1, y^1)} \frac{D_i^1(x^0, y^0)}{D_i^1(x^1, y^1)} \right]^{1/2} = \frac{D_i^0(x^0, y^0)}{D_i^1(x^1, y^1)} \left[\frac{D_i^1(x^0, y^0)}{D_i^0(x^0, y^0)} \frac{D_i^1(x^1, y^1)}{D_i^0(x^1, y^1)} \right]^{1/2} \tag{9}$$

The first part at the right-hand side captures technical efficiency change (i.e., the movement of the unit's position relative to the current frontier), whereas the second part captures technological change (i.e., the movement of the frontier). Without knowledge of the distance functions, however, it is impossible to calculate $M_i(x^1, y^1, x^0, y^0)$ from the data.

Using various assumptions, it appears possible to relate this theoretical productivity index to an empirical index of the form (6). Further, it can be shown that under the usual set of neo-classical assumptions – a constant-returns-to-scale technology and a competitively profit-maximizing unit – any empirical TFP index reduces to a measure of technological change. However, these assumptions are not very realistic. Though one could argue that the assumption of constant returns to scale can validly be made on a global level and for the long run, it appears to be hardly maintainable on a sectoral level and for the short run. There is also ample evidence that units are not behaving as nicely as theory would like them to do. However, any relaxation of assumptions comes at a price. One must invoke econometric methods in order to proceed.

6. ECONOMETRIC METHODS

Econometric methods are in the first place needed to estimate, within the framework chosen for the analysis, the function which represents the technology set. There are a number of techniques available. The first is the method of activity analysis.

The basic idea of this method is that every observed combination of inputs and outputs is an element of the technology set. Thus the technology set can be approximated by enveloping the observations as closely as possible – hence the alternative name data envelopment analysis (DEA) – by piecewise linear contours. A recent source on theory and practice is Cooper, Seiford, and Tone (2007). There have been developed a number of (semi) commercial software packages, such as Warwick DEA Software, Frontier Analyst, and On Front, to execute the necessary calculations.

The second technique is called stochastic frontier analysis (SFA). The basic idea behind this technique, or rather this set of techniques, can most easily be grasped by first considering the conventional approach. In the conventional approach, for instance, observed cost is assumed to deviate from optimal cost by stochastic noise. Stochastic frontier analysis explicitly recognizes the fact that units might not behave optimally. Thus, there is not only stochastic noise, but also an inefficiency term, with different stochastic properties.[10]

Whereas SFA is basically a regression method, yields a smooth frontier, is stochastic, and parametric, DEA is based on solving linear programming problems, yields a piecewise linear frontier, is deterministic, and nonparametric. Both methods have their pros and cons. Since its inception, a quarter of a century ago, the body of theory and applications relating to SFA has grown almost exponentially. There is a still very useful textbook by Kumbhakar and Lovell (2000). Coelli (1996) developed a non-commercial software package for stochastic frontier estimation.

The final approach considered here consists in specifying a complete parametric model. Assuming that the cost function framework is the appropriate one, this approach starts off at what Balk (1997) called 'the canonical form of cost function and cost share equations'. The distinctive element in these functional equations is the occurrence of the so-called shadow (input) prices. These shadow prices, which though as yet unknown can be proven to exist, serve to make the unit's actual cost as corrected by the unit's technical efficiency equal to the minimum cost as given by the cost function.

The next step is to select a suitable functional form for the cost function. Since the cost function is time-dependent, this implies that some hypothesis on the nature of technological change must necessarily be incorporated. Next, in order to reduce the number of free parameters to a manageable size, one must model the unit-specific input technical efficiencies as well as the relation between the unit-specific shadow input prices and the actual sector-specific prices which the units are facing. After all this work has been done, the resulting system of equations for costs and cost shares can be estimated by a suitable econometric method. For further details the reader is referred to Balk and Van Leeuwen (1999) and Balk (1998; Section 8.3). Related work, on the Dutch general hospitals sector, was reported by Blank and Eggink (2004) and by Blank and Vogelaar (2004).

Once armed with an estimated version of some functional representation of the technology set, it becomes possible to compute the measures which can be defined for the various components of productivity change. For instance, the Malmquist index can be computed as well as its decomposition into technological change and technical efficiency change components. But one can also enhance the Malmquist index with components referring to scale efficiency change and input- or output-mix change. An example was provided by Balk (2001).[11]

The framework sketched above can also be used for cross-section type comparisons of production units. Of course, in this setting there is no correlate to technological change since all units in the comparison are supposed to share the same technology. But one can compare units with respect to their technical efficiency, their scale efficiency, and their allocative efficiency.

Moreover, as demonstrated by a large literature, this framework can be used for intertemporal and cross-sectional studies of non-market production units and similar institutions, such as hospitals, schools, prisons, and police districts. All one has to do is to select the functional representation for the technology that fits the data and that is considered to be an appropriate behavioral objective. A nice collection of such studies is to be found in the volume edited by Blank (2000). The recent literature, such as contained in the present volume, also nicely illustrates the fact that the construction of appropriate input and output variables is not at all a trivial task.

7. CONCLUSION

Measuring productivity change or productivity differences requires both good theory and good data. The first sections of this survey laid out the basic accounting model that ties together the various concepts which play a role. A basic insight offered in Section 4 was that the natural measure of productivity change, gross output based TFP change, is the 'real' component of profitability change. Its computation requires the splitting of all value changes at the output and input side of the production unit considered into price and quantity components. This is not at all a trivial task, as discussed in Sections 2 and 3. It was also argued that, using imputations for output prices, non-market production units fit in the general model.

Insight into the components of TFP change is not only important for its own sake but also for any government policy that aims at productivity growth. For the fine-tuning of such a policy some understanding of the various factors that alone or together contribute to productivity change is indispensable. This point was also made by Diewert (2001). Should economic policy be directed at pushing the technological frontiers ahead (see, e.g. Chapter 6)? Or should economic policy be directed at removing the barriers for (more) efficient behavior (see, e.g. Chapters 10 and 11)?

Each of these factors would require a separate approach. At this level the role of statistical figures for guiding economic policy must be taken over by carefully designed case studies, whose role it is to stimulate the imagination of all involved.

NOTES

1. See Hulten (1990), OECD (2001), Diewert and Schreyer (forthcoming), and Balk and Van den Bergen (2006).
2. An interesting attempt to account for inventories at a distribution unit was developed by Diewert and Smith (1994).
3. In order to economize on notation the following convention will be used. When we are considering a single unit over time, the superscript designating the unit will be dropped. When we are considering a set of units during the same time period, the accounting period superscript will be dropped.
4. Real input (output) is cost (revenue) deflated by an input (output) price index.
5. To be precise, this should be called disembodied technological change. Technological change as embodied in any input category is taken care of by the quality adjustment that must be made in order to make any 'new' input comparable to an 'old' input in quantity terms. See Lipsey and Carlaw (2000) for more on this issue.
6. See Färe and Primont (1995) and Diewert (1982).
7. See also the excellent, non-technical overview by Lovell (2000) with references to the more technical literature.
8. In addition to the nine functions considered here, there are nonradial distance functions (see Färe & Primont, 2006) and all sorts of conditional distance and value functions.

9. For the history related to this concept, see Grosskopf (2003).

10. Frequently, instead of the cost function, the input or output distance function is the object of estimation, whereby the linear homogeneity properties of these functions are used to obtain estimable expressions. A recent attempt to escape from the straightjacket of estimating either an input or an output distance function is reported by Kumbhakar, Orea, Rodriguez-Alvarez, and Tsionas (2007).

11. As appears from this chapter, there is some debate on how to measure the various components of productivity change and how to relate those to the Malmquist index. Recent contributions include Lovell (2003) and Balk (2004).

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APPENDIX

The (direct) output distance function is most naturally defined by

$$1/D_o^t(x, y) \equiv \sup\{\delta | \delta > 0, (x, \delta y) \in S^t\} \tag{A.1}$$

The right-hand side of this expression looks for the largest factor δ by which the output quantity vector y can be multiplied such that the resulting quantity vector δy is still producible by the input quantity vector x. The inverse of this largest factor is called the output distance function. This function is a (radial) measure of technical efficiency, which attains values between 0 and 1, conditional on a certain input quantity vector x and the output-mix implied by y.

The (direct) revenue function is defined by

$$R^t(x, p) \equiv \max_y\{p \cdot y | (x, y) \in S^t\} \tag{A.2}$$

that is, the maximum revenue that can be obtained when output prices are given by p and the input quantities are fixed at x.

In some situations it is more appropriate to replace the condition of fixed input quantities by a budget constraint together with fixed input prices. Thus, the so-called indirect output distance function, defined by

$$1/ID_o^t(w/c, y) \equiv \sup\{\delta | \delta > 0, (x, \delta y) \in S^t, w \cdot x \leq c\} \tag{A.3}$$

is again a measure of technical efficiency, based on the output-mix of y, but now conditional on the set of input quantity vectors which satisfy the requirement that their cost $w \cdot x$ does not exceed a given budget c. Likewise, the indirect revenue function is defined by

$$IR^t(w/c, p) \equiv \max_y\{p \cdot y | (x, y) \in S^t, w \cdot x \leq c\} \tag{A.4}$$

that is, the maximum revenue that can be obtained when output prices are given by p and the input quantities are such that their cost at input prices w does not exceed the budget c.

For the input orientation a similar set of measures exist. The (direct) input distance function is most naturally defined by

$$1/D_i^t(x, y) \equiv \inf\left\{\delta \middle| \delta > 0, (\delta x, y) \in S^t\right\} \tag{A.5}$$

At the right-hand side we now look for the smallest factor δ by which the input quantity vector x can be contracted such that δx is still able to produce the output quantity vector y. The inverse of this smallest factor is called the input distance function. The right-hand side of the last expression itself is a measure of technical efficiency, conditional on the output quantity vector y, and the input-mix given by x.

The (direct) cost function is defined by

$$C^t(w, y) \equiv \min_x \{w \cdot x | (x, y) \in S^t\} \tag{A.6}$$

that is, the minimum cost that is necessary for producing the output quantities y when input prices are given by w.

The indirect functions replace the condition that output quantities be fixed by a revenue target together with an output price vector. Thus, the so-called indirect input distance function, defined by

$$1/ID_i^t(x, p/r) \equiv \inf\{\delta | \delta > 0, (\delta x, y) \in S^t, p \cdot y \geq r\} \tag{A.7}$$

is again an inverse measure of technical efficiency based on x's input-mix, but now conditional on the set of output quantity vectors which satisfy the requirement that their revenue $p \cdot y$ attains at least a prescribed target r. Likewise, the indirect cost function is defined by

$$IC^t(w, p/r) \equiv \min_x \{w \cdot x | (x, y) \in S^t, p \cdot y \geq r\} \tag{A.8}$$

that is, the minimum cost that is necessary, under input prices w, to yield revenue r when output prices are given by p.

Finally, the profit function is defined by

$$\prod\nolimits^t(w, p) \equiv \max_{x,y} \{p \cdot y - w \cdot x | (x, y) \in S^t\} \tag{A.9}$$

that is, the maximum profit that can be obtained when output prices are p and input prices are w.

CHAPTER 3

MEASURING HOSPITAL SERVICES

James F. Burgess, Jr.

1. INTRODUCTION

1.1. General

Research on hospital productivity has progressed over the last few decades considerably from early models where measurements of hospital services simply counted inpatient days, and perhaps outpatient visits or numbers of surgeries performed. This simplicity represents an extreme of aggregation, focuses the attention of the analysis entirely on the structure of the organization at the highest levels, and provides no insight into the specific services that might be provided to each patient as well as the characteristics of those patients, which might lead to specialization of their care. This process is fundamentally complex, which makes it especially difficult to model. This table-setting chapter will characterize some of the key contextual choices that must be made by researchers in this field which are then applied in subsequent chapters. The key point of this chapter will be to argue that there are very few "one size fits all" decisions in this process and thus the context of particular research objectives and questions will determine how modeling choices are made in practice. Some intuition about how these decisions have substantial implications for outcomes of measurement for hospital productivity will be provided; however, no attempt will be made to conduct a literature review of all the choices that have been made. Instead,

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we will suggest that new careful attention to the choices made can make future studies more effective in communicating to the communities implementing the research.

An unhelpful truism is that every patient and their experience of hospital services is different. More difficult is to determine how to aggregate up patients and services to useful levels of aggregation that explain relevant patient (and provider!) variation to an adequate degree. This process always will leave unexplained variation on the table and there are no good meta-evaluation loss function approaches that have been developed in the literature to guide a researcher in determining how far to go. While this is potentially an important question for future research, attempts to try to conduct hospital productivity research have generated no shortage of approaches to characterizing the heterogeneity of hospital services and these can be indexed and categorized to aid the researcher in determining the choices that must be made.

1.2. Key Tradeoffs in Performance Measurement

We will focus on three key tradeoffs to begin and then progress deeper into some particular examples in each area:

- complexity of patients and or procedures;
- quality of care and patient outcomes;
- aggregation of analysis.

First, the scope of services provided in a hospital can be characterized around the complexity of the patient and their comorbidities or it can be characterized around the scope of procedures provided by the hospital and its clinical staff. These two views of the complexity of services usually are closely related, but may generate very different measures of hospital complexity, so we may be more likely to want to use patient-oriented measures when trying to assess hospital productivity from a patient centered perspective and vice versa. Second, most of the hospital productivity analysis in the literature is conducted around cost/expenditure or in terms of resource utilization with little attention to quality of care and patient outcomes. But in many ways, a hospital really is a service entity that improves quality and length of patient lives and a more outcome focused view might be more favorable to the goals of what hospitals are trying to accomplish. Finally, while nearly all early hospital productivity analysis was focused at measuring productivity for the hospital as a whole, the trend has shifted sharply away from this focus toward study of smaller and smaller slices of hospital activity separately. This choice obviously influences the measures of services greatly, allowing for more homogeneous product definition.

1.3. Performance Differences

As individual research studies attempt to answer these questions, five key performance differences should be considered to determine how to measure hospital services for productivity studies:

- selection of patients;
- efficiency models;
- severity of patients;
- aggregation;
- perverse incentives.

First, of great importance to economists in general, but far too often overlooked in hospital productivity analyses, is *selection*. Hospitals may employ policies that directly or indirectly affect the mix of patients served or the scope of services provided, which makes measures of the productivity of those services endogenous with respect to the service measures themselves. Second, models of hospital productivity frequently focus directly on measuring *efficiency*; however great care is necessary to ask clear questions about just what conserving and overusing resources means in particular contexts in hospitals. Most often, researchers in this area make mistakes by just lining up some seemingly reasonable inputs and outputs and believing they have a model, when that generally is not the case. Third, hospitals may deliver differing levels of services to patients of differing levels of *severity* or hospitals may be limited in treating patients at certain levels of severity by service options. Thinking of hospital productivity in a population health perspective, which sometimes is the question of interest, also changes the view of severity. Fourth, *aggregation*, hospital productivity can be evaluated at the hospital level, separating inpatient from outpatient services, looking at different specific units of service, or all the way down to the patient level. The key tradeoff in aggregation is that as one aggregates toward the hospital level the specificity of measuring the services provided necessarily goes down while the ease in using aggregated service measures goes up. Conversely, as one disaggregates toward the patient level the specificity of measuring the services provided necessarily goes up but the need to design service specific input and output measures becomes more difficult.

The fifth tradeoff worth mentioning is the unintended consequences of measuring health services that are derived from the *perverse incentives* in the data generating process itself. The effect of the measurement incentives will increase as we use the measures to assess hospital productivity and that information is reported and used. Thus, particular care must be taken in looking at hospital productivity over time as a particular measurement system is implemented, since a great deal of increased productivity is likely to be reported initially that is essentially a result of more diligent measurement or coding creep. Moreover, additional unintended consequences may result as hospital administrators' focus on improving perceived productivity from what is being measured at the expense of harder to measure aspects of care or quality of care that is unmeasured. Table A1 in the Appendix contains a variety of measures that can be helpful in hospital productivity analysis, each of which is mentioned in one or more relevant places below.

2. SCOPE OF SERVICES

2.1. Diagnostic Related Groups, Case Mix Indices and Quality of Treatment

Hospitals coordinate care for patients across many departments, including intensive care units, emergency departments, surgical wards, and diagnostic services. This coordination and the complexity of output services that results from it can be studied from the patient point of view, the provider point of view, or sometimes from both together. If a single patient comes in through the emergency department, has diagnostic services performed, is admitted for surgery, and then ends up in an intensive care unit, then they have touched all of these departments in a single episode of care. For over 25 years now, categorizing these episodes in Diagnostic Related Groups (DRGs) has been a way of measuring the complexity of inpatient stays, in a way that can be aggregated into a case mix index. This case mix index then can be used as a multiplier against total hospital inpatient discharges to come up with an adjusted inpatient output measure. Hospitals also increasingly are doing more outpatient activity and the Ambulatory Patient Classifications (APCs) can do similar adjustments for hospital outpatient visits. Aside from the severity of illness and complexity of services, quality of services may also be included in services measurement. One can think about the number of post-operative complications and hospital infections or about the number of medical complaints or results of patient satisfaction surveys.

2.2. Procedures and Resource Based Relative Value Scale

However, this may or may not be the appropriate way to adjust, depending on what type of hospital productivity is being studied. If we are attempting to understand hospital economic efficiency, then it may be much more important how individual providers and units within the hospital are balancing the complexity of the services they provide across patients. How would we do this? One could collect information on the procedures conducted (e.g. Current Procedure Terminology (CPT) codes) and create a case mix index from weights on those. The weights in the Resource Based Relative Value Scale (RBRVS) system, determined separately for physicians and for the practice expense, can be used to do this, especially if one wanted to capture the productivity of physicians in the hospital. In some countries, like the US, hospitals seldom directly employ the physicians, so if one is uninterested in their productivity, then a discharge-weighted-by-DRG process might make more sense. Or, many people have used counts of surgical procedures as a measure of hospital output, but it might be preferable to use RBRVS or another similar system to weight those by the complexity of the surgery as well. One also might be able to use both patient-based and provider-based measures, depending on the model type and specification. In general, these approaches may differ in measuring the complexity of service provision at particular hospitals because one hospital could have many patients who each draw on many services to be complex in a patient sense, while another could have many patients who each draw on few services but those services are complex.

3. RESOURCES USED VS. OUTCOMES OBTAINED

The overarching point of providing health services is to trade off (ideally improving both) the length of life and the quality of life for the patients treated. Traditionally, health productivity measurement tended to ignore these fundamental goals and measure services provided or costs/expenditures for those services as representing their value. One reason for the discrepancy is the uncertainty of the impact of treatment on outcome for most health services, so one can spend a great deal on services that end up being ineffective for either length or quality of life. Hospitals spend significant amounts of their resources on end of life care, which essentially is merely postponed to a later time if hospital services lead to significant life extension

(Seshamani & Gray, 2004), so at any point in time much of the treatment being provided in hospitals is not helping the overarching goal. Hospital productivity analysis is part of that problem, but could be part of the solution if recast in significant ways using the overarching goal as the primary outcome measure.

Quality Adjusted Life Years (QALYs) are one way of combining the quality and length of life into one measure and these could be used more in hospital productivity analyses than they currently are. There are two primary methodologies being used to value quality of life (SF-36 and EQ-5D); many health care systems now routinely measure quality of life for a subset of their patient populations and these could be used to generate hospital outcomes. However, sometimes the question really is waste of resources or efficiency of resources toward converting inputs into services rendered, so the context is still important. Moreover, since all health care systems in the world are heavily encumbered with regulation to varying degrees, other outcomes arising from market friction like waiting times/waiting lists for services and amounts of charity care provided are legitimate outputs for hospitals. One can also measure the *change* in health status from a hospital stay, but researchers should be warned that these values quite frequently are negative as people actually get sicker while in a hospital (some of this is patient perception and some is "real," more research on this is needed in general). Pain relief and slowing down the deterioration in health status for patients also may be important hospital services.

Finally, much of the research in hospital productivity is focused on various types of cost function estimation. Once we begin studying hospital expenditures or costs, there frequently is reason to risk adjust those costs to normalize for patient comorbidities and other characteristics. We note a number of prominent measures for doing this (Adjusted Clinical Groups (ACGs), Diagnostic Cost Groups (DCGs), Chronic Illness and Disability Payment System (CDPS)), but generally it matters far less which risk adjuster one uses than whether or not one uses one at all (Fishman, Sloan, Burgess, Zhou, & Wang, 2006). Thus, ease of access to risk adjusted patient costs by one of these methods can be a deciding factor in determining which one to use. Additionally, these mostly diagnosis-based approaches to adjusting for patient level risk have many other characteristics that can be used to build useful measures for productivity analysis (e.g. grouping diagnoses together of similar cost implications that could be used to build comorbidity measures for studying the productivity of a specific service within the hospital).

4. LEVEL OF AGGREGATION

This area is ripe for further research since the problems one encounters trying to learn about hospital level productivity is driving more and more research below the hospital level to units within the hospital. The primary problem with trying to measure productivity at the hospital level is that the correlates one attempts to model are unlikely to have consistent impacts across all the services in the hospital, whether it is waste and inefficiency, measures of quality, measures of improved patient health status, or cost/production relationships between inputs and outputs. Since understanding this point has been difficult in the literature, a few examples may be helpful. The orthopedics and cardiology departments in a hospital (two of the largest services) essentially have nothing to do with each other in either of our two dimensions of scope of services. Very few patients receive services from both departments while in the same hospital stay and almost no members of the provider team cross over between these services. Why would we expect them to behave or produce services similarly? Much of the growing work of hospitals now occurs in their outpatient departments, doing diagnostic testing, one-day procedures, as well as the more traditional emergency department care. Some of this is scheduled, some is unscheduled, but again there is almost no relationship between these services except for the financial umbrella of the physical plant of the hospital.

As a result, it usually makes more sense to focus productivity analysis below the hospital level unless our interest is economic behavior that takes place at the hospital level, such as system affiliations and networks, merger activity, market behavior, and capital ventures. Much work remains to improve analysis of productivity of departments within the hospital. Making this shift in analytical focus does produce other problematic tradeoffs. Many services share labor and capital in ways that can be difficult to account for on the input side; however, on the output side analysis easily can become more focused. Counting the output of two of the most important service departments in a hospital (radiology and pathology) is nearly impossible to do usefully in a hospital level productivity analysis. But not only can one count X-rays and Magnetic Resonance Imaging (MRI) tests separately in a radiology productivity study, but one can use systems like the RBRVS to weight out the work and come up with a single measure of output. The radiology literature cautions that the RBRVS or other weighting systems have biases but current literature (Duszak, Sacks, & Manowczak, 2001) suggests that these might not be too problematic. Of course, each service and context within the hospital is different. But this opens a whole host of questions to the researcher that have been almost completely unexplored and it is time to focus inside the hospital in future work in this area.

5. FINAL THOUGHTS

In discussing issues that arise in measuring hospital services, the approach has been general. Any hospital productivity study must consider and resolve the questions presented in this chapter to align with the attributes of the study and data being used. These attributes are crucial and decisive in determining the course of measuring hospital productivity and they cannot be determined completely objectively. As a result, high quality hospital productivity research must carefully state research objectives and questions and align the analytic choices to that context and communicate clearly to the communities consuming the research. These research ideals have been set out assuming ideal data is available. As better hospital and patient level data on quality of care, costs, and outcomes become available and accessible, then research on hospital services will be much better specified and geared towards managerial and policy purposes. Researchers should carefully follow moves toward pay for performance and other initiatives in the National Health Service in Britain, by the Centers for Medicare and Medicaid Services in the US, in Australia, and in other countries that are expanding available measures and data dramatically and improving potentials for both analysis and application. Linna and Häkkinnen respond to these cautions in Chapter 10 by presenting the Finish benchmarking system which can link appropriate data to answering patient level research questions.

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APPENDIX

Table A1. Typology of Risk Classification Systems Useful for Hospital Service Measures.

Classification System	Aggregation Level	Type of Index Created	Range of Use	References
Diagnosis Related Groups (DRGs)	Inpatient discharge	Inpatient case mix index	Most countries worldwide	Fetter et al. (1980), Jones (1985)
Diagnostic Cost Groups (DCGs)	Annual patient risk	Patient risk score	Mostly US but expanding	Ash et al. (2000), Zhao et al. (2002)
Adjusted Clinical Groups (ACGs)	Annual patient risk	Patient risk score	Mostly US	Weiner et al. (1991), Weiner (2006)
Chronic Illness and Disability Payment System (CDPS)	Annual patient risk	Patient risk score	Mostly US Medicaid	Kronick et al. (2000)
Ambulatory Patient Classifications (APCs)	Outpatient hospital episodes	Outpatient case mix index	US Medicare outpatient payment	Asubonteng, Middleton, and Munchus (1996), MedPAC (1998), Wynn (2005)
Health Status Measures (SF-36/EQ-5D)	Patient	Health status	SF-36 more US, EQ-5D more elsewhere	EuroQoL Group (1990), Ware and Sherbourne (1992), Rabin and de Charro (2001)
Resource Based Relative Value Scale (RBRVS)	Individual provider and practice weights	Physician and outpatient indexes	Mostly US but expanding	Hsiao et al. (1988), Duszak et al. (2001)

PART II:
DEVELOPMENTS IN HOSPITAL INDUSTRY

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CHAPTER 4

HOSPITAL CONSOLIDATION AND INTEGRATION ACTIVITY IN THE UNITED STATES

Gloria J. Bazzoli

INTRODUCTION

Over the last decade, the United States (US) hospital industry has become increasingly consolidated through the formation of multi-hospital health systems and networks and the legal merger of institutions under a single license. In relation to the former, health networks are strategic alliances or contractual affiliations of hospitals, in which affiliated institutions retain their individual ownership. Health systems, on the other hand, typically own and operate a core set of hospitals that offer an array of services and products. In many markets across the country, there are now only three to five hospital organizations in operation, after one accounts for their combined ownership or network affiliations.

Despite extensive structural consolidation, service line integration, in which affiliated hospitals restructure service offerings across involved facilities, has lagged far behind. Industry observers were surprised by this limited activity because it was believed that service integration was a major objective of structural consolidation, given that it could lead to improved organizational efficiency and financial performance. However, in many cases,

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consolidating hospitals looked no different after these actions than they did before.

Over the last few years, there has been some success in service line reorganization, especially in selected systems and service areas. We are beginning to see more efforts in this regard given new market imperatives in the US health system. In prior years, managed care pressures were considered a driving force to service integration to create cost efficiencies. In the last few years, service line reorganization has been a response to strained hospital capacity and to specialty facility development in particular US markets.

This essay examines what consolidating hospitals have accomplished in terms of increased efficiency and productivity through service and operational integration. It first describes historical trends in structural consolidation. Then, operational and service integration is examined, followed by consideration of the barriers and facilitators to these activities. Research on the economic effects of structural consolidation on hospital costs and prices is then discussed. Finally, changes that could affect future consolidation and service integration activities are considered.

STRUCTURAL CONSOLIDATION IN THE HOSPITAL INDUSTRY

As noted above, structural consolidation in the hospital industry has included not only ownership consolidation but also cooperative relationship development between hospitals that retain their original ownership. Thus, it includes a range of activities, including full-legal asset merger and system acquisition to less formal development of health networks, in which involved hospitals agree to work together to meet certain objectives. Primary sources of data on trends in structural consolidation come from *Modern Healthcare* and the American Hospital Association.

Historical Trends in Hospital Consolidation

Table 1 presents data from the trade magazine, *Modern Healthcare*, which conducts a survey of hospital merger and acquisition activity annually. The actions captured in their survey include mergers, system acquisitions, joint ventures, long-term leases, and formation of partnerships to coordinate activities. The number of "deals" relates to a count of these different actions

Table 1. Modern Healthcare: Annual Merger and Acquisition Activity.[a]

	1998	1999	2000	2001	2002	2003	2004
# of deals	198	142	129	95	60	68	84
# of involved hospitals	687	530	318	272	163	100	170

Source: Modern Healthcare, which reports the results of its survey of annual merger and acquisition activity in January of each year. See, for example, Gallaro and Evan (2005).
[a]Defined to include: mergers, system acquisitions, joint ventures, long-term leases and other partnerships involving coordinated activity.

each year. The total number of hospitals involved in these actions is also recorded.

These data indicate that merger and acquisition activity dropped markedly from 1998 to 2002, both in terms of the number of deals and the number of involved hospitals. The number of deals, though, started to increase in 2003 and continued to do so in 2004. This was not a large increase but it surprised many industry observers. Generally, it was felt that the consolidation trend had run its course in the US hospital sector, in part because there were very few independent organizations remaining to become involved in new arrangements.

Table 2 presents American Hospital Association data on two types of organizational arrangements that are tracked: multi-hospital systems and multi-hospital networks. The American Hospital Association defines a multi-hospital system as a corporate body that owns, leases, religiously sponsors, and/or manages health provider facilities. A health network, on the other hand, is a group of hospitals, physicians, other providers, insurers, and/or community agencies that voluntarily work together.

Table 2 reports the number of systems and networks in each study year and also the number of involved hospitals. While Table 1 focused on the number of new transactions that occurred annually, Table 2 examines more of a ‘‘stock’’ concept rather than a ‘‘flow.’’ Some hospitals have been in multi-hospital arrangements for years whereas others may be newly affiliated a given year. The data in Table 2 capture both long-standing and new members but only the latter is picked up in the *Modern Healthcare* numbers.

As reported in Table 2, the number of health systems has grown steadily over time. The number of hospitals has also increased to the point where over one-half of US community hospitals are in systems. Overall, the number of hospitals per system went from 8.8 in 1998 to 7.3 in 2004.

Table 2. American Hospital Association: Multi-Hospital Arrangements.

	1998	2000	2002	2004
Multi-hospital systems				
# of systems	271	296	299	330
# of hospitals	2,387	2,382	2,400	2,420
Percent of US community hospitals	47.6	48.5	48.7	52.4
Multi-hospital networks				
# of networks	247	n.a.	n.a.	n.a.
# of hospitals[a]	1,325	1,285	1,284	1,386
Percent of US community hospitals	26.9	26.1	26.1	30.0

Source: Author analysis of annual American Hospital Association Annual Survey data.
n.a. = not available.
[a]Approximately 50% of network hospitals are also in systems.

In terms of health networks, the number of hospitals in these arrangements declined from 1,325 in 1998 to 1,284 in 2002. In fact, the number of network hospitals had been declining since 1995 when 1,450 hospitals reported being in these arrangements. However, there was an increase in the network numbers for 2003 and also in 2004. Overall, the data in Table 2 indicate that about 67% of US hospitals in 2004 were involved with a health system or network, and as noted in the table, about 50% of system hospitals also belong to some form of health network.

Changes in System Strategy over Time

System formation and acquisition strategies have changed in relation to the hospitals typically targeted for acquisition. Alexander and Morrisey (1988) examined the distinguishing characteristics of hospitals joining systems in the 1980s. They found that small, financially weak urban hospitals were most often the primary acquisition targets. These hospitals were ailing and in need of new management expertise. At that time, health systems, which tended to be large national organizations, typically searched for good turnaround candidates.

In Bazzoli, Manheim, and Waters (2003), a very different system acquisition strategy was identified for the 1990s. This was the era of organized delivery system development and, in that period, larger hospitals (namely, those with bed-sizes of around 200 to 300) and those that were more technically advanced were the primary system acquisition targets. In this period, the objective was to create strong local delivery systems that could become more efficient, manage capitation, and gain leverage with managed care plans.

In the 2000s, it appears that rural and small urban hospitals are more common targets for system acquisition. The improved financial condition of these hospitals after enactment of the 2003 Medicare Modernization Act may have been a factor in their increased attractiveness. In addition, their small size may provide opportunities to improve operational efficiencies, especially through administrative economies of scale. However, these latter observations have not been rigorously examined empirically.

Accompanying the changes in acquisition strategy described above was another change in strategy illustrated in Table 3. This table presents a long time trend to illustrate the strategy change. The data indicate that urban system hospitals increasingly have local system partners present within their Metropolitan Statistical Areas (MSAs). Specifically, the percentage of system hospitals located in US MSAs with at least one local system partner increased from 23.2% in 1990 to 43.7% in 2004. On average, systems with multiple local hospitals had four hospital affiliates in an MSA in 2004. Large, geographically dispersed systems still exist in the US, and they own many facilities in multiple markets. However, the data in Table 3 indicate increased focus on the development of localized health systems. Cuellar and Gertler (2003) were the first to note this trend. Overall, the focus on local development provides opportunities for expanded hospital productivity and efficiency if potential economies of scale and scope can be realized.

Table 3. System Status of Urban Hospitals.[a]

Hospital System Status	1990 (%)	1994 (%)	1998 (%)	2004 (%)
Hospital in a system with at least one system partner in MSA	23.2	31.3	40.5	43.7
Hospital in a system with no local system partner in MSA	21.8	9.7	17.8	19.4
Non-system hospital	55.0	59.0	41.6	36.9

Source: Author analysis of annual American Hospital Association Annual Survey data.
[a]Urban hospitals are defined as those located in Metropolitan Statistical Areas (MSAs).

The historical data presented thus far cover the period in which hospitals and their systems were seeking to develop organized delivery systems. During this period, hospitals and their systems were developing relationships vertically as well as horizontally. These vertical relationships included aligning with physicians who either referred patients to the hospital or who would serve as primary parties managing care under capitated contracting arrangements. In addition, systems vertically integrated the financing or insurance side of health care business into their systems through the development of provider-based insurance arrangements.

Table 4 provides trend data on the vertical arrangements hospitals had in place over the last decade and are based on analysis originally reported in Bazzoli, Shortell, Ciliberto, Kralovec, and Dubbs (2001). The conclusion drawn from this table is consistent with earlier empirical research and also with observations of Lesser and Ginsburg (2000). Specifically, multi-hospital systems have been eliminating vertical features of organized delivery systems. The percent of hospitals that have contractual arrangements with physicians (such as Physician Hospital Organizations or Management Services Organizations) has diminished sharply, from 49.2% in 1998 to 26.5% in 2003. In addition, system ownership of physician practices has declined from 23.4% to 18.2% over the period.

Table 4 data also indicate that system ownership of insurance products or development of Preferred Provider Organization networks was never

Table 4. Health System Involvement in Physician Arrangements and Insurance Products.

	1998	2000	2002	2003
Physician-hospital arrangements				
Percent with contractual affiliations[a]	49.2	35.7	29.2	26.5
Percent that own physician practices[b]	23.4	20.1	17.6	18.2
Provider-owned insurance products				
Percent with Health Maintenance Organization insurance products	21.3	18.7	15.0	15.2
Percent with Preferred Provider Organization networks	22.2	18.7	15.9	14.9

Source: Author analysis of annual American Hospital Association Annual Survey data.

[a]Includes hospital-sponsored Independent Practice Associations, Physician-Hospital Organizations, Management Service Organizations.

[b]Includes medical foundations, in which a hospital affiliate or subsidiary owns practice assets and physicians sign a professional service agreement.

widespread even at the height of the organized delivery system movement in 1998. Further, limited initial system involvement in this area has since declined. In relation to system-sponsored Health Maintenance Organizations, the percent of systems with this feature declined from 21.3% in 1998 to 15.2% in 2003. In many markets, hospital systems have sold their provider-sponsored insurance products to private health plans and thus have contributed to the consolidation we observe in the health insurance industry. Generally, researchers and industry observers have concluded that hospital systems were not achieving the anticipated efficiencies and increases in revenues from vertical arrangements that they had initially expected.

Summary of Structural Consolidation Activity

Overall, the data reported in this section indicate that the pace of US hospital consolidations slowed in the early 2000s, but the consolidation that did occur has resulted in a very concentrated hospital industry. Multi-hospital arrangements represent a dominant organizational form in most markets in the US. About 67% of US hospitals in 2004 were in a health system or network. In urban areas, this percentage is even higher, with about 72% of hospitals in a system or a network. In many urban markets, there may be only three to five dominant hospital organizations once one accounts for system/network arrangements. Additionally, multi-hospital systems are becoming increasingly localized. Large national systems still do exist and some own several hundred hospitals, but system development primarily focused on the local level recently.

OPERATIONAL AND SERVICE INTEGRATION IN CONSOLIDATED HOSPITAL ORGANIZATIONS

Given all the structural consolidation that has occurred in the hospital industry, an important question is: how have hospital operations and service structure changed as a result? Organization researchers typically expect that some aspects of operation will change as institutions combine together under common ownership or under a common objective.

Existing research provides insights into the areas of operation and service structure that hospitals themselves expected to reorganize as they consolidated. Specifically, Bogue et al. (1995) surveyed hospitals that merged during the 1980s and Bazzoli, LoSasso, Arnould, and Shalowitz (2002) conducted a similar survey of mergers in the 1990s. In both studies, the three top reasons identified by hospitals were:

- To strengthen combined financial position of involved organizations;
- To achieve operational efficiencies by consolidating duplicative administrative and support functions;
- To consolidate clinical services that were redundant across merging hospitals.

In relation to the top reason for merging, existing research has consistently demonstrated that structural consolidation has led to higher hospital revenues and thus better financial performance. This is true of both hospital mergers and system formation (c.f., Cuellar & Gertler, 2005; Bazzoli, Dynan, Burns, & Yap, 2004).

Existing evidence about the other two objectives – streamlining duplicative functions and consolidating service lines – will be examined in the following subsections. There have been a number of studies that have shed light on these areas. Some studies have examined hospitals that have undertaken full asset merger, in which involved hospitals consolidate under one owner and one license. Other studies have examined changes implemented by hospital systems. Merger studies have examined a broader array of operational and service changes than have the hospital system studies, which largely focused on service integration.

Hospital Merger Reorganization Activities

Bogue et al. (1995) and Bazzoli et al. (2002) both examined survey data for merging hospitals to assess what reorganization activities were implemented. They focused on hospitals that had been merged for at least 2 years prior to the time of the survey because this provided time for hospitals to begin to implement their merger plans. Survey items covered a broad range of reorganization activities including consolidation of: administrative units; support functions and departments; selected clinical departments; and closure and conversion of involved institutions. Table 5 provides summary data adapted from Bazzoli et al. (2002: Table 4).

The survey data indicate that substantial administrative consolidation occurred after hospital merger – 87% of responding hospitals indicated that some type of administrative streamlining took place. In relation to support departments, the study divided various responses reflective of medical

Table 5. Operational/Service Integration and Hospital Mergers: 1990s.

Operational Change	% Implementing
Consolidate administration	87
Consolidate support depts	
medical support	26
non-medical support	21
Consolidate clinical services	
inpatient pediatrics	29
obstetrics/gynecology	32
inpatient psychiatrics	7
cardiac surgery	1
Convert service line	35
Closed a facility	7

Source: Adapted from Bazzoli et al. (2002, Table 4).

support units (such as nursing, pharmacy, laboratory services) and non-medical support (such as dietary, laundry, and housekeeping). Generally, about one in four or about one in five responding hospitals reported consolidation in these support functions after merger.

Table 5 also reports on clinical service line consolidation. The survey examined 11 different service areas, and the reported findings in Table 5 illustrate the range of survey responses obtained. Specifically, the table reports two services that had the most consolidation (i.e., inpatient pediatrics and obstetrics/gynecology), one service with a moderate level of consolidation (inpatient psychiatrics), and a final service with the least consolidation (cardiac surgery). The two services reported to have the most consolidation were ones that typically plagued hospitals with large amounts of excess capacity and peak load problems during the study period. Thus, their consolidation into one facility made good financial sense. Cardiac surgery, on the other hand, has had high profit margins and is often difficult for a facility to give up as a matter of organizational prestige or due to strong physician resistance. This most likely explains the limited amount of consolidation for this service observed among study hospitals.

Finally, in relation to closure and service conversion, a diversity of action took place. Service conversion was common with one in three mergers deciding to convert the service focus of one of the merging institutions after the transaction. Common service conversions included transition to a psychiatric or rehabilitation hospital for merging urban hospitals or transition to a long-term care facility or primary/urgent care center when one of the merging hospitals was rural. Full-scale closure of one merging hospitals with the transition of all patient care to the remaining open institution was rare, occurring for only 7% of the mergers studied.

Health System Reorganization Activities

Research examining changes in service structure among hospitals in health systems assessed whether particular service lines were centralized in one or a few system hospitals rather than being dispersed across many system affiliates. Overall, existing analysis indicates only limited activity to centralize health services within systems (Bazzoli et al., 2001). Centralization has been growing over time for some hi-tech services, such as Level 3 obstetrics care, transplant services, open heart surgery, and lithotripsy. But centralization in other services, such as long-term care, surgical, and diagnostic services, has been limited and has not changed over time.

The studies discussed above have found that hospital organizations were able to streamline administrative units and functions, such as financial management, human resources, and managed care contracting. In addition, support departments, such as nursing, pharmacy, laboratory, laundry, and housekeeping, and low-volume clinical services were combined in a significant number of cases. However, there was only limited success in broader clinical service integration among hospitals that merged and those that joined health systems. Thus, while some increases in hospital productivity and efficiency have occurred through merger and system development, large cost savings that could result through clinical service integration have not.

BARRIERS AND FACILITATORS TO CLINICAL SERVICE INTEGRATION

Some researchers have examined why certain hospitals have made headway in clinical service integration and others have not. This research is mostly based on qualitative case studies from the Center for Studying Health System Change as well as work by Shortell, Gillies, Anderson, Erickson, and Mitchell (1996). A shortcoming with qualitative research is that one cannot quantify the significance and relative contribution of various factors in explaining a given phenomenon. However, many qualitative studies have taken place and they generally reach similar conclusions about key barriers and facilitators, which adds credence to their findings. This section first examines identified barriers to clinical service integration and then facilitating factors.

Barriers to Clinical Service Integration

The primary barrier to service integration noted in existing research was the lack of buy-in among physicians and other key staff. This finding comes as no surprise given that physicians do not want their admission patterns disrupted. For example, if physicians are performing orthopedic surgery at a hospital near their offices, they do not want to travel to a farther away facility where the service has been centralized because time lost from their office translates into fewer patients seen and lower revenues.

Another barrier noted by Wicks, Meyer, and Carlyn (1998) and Eberhardt (2001) was a lack of patience among hospital executives and board members as they awaited major organizational change to be implemented. In other words, defeat may have been declared too soon, perhaps given the length of time required to win over dissenting parties and identify an acceptable resolution.

In addition, the lack of good benchmarking data has been identified as an impediment to clinical service line integration in a number of studies. The right data can be very persuasive in winning over dissenters because it can make apparent that inefficiency or poor clinical outcomes exist and that change is needed. In addition, data can be used to track progress and demonstrate that change is having a tangible effect. Often, though, organizations do not have good data to use as benchmarks nor do they have information systems in place to track their progress.

Another barrier identified by Eberhardt (2001) was community resistance, which has been a major impediment to clinical service integration among hospitals. Specifically, he found that merging hospitals in New Hampshire were on the brink of implementing wide-scale clinical service integration in which an underutilized hospital was going to be closed and patients transferred to the remaining facility that was operating. However, community representatives were more concerned about the loss of convenient access to care than achieving operational efficiencies. After regulatory intervention, the merger fell apart and the organizations eventually returned to the operational and service structures that existed pre-merger.

A final barrier to implementing clinical service integration noted in the literature is the distractive nature of short-term gains. Many hospitals that merged or formed systems suddenly discovered they had more leverage with health plans and were able to negotiate improvements in payments. While enhancing revenues, this provided reasons to abandon plans to integrate clinical services because hospital financial performance had improved without these actions.

Facilitators to Clinical Service Integration

A number of consolidated hospital organizations have been successful in integrating clinical services. A key question is: what factors set these organizations apart and may have facilitated their success? Existing research points to several specific management actions that were important. One major action identified in several studies, including Shortell et al. (1996), Kastor (2001), Shih-Jen, Chan, and Kidwell (1999), Walston, Burns, and Kimberley (2000), and Cohen, Dowling, and Gallagher (2000) was the establishment of a centralized decision-making authority that spanned the involved organizations and key clinical departments. Shortell and colleagues also noted the importance of this centralized authority developing shared values and vision that provided a clear and sensible description of the future that involved organizations could buy into.

In addition, researchers have found that there must be a commitment of staff and budget to the centralized authority. Too many times, hospital staffs are assigned to a merger task force in addition to doing their regular work activities. This approach consistently fails because it is difficult and time-consuming to develop detailed implementation strategies and identify methods to gain stakeholder buy-in.

Two additional facilitating factors noted by Shortell et al. (1996) include: the need to develop information systems that allow data sharing, especially clinical information sharing; and the development of budgeting policy and practices that promote coordination rather than continued fragmentation. These are important to ensure that organizations have mutual dependency and a sense of a shared future.

Finally, several studies talk about the importance of clear strategic communication, not only within an organization but externally. Communication is important because uncertainty can result in organizational paralysis. Shih-Jen et al. (1999) and Woodard, Fottler, and Kilpatrick (1999) noted that strategic communication was important in the mergers they studied for creating bottom-up acceptance in relation to a hospital restructuring project and for minimizing internal conflict.

RESEARCH ON THE EFFECTS OF CONSOLIDATION ON US HOSPITAL COSTS AND PRICES

Given the limited clinical service integration and the growth in market concentration that has occurred, one would expect that little efficiency and productivity gains have resulted through US hospital consolidation and also that higher hospital prices have resulted. Indeed, empirical research on US hospitals demonstrates this to be the case. In relation to hospital costs, researchers examining the effects of structural consolidation have found different results depending on whether they studied hospitals that legally merged under one license and owner or hospitals that joined multi-hospital health systems. Studies specifically examining mergers typically find some cost savings (Alexander, Halpern, & Lee, 1996; Connor, Feldman, Dowd, & Radcliff, 1997; Connor, Feldman, & Dowd, 1998; Dranove, 1998; Eberhardt, 2001; Lesser & Brewster, 2001; Spang, Bazzoli, & Arnould, 2001; US Department of Health and Human Services, 1992; Wicks et al., 1998). However, studies of hospitals joining systems have found no costs savings, or in fact observed cost increases (Clement et al., 1997; Cleverley, 1992; Dranove, Durkac, & Shanley, 1996; Dranove & Shanley, 1995). Recent research by Dranove and Lindrooth (2003) specifically contrasted cost changes after merger with those after system affiliation and their results confirm that mergers lead to efficiencies but system affiliations do not.

Even though empirical studies suggest that merging hospitals improve efficiency, these studies have found that resulting cost-savings tend to small in magnitude (Connor et al., 1997, 1998; Lesser & Brewster, 2001; Spang et al., 2001). In addition, these savings may simply represent a movement away from prior inefficiency (Alexander et al., 1996) rather than a movement towards greater efficiency when merging hospitals are compared to peer organizations in their markets. Existing research also indicates that efficiencies are limited to mergers between small hospitals and that any observed economies of scale achieved through merger are quickly exhausted as the size of involved hospitals increases (Dranove, 1998).

In addition to examining costs, several studies have examined the effects of US hospital structural consolidation on prices, revenues, and profitability. These studies have been very consistent, showing that higher prices, revenues per patient day, and profitability levels are present for consolidating hospitals when contrasted to comparable independent hospitals (Clement et al., 1997; Cleverley, 1992; Cuellar & Gertler, 2005; Dranove et al., 1996; Dranove & Shanley, 1995; Krishnan, 2001). These findings are consistent for hospitals that legally merge or join multi-hospital arrangements. A few studies by Connor et al. (1997, 1998) and Spang et al. (2001) found lower price growth among merging hospitals compared to non-merging hospitals, but only in US markets with very high pre-merger competition levels.

PROSPECTS FOR FUTURE CONSOLIDATION AND INTEGRATION IN THE US HOSPITAL INDUSTRY

There are a number of current market imperatives that necessitate the rethinking of clinical service integration within hospital organizations. Previously, the primary market imperative was the growth of managed care but this factor dissipated in the late 1990s. New forces shaping hospital system strategies in several markets include: (1) the substantial wave of US hospital construction and renovation that is currently underway; and (2) the recent development of specialty facilities in certain hospital markets.

Nationwide, many US hospital systems are engaged in renovation and construction to replace aging hospital facilities, to create amenities that patients desire (especially private rooms), and to restructure capacity so that new clinical and information technology can be utilized (Bazzoli, Gerland, & May, 2006). In some markets, hospital systems are also expanding capacity in response to increased demand for health services. These activities present interesting opportunities for hospital organizations to reconsider how to arrange services across their affiliated hospitals. Is there a way to do so that is more efficient, increases labor productivity, and leads to improved financial performance? In some US markets, hospital organizations are building new facilities in a central location to house specific services, such as cardiac care or oncology services and their plans are to move these services out of several affiliated hospitals to the central facility (Bazzoli et al., 2006). These actions will in turn free up space in existing hospital facilities for further service restructuring. For the most part, systems involved in these actions have the objective of better utilizing their available space and creating more efficient patient throughput.

A second factor in the environment that is causing hospital systems to rethink service structure is the threat of specialty facility development. There was a wave of specialty hospital development in the late 1990s and early 2000s, which has slowed given a recent federal moratorium on these facilities. However, currently there are about 100 specialty hospitals nationwide and an additional 40 that obtained approval before the moratorium took effect (General Accounting Office, 2003; Center for Medicare and Medicaid

Services, 2005). One response of existing hospital organizations in markets where specialty facilities are arising is the development of hospital-based centers of excellence or hospitals-within-hospitals. These system-developed facilities provide a means for centralizing certain hospital service lines in one place. Additionally, some hospital organizations are attempting to emulate the features of specialty hospitals within their own centers of excellence given growing evidence that patients and their families like the amenities and atmosphere of specialty hospitals (Center for Medicare and Medicaid Services, 2005).

Overall, recent actions in selected US markets suggest that hospital organizations are seeing advantages to clinical service integration given current market realities. Hopefully these recent efforts will be informed by what has been learned in the past, especially in relation to obstacles to action and factors facilitating progress. It is unclear whether these new efforts will generate efficiencies and increased productivity in US hospitals because most actions appear to be focused on growing or maintaining market share.

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CHAPTER 5

ORGANIZATIONAL STRUCTURE AND PRODUCTIVE EFFICIENCY OF NON-PROFIT HOSPITALS

Ila Semenick Alam and Gerald Granderson

1. INTRODUCTION

This chapter investigates whether signing more hospital contracts with Health Maintenance Organizations (HMOs) and Preferred Provider Organizations (PPOs), hospital affiliation in a system, having more system hospital members located in the same area, and increased competition from area hospitals, contributes to improvements in the cost efficiency of U.S. Midwestern hospitals. Hospitals may offer HMOs and PPOs discounts on contracts to provide health care services to firm employees enrolled in HMOs and PPOs (discounts would lead to smaller price mark-ups over costs for hospital services). Enacting policies to enhance cost efficiency may help hospitals maintain a specified level of profits.

A multi-hospital system consists of two or more hospitals that are owned, leased, sponsored, or contract managed, by a central organization.[1] System owners may be able to provide hospital services at lower costs by coordinating and allocating the treatment of patients across system members. Such allocations could allow system member hospitals to treat a smaller range of cases (hospital A perform heart surgeries, hospital B treats

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cancer patients, etc.). Having more system member hospitals in the same area can allow for greater hospital specialization in handling a narrower range of cases, and can lead to improvements in cost efficiency of treating patients, more profits for the system, and potentially lower prices of hospital services for consumers.[2]

The impact of system membership on hospital cost efficiency may differ based on whether the system's central organization owns, contract manages, or sponsors the hospital. In contract management, the central organization manages daily operations of either the entire hospital, or departments in the hospital. In system sponsorship, an agreement between a religious organization (system's central organization is religious organization) and a hospital helps promote the religious organization's objectives, or establishes limits on activities the sponsored hospital performs. In system ownership, the hospital CEO and employees essentially work for the central organization, thus it may be less difficult and less expensive for the central organization to enact policies to enhance hospital cost efficiency (reward hospital CEO and employees for improving cost efficiency).

System sponsored hospitals may experience smaller improvements in cost efficiency than system owned hospitals, because the central organization may not limit activities that contribute to reductions in hospital cost efficiency. Cost efficiency may improve by a smaller amount under contract management than under system ownership, because contract managing an entire hospital can be very expensive (the central organization charges the hospital a fee that exceeds the central organization's marginal cost of providing the service, but is less than the hospital's cost of developing its own policies to operate more efficiently. The hospital's benefit of operating more efficiently exceeds the cost). The chapter examines how system ownership, contract management, and system sponsorship, affect hospital cost efficiency.

The data sample is a 1996 to 1999 panel of 248 non-profit and non-federal government general medical and surgical hospitals in Illinois, Indiana, Ohio, and Wisconsin.[3] Midwestern hospitals likely face similar regulations, making it less difficult to compare hospitals across states. Separate stochastic cost frontiers are estimated for rural and urban hospitals. Empirical results show that for urban hospitals on average, signing more HMO contracts, increasing the number of hospitals in a system, and membership in multiple organizations (alliance and system) compared to membership in only a system, contributes to improvements in cost efficiency. Signing more PPO contracts, system ownership, and system contract management/sponsorship of hospitals, did not contribute to improvements in cost efficiency. For rural hospitals on average, system ownership and system contract management/sponsorship of hospitals contributed to improvements in hospital cost efficiency. Increasing the number of hospitals in a system led to a small improvement in cost efficiency. Signing more HMO and PPO contracts, and membership in multiple organizations (system and alliance), compared to membership in only a system, did not help enhance hospital cost efficiency.

The chapter is organized as follows. Section 2 reviews studies on hospital cost efficiency, and how system affiliation affects financial performance. Section 3 examines factors that influence cost efficiency. Section 4 describes the model and estimation technique. Section 5 presents the data sample. Section 6 discusses the estimation results. Section 7 concludes.

2. HOSPITAL COST EFFICIENCY, AFFILIATIONS, AND FINANCIAL PERFORMANCE

In studying cost efficiency in U.S. hospitals, Rosko (2004, 2001) and Sari (2003) found that for-profit hospitals operated more efficiently than non-profit hospitals, and that increased competition from area hospitals, along with greater HMO penetration, contributed to improvements in cost efficiency. Ferrier and Valdmanis (1996) concluded that higher occupancy rates, greater intensity of care provided, and a higher outpatient to total patient ratio, helped enhance cost efficiency.[4] Folland and Hofler (2001) reported statistically different estimates of cost efficiency when sorting hospitals (for-profit versus non-profit, teaching versus non-teaching, urban versus rural) compared to when pooling hospitals (pooling urban and rural hospitals, profit and non-profit hospitals).

In studying the relationship between organization membership (alliance, network, or system) and hospital financial performance, Bazzoli, Chan, Shortell, and D'Aunno (2000) reported that hospitals in highly centralized networks, with unified ownership, had more revenues on assets, larger profit margins, and lower expenses, than hospitals in contractually based (less centralized) networks.[5] Clement et al. (1997) found that while hospitals in alliances earned higher total revenues than hospitals not in alliances, hospitals in alliances did not operate at lower costs than hospitals not in alliances. Renn, Schramm, Watt, and Derzon (1985) reported that investor-owned chained hospitals earned more profits, had larger patient revenues per adjusted admissions, and higher general and administrative cost per adjusted admissions than non-profit chain hospitals. Becker and Sloan (1985) found little statistical difference in the total cost per adjusted admission (and total cost per adjusted patient day) between government and non-profit hospitals that were long-term members of multi-hospital systems. Fournier and Mitchell (1997) found that in Florida, the average cost of hospitals that were members of a system was less than the average cost of non-system, non-profit hospitals. Excluding Fournier and Mitchell (1997), least squares regression was used to analyze the organization membership/hospital performance relationship. This chapter examines how organization affiliation influences the cost efficiency of urban and rural hospitals.

3. FACTORS THAT INFLUENCE COST EFFICIENCY

To set up the framework for estimating cost efficiency, and factors that affect cost efficiency, we begin with the given quantities of inputs (denote x) each hospital uses. Suppose that one hospital produces its output quantities (denote y) at a lower cost than any other hospital. This one hospital would be the most cost efficient hospital. For the remaining hospitals, one could measure what total cost firms would incur if they produced their output levels as efficient as the most cost efficient firm. In other words, we focus on the percent reduction of observerable total cost (denote wx) that a firm could produce its current output levels at, if the firm operated as efficient as the most cost efficient firm. Denoting c(y,w) the firms minimum cost of producing outputs, the Farrell (1957) measure of cost efficiency (CE) is given by equation 1: $CE = c(y,w)/wx$. A cost efficiency score of one implies that the firm is cost efficient. A cost efficiency score of less than one indicates that the firm uses more than the cost minimizing input quantities to produce its observed output levels.

Changes in the variables discussed below may affect hospital cost efficiency,[6] because these variables may alter the relationship, i.e., 'function' that translates inputs into outputs. One variable that could alter how efficient hospitals produce their outputs is hospital market share. A reduction in hospital market share and profits, possibly due to increased competition from area hospitals, makes it more difficult to provide the same quantity and/or quality of health care services (non-profit hospitals providing similar or higher quality health care services helps them compete with for-profit hospitals in treating patients). Changes in the market share by enacting policies that help enhance cost efficiency could give non-profit hospitals the necessary finances to provide the same quantity/quality of health care services.

A hospital's market share of beds (denoted ms_t) equals the number of beds regularly set up and staffed for inpatient use in period t divided by the corresponding number of beds for all county general medical and surgical hospitals.[7] Theoretically, a reduction in ms_t (hospital facing more competition from area hospitals) may contribute to improvements in hospital cost efficiency (implement policies that help enhance cost efficiency to maintain a specified level of profits).

The number of contracts hospitals signed with HMOs (denote $hmoc_t$ the number of HMO contracts) and the number of contracts hospitals signed with PPOs (denote $ppoc_t$ the number of PPO contracts) may also change how efficient hospitals produce their outputs.[8] Hospitals may offer HMOs and PPOs contracts, with discounts on fees, to provide health care services to firm employees enrolled in HMOs and PPOs. Hospitals could benefit from treating more patients, and earning higher profits, after signing the contracts (fewer patients would be treated, and less profits earned, without the contracts). Managed care organizations could obtain discounts on fees (via greater bargaining power) from hospitals with low occupancy rates, since a larger portion of hospital revenues and profits may come from patients covered by the contracts. If hospitals use mark-ups over cost to price their services, then offering discounts yields smaller mark-ups. Enacting policies that contribute to improvements in cost efficiency, and lower treatment cost, can help hospitals maintain a specified level of profits. Theoretically, increases in $hmoc_t$ and $ppoc_t$ may help enhance hospital cost efficiency (enact procedures to help enhance cost efficiency).

Managed care organization enrollees who are treated by network physicians pay hospitals negotiated fees that are less than regular hospital fees. HMO enrollees treated by non-network doctors pay the regular hospital fees, while PPO enrollees treated by non-network doctors pay fees that are more than the negotiated PPO hospital fees, but less than the regular hospital fees. On average, HMO enrollees pay a lower deductible than PPO enrollees, which allows for the possibility that HMOs may obtain larger discounts (earning smaller price mark-ups over cost) on fees from hospitals than PPOs. The chapter tests whether increases in $hmoc_t$ and $ppoc_t$ have identical affects on hospital cost efficiency.

Next, having more system hospital members in the same area may help enhance hospital cost efficiency, by allowing for greater hospital specialization among each hospital in the system in treating a smaller range of cases (e.g. with 20 hospitals in the same area, 2 can specialize in performing heart surgeries, 2 can specialize in treating cancer, etc.). Treating a smaller range of cases can allow hospitals to become more efficient at providing health care services. However, coordinating and allocating patients across system member hospitals can become more difficult and expensive as more hospitals join the system. There is the possibility that the change in cost efficiency due to having an additional hospital join a system changes as the number of hospitals in the system changes (possible improvements in cost efficiency may become smaller when there are more hospitals in the system).

To test whether the change in cost efficiency from membership in a system changes as the number of hospitals in the system varies, for each hospital, denote nhs_t the number of system hospital members in the state in period t (nhs_t is zero for non-system members), and $snhs_t = nhs_t * nhs_t$. By including nhs_t and $snhs_t$ as independent variables in the cost efficiency equation, the chapter tests whether an increase in the number of hospitals operating in the same system in the same state contributes to an improvement in hospital cost efficiency.

With hospital affiliation in a system, allocating and coordinating patients across system members, and implementing policies that contribute to improvements in cost efficiency, can lead to lower production costs, and the opportunity to provide higher quality service. Hospitals owned by the system likely have the least difficulty and expense in enacting such procedures, and would likely experience the greatest improvements in efficiency. Cost efficiency may improve by a smaller amount under contract management or system sponsorship, than under system ownership, because the central organization can charge the managed or sponsored hospital a high price for providing its services, making it expensive for the hospital to operate more efficiently (also, the cost of writing a complete contract can make enhancing efficiency via system ownership less expensive than enhancing efficiency via outsourcing). The data does not identify whether the entire hospital or a department within the hospital is contract managed. Having more system owned hospitals in the data sample than contract managed or sponsored hospitals, the models in this chapter are used to test whether system ownership of hospitals helps enhance cost efficiency more than contract management or sponsorship of hospitals.

If affiliation in a system leads to greater allocation of patients across hospitals, then the hospital's mix of patients would change following system membership. Denote $cmad_t$ hospital case mix adjusted discharges (number of hospital discharges times the hospital's Medicare case mix index) in period t, $cmad_{1995}$ case mix adjusted discharges in 1995, and $abcd_t$ is defined as the absolute value of $((cmad_t - cmad_{1995})/cmad_{1995})$. If hospital cost efficiency improves (declines) following an increase in $abcd_t$, and system membership helps hospitals become more efficient in treating patients, then system member hospitals should experience larger improvements (smaller declines) in cost efficiency than non-system hospitals. In our empirical model, we also include some categorical variables. The variables own_t and csm_t equal one for hospitals that are owned (own_t) and contract managed/sponsored (csm_t) by a multi-hospital system in period t, zero otherwise. Denote the variables $owcd_t = own_t * abcd_t$ and $cscd_t = csm_t * abcd_t$. The variables own_t, csm_t, $owcd_t$, and $cscd_t$ are independent variables used to test whether system ownership and contract management/sponsorship help enhance hospital cost efficiency.

Finally, hospitals in a system may also join an alliance. Affiliation in multiple organizations (system and alliance) may or may not contribute to improvements in cost efficiency, compared to membership in only a system. To test how membership in multiple organizations affects cost efficiency, the variable sna_t is one for membership in a system and an alliance, zero otherwise. Overall, the chapter tests whether increased competition from area hospitals (reduction in ms_t), signing more HMO (increase in $hmoc_t$) and PPO (increase in $ppoc_t$) contracts, having more system hospital members serving the same area (increase in nhs_t), ownership by a multi-hospital system compared to contract management/sponsorship by a multi-hospital system, and affiliation in multiple organizations (system and alliance) compared to affiliation in only a system, helps to enhance hospital cost efficiency.

4. EMPIRICAL MODEL AND ESTIMATION TECHNIQUE

A stochastic cost frontier is estimated that allows for time-varying efficiency, following the approach developed by Battese and Coelli (1995). The specification of the empirical model and estimation technique are given in the Appendix.[9] Production cost of a hospital may also be affected by factors outside of the hospital manager's control. One such factor is a hospital's teaching status. Teaching hospitals may have higher production cost than non-teaching hospitals, because teaching hospitals may employ a wider variety of highly skilled physicians and equipment in order to treat patients and educate students.[10] A variable tea_t (one for teaching hospitals, zero otherwise) is added to the cost function to allow for potential cost differences between teaching and non-teaching hospitals.

5. DATA SAMPLE

Data for this study come from the AHA *Guide to the Health Care Field*, *Profiles of U.S. Hospitals*, *AHA Annual Survey*, *HMO/PPO Directory*, and the *Medicare Cost Report Data*. The data sample is a 1996 to 1999 panel of 248 general medical and surgical hospitals (144 urban and 104 rural) in Illinois (90), Indiana (42), Ohio (61), and Wisconsin (55). There are 51 non-federal (state, city, county, or hospital district) government hospitals and 197 non-profit hospitals, where 56 of the 248 hospitals are teaching hospitals (11 major teaching, 45 minor teaching). Outputs used in the study are the quantities of hospital surgeries performed, outpatient visits, inpatient days, and case mix adjusted discharges.[11]

Inputs used in the study are the number of full-time equivalent hospital personnel (labor measure, which excludes interns (medical and dental) and physicians), and the number of hospital beds regularly set up and staffed for inpatient use (capital measure).[12] The sum of payroll expenses and employee benefits is divided by the quantity of labor to compute the labor price.[13] The sum of hospital expenditures on buildings, fixtures, and moveable equipment (expenses for depreciation, lease, interest, insurance taxes, and other capital-related costs) are divided by the quantity of capital to compute the capital price (data to compute the cost of equity capital is not available).[14]

Summary statistics of relevant variables are presented in Table 1A for urban hospitals and Table 1B for rural hospitals. For hospitals that belong to a multi-hospital system, the average number of urban hospitals that belong to a multi-hospital system located in the same state for urban hospitals

Table 1A. Summary Statistics of Urban Hospital Variables.

Variable	Mean	Std. Dev.	Minimum	Maximum
N. Beds	214	142	20	802
N. Workers	1,090	937	86	5,577
Market Share	0.388	0.342	0.005	1.000
N. Hosp in system	2.60	3.791	0	16
N. Surgeries	7,429	6,270	175	51,591
N. Inpatient days	46,101	36,728	2,558	190,003
N. Outpatient visits	145,919	136,369	10,840	1,050,657
C. Adjust discharges	13,546	11,747	727	67,633
N. HMO Contracts	10	10	0	93
N. PPO Contracts	23	18	0	180

Table 1B. Summary Statistics of Rural Hospital Variables.

Variable	Mean	Std. Dev	Minimum	Maximum
N. Beds	93	74	16	524
N. Workers	412	325	55	1,936
Market Share	0.737	0.325	0.014	1.000
N. Hosp in system	2.938	3.918	0	16
N. Surgeries	2,982	2,449	73	13,535
N. Inpatient days	15,254	14,974	1,095	98,555
N. Outpatient visits	70,456	53,966	9,158	260,064
C. Adjust Discharges	4,110	3,902	303	28,554
N. HMO Contracts	5	6	0	44
N. PPO Contracts	15	13	0	70

N. denotes the number of, C. Adjust Discharges is hospital case mix adjusted discharges, for hospitals in a system the variable N. Hosp in system indicates the number of system hospital members located in the same state, Market share is the hospital market share, HMO contracts and PPO contracts denotes hospital contracts with HMOs and PPOs.

(2.600) is approximately equal to the corresponding number for rural hospitals (2.938). Given the similar average numbers (2.938 compared to 2.600), the impact of more system hospital members in the same area on the cost efficiency for rural hospitals may not differ from the impact of more system hospitals members located in the same area on the cost efficiency of urban hospitals. The lower average market share of beds for urban hospitals (38.81%) compared to rural hospitals (73.65%) suggests that urban hospitals compared to rural hospitals, face more competition from area hospitals in providing health care services. However, urban hospitals, on average, signed almost twice as many HMO and PPO contracts as rural hospitals. Also, the average occupancy rate for urban hospitals in the data sample (54.54%) is higher than the corresponding rate for rural hospitals in the data sample (41.94%). Tying these concepts together, more competition from area hospitals, and a higher occupancy rate, have opposite affects on the ability of HMOs and PPOs to obtain discounts from hospitals.

Hospitals with few HMO/PPO contracts, and high occupancy rates, face less pressure to offer HMOs and PPOs large discounts to obtain new contracts (a financially stable hospital does not have the most urgent need to obtain the contracts at all costs, when a small percentage of hospital revenues come from managed care contracts). However, hospitals with few HMO/PPO contracts, and low occupancy rates, face more pressure to offer HMOs and PPOs large discounts to obtain new contracts (a larger percentage of hospital revenues likely comes from the contracts). With rural hospitals signing fewer managed care contracts, facing less competition from area hospitals in treating patients (higher market share), and having lower occupancy rates, we cannot state theoretically whether HMO and PPO contracts would have a larger impact on the cost efficiency of urban hospitals compared to rural hospitals (hospital specific data on the numbers or percentages of hospital patients or revenues that come from HMO/PPO contracts is not publicly available).

Hospital costs are also influenced by the case-mix severity of the patients treated. As stated above, if hospitals in a multi-hospital system allocate patients among system members, then system members would most likely treat a narrower range of cases compared to non-system members. Treating a narrower range of cases could likely be reflected as a smaller variation in the hospital's Medicare case mix index (the Medicare case mix index can provide some information on the complexity and costliness of the mix of cases a hospital treats relative to that of an average hospital). Listed below are the standard deviation (std. dev.), coefficient of variation (std. dev./mean), and maximum minus minimum values (Max − Min), of the Medicare case mix index number for hospitals in the data sample that are and are not in a multi-hospital systems (case mix number in parentheses) (Table 2).

For urban hospitals, system members on average treated a more complex mix of Medicare patients (case mix of 1.4699) than hospitals not affiliated with a system (case mix of 1.3358). System member hospitals on average treated a slightly narrower range of Medicare patients relative to its mean (coefficient of variation is 0.1516) compared to hospitals not affiliated with a system (coefficient of variation is 0.1589). For rural hospitals, system member hospitals on average treated a more complex mix of Medicare patients (case mix of 1.2033) than hospitals not affiliated with a system (case mix of 1.1701). System member hospitals on average treated a slightly larger range of Medicare patients relative to its mean (coefficient of variation is 0.1224) compared to hospitals not affiliated with a system (coefficient of variation is 0.1076). If there is a reallocation of patients across alliance or

Table 2. Medicare Case Mix Index.

Hospital	System Member	Std. Dev.	Coeff. Var.	Max – Min
Urban	Yes (1.4699)	0.2228	0.1516	1.0465
Urban	No (1.3358)	0.2122	0.1589	1.2084
Rural	Yes (1.2033)	0.1224	0.1018	0.7627
Rural	No (1.1701)	0.1076	0.0920	0.5517

system members, the numbers suggest the possibility of greater reallocation across urban hospitals compared to rural hospitals.

Finally, hospitals in a system may also join an alliance. Affiliation in multiple organizations (system and alliance) may or may not contribute to improvements in cost efficiency, compared to membership in only a system. To test how membership in multiple organizations affects cost efficiency, the variable sna_t is one for membership in a system and an alliance, zero otherwise.

Overall, chapter tests whether increased competition from area hospitals (reduction in ms_t), signing more HMO (increase in $hmoc_t$) and PPO (increase in $ppoc_t$) contracts, having more system hospital members serving the same area (increase in nhs_t), ownership by a multi-hospital system compared to contract management/sponsorship by a multi-hospital system, and affiliation in multiple organizations (system and alliance) compared to affiliation in only a system, helps to enhance hospital cost efficiency.

6. ESTIMATION RESULTS

6.1. Cost Function Results[15]

We first examine whether urban and rural hospitals can be modeled together in order to arrive at a single frontier facing all hospitals. This is done via a Chow test that is used to test the null hypothesis of pooling the data (estimating a single cost frontier model) compared to sorting the data (estimating separate rural and urban cost frontiers). The null hypothesis that estimating a single cost frontier model is more appropriate is stating that the parameters in Eqs. (A.2) and (A.3) are identical for urban and rural hospitals. The alternative hypothesis that estimating separate frontiers for urban and rural hospitals is more appropriate is stating that the parameters in Eqs. (A.2) and (A.3) for rural hospitals are different from the corresponding parameters for urban hospitals. A rejection of the null hypothesis (χ^2 test statistic of 133.620, χ^2 critical is 43.773 at the 95% confidence level) indicates that the more appropriate empirical procedure is to estimate separate rural and urban stochastic cost frontiers.

The empirical results described below are obtained from estimating separate translog cost frontiers for urban and rural hospitals. Both the estimated rural hospital cost function, and the estimated urban hospital cost function satisfy important modeling criteria (monotonicity in outputs, as well as monotonicity and concavity in input prices).[16] The next hypothesis tested for urban and rural hospitals is whether a simpler functional form of the cost frontier specified in Eq. (A.2) can more accurately describe how changes in outputs, input prices, and time, affects production cost. The null hypothesis is that the simpler functional form, where the parameters on all squared and interaction terms equal zero ($\beta_{vv} = \beta_{pp} = \beta_{dd} = \beta_{ss} = \beta_{vl} = \beta_{pl} = \beta_{dl} = \beta_{sl} = \varphi_{tt} = \varphi_{tl} = \varphi_{ll} = 0$) can more accurately characterize the cost frontier.[17] The functional form under the null hypothesis is called the Cobb-Douglas functional form. A rejection of the null hypothesis for urban (χ^2 test statistic of 200.480) and rural (χ^2 test statistic of 88.354) hospitals (χ^2 critical is 19.675 at 95% confidence level) indicates that for rural and urban hospitals, the Cobb-Douglas functional form does not accurately characterize the cost frontier.

Using the estimated coefficients from the rural (Table 5) and urban (Table 4) cost frontiers, we compute the derivatives of log cost[18] with respect to time and the various outputs. Evaluated at the sample mean, the derivative $\partial \ln C / \partial t = -0.0169$ for urban hospitals indicates that urban hospitals on average experienced lower costs in treating patients over time, from improvements in the state of technology in providing health care services. The derivative $\partial \ln C / \partial t = 0.0162$ for rural hospitals suggests that on average, rural hospitals did not experience lower costs in treating patients over time from improvements in the state of technology. This result for rural hospitals, compared to urban hospitals, is consistent with Reardon's (1996) theory that urban hospitals likely have more access to advances in technology than rural hospitals.

Computing the derivative of cost with respect to each output variable (y_v for outpatient visits, y_p for inpatient days, y_d for discharges, and y_s for surgeries) reveals the percent change in cost due to a 1% change in the output level. Based on the types of care provided, we find that urban hospitals experience a larger percent increase in cost following a 1% increase in the quantities of outpatient visits (0.1725%) than rural hospitals (0.1108%). Conversely, rural hospitals experience a larger percent increase in cost following a 1% increase in the number of surgeries performed (0.1689%) than urban hospitals (0.0173%).

In the urban regression, the coefficient on tea_t ($\alpha_1 = 0.0036$) is not statistically significant at the 95% confidence level. When estimating Eqs. (A.2) and (A.3) for urban hospitals where separate dummy variables are used for major and minor teaching hospitals, the parameter estimate for each dummy variable (0.0762 for major and 0.0187 for minor) is not statistically significant.[19] Using the usual statistical approach, we find that the likelihood ratio test rejects the null hypothesis that the coefficients on the major and minor teaching dummy variables are equal. These results suggest that the cost of treating patients at major teaching hospitals is statistically different from the corresponding cost at minor teaching hospitals, and that the cost of treating patients at major or minor hospitals does not appear to be statistically higher than the cost of treating patients at non-teaching hospitals.

Conversely, the statistically significant coefficient on tea_t ($\alpha_1 = -0.0787$) in the rural regression indicates that for rural hospitals, the cost of treating patients at minor teaching hospitals is statistically lower than the treatment costs at non-teaching hospitals. Rural teaching hospitals likely have greater access to advances in technology in treating patients than rural non-teaching hospitals. Also, there are likely to be few small rural teaching hospitals in any given area. Rural teaching hospitals may have more opportunities, than rural non-teaching hospitals, to use more technologically advanced procedures to treat patients. The use of more advanced treatment procedures on a more frequent basis could lead to lower hospital costs for rural teaching hospitals compared to rural non-teaching hospitals.

6.2. Cost Efficiency Scores and Non-Organization Cost Efficiency Results

Mean cost efficiency scores listed in Table 3 show that rural and urban hospitals on average experienced steady reductions in cost efficiency. The rising standard deviation of cost efficiency scores over time suggests that the more cost inefficient hospitals were moving away from the more cost efficient hospitals.

In discussing parameter estimates from the urban (Table 6) and rural (Table 7) cost efficiency equations, a negative (positive) coefficient implies that cost efficiency increases (decreases) with a unit increase in the variable.[20] The statistically significant coefficient on $ms_{k,t}$ in the urban ($\gamma_2 = 0.1089$) and rural ($\gamma_2 = 0.0814$) regressions indicates that for urban and rural hospitals, a reduction in firm market share contributed to an

Table 3. Mean Cost Efficiency Scores for Urban and Rural Hospitals.

Year	Urban Hospitals		Rural Hospitals	
	Mean	Std. dev.	Mean	Std. dev.
1996	0.9645	0.0357	0.9121	0.0404
1997	0.9511	0.0448	0.9117	0.0417
1998	0.9395	0.0491	0.9081	0.0472
1999	0.9215	0.0573	0.9048	0.0476

Table 4. Urban Cost Function Parameter Estimates (Standard Errors in Parentheses).

Parameter	Estimate	(Std. Error)	Parameter	Estimate	(Std. Error)
β_o	−0.3224	0.9665	β_{dl}	0.0443	0.0468
β_v	0.7756	0.2056*	β_{sl}	0.0555	0.0285*
β_p	0.4904	0.3042	φ_t	−0.0175	0.0313
β_d	−0.6061	0.2952*	φ_{tt}	−0.0001	0.0119
β_s	−0.4363	0.1445*	φ_{tl}	0.0013	0.0098
β_{vv}	−0.0500	0.0172*	ρ_l	1.0027	0.1693*
β_{pp}	−0.0069	0.0301	ρ_{ll}	0.0716	0.0114*
β_{dd}	0.1027	0.0328*	α_1	0.0036	0.0156
β_{ss}	0.0495	0.0173*	Gamma	0.0342	0.0145*
β_{vl}	−0.0476	0.0268*	Sig. square	0.0181	0.0012*
β_{pl}	−0.0553	0.0438	Log likelihood		339.854

v = outpatient visits, p = inpatient days, d = discharges, s = surgeries, t = time, l = labor, α_1 for teaching hospital. Sig square = sigma squared.
*Significant at the 10% level.

Table 5. Rural Cost Function Parameter Estimates (Standard Errors in Parentheses).

Parameter	Estimate	(Std. Error)	Parameter	Estimate	(Std. Error)
β_o	4.9551	1.0271*	β_{dl}	0.2061	0.1134*
β_v	−0.4995	0.2431*	β_{sl}	−0.0870	0.0381*
β_p	0.9655	0.4308*	φ_t	0.0832	0.0372*
β_d	−1.2545	0.4689*	φ_{tt}	−0.0289	0.0142*
β_s	0.1150	0.1955	φ_{tl}	0.0088	0.0129
β_{vv}	0.0543	0.0219*	ρ_l	0.7581	0.2704*
β_{pp}	−0.0619	0.0431	ρ_{ll}	0.0047	0.0492
β_{dd}	0.1775	0.0530*	α_1	−0.0787	0.0294*
β_{ss}	0.0071	0.0239	Gamma	0.1349	0.0823*
β_{vl}	0.0288	0.0382	Sig. square	0.0197	0.0015*
β_{pl}	−0.1322	0.0856	Log likelihood		236.627

v = outpatient visits, p = inpatient days, d = discharges, s = surgeries, t = time, l = labor, α_1 for teaching hospital.Sig square = sigma squared.
*Significant at the 10% level.

improvement in hospital cost efficiency. These results are consistent with the theory that declining firm market shares are likely followed by reductions in firm profits. Hospitals would have an incentive to enhance cost efficiency to earn a specified level of profits.

Table 6. Urban Cost Efficiency Equation Parameter Estimates.

Variable	Parameter	Estimate	Standard Error
Constant	γ_0	−0.0459	0.0279*
Time (t)	γ_1	0.0255	0.0079*
Market share (ms)	γ_2	0.1089	0.0250*
HMO Con. (hmoc)	γ_3	−0.0044	0.0007*
PPO Con. (ppoc)	γ_4	0.0001	0.0002
N. hospital sys (nhs)	γ_5	−0.0010	0.0007
Change cmix (abcd)	γ_6	−0.1046	0.0660
Own	γ_7	0.1003	0.0266*
Own cmix (owcd)	γ_8	−0.0753	0.0766
Cmspon (csm)	γ_9	0.1221	0.0309*
Cmspon cmix (cscd)	γ_{10}	0.1185	0.0527*
Multiple org. (sna)	γ_{11}	−0.0614	0.0260*
N. sys hos2 (snhs)	γ_{12}	−0.0009	0.0002*

N. hospital sys = number of hospitals in system, N. sys hos2 = nhs*nhs, Change cmix = percent change in case mix adjusted discharges, Own cmix = own times Change cmix, Cmspon = contract managed/sponsored, Cmspon cmix = Cmspon times Change mix.
* Significant at the 10% level.

Table 7. Rural Cost Efficiency Equation Parameter Estimates.

Variable	Parameter	Estimate	Standard Error
Constant	γ_0	0.0220	0.0666
Time (t)	γ_1	0.0060	0.0211
Market share (ms)	γ_2	0.0814	0.0323*
HMO Con. (hmoc)	γ_3	0.0012	0.0014
PPO Con. (ppoc)	γ_4	0.0005	0.0007
N. hospital sys (nhs)	γ_5	−0.0024	0.0010*
Change cmix (abcd)	γ_6	−0.2492	0.1092*
Own	γ_7	−0.0623	0.0297*
Own cmix (owcd)	γ_8	0.0496	0.0593
Cmspon (csm)	γ_9	−0.1078	0.0377*
Cmspon cmix (cscd)	γ_{10}	−0.0059	0.0811
Multiple org. (sna)	γ_{11}	0.0823	0.0292*
N. sys hos2 (snhs)	γ_{12}	0.0008	0.0002*

N. hospital sys = number of hospitals in system, N. sys hos2 = nhs*nhs, Change cmix = percent change in case mix adjusted discharges, Own cmix = own times Change cmix, Cmspon = contract managed/sponsored, Cmspon cmix = Cmspon times Change mix.
*Significant at the 10% level.

In the rural regression, the parameter estimates on $hmoc_{k,t}$ ($\alpha_3 = 0.0012$) and $ppoc_{k,t}$ ($\alpha_4 = 0.0005$) are not statistically significant at the 95% confidence level. A likelihood ratio test rejects the null hypothesis $\alpha_3 = \alpha_4$ (χ^2 test statistic = 11.620, χ^2 critical is 5.991) at the 95% confidence level. These test results suggest that for rural hospitals on average (i) HMO and PPO contracts have different influences on cost efficiency ($\gamma_3 \neq \gamma_4$), and (ii) signing more HMO and PPO contracts did not contribute statistically to improvements in hospital cost efficiency. If rural hospitals on average have high occupancy rates before signing the contracts, then a large portion of hospital revenues would not necessarily come from HMO and PPO contracts (in the data sample, for rural hospitals that signed HMO or PPO contracts, the correlation coefficient between the total number of signed contracts and the hospital's occupancy rate is −0.02895 (not statistically different from zero)). The HMOs and PPOs may not have been very successful in obtaining discounts on fees from rural hospitals. If rural hospitals did not experience major financial constraints from signing the contracts, they would not necessarily need to enact policies that greatly enhance cost efficiency in order to maintain a specified level of profits.

In the urban regression, the coefficient on $hmoc_{k,t}$ ($\gamma_3 = -0.0044$) is statistically significant at the 95% confidence level, whereas the coefficient on $ppoc_{k,t}$ ($\gamma_4 = 0.0001$) is not statistically significant. A likelihood ratio test rejects the null hypothesis $\gamma_3 = \gamma_4$ (χ^2 test statistic = 26.324, χ^2 critical is 5.991) at the 95% confidence level. These test results suggest that for urban hospitals (i) HMO and PPO contracts have different influences on cost efficiency ($\gamma_3 \neq \gamma_4$), (ii) signing more HMO contracts contributed statistically to improvements in hospital cost efficiency, and (iii) signing more PPO contracts did not contribute statistically to improvements in cost efficiency. In the data sample, for urban hospitals that signed HMO or PPO contracts, the correlation coefficient between the total number of signed contracts and the hospital's occupancy rate is 0.39475 (statistically different from zero).

If urban hospitals have low occupancy rates before signing the contracts, then a large portion of hospital revenues could come from HMO and PPO contracts. The statistically insignificant coefficient on $ppoc_{k,t}$, and the higher average deductible paid by PPO enrollees, lend support to the possibility that hospitals offered PPOs smaller discounts than HMOs. Hospitals that offer HMOs larger discounts to sign contracts, and that have a large portion of revenues coming from HMO and PPO contracts, would have more of an incentive to enact policies that enhance cost efficiency in order to maintain a specified level of profits.

6.3. Urban Hospital Organizational Affiliation Results

Coefficients on the dummy variables own_t ($\gamma_7 = 0.1003$), contract manage/sponsor (variable csm_t, $\gamma_9 = 0.1221$), and the interaction term involving contract manage/sponsor and the case mix adjusted discharges (variable $cscd_t$, $\gamma_{10} = 0.1185$) are statistically significant at the 95% confidence level. The coefficient on the interaction term involving own and case mix adjusted discharges (variable $owcd_t$, $\gamma_8 = -0.0753$) is not statistically significant. A rejection of the null hypothesis $\gamma_7 = \gamma_8 = \gamma_9 = \gamma_{10} = 0$ (χ^2 statistic of 32.502, χ^2 critical of 9.448) suggests that ownership and/or contract management/sponsorship of hospitals in a multi-hospital system affected hospital cost efficiency.

Evaluated at the sample mean, the derivatives $\partial u_{k,t}/\partial own_{k,t} = \gamma_7 + \gamma_8 abcd_{k,t} = 0.0915$, and $\partial u_{k,t}/\partial csm_{k,t} = \gamma_9 + \gamma_{10} abcd_{k,t} = 0.1359$, are statistically significant at the 95% confidence level. Also, likelihood ratio tests rejects the null hypotheses $\gamma_7 = \gamma_8 = 0$ (hospital ownership by system influences efficiency, χ^2 statistic of 15.300) and $\gamma_9 = \gamma_{10} = 0$ (hospital contract management/sponsorship by system influences efficiency, χ^2 statistic of 30.878) at the 95% confidence level (χ^2 critical of 5.991). These test results suggest that for the urban hospitals, ownership and contract management/sponsorship by a multi-hospital system contributed to increases in hospital cost efficiency. The derivative $\partial u_{k,t}/\partial nhs_{k,t} = \gamma_5 + 2\gamma_{12} nhs_{k,t} = -0.0033$, statistically significant at the 95% confidence level, and a rejection (via the likelihood ratio test) of the null hypothesis $\gamma_5 = \gamma_{12} = 0$, show that for urban hospitals having more hospitals join a system helped to enhance hospital cost efficiency. Having more hospitals in a system may have helped hospitals become more effective at coordinating and allocating patients across system members. If system member hospitals became more specialized at treating a narrower range of patients, then the increased specialization may have contributed to improvements in hospital cost efficiency. Finally, the statistically significant coefficient on the variable sna_t ($\gamma_{11} = -0.0614$) indicates that for urban hospitals, membership in a multi-hospital system and an alliance (or membership in all three organizations) helped to enhance hospital cost efficiency.

The average cost efficiency scores of system owned urban hospitals (44 hospitals) and system contract managed/sponsored urban hospitals (21 hospitals) are 0.9477 (owned) and 0.9231 (contract managed/sponsored), respectively. The average cost efficiency score of the 27 urban hospitals who are only members of a system (not affiliated with an alliance or network) is 0.9310. The average cost efficiency score of the 20 urban hospitals who are members of both a system and an alliance (may also be affiliated with a network) is 0.9389. The Mann-Whitney non-parametric test is performed to examine whether there are statistical differences in cost efficiency scores between (i) system ownership compared to system contract management/sponsorship, and (ii) joining only a system compared to joining a system and an alliance for urban hospitals in our sample. A brief description of the Mann-Whitney test, and how the test is performed, are included in the appendix.

Employing a bootstrap option to adjust *p*-values via resampling (60,000 times), the null hypothesis $\mu_1 = \mu_2$ is rejected at the 95% confidence level. On the basis of the statistically significant Mann-Whitney test, we find that system owned urban hospitals operated more cost efficiently than system contract managed/sponsored urban hospitals. Regarding membership in multiple organizations, urban hospitals that are members of an alliance and a system operated slightly, but not at statistically significant levels, more cost efficient than urban hospitals that were only members of a system.

6.4. Rural Hospital Organizational Affiliation Results

Coefficients on the dummy variables own_t ($\gamma_7 = -0.0623$) and contract manage/sponsor (variable csm_t, $\gamma_9 = -0.1078$) are statistically significant at the 95% confidence level. Coefficients on the interaction term involving own and case mix adjusted discharges (variable owcd_t, $\gamma_8 = 0.0496$), and the interaction term involving contract manage/sponsor and the case mix adjusted discharges (variable cscd_t, $\gamma_{10} = -0.0059$) are not statistically significant at the 95% confidence level. A rejection of the null hypothesis $\gamma_7 = \gamma_8 = \gamma_9 = \gamma_{10} = 0$ (χ^2 statistic of 14.228, χ^2 critical of 9.448) suggests that ownership and/or contract management/sponsorship of hospitals in a multi-hospital system affected hospital cost efficiency.

Evaluating the derivative of $u_{k,t}$ with respect to the ownership variable ($\text{own}_{k,t}$) and the contract management/sponsorship variable ($\text{csm}_{k,t}$) variables at the sample mean, we find that for our sample rural hospitals ownership (derivative $= -0.0573$) and contract management/sponsorship (derivative $= -0.1084$) by a multi-hospital system contributed to improvements in hospital cost efficiency (both derivatives are statistically significant at the 95% confidence level).

Using statistical testing, our results indicate that for rural hospitals having more hospitals join a system contribute a small improvement in hospital cost efficiency (derivative of $u_{k,t}$ with respect to $\text{nhs}_{k,t} = -0.0001$, not statistically significant). Having more hospitals in a system may have helped hospitals become more effective at coordinating and allocating patients across system members. This premise is true if system member hospitals became more specialized at treating a narrower range of patients, then the increased specialization may have contributed to improvements in hospital cost efficiency.

Finally, the statistically significant coefficient on the variable sna_t ($\gamma_{11} = 0.0823$) indicates that for rural hospitals, membership in a multi-hospital system and a network or alliance (or membership in all three organizations) contributed to a reduction in hospital cost efficiency. The positive estimate may hint at the possibility that the more cost inefficient hospitals may have joined multiple organizations with the hope that affiliation in multiple organizations may provide hospitals with more ways to improve cost efficiency.

The average cost efficiency scores of system rural urban hospitals (24 hospitals) and system contract managed/sponsored rural hospitals (25 hospitals) are 0.9117 (owned) and 0.9319 (contract managed/sponsored), respectively. The average cost efficiency score of the 30 rural hospitals who are only members of a system (not affiliated with an alliance or network) is 0.9373. The average cost efficiency score of the 10 rural hospitals who are members of both a system and an alliance (may also be affiliated with a network) is 0.8942. The Mann-Whitney non-parametric test described in the appendix was performed to examine for rural hospitals the null hypotheses $\mu_1 = \mu_2$ (no statistical difference in cost efficiency between ownership and contract management/sponsorship) against the alternative hypotheses $\mu_1 \neq \mu_2$, and the null hypothesis $\mu_3 = \mu_4$ (no statistical difference in cost efficiency between hospital membership in only a system compared to hospital membership in multiple organizations (system and alliance)), against the alternative hypothesis $\mu_3 \neq \mu_4$.

Employing the same bootstrap option as described in the appendix, the null hypothesis $\mu_1 = \mu_2$ is rejected at the 95% confidence level. The average cost efficiency scores, and the Mann-Whitney test result, suggest that statistically, system contract managed/sponsored rural hospitals operated more cost efficient than system owned rural hospitals. The null hypothesis $\mu_3 = \mu_4$ is rejected at the 95% confidence level. The average cost efficiency scores and the Mann-Whitney test results suggest that statistically, rural hospitals that are members of an alliance and a system operated less cost efficient than rural hospitals that were only members of a system.

Finally, note that in the urban (Table 6) and rural (Table 7) efficiency equation regression results, the coefficient on the variable $abcd_t$ (percent change in case mix adjusted discharges) is negative ($\gamma_6 = -0.1046$ for urban hospitals, $\gamma_6 = -0.2492$ for rural hospitals). None of the parameter estimates on the variables owcd_t (dummy variable own_t interacted with abcd_t, parameter γ_8) and cscd_t (dummy variable csm_t interacted with abcd_t, parameter γ_{10}) are negative and statistically significant (for urban hospitals $\gamma_8 = -0.0753$ and $\gamma_{10} = 0.1185$, for rural hospitals $\gamma_8 = 0.0496$ and $\gamma_{10} = -0.0059$). Also, for rural and urban hospitals, there is insufficient evidence to reject the null hypothesis $\gamma_8 = \gamma_{10} = 0$ at the 95% confidence level. These test results appear to indicate that a change in the mix of patients treated (change in variable abcd_t) contributes to an improvement in hospital cost efficiency, then being owned or contract managed/sponsored by a multi-hospital system did not lead to an even greater improvement in cost efficiency. Thus, if membership in a multi-hospital system contributed to lower costs of treating patients, the cost reductions may come more from allocating costs across system members, and less from increased specialization (in treating a narrower range of patients) that may occur from allocating patients across system members.

7. CONCLUSIONS

This chapter examined how ownership by a multi-hospital system affected hospital cost efficiency compared to contract management or sponsorship by a multi-hospital system. The chapter also examined how having more hospitals in a system, and hospitals signing more HMO and PPO contracts, impacted hospital cost efficiency. The data sample was a 1996 to 1999 panel of 248 non-profit and non-federal government general medical and surgical hospitals in Illinois, Indiana, Ohio, and Wisconsin. Separate stochastic cost frontiers were estimated for rural and urban hospitals.

Empirical results showed that for urban hospitals in our sample, signing more HMO contracts, increasing the number of hospitals in a system, and affiliation in multiple organizations (alliance and system), compared to membership in only a system, contributed to improvements in cost efficiency. Signing more PPO contracts, system ownership, and system contract management/sponsorship of hospitals, did not contribute to improvements in cost efficiency. For rural hospitals in our sample, system ownership and system contract management/sponsorship of hospitals contributed to improvements in hospital cost efficiency. Increasing the number of hospitals in a system led to a small improvement in cost efficiency. Signing more HMO and PPO contracts, and membership in multiple organizations (system and alliance), compared to membership in only a system, did not help enhance hospital cost efficiency.

NOTES

1. The number of U.S. multi-hospital systems (number of general medical and surgical hospitals in parentheses) increased from 256 systems (containing 1,877 hospitals) in 1980 to 319 systems (containing 2,738 hospitals) in 2003. From 1995 to 2001, over 50% of the hospitals in multi-hospital systems were non-profit hospitals. The chapter excludes a discussion of systems leasing hospitals because there are no leased hospitals in the data sample. Definitions of multi-hospital systems, contract management, and sponsorship of hospitals, come from the American Hospital Association's (AHA) Guide to the Health Care Field (2000 edition).

2. Given the physical limitations with such coordination, and other factors, allocating patients across hospital system members is profitable only if the marginal revenue from such allocation equals or exceeds the marginal cost.

3. For-profit hospitals were excluded from the sample because (i) there were few for-profit general medical and surgical hospitals in the region, and (ii) many of the for-profit hospitals had missing observations over the sample period.

4. Rosko (2004, 2001) analyzed urban hospitals, while Ferrier and Valdmanis (1996) focused on rural hospitals in Arkansas, Louisiana, Oklahoma, and Texas.

5. An alliance is an organization, usually owned by shareholders/members that works on behalf of its members to provide services and products, and to promote activities and ventures. The alliance functions under bylaws or written rules that each member agrees to abide by. A network is a group of hospitals, physicians, other providers, insurers, and/or community agencies that work together to coordinate and deliver a broad spectrum of services to their community. The descriptions of the alliance and network come from the 2000 edition of the AHA Guide to the Health Care Field.

6. Firms benefit from implementing procedures that help enhance cost efficiency when the marginal revenue from enacting such procedures equals or exceeds the marginal cost.

7. Sari (2003) and Rosko (2004) computed measures of competition with area hospitals based on the county a hospital was located in.

8. Firm specific data on the quantity (or percentage) of hospital patients or revenues covered by HMO and PPO contracts are not publicly available.

9. Interested readers can review the econometrics used in this chapter provided in the Appendix. Other readers can skip this econometrics discussion without losing understanding in the implications.

10. As defined by the Profiles of U.S. Hospitals, major teaching hospitals are members of the Council of Teaching Hospitals (COTH). Minor teaching hospitals have at least one intern and resident, but are not members of COTH. Non-teaching hospitals have no intern or resident, and are not members of COTH. Having major and minor teaching hospitals in the urban data sample, and only minor teaching hospitals in the rural sample, the chapter does not distinguish between major and minor teaching hospitals (estimating the same model for both samples).

11. The outputs and inputs in the chapter are measures that have been used in previous studies.

12. Information from the various data sources are not sufficiently detailed to (i) allocate labor and capital among specific hospital services, such as intensive care

units or surgeries, or (ii) obtain information on the quantities of materials, supplies, and the different types of capital (X-ray machines, scanning equipment, etc.) hospitals use. Thus, we could not compute input quantities and prices of materials, supplies, or the different types of capital.

13. The average wage rate (excluding benefits) and benefit per worker varies by state. States with the highest average wage rate per worker also have the highest average benefit per worker (leading to variations in the labor price across states).

14. Hospital beds, wheel chairs, and IV pumps are examples of (categorized as) moveable equipment, while X-ray machines and MRI units are examples of (categorized as) buildings and fixtures. The AHA Guide is used to compute the quantity of capital, while the Medicare Cost Report is used to obtain hospital expenses on buildings, fixtures, and moveable equipment. For consistency in computing the price and quantity of capital, hospital expenses on depreciation, lease, interest, and other expenses from the Medicare Report are divided by total operating and non-operating expenses from the Medicare Report. Multiplying this ratio by the total operating and non-operating expenses from the AHA Guide yields total capital expenses on buildings, fixtures, and moveable equipment. Payroll expenses and the quantity of labor come from the AHA Guide.

15. A description of how the cost frontier is estimated, and some hypotheses that are tested regarding the cost frontier, are stated in the appendix.

16. The estimated rural cost function satisfies monotonicity in every output for 97% of the sample observations, and monotonicity and concavity in input prices for every observation. The estimated urban cost function satisfies monotoniticy and concavity in input prices for 99% of the sample observations, and monotonicity in three of the four outputs for 99% of the sample observations (monotonicity in the fourth output is satisfied for 75% of the sample observations).

17. The beta parameters have the following subscripts: v for outpatient visits, p for inpatient days, d for case mix adjusted discharges, s for surgeries, t for time, and l for the labor price.

18. The logarithms of costs are taken since hospital costs do not follow a normal distribution.

19. There are more minor teaching hospitals than urban teaching hospitals in the data sample.

20. The estimation package assigns a cost efficiency score of one (larger than one) to the most efficient firm (inefficient firms). Larger cost efficiency scores correspond to more cost inefficient firms.

21. Having four output variables (y), two input price variables (w), and a time trend (t), contributed to multicollinearity problems; thus the output variables were not interacted with the time trend.

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APPENDIX

Using econometric techniques, we estimate a model that analyzes how various factors affect both total cost, and how the variables described above affects the deviation of hospital total cost from total cost minimization (i.e., the best practice frontier). We take the log of costs since hospital costs are typically not normally distributed and by taking the log, we can normalize the distribution which is necessary for modeling purposes.

Factors that affect log cost directly, but may not contribute to the deviation of total cost from minimum total cost are outputs, inputs, input prices, the teaching variable, and a time trend (t) that allows for measuring the change in cost over time due to changes in the state of technology. These variables affect the cost function. The functional form of the cost function that is estimated is given by Eq. (A.2). This specification is referred to as a translog cost function, developed by Christensen, Jorgenson, and Lau (1971).[21]

A non-negative (value of zero or positive) random variable $u_{k,t}$ (for hospital k in time period t) is incorporated to measure the systematic (consistent) deviation of hospital total cost from minimum total cost due to cost inefficiency (the firm not operating as cost efficient as possible). The value of $u_{k,t}$ itself is difficult to measure. Not being able to observe $u_{k,t}$ itself, one variable that we try to estimate to describe the distribution of $u_{k,t}$ is the mean of $u_{k,t}$ (denote the mean $h_{k,t}$). The variable $h_{k,t}$ helps to identify the 'distance' to the minimum cost frontier that is attributed to environmental and market factors. The variables discussed above that affect cost efficiency (numbers of HMO and PPO contracts, hospital market share, numbers of hospitals in system, membership in multiple organizations, system ownership, contract management/sponsorship) are variables that are hypothesized to impact $h_{k,t}$. The functional form that is used to examine how the variables in parentheses affects $h_{k,t}$ is defined in Eq. (A.3).

$$\begin{aligned}\ln C = {} & \beta o + \Sigma\beta_m(\ln y_m) + (1/2)\Sigma\Sigma\beta_{mp}(\ln y_m)(\ln y_p) \\ & + \Sigma\Sigma\beta_{mi}(\ln y_m)(\ln w_i) + \varphi_t(t) + (1/2)\varphi_{tt}(t)^2 \\ & + \Sigma\varphi_{ti}t(\ln w_i) + \Sigma\rho_i(\ln w_i) + (1/2)\Sigma\Sigma\rho_{ij}(\ln w_i)(\ln w_j) \\ & + \alpha_1 tea_t + v_{k,t} + u_{k,t}\end{aligned} \tag{A.2}$$

$$\begin{aligned}h_{k,t} = {} & \gamma_0 + \gamma_1 t + \gamma_2 ms_{k,t} + \gamma_3 hmoc_{k,t} \\ & + \gamma_4 ppoc_{k,t} + \gamma_5 nhs_{k,t} + \gamma_6 abcd_{k,t} \\ & + \gamma_7 own_{k,t} + \gamma_8 owcd_{k,t} + \gamma_9 csm_{k,t} \\ & + \gamma_{10} cscd_{k,t,} + \gamma_{11} sna_{k,t} + \gamma_{12} snhs_{k,t}\end{aligned} \tag{A.3}$$

with subscripts i, j = {l, c} representing the labor (l) and capital inputs (c). Specifically, for econometric purposes, we performed the following procedure. Parameters in Eqs. (A.2) and (A.3) are estimated simultaneously, with linear homogeneity of the cost function in input prices imposed by normalizing the cost function with respect to the price of capital. Estimated cost efficiency scores are equal to $\exp(-u_{k,t}\hat{})$, where $u_{k,t}\hat{}$ is the predicted value of $u_{k,t}$.

DESCRIPTION OF THE COST FRONTIER AND HYPOTHESIS TESTS

Let $k = 1$ to N and $t = 1$ to T denote the firm (k) and time period (t), respectively. The model has a normally distributed purely random error term $v_{k,t}$ (mean zero, variance σ_v^2), and an error term $u_{k,t}$ (mean $h_{k,t} = z_{k,t}\gamma$, variance $\sigma_u^2) \geqslant 0$ accounting for inefficiency, where $z_{k,t}$ and γ are vectors of variables that affect cost efficiency ($z_{k,t}$), and parameters to be estimated (γ). The error term $u_{k,t}$ is assumed to follow a truncated (at zero) normal distribution. The Frontier package version 4.1 by Tim Coelli (1996) is used to estimate the stochastic cost frontier. Parameter estimates in the tables are used to test several hypotheses via the likelihood ratio test.

We estimate only the cost frontier in Eq. (A.2), specifying truncated normal and half-normal distributions for the cost inefficiency error term $u_{k,t}$, to test the null hypothesis that $u_{k,t}$ can be more accurately characterized via a truncated half-normal distribution. A rejection of the null hypothesis for urban (χ^2 test statistic of 29.278) and rural (χ^2 test statistic of 28.002) hospitals (χ^2 critical of 3.841 at 95% confidence level) indicates that $u_{k,t}$ is more accurately characterized as following a truncated normal distribution. A rejection of the null hypothesis that the parameters γ_2 through γ_{12} in the cost efficiency equation all are zero for urban (χ^2 test statistic of 56.860) and rural (χ^2 test statistic of 33.166) hospitals (χ^2 critical is 19.675 at 95% confidence) shows that, excluding the time trend, the remaining exogenous cost efficiency equation variables as a group have a statistically significant affect on $u_{k,t}$.

BRIEF DESCRIPTION OF HOW THE MANN-WHITNEY TEST IS PERFORMED

Let group S_1 consist of system owned urban hospitals, and group S_2 consist of system contract managed/sponsored urban hospitals. Denote S_1 (S_{11}, S_{12}, …, S_{p1}) and S_2 (S_{21}, S_{22}, …, S_{p2}) populations with means μ_1 (S_1) and μ_2 (S_2), respectively. The null hypothesis $\mu_1 = \mu_2$ (no statistical difference in cost efficiency between ownership and contract management/sponsorship) is tested against the alternative hypothesis $\mu_1 \neq \mu_2$ (statistical difference in cost efficiency between ownership and contract management/sponsorship). A second null hypothesis $\mu_3 = \mu_4$ (no statistical difference in cost efficiency between hospital membership in only a system compared to hospital membership in multiple organizations (system and alliance)) is tested against the alternative hypothesis $\mu_3 \neq \mu_4$ (statistical difference in cost efficiency between hospital membership in only a system compared to hospital membership in multiple organizations (system and alliance). A SAS estimation procedure uses a *t*-test to perform the Mann-Whitney test of each null hypothesis. In the estimation procedure, a bootstrap option is employed to adjust the *p*-values via resampling (60,000 times).

CHAPTER 6

INNOVATIONS AND PRODUCTIVITY: AN EMPIRICAL INVESTIGATION IN DUTCH HOSPITAL INDUSTRY

Jos L. T. Blank

1. INTRODUCTION

There is a large body of literature on the efficiency and productivity of hospitals. Most studies focus on the effects of environmental pressures on hospital efficiency, such as payment systems (Dismuke & Sena, 1999; Sommersguter-Reichmann, 2000), competition (Rosko, 1999, 2004), Sari, 2003), and property rights (Gruca & Nath, 2001). Other studies pinpoint their attention to economic phenomena, such as economies of scale (Lindrooth, Lo Sasso, & Bazzoli, 2003; Dranove & Lindrooth, 2003), economies of scope (Prior & Sola, 2000; Grosskopf, Margaritis, & Valdmanis, 2001; Li & Rosenman, 2001), chain membership (Menke, 1997), economic behavior (Blank & Merkies, 2004), and expense preference (Rodriguez-Alvarez & Lovell, 2004).

Less attention is paid to the influence of technological developments and innovation on productivity. However, in particular in the hospital industry major technical changes may be expected (see e.g. Maniadakis,

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Hollingsworth, & Thanassoulis, 1999; Okunade, 2001; McCallion, Glass, Jackson, Kerr, & McKillop, 2000; Spetz & Baker, 1999). From these studies, the developments that are particularly interesting include innovations that may be either saving or pushing cost. A clear insight in the relationship between technology and cost may provide policymakers with pertinent information that could influence long-term cost growth by controlling the availability and diffusion of new technologies.

Since in efficiency and productivity analysis innovations are neglected three issues arise. The first issue focuses on the measurement of innovations. The second relates to the appropriate measurement of productivity and the third issue concerns the extent to which innovations are affecting outcomes on productivity.

In this chapter we are primarily interested in the last issue and the policy recommendations that follow from the empirical results. However, to provide an adequate insight into the relation between innovations and productivity a thorough investigation in the first two issues is necessary. We therefore introduce measures of technology and investigate productivity differences from innovations. The study investigates innovations and productivity of Dutch general hospitals operating during years 1995–2002.

The chapter is organized as follows: in Section 2 we discuss the Dutch hospital industry. Special attention is paid to the characteristics of the Dutch hospital industry. The appropriate economic model is specified in Section 3. It is argued that considering relevant characteristics of the Dutch hospital industry a cost function model is the most appropriate model. We also go into the specifying innovations. In Section 4, we summarize the data and in Section 5 the results of the empirical analyses are given. The last section closes by briefly summarising and drawing conclusions for further analysis.

2. DUTCH HOSPITAL INDUSTRY

In this section we describe the Dutch general hospital industry. These hospitals comprise about 80% of hospital beds and almost 70% of the cost of the Dutch hospital sector. The remainder of total hospital cost is absorbed by academic and specialty hospitals (such as eye clinics and rehabilitation clinics). In order to give an impression of the size of the Dutch hospital sector Table 1 contains some quantitative characteristics of general hospitals in 1995 and 2002.

Table 1. Some Characteristics of the Dutch Hospital Industry, 1995 and 2002.

	1995	2002
Number of general hospitals	109	89
First-time visits (x 1,000)	5,491	7,462
Discharges (x 1,000)	1,353	1,329
Day-care patient days (x 1,000)	568	888
Inpatient days (x 1,000)	12,619	9,627
Total cost (x € million)[a]	5,504	8,553
Variable cost (x € million)[a]	4,578	7,515
Capital cost (x € million)[a]	927	1,038
Personnel (x 1,000 ftes)[b,c]	100	112

Source: Prismant, Statistics Netherlands.
[a]€1 ≈ $1 (exchange rate 2002).
[b]Including physicians.
[c]In 1995 an fte consists of 38 working hours a week, in 2002 this is 2 hours less due to a shortening of the number of working hours in a week.

In 1995 there were 109 general hospitals in the Netherlands. As a result of closures and mergers of hospitals, the number of general hospitals decreased to 89 in 2002. This was accompanied at the same time by an increase in the size of hospitals. In 1995 the hospitals "produced" 5.5 million first-time visits, and over 1.3 million hospital discharges. In 2002 the number of first-time visits had increased to 7.5 million but with a slightly decreased number of discharges, increasing the number of outpatient treatments. In 1995 inpatient days in general hospitals numbered 12.6 million along with 600,000 day-care patient days were produced. In 2002 the number of inpatient days had decreased substantially. The total cost of general hospitals in 1995 equalled €5.5 billion. Sixteen per cent of total cost was spent on capital inputs, the remaining 84% on personnel and material supplies and is seen as variable cost.

In 2002 cost had risen by more than 50% in nominal terms (30% in real terms) with an increase in the share of variable cost. Between 1995 and 2002 the number of FTE employees in the hospitals rose by 12% to 112,000. As a result of the hospital consolidation the number of physicians per hospital increased substantially (not in table), indicating potential opportunities for more specialisation within hospitals. A minority of the physicians were employed by general hospitals; the others were self-employed, but associated with a hospital.

In addition to the description of the Dutch hospital industry given above, it also has some special characteristics. Capacity is regulated by the central government as well as fully reimbursed by the central government on a prospective basis. Budgets consist of a fixed component related to capacity and a variable component related to production. The fixed component is based on the so-called adherence (the number of patients potentially using the hospital), the number of beds and the number of associated physicians. The production-related component is based on regional agreements on the numbers of first-time visits, inpatient days, day-care patient days and the number of discharges. To some extent budgets are based on the severity of cases, since larger hospitals, which are assumed to treat more severe cases, receive higher budget rates per case. Some budget rates depend on the types of specialties supplied by the hospital, also indicating differences in care need. The hospitals receive this budget only virtually; they have to earn their revenues by producing medical treatment or procedures. For each medical procedure a price is fixed by the Central Tariffs Health Care, and this price is paid by the insurance companies.[1]

If total revenues of the hospital exceed the budget, this is balanced in the next time period. Thus, in the long run revenues always coincide with the budget. A surplus in the operating results can only be generated by keeping expenses (cost of production) smaller than the budget. Although it is not allowed to make any profits, any surplus does remain available to the hospital and is added to the capital assets. However, incentives such as maintaining market share exist and may be realized in terms of non-price, i.e. quality measures. However, if general hospitals with deficits and negative capital assets will be subjected to budget cutbacks and finally closed down. Through closures of inefficient hospitals the average efficiency of the health care sector can be improved.

Another important feature of the Dutch hospital sector is that hospitals cannot choose their patients. Patients are referred to a hospital by general practitioners. They choose a hospital with a convenient location as compared to other hospitals in the neighborhood and to the availability of the proper specialty. Hospitals are obliged to treat any patient presented to them, provided that their medical staff have the medical knowledge required for the treatment. In practice, hospitals can attract patients by supplying particular specialties or a high quality of care. This implies that expansion of high tech medical treatments may be another goal.

Since capital is also strongly regulated and some of the innovations are connected with housing and medical equipment technology diffusion is also affected by regulation.

3. ECONOMIC MODEL

As mentioned before, in the Netherlands product prices output prices are exogenous. Since input prices are determined by market conditions they can also be assumed to be exogenous.[2] Yet the theory of the firm is not fully applicable, as Dutch hospitals are in general not allowed to close a production line completely. Usually it is even argued that production is exogenous to Dutch hospitals because they are not allowed by law to refuse patients requiring treatment. Capital inputs also are exogenous to hospital management.

In such settings the economic model of (variable) cost minimizing subject to a technology constraint is probably the most appropriate one. Clearly the model thus obtained is equivalent with the direct cost function model (see e.g. Lovell, 2000). The cost function model relates (variable) cost to service deliveries, input prices and fixed capital resources. The cost function model is derived from a standard production function and the optimal choices of resources under the assumption of cost minimizing. From the cost function these optimal allocations on resources (measured in terms of cost shares) can be derived by using Shephard's Lemma (see e.g. Färe & Primont, 1995).

One of the strengths of the cost function is that it allows for the use of multiple services and multiple resources. The measurement of the effect of innovations on cost (and therefore productivity) can also be easily included in the cost functions. To illustrate this point in a one-service industry we present Fig. 1.

Fig. 1 relates services (on the horizontal axis) to cost (on the vertical axis). Line T^0 represents the cost relation (technology) under the technology 0, Line T^1 under the technology 1. Clearly, technology 1 represents a technology with lower cost than technology 0. In this example the graphs of T^0 and T^1 are not parallel implying that cost savings under technology 1 increases with the scale of production. This is defined as output biased technological change. Under both technologies increasing services may correspond with increasing or decreasing cost shares of labor implying that labor becomes relatively more or less important in larger sized hospitals. Under technology 1 lower or higher input of labor is needed than under technology 0. This phenomenon is defined as input biased technological change. If technological change is neither output nor input biased technological changes is said to be Hicksian neutral or disembodied. Hicksian neutrality implies parallel graphs in Fig. 1 and constant cost shares through time.

Of particular interest is modeling the influence of the technology. In general the first- and second-order time trends in economic models tend

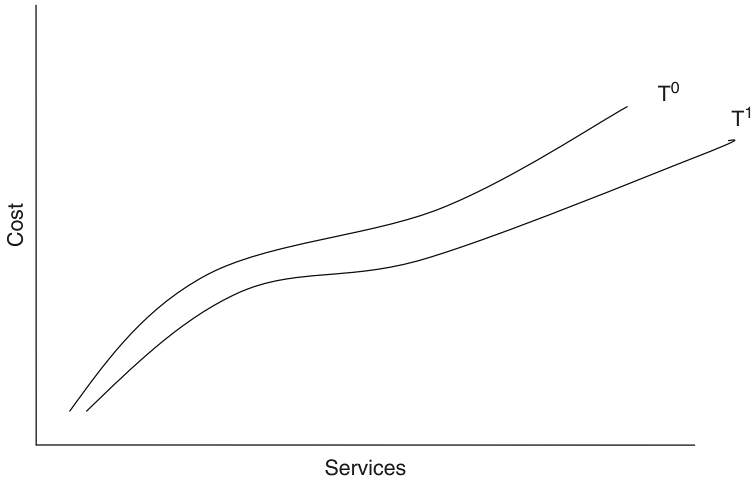

Fig. 1. Relationship between Cost and Services for Different Technologies.

to dominate, producing a smooth and slowly changing characterization of the pace of technical change. However, from other studies we also know that the introduction of new technologies and innovations show highly variable rates of adaptation, as suggested by Kopp and Smith (1983). However, Baltagi and Griffin (1988) advocated another process for estimating a general index of technical change within the context of a quite general production technology. Their procedure yields a general index that may be both non-neutral and scale augmenting. The technology index is a weighted sum of time dummies (see also Blank & Vogelaar, 2004).

In all the above-mentioned studies technology change is measured by a proxy, namely a time trend of a series of year dummies, instead of a variable that actual measures the technology used. In practice however, innovations slowly spread over all hospitals in the sector and so different hospitals are operating under different technologies at the same point of time.

In this study we therefore suggest a more explicit measurement of technology change. We inventory specific and well-known innovations in Dutch hospital industry in the past 10 years, such as specialized "mamma clinics" (clinics for women with breast cancer),[3] and include them explicitly in the analysis. In terms of the earlier mentioned cost function it implies that the graph is assumed to shift when a different technology is being used. By analyzing the cost function we simultaneously measure the influence of these innovations on cost and how they contribute to productivity.

3.1. Specifying Innovations

Before we introduce our concept of technology measurement we distinguish three notions of innovations:

- Single (or individual) innovations;
- Clusters of innovations;
- Innovation index.

Examples of single innovations are specialized mamma clinics or specialized chronic obstructive pulmonary disease (COPD) nurses. Individual innovations are present or not and therefore measured by a set of dichotomous variables. A large number of innovations are strongly related. Aside from the specialized mamma clinics, hospitals also include specialized clinics for people with a sleeping disorder, pain relief etcetera. These related innovations are aggregated into one group and designated as a cluster of innovations, for instance the cluster "specialized clinics." We measure technology for a certain cluster of innovations by the number of innovations present.

An alternative measure is based on a concept of Spetz and Baker (1999), referred to as the Saidin index, which is a weighted sum of various single technologies. Each weight reflects the percentage of hospitals that do not possess the technology or service. For example, technologies that are rare – whether they are rare because they are new, expensive, or difficult to implement – receive higher weights in this measure. Technologies that are common receive low weights. This weighting scheme corresponds with most people's idea of what defines "high technology": that which is rarely found, whether it is rare due to newness, expense, or difficulty of operation. When a technology becomes common, it is no longer perceived as being of a high level. To ensure a consistent comparison over time we define indices using a set of technologies and weights that are defined in a base year and held fixed for subsequent years.

The index has two properties. First, it accurately reflects the degree of technology advancement across hospitals at a single point in time. That is, in any given year, hospitals with higher values of the index are "more advanced." Adding technologies will increase the index value, especially if the technologies that are relatively rare as compared to adding technologies that are common. In general, hospitals that have more, rarer technologies will have higher index values than hospitals with fewer, more-common technologies.

The second property of the index is the ability to identify changes in technology over time. That is, the index increases over time with increases in the degree of technology advancement. If a hospital has a higher index value this year than last year, we may conclude that the hospital became more advanced.

4. THE DATA

4.1. General

Data for this study covering the years 1995–2002 were obtained from the Ministry of Health, Welfare and Sport and from a separate survey amongst hospitals based on a questionnaire about innovations. The financial, patient and personnel data were collected by the Institute for Health Care Management. The surveys contain information on almost all general hospitals yielding approximately 100 observations each year, situated in 27 health care regions. The data on innovations were collected by ECORYS and the Public Health Council. This survey contains information on 63 innovations of about 66 general hospitals in the period 1995–2004. For the purposes of this study, observations on hospitals with missing or unreliable data were excluded from the dataset. Various consistency checks were performed on the data to ensure that changes, in average values and the distribution of values across time, were not excessive. After eliminating observations containing inaccurate or missing values in the dataset, an unbalance panel data set of 362 observations over the 8 years of study remained.

4.2. Production

The main service delivery of hospitals is treating patients. The production of hospitals is therefore measured by the number of discharges and first time visits (not followed by an admission). The discharges have been separated into over 30 medical specialties in order to measure case-mix. Since it is not possible to use such a large number of categories, these were aggregated into four categories on the basis of average stay homogeneity and the distinction between surgery/contemplative specialty. We distinguish therefore the following groups of specialties:

- Contemplative with average stay less than 4 days;
- Contemplative with average stay more than 4 days;

- Surgery with average stay less than 4 days;
- Surgery with average stay more than 4 days.

4.3. Resources

Resources include staff, and administrative and maintenance personnel (including security and cleaning), nursing personnel, paramedical personnel (such as lab technicians), material supplies and capital. Physicians are not included in these personnel variables, to ensure that hospitals with physicians on their payroll and hospitals with physicians who are self-employed are treated equally. The costs of physicians (wages) are not included in the cost or price variables either.

Material supplies include such aspects as medical supplies, food and heating. Personnel and material supplies are treated as variable resources since the hospital can change these in the short run. Capital is included as a fixed resource, since the capital assets such as buildings and medical equipment can only be changed in the long run.

There are data on the costs and the quantity for each resource personnel category. For each region and time period wages are defined as the average wages per full time equivalent. This is considered as the market price for labor; qualitative differences between hospitals are included in the volume of labor.

Since there is no natural unit of measurement for material supplies, a circumventing construction was used. The price of material supplies is a weighted index based on components of the consumer index calculated for the Netherlands by Statistics Netherlands. The weights are derived from cost shares of the various components of material supplies (energy, housing, food, medical supplies).

4.4. Innovations

The primary clusters of innovations are listed below (between parentheses the number of innovations included in the cluster):

- Multidisciplinary diagnostics and treatment (14);
- Technical (medical) quality (14);
- Nursing consulting hours (13);
- Chain care (11);
- Logistic optimalization (5);

Table 2. Descriptive Statistics, Dutch General Hospitals 2002 ($N=66$).

Variable	Mean	Std. Dev.
Discharges 1	8,360	3,891
Discharges 2	6,210	3,012
Discharges 3	5,329	3,016
Discharges 4	5,895	3,223
First-time visits	65,769	31,189
Price auxiliary personnel	1.00	0.04
Price nursing personnel	1.00	0.02
Price paramedical personnel	1.00	0.03
Price material supplies	1.00	0.00
Cost (x € million)	102	88
Cost share auxiliary personnel	0.20	0.02
Cost share nursing personnel	0.28	0.04
Cost share paramedical personnel	0.18	0.03
Cost share material supplies	0.34	0.03
Multidisciplinary diagnostics and treatment	5.62	2.62
Technical (medical) quality	7.21	3.00
Nursing consulting hours	8.03	2.11
Chain care	5.87	2.02
Logistic optimalization	1.25	1.14
Hospital transferred care	0.77	0.82
Information and communication technology	1.13	0.92

- Hospital transferred care (4);
- Information and communication technology (3).

[For a complete list see Appendix]

For calculation of the Saidin index we defined a list of technologies available in 1990, and determine their relative rarity in 1990, and then computed index values for all hospitals in all years using the 1990 list and the 1990 weights. Descriptive statistics of the variables are given in Table 2.

5. EMPIRICAL ANALYSIS

5.1. Estimation of Effects

As stated in Section 2 we analyze a cost function model, which constitutes a system with an equation describing cost and a number of equations describing cost shares of various resources. For a technical description we refer to the appendix. In this paragraph we focus on the measured effects and the reliability of the outcomes.

The specification of the direct cost function model contains five output quantities, four input prices, one fixed input quantity, and a technology index based on the innovation clusters. These variables are discussed in the previous section.

We analyze the cost function model by econometric methods. We evaluate the models based on standard statistical properties (such as R^2 and t-values), theoretical requirements derived from economic properties (such as monotonicity and concavity), formal test (likelihood ratio test) and economic plausibility (such as productivity change due to innovations).

First of all, we test the nature of technical change. We distinguish four models, each with a different type of technology change:

- Disembodied technical change (model 1);
- Output biased technical change (model 2);
- Input biased technical change (model 3);
- Input and output biased model (model 4).

We also test the null hypothesis that the models excluding the technology index performs as well as the models including the technology index. In other words, we test whether or not a time trend variable is a good proxy for measuring differences in technology. Or to put in economic terms: we test whether technology change is a smooth on going process or a rather volatile process.

Similarly we test a second null hypothesis that the models with a technology index excluding the time trend variable performs as well as the models with a technology index including a time trend variable. Here we actually investigates whether the distinct technology clusters cover technical changes through time adequately or that there are remaining (unmeasured) technical changes affecting resource usage.

We also test the difference between the models based on an unweighted sum of innovations and models based on a weighted sum of innovations with weights depending on rarity Saidin index.

From various statistical tests (see Table A2 in appendix) we conclude that the most appropriate model is the output biased model including a time trend variable and a technology index based on an unweighted sum of underlying technologies. The statistical tests show that the fit of this model is clearly better than the other models. The model with the rarity index does not perform better than the model with the unweighted sum of innovations.

Table 3. Elasticities Estimates[a] Average Hospital (Output Biased).

Variable	Estimate
Multidisciplinary diagnostics and treatment	0.001
Technical (medical) quality	**0.027**
Nursing consulting hours	**0.024**
Chain care	−0.010
Logistic optimalization	0.006
Hospital transferred care	**0.078**
Information and communication technology	**−0.051**
Time	**−0.019**
Discharges group 1	**0.189**
Discharges group 2	0.067
Discharges group 3	**0.183**
Discharges group 4	0.058
First-time visits	**0.510**
Price auxiliary personnel	**0.198**
Price nursing personnel	**0.297**
Price paramedical personnel	**0.178**
Price material supplies	**0.326**

[a]Bold figures indicate significance at 5% level for *t*-test.

So there is no explanatory power coming from this rarity approach in contrast with the study of Spetz and Baker (1999).

We further only present the outcomes of the most appropriate model (output biased model with unweighted technologies), which was chosen by the above-mentioned formal tests. Table 3 presents the elasticities derived from the outcomes of the econometric analysis. The elasticities are calculated at the means of services and resource prices. For other hospitals than the ‘‘average’’ hospital the elasticities show slightly deviate outcomes.

From Table 3 we conclude that changes in technology affect cost. Innovations in multidisciplinary diagnostics and treatment, technical medical quality, nursing consulting hours, logistic optimization and hospital transferred care require more resources, whereas chain care and information and communication technology are cost reducing. Statistical tests show that from the cost enhancing innovations only the effects of innovations in technical quality, nursing consulting hours and hospital transferred care are significant (in bold); from the cost reducing innovations only information and communication technology is significant. Other non-measured technical changes approximated by the time trend variable have a significant cost reducing effect.

From the estimates we can also derive the effect of technology index on the (marginal) cost of specific products. We therefore introduce the effect of

Table 4. Product Specific Cost Elasticities with Respect to Technology Change.

Technology	Discharge 1	Discharge 2	Discharge 3	Discharge 4	First-Time Visits
Multidisciplinary diagnostics	0.00	0.00	0.00	0.00	0.00
Technical (medical) quality	−0.04	**0.12**	−0.02	**0.04**	**−0.05**
Nursing consulting hours	−0.03	**0.10**	−0.02	**0.03**	**−0.05**
Chain care	0.01	−0.04	0.01	−0.01	0.02
Logistic optimalization	−0.01	0.03	0.00	0.01	−0.01
Hospital transferred care	−0.10	**0.34**	−0.06	0.11	−0.15
Information and communication technology	0.07	**−0.22**	0.04	−0.07	0.10
Time	0.03	**−0.08**	0.01	**−0.03**	0.04

a technology on the product specific cost elasticity of a technology cluster. These elasticities measure the percentage change in cost due to a 1% change in the technology index. Suppose the technology index rises from 5 to 6 (+20%) and the measured elasticity equals −0.10 then cost decrease by 2% (20% x −0.10). A positive effect thus indicates an increase in cost with increasing technology and vice versa. Since we have five services and seven clusters of technology we have calculated 35 effects. Table 4 presents the results of the specific cost elasticities of each technology cluster. The bold figures indicate that the measured effects are statistically significant (at a 5% level).

From Table 4 we note that the marginal cost is affected by the technology used. For example, multidisciplinary diagnostics and treatment affect discharges 2 and discharges 4 in a significant positive way. In other words, multidisciplinary diagnostics and treatment make discharges 2 and 4 more expensive to produce. On the other hand, inpatient visits are getting less expensive when utilizing more of these technologies. So the results are rather ambiguous. However, it seems that hospital transferred care is in general a cost pusher, whereas ICT is a cost saver.

An interesting aspect of the analysis is the effect of technological change on productivity through time. Fig. 2 depicts average productivity growth as a result of technical change through time. These growth rates are computed by averaging the fitted technology index in year T for each hospital and comparing with the averaged fitted technology index assuming base year technology (see appendix for calculation).

Fig. 2 includes two lines. The upper line represents productivity change according to the above formula. The lower line represents productivity

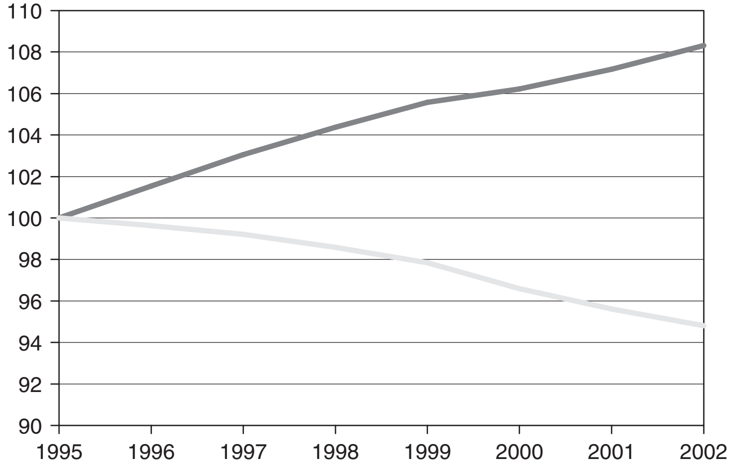

Fig. 2. Productivity Growth by Technology Change, Including and Excluding Time Trend.

change purely based on the measured innovations. So this line excludes the impact from the unmeasured time varying technological changes variable.

According to the upper line Fig. 2 shows a steady growth in productivity. In the 7-years period productivity grows with more than 8%. This growth is dominated by the time trend variable in the estimates. When we exclude the time trend effect and recalculate productivity based on the parameters of the innovations only, we observe a different picture. There is technical regress; productivity slows down by 5% in the 7-years period. All innovations under inspection here are in some way related to the "processing of patients." These innovations mainly influence medical procedures and treatments. The introduction of these technologies is probably not motivated by productivity reasons, but merely by quality reasons. The productivity growth has obviously been realized on the "input side." More qualified and trained personnel, efficient working procedures, better IT in administrative procedures and outsourcing are examples of determinants that are likely to have improved productivity substantially.

6. SUMMARY AND CONCLUDING REMARKS

In this chapter I present relationship between technology and productivity of Dutch hospitals. In most previous studies technology change is measured by a proxy, namely a time trend. In practice however, innovations slowly spread over all hospitals and so different hospitals are operating under different technologies at the same point of time. In this study we explicitly inventory specific and well-known innovations in Dutch hospital industry in the past 10 years. These innovations are aggregated into a limited number of homogenous innovation clusters, which are measured by a set of technology index numbers. The index numbers are included in a cost function model and the parameters are set by an econometric procedure.

The outcomes from the modeling show that some technologies affect cost in a positive way, while others affect cost in a negative way. The outcomes also show that technology change is non-neutral and output biased. This means that technology does not only affect the level of cost, but also the marginal cost of services. Thus, the shape of the cost function also changes. For example, multidisciplinary diagnostics and treatment make type 2 and type 4 discharges more expensive to produce. On the other hand, inpatient visits are becoming less costly when utilizing more of these technologies. In general, hospital transferred care is a cost increasing innovation, whereas ICT is a cost saving innovation.

Further we show that in explaining hospital's cost accounting for the rarity of innovations, does not lead to a better statistical performance than ignoring the rarity. Outcomes showing productivity gains through time are realized only on the input side of the production process. Innovations in medical procedures and treatments lead in general to increasing hospital cost.

NOTES

1. Since 2005 about 10% of the treatment prices are set by market conditions. However, for our period of analysis this reform is not relevant.
2. Since January 1, 2005 for a limited number of procedures services prices are free.
3. These clinics integrate medical treatment, nursing support, social work and counseling.
4. Strictly speaking, the models with the underlying technologies based on the unweighted sum and the Saidin index are not nested and can therefore not be tested by a likelihood ratio test. However, both models can be seen as restricted models of a model in which the parameters of all individual technologies are being estimated.
5. For most observations there is only one eigenvalue slightly greater than zero.

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APPENDIX. COST MODEL SPECIFICATION

The general representation of a cost function is:

$$VC = c(Y, W, K, t_i, .., t_N) \tag{A.1}$$

Following Shepard's Lemma we derive the cost share equations from the cost function as the first order derivative with respect to resource prices:

$$S_i = dC/dw_i \tag{A.2}$$

With:

VC = variable cost;
Y = services delivered;
W = resource prices;
K = capital input;
t_i = technology at time period i.

In applications a specification of the cost function $c(Y, W, K, t_i, \ldots, t_N)$ is acceptable if it satisfies the following conditions:

(i) monotonic non-decreasing in input prices;
(ii) concave in input prices.

In our analysis the cost function is specified as a translog function and the share equations are derived from it. Homogeneity of degree one in prices and symmetry is imposed by putting constraints on some of the parameters to be estimated.

The models are estimated as multivariate regression systems with various equations with a joint density, which we assume to be a normally distributed. Because disturbances are likely to be cross-equation-correlated, Zellner's seemingly unrelated regression method is used for estimation (Zellner, 1962). As usual, because the shares add up to one, causing the variance–covariance matrix of the error terms to be singular, one share equation in the direct cost function model is eliminated.

Measuring Technology

In this chapter we distinguish two approaches of aggregating innovations into an index. In the first approach the value of the function equals the unweighted sum of the corresponding technologies of T_L.

$$a_h(T_L) = \sum_{i \in L} t_{hi} \tag{A.3}$$

With:

$a_h(T_L)$ = number of innovations present in cluster L for hospital h ;
t_{hi} = technology i present in hospital h.

In the second approach we weight each technology in a different manner based on the rarity of the technology.

$$a_h(T_L) = \sum_{i \in L} r_i t_{hi} \tag{A.4}$$

With:

$a_h(T_L)$ = index of innovations present in cluster L for hospital h;
r_i = share of hospitals not possessing technology i in a base year;
t_{hi} = technology i present in hospital h (1 = present; 0 = not present).

Statistical Tests

Deriving the likelihood ratios and the usage of a critical value of 0.025 all mutual model tests favors the output biased model with a trend and an unweighted technology index.[4]

Exemplifications to Estimation Results

The estimates are available upon request with the author (j.l.t.blank@tudelft.nl). The outcomes show that in a statistical sense the cost function model fits the data rather well. Results derived from this cost function are plausible. The cost equation has a high R^2, i.e. 0.97. About 60% respectively of the estimated parameters are significant at the 5% level. Most R^2's of the share equations are reasonable. The requirements on monotonicity and concavity are also fulfilled to a large extent. The monotonicity property tells us that input demand is always positive, which is the case for all observations. A necessary condition for concavity is the negativity of the "own" elasticities of substitution. This condition also holds for all observations. However, the condition of negative semi-definite of the matrix of elasticities of substitution only holds for 20% of the observations.[5]

Productivity Growth

Productivity growth through time is measured as:

$$TC\,(t,\,t0) = \left[\frac{\sum_h \hat{A}_{ht}}{\sum_h \hat{A}_{ht0}}\right]^{-1} x100 \tag{A.5}$$

With:

$TC(t,t0)$ = technical change year t related to base year t^0;
$\hat{A}_{ht}$ = technology at hospital h in year t.

List of Innovations

We have investigated 63 innovations in the time period 1995–2002. The list is given in Table A1:

Table A1. List of Innovations.

Multidisciplinaire Diagnostic and Treatment	Technical Quality	Nurse Consulting Hour
Pelvis policlinic	Laparoscopic gallbladder removement	COPD nurse
Diabetes foot policlinic	Laparoscopic intestine neoplasm section	CVA consultant
Mamma policlinic	Laparoscopic kidney removement	Decubitus nurse

Table A1. (*Continued*)

Multidisciplinaire Diagnostic and Treatment	Technical Quality	Nurse Consulting Hour
Constipation and wee-wee policlinic (children)	Use of seal equipment at intestine surgery	Diabetes nurse
Mother child unit	MRI instead of muelografics	Cardiac nurse
Proctologic policlinic	Shaver blades at endonasal surgery	Mamma care nurse
Vascular or risk policlinic	Stroke care unit	MS nurse
Cardiac policlinic	Thermo therapy gynecology	Stoma nurse
Pain policlinic	TVT devices	Wound consultant
Sleep disorder policlinic	Preoperative nutrition	Rheumatic consultant
Lung revalidation	Decubitus prevention	Oncology consultant
Down policlinic	Preoperative screening by anaesthesiology	Function differentiation
Protocol of reference by general practitioner	(Postoperative) pain registration	Other innovation
Other innovation	Other innovation	

Chain Care	Logistics	ICT
Stroke service	Cataract line	Electronic data at consultation room and the ward
Total hip (reduction of hospital stay duration)	Joint care for orthopaedics	Process support ICT
Total knee (reduction of hospital stay duration)	One stop visit (MRI, varicose vein, Hernia)	Other innovation
Integrated psycho geriatric care	Filtering of patients (elective, emergency/focused care)	
Integrated diabetes care	Other innovation	
Integrated COPD care		
Transmural care for oncology patients	Outside hospital care	

Table A1. (*Continued*)

Chain Care	Logistics	ICT
Transmural care for palliative care	Home monitoring of pregnancy	
Cooperation with general practitioner (first aid)	Self-measurement thrombotic care	
Transmural care	Night home dialysis	
Other innovation	Other innovation	

Table A2. Loglikelihoods Various Models ($N = 362$).

Variable	No Trend	Neutral	Output Biased	Input Biased	Input–Output Biased
Unweighted index, including trend	3,229.0	3,258.2	3,269.3	3,262.4	3,275.6
Only trend	3,229.0	3,235.2	3,243.3	3,239.1	3,247.1
Saidin, including trend	3,229.0	3,254.8	3,270.1	3,261.1	3,276.8

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PART III:
GOVERNMENT POLICY

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CHAPTER 7

THE IMPACT OF OWNERSHIP ON THE COST-EFFICIENCY OF U.S. HOSPITALS

Ryan L. Mutter and Michael D. Rosko

1. INTRODUCTION

There were 4,919 registered, short-term, community hospitals in the 2004 American Hospital Association (AHA) Annual Survey of Hospitals; 60 percent of those hospitals were non-profit (NP), 23 percent of them were public (non-federal government owned and operated), and 17 percent were for-profit (FP). In general, while the absolute number of hospitals in the United States has decreased in recent years, the share of hospitals that are FP has increased. For example, in 1997, the AHA reported 5,057 registered, short-term, community hospitals, of which 59 percent were NP, 25 percent were public, and 16 percent were FP.

The increased share of FP hospitals was due, in part, to conversions. Shen (2003) identifies 130 hospitals that switched from NP to FP status from 1987 to 1999. (Conversions from FP to NP status were less common, although they did occur.)

The majority of FP hospitals belong to a multi-hospital system. Whereas 56 percent of all registered, short-term, NP community hospitals belonged to a multi-hospital system in 2004, over 84 percent of FP hospitals were part

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of a system. The FP hospitals that have remained independent are small. In 2004, the average size of a system-member FP hospital was 143 beds. The corresponding figure for an independent FP hospital was 84 beds. Sloan (2000, p. 1145) refers to independent FP hospitals as ''a vanishing breed.''

The existence of FP hospitals as a minority of total hospitals is not a uniquely American phenomenon. Sloan (2000) reports that 19 percent of hospitals in France, 14 percent of hospitals in Germany, and 22 percent of hospitals in Switzerland were FP institutions.

Very few industries are characterized by a predominance of NP firms (Sloan, Picone, Taylor, & Chou, 2001).[1] In his seminal work, Arrow (1963) argues the NP hospitals arose because of the unique characteristics of medical markets.[2] He asserts that NP hospitals can assuage patient fears that they are being given insufficient care, unnecessary procedures, or are otherwise being exploited because of their lack of knowledge about their condition (asymmetric information) in an attempt by hospitals to increase profits. Arrow's assertion about the importance of NP status in establishing the trustworthiness of care has been elaborated upon in a considerable literature. See, for example, Gray (1997), Schlesinger, Mitchell, and Gray (2004), Schlesinger and Gray (2006). He also suggests that a ''simpler'' explanation is that NP hospitals exist because they receive donations to provide care for the indigent. However, the importance of donations has decreased over time (Sloan, 2000).

It has also been argued that NP hospitals may arise to meet unmet demand for public health services and other social goods (Weisbrod, 1977, 1988). Some people receive utility from knowing that NP hospitals exist to provide needed health care services to people who otherwise could not afford them (Rose-Ackerman, 1996). Therefore, they support giving favorable tax treatment to NP hospitals so that the hospitals can better carry out their charitable mission.

There have been charges that NP hospitals have evolved so that they behave more like profit-maximizing institutions and do not provide sufficient community benefits to justify their tax exemption. Indeed, recent Congressional investigations have looked into whether certain NP hospitals have failed to provide adequate charitable services (Grassley, 2005). These charges not only have implications for tax policy but also for government policy concerning ownership conversions and NP antitrust.

Although there are many conflicting findings on the comparative performance of NP and FP hospitals in the literature, there is an emerging consensus that there are meaningful behavioral differences between the two ownership forms and that both serve a valuable role and should, therefore, be retained (Horwitz, 2005; Schlesinger & Gray 2006). In particular, it has been argued that FP institutions can stimulate greater efficiency in the delivery of care (Reeves & Ford, 2004; Schlesinger & Gray 2006). Shen (2003) demonstrates that hospital conversions from NP to FP status can be efficiency enhancing.[3]

Nevertheless, the empirical findings on the efficiency impact of hospital ownership have been mixed (Rosenau & Linder, 2003; Shen, Eggleston, Lau, & Schmid, 2005; Schlesinger & Gray, 2006). This study contributes to this body of literature by comparing the hospital-level cost-inefficiency of NP hospitals and FP hospitals using stochastic frontier analysis (SFA). It builds on recent work that offers preferred strategies regarding data, study design, and assumptions in testing the impact of ownership on hospital performance (Shen et al., 2005) and in the conduct of SFA (Rosko & Mutter, 2007).

Section 2 discusses theoretical differences between NP and FP hospitals. Section 3 reviews the empirical work on differences between the two ownership types. Section 4 discusses SFA; Section 5 describes the data we use. We present our results in Section 6, and Section 7 concludes.

2. THEORETICAL DIFFERENCES

There are no laws limiting how much profit or operating surplus NP hospitals can earn. There are, however, legal restrictions on how those profits can be used. The fundamental difference between the ownership forms is the non-distribution constraint faced by NP hospitals (Sloan, 2000).[4] This constraint precludes them from distributing profits to individual owners and gives rise to theorized differences in behavior.

Property Rights Theory asserts that profit maximization will be a higher priority for the well-defined residual claimants of a FP hospital than for the decision makers in a NP hospital. Since profits can be increased by reducing inefficiency, this theory suggests that FP hospitals will engage in more efficient production than NP hospitals (Folland, Goodman, & Stano, 2007).

Not all theories based on the non-distribution constraint necessarily imply that FP hospitals will be more efficient than NP hospitals, however. Newhouse (1970) assumes that hospital decision makers (i.e., administrators, trustees, and the medical staff) maximize the quantity and the quality of services a NP hospital provides subject to a budget constraint. His model implies that NP hospitals can behave like FP hospitals and engage in least-cost production. However, he notes that there are several unique features of hospital markets, including philanthropy, preferential tax treatment, and the presence of third-party payers, that bias against this outcome. Therefore, the theoretical predictions of the Newhouse (1970) model of the effects of ownership on efficiency are ambiguous.

Pauly and Redisch (1973) model NP hospitals as cooperatives over which physicians exercise de facto control.[5] This control is used by doctors to maximize their net incomes. Physicians could direct NP hospitals to behave like FPs. They could minimize hospitals' costs so that they can have more resources to allocate to themselves. However, non-cooperative behavior among a hospital's doctors could lead to the oversupply of quality as physicians direct the hospital's capital and non-physician labor without fully taking into account the behavior of other doctors at the hospital. Thus, the efficiency implications of hospital ownership in their model are not straightforward.

Recent work has highlighted the important impact of NP–FP ownership mix in a market on hospitals' performance (Duggan, 2002; Kessler & McClellan, 2002; Silverman & Skinner, 2004; Santerre & Vernon, 2006; Schlesinger & Gray, 2006), as well as the confounding effects of hospital competition on the impact of ownership (Sloan, 2000; Reeves & Ford, 2004; Shen et al., 2005).

3. EMPIRICAL DIFFERENCES

The empirical literature that examines the differences in hospital performance by ownership type reflects the ambiguity in the theoretical literature. Studies measuring efficiency using SFA have found that NP hospitals are more efficient than FP hospitals (Zuckerman, Hadley, & Iezzoni, 1994; Koop, Osiewalski, & Steel, 1997; Rosko, 1999; Folland & Hofler, 2001; Rosko, 2001b; McKay, Deily, & Dorner, 2002/2003; Brown, 2003; Rosko, 2004; Rosko, Proenca, Zinn, & Bazzoli, 2007) and that FP hospitals are more efficient than NP hospitals (Li & Rosenman, 2001; Rosko, 2001a; Sari, 2003; McKay & Deily, 2005).

A similar mix of findings has been reported in research using another frontier technique, data envelopment analysis (DEA).[6] DEA studies have also found that NP hospitals are more efficient than FP hospitals (Ozcan, Luke, & Haksever, 1992; Ozcan & Luke, 1993) and that FP hospitals are more efficient than NP hospitals (Chirikos & Sear, 1994; Ferrier & Valdmanis, 1996; Burgess & Wilson, 1996; Chirikos & Sear, 2000).

Additional insight can be gained from research where efficiency is not measured by means of a best-practice frontier. Becker and Potter (2002) measure hospital efficiency as full-time equivalent (FTE) hospital employees per bed and find that FP hospitals are more efficient than NP hospitals. Shen (2003) finds that, in general, hospitals that changed ownership from NP to FP status experienced increased profits due to higher revenues and lower operating costs. The lower operating costs were due, in part, to reductions in staff-to-bed ratios, especially the registered nurse-to-bed ratio. Mark (1999), Thorpe, Florence, and Seiber (2000), and Picone, Chou, and Sloan (2002) report similar findings.[7]

Findings from related research on the effects of hospital ownership on hospital cost mirror the ambiguous findings in the literature on the impact of ownership on efficiency. Indeed, of the 18 studies reviewed by Shen et al. (2005), 11 found that FP hospitals had higher costs while 7 had the opposite finding.[8] Schlesinger and Gray (2006) report similar findings in their review.[9]

Research on the comparative quality of care produced by NP and FP hospitals has the potential to yield insight into the efficiency of their operations. Thus far, the emerging literature on this topic has not found that NP and FP ownership leads to differences in the quality of care provided by hospitals (Sloan, 2000; Sloan et al., 2001; Kessler & McClellan, 2002).

In their quantitative review of the literature, Shen et al. (2005) identify rigorous and preferred strategies for testing the effects of ownership on hospital performance. They find that researchers' choices with respect to these strategies can impact the findings of their studies. We contribute to the literature by adopting the following rigorous and preferred strategies identified by Shen et al. (2005) in our assessment of the difference in efficiency between NP and FP hospitals: use of panel data, employment of controls at the hospital and market levels, log transformation of the dependent variable, and analysis of a geographic region larger than one state.

We use SFA to test whether there is an efficiency difference between NP and FP hospitals, and we rely on the approach recommended by Rosko and Mutter (2007) for conducting SFA in the hospital industry.

4. METHODS

We used a time-varying SFA model developed by Battese and Coelli (1995) to estimate hospital-specific inefficiency. The technical details of our methods are presented in the Appendix. Our discussion here will be more intuitive.

SFA can be used to estimate a best-practice cost or production frontier. In this study we used the former. Cost-inefficiency is defined as the percentage by which observed costs exceed minimum costs predicted for the best-practice cost frontier (Lovell, 1993). For example, assume that Hospital X, a medium-sized, non-teaching hospital, had total costs amounting to $120 million last year. However, predicated best-practice costs for a hospital with identical input prices, outputs, and characteristics was $100 million. The predicted cost-inefficiency for this hospital would, therefore, be 0.20 (i.e., ($120 million − $100 million)/$100 million). Hospital Y is a much more expensive teaching hospital, and its total costs were $500 million. However, predicted best-practice costs for a hospital with identical input prices, outputs, and characteristics was $550 million. Although its total costs were more than Hospital X, it provides care to more resource intensive patients. Thus, the predicted cost-inefficiency for this hospital is 0.10 (i.e., ($550 million − $500 million)/$500 million), an estimate that is less than Hospital X's even though its total costs were five times greater.

An important part of the SFA model is the cost function. It is used to locate the best-practice cost frontier. A key challenge in estimating the cost-inefficiency of hospitals is to control for heterogeneity. If the cost function is mis-specified, then bias could occur. For example, a standard technological hospital cost function assumes that total costs are a function of the outputs a hospital produces and input prices it pays. Typically, hospital outputs are divided into inpatient and outpatient categories, with the former recognized by either inpatient days or admissions and the later represented by outpatient visits. However, it is widely recognized that hospital patients are treated for a wide variety of health problems that require different types and amounts of resources. If this heterogeneity is not taken into account, hospitals that treat more resource-intensive patients would have higher estimated inefficiency. As described in the Appendix, we followed Rosko and Mutter (2007) and conducted statistical tests which led us to use a hybrid translog cost function that controls for heterogeneity of patient mix among inpatients and outpatients. Since it is possible that variations in quality might masquerade as inefficiency, we also included structural and outcome measures of quality.

Greene (2005) suggests that heterogeneity might also reside in the residual that represents cost-inefficiency. Accordingly, we entered inefficiency-effects variables to control this source of inefficiency. These variables reflect internal and external pressures for efficiency. The internal factors include ownership variables for FP and government hospitals (NP ownership is the reference category). Besides controlling for heterogeneity, these variables are used to address the primary research question of this study – does ownership affect cost-inefficiency? We also used variables to account for variations in payment and competitive pressures. The inefficiency-effects variables are described in more detail in the Appendix, and the descriptive statistics for the variables in the SFA regression equation are presented in Table A1.

5. DATA

We used panel data on 869 urban, acute care hospitals that were in continuous operation during the period 1999–2002 (T = 4).[10] Of these, 125 were classified as FP hospitals, 654 were NP hospitals, and 90 were publicly owned hospitals. The individual hospital constitutes the level of analysis. The market area is defined as the county, a definition used frequently in hospital studies (Wong, Zhan, & Mutter, 2005). Although there has been some controversy in the literature about the appropriate definition of a hospital's market area, Wong et al. (2005) report that for the purpose of controlling for hospital competition in empirical analysis, it makes little difference whether the hospital's market was defined using strategies based on geopolitical boundaries, fixed or variable radii, or patient flows.

As noted in footnote 10, this project, which was supported in part by the Agency for Healthcare Research and Quality (AHRQ), was confined to urban, acute-care hospitals in 20 states participating in AHRQ's Healthcare Cost and Utilization Project (HCUP). There are 1,801 urban, acute-care hospitals in those 20 states. Nearly 1,000 hospitals were eliminated from the sample because of missing observations in the panel and/or missing variables that were of interest to AHRQ in a study that was performed separately (some of these variables are included in this study and some are not included). As shown in Tables 1 and 2 , the 869 hospitals in our sample were larger on average than the universe of urban, acute-care hospitals in the 20 states. However, they were fairly similar on a number of important dimensions including: proportion of public hospitals and several case- or payer-mix variables.

The primary source for hospital-level data was the AHA Annual Survey of Hospitals. These data were augmented by two variables from the Medicare Hospital Cost Report Minimum Data Set – days in non-traditional (i.e., skilled nursing facility, long-term care, hospice, etc.) hospital units and price of capital (i.e., depreciation and interest per bed). We included a risk-adjusted, all causes inpatient mortality rate and a market-level health maintenance organization (HMO) penetration rate from

Table 1. Descriptive Statistics, Sample Hospitals.

Variable	*N*	Mean	Std. Dev.
GOVT	869	0.1047181	0.3063661
NP	869	0.7456847	0.4357264
FP	869	0.1495972	0.3568816
Beds	869	306.8411968	224.6003314
Discharges	869	14,716.57	10,634.65
Outpatient Visits	869	218,394.15	210,081.36
% Medicare Discharges	869	0.4161900	0.1147617
% Medicaid Discharges	869	0.1677401	0.1133569
% Surgical Discharges	869	0.2907529	0.1041332
Teaching Hospital	869	0.3498274	0.4771899

Table 2. Descriptive Statistics, All Urban, Acute-Care Hospitals in 20 States.

Variable	*N*	Mean	Std. Dev.
GOVT	1,801	0.0999445	0.3000093
NP	1,801	0.6851749	0.4645752
FP	1,801	0.2148806	0.4108536
Beds	1,801	240.2648529	204.9798753
Discharges	1,801	10,957.39	9,886.86
Outpatient Visits	1,801	163,626.91	190,412.62
% Medicare Discharges	1,801	0.4310756	0.1554755
% Medicaid Discharges	1,801	0.1641051	0.1243406
% Surgical Discharges	1,801	0.2874959	0.1954783
Teaching Hospital	1,801	0.2903942	0.4540704

Solucient, Inc. We controlled for hospital competition using county-level, Herfindahl-Hirschman Indexes (HHIs) provided by HCUP.[11]

6. RESULTS

The estimated parameters of that stochastic frontier regression are presented in the Appendix (see Table A2). Some of the estimated coefficients of the input price and output variables are insignificant ($p < 0.05$) and counter-intuitive. This may be due to the multi-colinearity of the squared and interaction terms. While multi-colinearity may reduce the reliability of parameter estimates it does not introduce a bias in the estimates of inefficiency. When a Cobb-Douglas cost function model was used, the coefficients of input price and output variables were significant ($p < .05$) and had the expected positive coefficient.

We will discuss the cost function part of the model first. Then we will review the results for the inefficiency effects variables. (It is important to note that whereas a negative coefficient on a cost function variable indicates a variable that is cost reducing, a negative coefficient on an efficiency effects variable identifies a variable that is efficiency enhancing.)

The coefficients of the teaching variables suggested that, compared to non-teaching hospitals, hospitals that belonged to the Council of Teaching Hospitals (COTH) were 26.9 percent more expensive and other teaching hospitals were 5.1 percent more expensive. Product descriptors for inpatient case-mix, outpatient surgery percentage, and risk adjusted mortality rate were positive and highly significant ($p < 0.001$). The other product descriptors had insignificant estimated coefficients. Next, we discuss the results for the inefficiency effects variables.

The coefficient of FP was negative and that for government hospitals (GOVT) was positive. Both were significant at $p < -0.05$ level. This suggests that hospitals in the reference category, NP, lie between FP and GOVT facilities in terms of cost-inefficiency. The estimated coefficients of the other inefficiency effects variables were significant at the $p < 0.01$ confidence level except for HMO penetration (HMO%), which was significant at $p < 0.05$, and the time trend variable, which was not significant. (This suggests that cost-inefficiency did not change over time.) HHI and Medicare share of admissions (MEDICARE%) had negative coefficients. The former result is consistent with the practice of service-based competition; while the latter result suggests that hospitals responded to the incentives for increased efficiency embedded in the Medicare Prospective Payment System (PPS).

The positive coefficients for HMO% and Medicaid share of admissions (MEDICAID%) were contrary to expectations. There are two possible explanations for the positive estimate for HMO%. First, the demand for HMOs might be greater in areas where hospitals expenses and inefficiency is greater. Second, beginning in the late 1990s HMOs have begun to de-emphasize tight utilization controls in response to a consumer backlash. The location of higher HMO enrollment combined with looser utilization controls might be responsible for this result. MEDICAID% might be associated with more cost-inefficiency because of unmeasured case-mix effects or because hospitals with higher concentrations of Medicaid patients tend to be located in less affluent areas associated with an unfavorable

Table 3. Descriptive Statistics for Estimated Inefficiency Scores, by Ownership Status.

Ownership Type	N[a]	Mean Cost-Inefficiency	Std. Dev.	Mean Ranking of Cost-Inefficiency
FP	503	0.0860	0.0777	1042.6
GOVT	360	0.2579	0.2466	2712.1
NP	2,613	0.1129	0.0761	1783.3
All Hospitals	3,476	0.1240	0.1169	1738.0

[a]These were 4 years of data for each of the 869 hospitals in our analytical file.

payer-mix (i.e., more Medicaid and uninsured patients). This type of payer-mix might have had an adverse effect on operating surplus, thereby precluding the acquisition of capital equipment needed to facilitate productivity gains. Of course, these explanations are speculative and should be examined in future empirical research.

Descriptive statistics for mean estimated cost-inefficiency by ownership status are presented in Table 3. For the entire sample the estimated mean cost-inefficiency was 12.4 percent. Cost-inefficiency estimates of most U.S. hospital studies have fallen within the range of 9–23 percent (Rosko & Mutter, 2007). The FP hospitals were the least cost-inefficient (8.6%), followed by NP (11.3%), and GOVT (25.8%).

Since concern has been expressed about the appropriateness of using SFA cost-inefficiency point estimates, we also supply rankings in Table 3. We conducted a Mann-Whitney test (a non-parametric test based on rankings), and these results also suggest that cost-inefficiency differs by ownership group ($p<0.01$). Consistent with the regression results, the mean values (overall and by ownership type) were very stable over time.

7. DISCUSSION AND CONCLUSIONS

Theoretical ambiguities necessitate the use of empirical analysis to understand the impact of ownership on hospital efficiency. This chapter uses rigorous and preferred strategies identified by Shen et al. (2005) for assessing differences in hospital performance by ownership type as well as the approach recommended by Rosko and Mutter (2007) for using SFA to estimate efficiency in the hospital industry. Using SFA, we find that FP hospitals are more cost-efficient than NP hospitals, which, in turn, are more cost-efficient than publicly owned hospitals.

Table 4. Descriptive Statistics for Case-Mix Index and Selected Performance Ratios, by Ownership Status, 2002.

		N	Medicare Case-Mix Index	Average Length of Stay[a]	FTE Employee per Admission[b]	Expenses per Admission[b]
FP	Mean	130	1.386	3.658	0.041	4,537.244
	Std. Deviation		0.173	1.336	0.011	1,225.444
GOVT	Mean	91	1.464	4.411	0.060	6,787.943
	Std. Deviation		0.245	2.393	0.018	2,857.488
NP	Mean	648	1.436	3.735	0.048	4,988.930
	Std. Deviation		0.220	1.362	0.013	1,484.714
All Hospitals	Mean	869	1.432	3.794	0.048	5,109.748
	Std. Deviation		0.218	1.512	0.014	1,751.621

[a]Adjusted for case-mix.
[b]Adjusted for case-mix and outpatient volume.

These findings are supported by the analysis of ratios (using 2002 data) commonly used by hospital executives to assess the performance of their institutions. The ratios reflect patient management (case-mix adjusted average length of stay), labor efficiency (full-time equivalent employees per admission adjusted for outpatient activity and for case-mix), and average cost (total expense divided by admissions adjusted for outpatient activity and for case-mix). These ratios are summarized in Table 4. It was important to adjust for case-mix because for-profit hospitals might minimize costs not by increasing efficiency but by ‘‘cream-skimming’’ or serving less resource-intensive patients that tend to be more profitable in risk-based payment mechanisms such as prospective payment or capitation. While we cannot address motivation in this study, we did find that the mean Medicare case-mix index was significantly ($p<0.05$) lower in FP (1.38) hospitals than in their NP (1.43) or GOVT (1.46) counterparts. However, as Table 4 illustrates and consistent with our SFA results, FP hospitals had significantly ($p<0.05$) lower case-mix adjusted means for all three ratios described above. These findings are consistent with Property Rights Theory.

Our results support the subset of the frontier literature that finds that FP hospitals are more efficient than hospitals faced with a non-distribution constraint. They also corroborate the research that does not rely on frontier techniques that finds that FP hospitals are more efficient than NP hospitals (Becker & Potter, 2002) and that hospitals become more efficient when they convert from NP to FP status (Shen, 2003).

Our findings contribute to the ongoing discussion on the relative merits of FP and NP hospitals, which informs government policy in the areas of taxation, conversion, and anti-trust. Our findings support the notion that FP hospitals have an important role to play by enhancing the efficiency of the hospital sector.

Yet there is concern that the greater efficiency of FP hospitals comes at the expense of lower quality. Research conducted thus far has suggested that there are no quality differences between NP and FP hospitals. Future analyses of differences in hospital efficiency by ownership type using frontier techniques could address a gap in the literature by employing indicators that more accurately reflect the multi-dimensional nature of hospital quality.

We find support for the assertion that market forces, such as hospital competition and payer mix, have important impacts on the efficiency of hospitals' operations. It has been hypothesized that control (i.e., local versus system) has an important impact on how a hospital delivers services (Sloan, 2000). Future research investigating the relative importance of the impact of ownership and control on hospital efficiency is warranted, as are contributions to the emerging literature exploring the impact of ownership mix in a market on hospital performance. SFA could be particularly useful in assessing how a market's ownership mix affects hospital efficiency.

NOTES

1. See Rose-Ackerman (1996) for a review of industries with multiple ownership types.

2. See Needleman (2001) for a review of Arrow's (1963) contributions to understanding NP hospitals and how his work has been extended by subsequent research.

3. Sloan (2000) questions the notion that FP status necessarily implies greater efficiency. If that were automatically the case, he wonders, then why were there not more conversions to FP status in the late 1980s and 1990s when price-based competition emerged? He may have answered his own question by suggesting that the lack of a well-defined owner makes NP status difficult to change: "For this reason, the forces of market selection operate slowly, and the form remains dominant long after the rationale for the form has disappeared" (Sloan, 2000, p. 1151).

4. Although the non-distribution constraint is regarded as the most important distinction between NP and FP hospitals, there are additional differences between the ownership forms that have implications for behavior. By selling stock, FP

hospitals are able to raise equity capital. As already noted, NP hospitals enjoy income and property tax exemptions, and they receive private donations. There is debate over whether differences in the way that NP and FP hospitals select their boards have behavioral implications (Sloan, 2000).

5. Sloan (2000) notes that physician influences on the behavior of individual hospitals are mitigated in hospitals that are members of a chain.

6. See Worthington (2004) for a review of the similarities and differences between SFA and DEA.

7. The effects of conversion from NP to FP status on uncompensated care have also been studied. The findings have been mixed: some research indicates that hospitals converting to FP status provide less uncompensated care after the change, while other studies find that the conversions have no effect on the provision of uncompensated care. See Young, Desai, and Van Deusen Lukas (1997), Needleman, Lamphere, and Chollet (1999), and Desai, Van Deusen Lukas, and Young (2000).

8. The differences in performance between NP and FP hospitals in these studies were typically small and statistically insignificant.

9. Woolhandler and Himmelstein (1997) find that (compared to NP hospitals) a higher percentage of FP hospitals' costs go to administration.

10. This study is part of a larger project where data were restricted to 20 states participating in the Healthcare Cost and Utilization Project (HCUP). HCUP is a family of health care databases and related software tools developed through a Federal-State-Industry partnership to build a multi-State health data system for health care research and decision-making. For more information, go to http://www.hcup-us.ahrq.gov/home.jsp. The 20 states are Arizona, California, Colorado, Florida, Illinois, Iowa, Maine, Maryland, Massachusetts, New Jersey, New York, North Carolina, Oregon, Pennsylvania, South Carolina, Texas, Utah, Virginia, Washington, and Wisconsin. These states are diverse in terms of geography and demographics. We excluded specialty hospitals because SFA requires the output of hospitals analyzed together to be relatively homogenous. For that reason, we did not pool urban and rural facilities based on the results of a Chow test ($p<0.01$).

11. The Hospital Market Structure File contains various measures of hospital market competition. These measures are aggregate and are meant to broadly characterize the intensity of competition that hospitals may be facing under various definitions of market area. They are available to the public for free online at http://www.hcup-us.ahrq.gov/toolssoftware/hms/hms.jsp

12. Chi-square statistics with critical values at the $p<0.05$ level are used to test hypotheses.

13. Compared to the normal-half-normal distribution, the truncated normal distribution has an additional parameter, μ, which is the estimated mode. The parameter, μ, serves to place the distribution and allows the normal distribution to have a non-zero mode. A lengthier discussion is available in Kumbhakar and Lovell (2000).

14. Although the use of the half-normal distribution could be tested because it is a special case of the truncated normal distribution, there are other plausible distributions, such as the gamma, that cannot be formally evaluated by the restriction tests.

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APPENDIX

A.1. Background

SFA was developed by Aigner, Lovell, and Schmidt (1977) and Meeusen and van den Broeck (1977). The purpose of SFA is to decompose variations from the best-practice cost frontier into a random or classical error and a deterministic error, which is assumed to represent, in the case of this chapter, cost-inefficiency.

The first health care application of SFA was published by Wagstaff (1989), who examined 49 Spanish hospitals. Since then, there have been over 19 studies conducted in the United States (Rosko & Mutter, 2007) and over 10 in Europe (Hollingsworth, 2003; Worthington, 2004).

A.2. Model Specification

We assume a cost function of the following general form:

$$TC_i = f(Y_i, W_i) + e_i \tag{A.1}$$

where, TC represents total costs; Y is a vector of outputs; W is a vector of input prices; and e is the error term, which can be decomposed as follows:

$$e_i = v_i + u_i \tag{A.2}$$

where v is statistical noise (i.e., assumed to be distributed as N(0, σ^2)) and u consists of positive departures from the cost-frontier and represents cost-inefficiency (i.e., the percentage by which observed costs exceed minimum costs predicted for the best-practice cost frontier [Lovell, 1993]).

Although u is frequently assumed to follow a half-normal distribution, there is no theoretical reason for the selection of this or other distributional forms for u. Coelli, Rao, O'Donnell, and Batteese (2005) indicate that the specification of a more general distribution such as the truncated normal (Stevenson, 1980) has partially alleviated concerns about the arbitrary choice of a distribution. Moreover, concerns about this issue may be overstated as reviews of both the general literature (Coelli et al., 2005) and the health services research literature (Rosko & Mutter, 2007) have consistently reported that varying assumptions about the distribution of the deterministic error has had little impact on estimated inefficiencies.

In this chapter, we used a general form of the translog cost model to estimate the stochastic frontier for U.S. hospitals. It can be expressed as follows:

$$\begin{aligned}\ln \mathrm{TC}_{it} = \alpha_0 &+ \sum_{j=1}^{J} \alpha_j \ln \mathrm{Y}_{jit} + \sum_{k=1}^{K} \beta_k \ln \mathrm{W}_{kit} \\ &+ .5 \sum_{j=1}^{J} \sum_{l=1}^{J} \delta\zeta_{jl} \ln \mathrm{Y}_{jit} \ln \mathrm{Y}_{lit} \\ &+ .5 \sum_{k=1}^{K} \sum_{m=1}^{K} \gamma_{jl} \ln \mathrm{W}_{kit} \ln \mathrm{W}_{mit} \\ &+ \sum_{j=1}^{J} \sum_{k=1}^{K} \rho_{ij} \ln \mathrm{Y}_{jit} \ln \mathrm{W}_{kit} \\ &+ \varphi \mathrm{PD}_{it} + \mathrm{v}_{it} + \mathrm{u}_{it}\end{aligned} \tag{A.3}$$

where TC represents total expenses; Y is a vector of outputs; W is a vector of input prices, PD is a vector of product descriptors; α, β, δ, γ, ρ, and ϕ are parameters to be estimated; and v_{it} and u_{it} are random variables described above.

To estimate hospital-specific inefficiency, we used a time-varying model developed by Battese and Coelli (1995). In this model the inefficiency effects are defined by:

$$\mathrm{u}_{it} = \eta_i \mathrm{Z}_{it} + \mathrm{w}_{it}, \quad \mathrm{u}_{it} \geq 0 \tag{A.4}$$

where Z_{it} is a vector of explanatory variables associated with the inefficiency-effects; η is a vector of unknown parameters to be estimated; and w_{it} are unobservable random variables, assumed to be independently distributed, obtained by truncation of the normal distribution with mean zero and unknown variance, σ^2.

This model allows an estimation of the impact of firm-specific and environmental factors on inefficiency (Hjalmarsson, Kumbhakar, & Heshmati, 1996). By including time in the Z vector with other firm-specific variables, inefficiency can differ by firm and by time.

The parameters of the cost frontier were simultaneously estimated by a maximum likelihood method using the FRONTIER 4.1 program, which uses a random-effects regression technique (Coelli, 1996). This model estimates inefficiency and the parameters of the inefficiency effects variables simultaneously.

The cost-efficiency of the i-th hospital in the t-th year (where t ranges from 1 in 1999 to 4 in 2002) is defined as the ratio of the stochastic frontier total costs to observed total costs. The stochastic total cost frontier is defined by the value total costs would be if u_{it} (i.e., the cost-efficiency effect) was zero (i.e., full efficiency). Battese, Heshmati, and Hjalmarsson (1998) show that

$$CE_{it} = \exp(-u_{it}) \tag{A.5}$$

where CE_{it} is cost-efficiency, and u_{it} was defined above. The amount by which $\exp(u_{it})$ exceeds 1 is a measure of cost-inefficiency.

A.3. Cost Function Variables

We imposed the standard assumption of linear homogeneity in input prices by normalizing the equation by the wage rate. Thus, the dependent variable is the logarithm of total expenses divided by the wage rate. The continuous output and input price variables also were log-transformed. Two price of two inputs, capital (Pk) and labor (Pl), are recognized by the cost function. Pl was approximated by the Medicare area average wage index, and Pk was approximated by area average depreciation and interest expenses per bed. For both inputs, the average price was computed for all short-term general hospitals in the county in which the study hospital was located. This approach is similar to that used by Dor and Farley (1996). A more complete specification of input prices would be desirable. However, given the relatively poor quality of input price information, we will follow past practices (Zuckerman et al., 1994; Grannemann, Brown, & Pauly, 1986) and use this limited set of price variables. The model assumes that excluded input prices are proportional across hospitals.

The outputs in the cost function included inpatient admissions (ADMITS), outpatient visits (OPV), and patient days in non-acute care units (OTHERDAYS). We used patient days for the latter variable because compared to acute care units the length of stay in these units is much longer and more variable. The results of a Hausman specification test ($p<0.05$) suggest that hospital outputs can be treated as exogenous, an assumption common to hospital cost studies (Grannemann et al., 1986).

We used a variety of product descriptor variables to control for the heterogeneity of output in hospitals. The Medicare Case-Mix Index

(MCMI) was included to control variations in resource requirements by inpatients. The MCMI is weighted according to the relative costliness of DRGs into which the hospital's patients have been classified. A study of Pennsylvania hospitals found that the MCMI is highly correlated ($r > 0.90$) with a DRG case-mix index based on all patients (Rosko & Carpenter, 1993). We also included an index of 7 high-technology services (Zuckerman et al., 1994) in the model. Hospitals that offer more of these services are likely to attract more patients with high resource requirements.

Although outpatient visits may be heterogeneous, an outpatient case-mix measure comparable to the MCMI was not available. Accordingly, two independent variables suggested by Dor and Farley (1996) – ER% (emergency room visits as a percent of total outpatient visits) and OUTSURG% (outpatient surgery as a percent of total outpatient visits) – were added to the model to control for variations in outpatient case-mix. Each is expected to have a positive relationship with total costs.

We employed structural (teaching status) and outcome (mortality rate) measures of quality. Taylor, Whellan, and Sloan (1999) reported that quality of care was positively associated with teaching activities. We used two binary teaching variables to represent different levels of commitment to graduate medical education – membership in the Council of Teaching Hospitals (COTH) and non-COTH hospitals with one or more medical residents or interns. COTH-members tend to have a much higher ratio of interns and residents per bed than non-COTH teaching hospitals.

Recognizing that outcomes are the "gold-standard" of quality measurement, we used risk-adjusted inpatient morality index (MORTINDEX) to represent the rate of adverse outcomes. The variable was constructed by dividing actual inpatient deaths by expected inpatient deaths. The latter was developed by Solucient, Inc., and it considered a variety of risk factors including severity of illness, complications, and age.

A.4. Inefficiency-Effects Variables

A set of variables, commonly thought to influence efficiency, is also included in the stochastic frontier regression model as inefficiency effects. These variables are used to locate the distance between the hospital and the best-practice cost frontier. We included binary variables for FP and GOVT ownership of hospitals. NP status was the omitted reference category. These variables were used to test our hypothesis about the association between ownership form and cost-inefficiency.

We also included a number of other variables to control environmental pressures for efficiency. This is important because FP hospitals are thought to locate in more munificent environments than NP and public hospitals (Sloan et al., 2001). HMO penetration (HMO%), defined as the percentage of the population in the county that is enrolled in HMOs, reflects the financial pressures exerted by managed care organizations. Increases in HMO penetration have been associated with reduced hospital cost inflation (Robinson 1991, 1996; Gaskin & Hadley, 1997; Anderson, Zhang, & Worzala, 1999) and reduced hospital inefficiency (Rosko, 2001b).

Medicare share (MEDICARE%) and Medicaid share of admissions (MEDICAID%), were used to reflect the regulatory pressures of public payers. Medicare is a federal program for the elderly. Since November 1983, a prospective payment system (PPS) has regulated payment rates made by Medicare. Hospitals are allowed to keep the difference between the payment rate and actual costs of providing service. Conversely, hospitals can lose money if their costs exceed the PPS rate. Medicaid is a joint state and federal program that pays for services provided to ‘‘categorically-needy’’ individuals. Medicaid payment mechanisms vary across states. Several states have implemented some form of PPS; however, even in states where PPS is not used, the payment rates generally are set well below cost (ProPAC, 1995).

A Herfindahl-Hirschman Index (HHI) was used to reflect competitive pressures. HHI was calculated by summing the squares of the market shares of admissions for all of the hospitals in the county. This index takes on a value of 1 in monopolistic markets and approaches 0 as output is dispersed among more firms. Thus, higher values reflect less competitive pressure.

Table A1 presents the definitions and descriptive statistics of the variables used in the stochastic frontier regression equation.

A.5. Log-Likelihood Tests

Kumbhakar and Lovell (2000) indicated that there are many different specifications that could be used to estimate a stochastic frontier cost function with panel data and these choices are not guided by theory. Specifically, in developing a preferred model the following decisions had to be made: (1) should OLS or SFA be used? (2) what should the structural form of the cost function be? (3) what theoretical distribution should the

Table A1. SFA Regression Variables and Descriptive Statistics.

Variable	Description	Mean	Std. Dev.
COTH	Binary variable (1,0) for hospitals that are members of the Council of Teaching Hospitals	0.151	0.358
ER%	(ER visits/total outpatient visits)* 100	27.091	15.505
FP	Binary variable (1,0) for for-profit hospitals	0.145	0.352
GOVT	Binary variable (1,0) for government hospitals	0.104	0.305
HHI	Herfindahl-Hirschman Index for concentration of adjusted hospital admissions	0.273	0.262
HITECH INDEX	Index of 8 high technology services	4.623	2.114
HMO%	(HMO enrollment/population)* 100	28.623	13.000
LADM	Log of admissions	9.331	0.690
LODAY	Log of otherdays	9.306	1.175
LOPV	Log of outpatient visits	11.895	0.823
MCMI	Medicare Case-Mix Index	1.425	0.213
MEDICAID%	(Medicaid admissions/total admissions)* 100	15.322	10.516
MEDICARE%	(Medicare admissions/total admissions)* 100	40.643	11.362
MORTINDEX	Actual mortality rate/expected mortality rate	0.988	0.207
OTHERTEACH	Binary variable (1,0) for teaching hospitals that are not COTH-members	0.314	0.464
OUTSURG%	(Outpatient surgeries/OPV)* 100	4.272	3.138
Pk	Log((interest + depreciations)/beds))	6.622	0.199
TOTAL COST	Log(Total expenses/price of labor)	7.750	0.820
YEAR	Time-trend variable for year of observation	2.500	1.118

composed error follow? and (4) should inefficiency-effects variables be included?

Our preferred model was based on the results of a number of restriction tests. Table A2 presents the results of hypotheses tests that examined a number of restrictions. These are likelihood ratio tests (Greene, 2003). The hypotheses tests, involving the parameters of the stochastic cost frontier, were obtained using the generalized likelihood statistic, $\lambda = -2[\ln(L(H_0)] - \ln[L(H_1)]$, where $L(H_0)$ and $L(H_1)$ are the values of the likelihood function under the two hypotheses (i.e., restricted and unrestricted versions of the model). If the null hypothesis is true, λ has a Chi-square distribution with degrees of freedom equal to the difference between the number of parameters estimated under H_1 and H_0 (Coelli et al., 2005). If the restriction has little impact on the parameter estimates, the value of the log likelihood function will not change much, and the null hypothesis will not be rejected.[12]

Table A2. Generalized Likelihood-Ratio Tests of Null Hypotheses for Parameters of the Translog Stochastic Cost Frontier Model.

Null Hypothesis	Test Statistic, λ^a	Implication
H_0: $\gamma = 0$	571.471	Use SFA rather than OLS
H_0: $u = 0$	26.795	Assume truncated-normal distribution for residuals
H_0: $B_{ij} = 0$	193.211	Use translog model rather than Cobb-Douglas
H_0: $\delta_1 = \delta_7 = 0$	58.791	Include X-inefficiency variables in SFA model

[a]None of the null hypotheses could be accepted ($p < 0.05$).

First, to determine if SFA was a more appropriate estimation technique than OLS regression, the hypothesis, $\gamma = 0$, was tested. Battese and Corra (1977) replaced σ_v^2 and σ_u^2 with $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \sigma_u^2/(\sigma_v^2 + \sigma_u^2)$. Larger values of γ imply that the variance of the inefficiency effects represent larger proportions of the total variance of the error terms, u and v. Accepting the null hypothesis (H_0: $\gamma = 0$) implies that σ_u^2 is zero. If so, the u_{it} term should be removed from the model. This leaves a specification with parameters that can be consistently estimated using OLS regression (Coelli, 1996). If γ equals zero then the deviations from the cost frontier are due entirely to statistical noise. As indicated in Table A2, this hypothesis could not be accepted, and SFA was used.

Second, the translog function has become the most frequently applied cost function because of its flexibility. However, the translog function can require many independent variables and the squared and cross-product terms are highly correlated raising the possibility of multi-collinearity problems. Thus, a simpler model, such as the Cobb-Douglas function, which is a special case of the translog function in which the parameters of the higher order output and input price variables are restricted to equal zero, should be considered. However, the hypothesis for the Cobb-Douglas cost function model could not be accepted.

Third, an assumption about the theoretical probability distribution of the inefficiency effects, $\mu_{i,}$ must be made. Although the half-normal distribution has been used the most, there is no a priori justification for the use of any particular distribution for the cost-inefficiency effects, $u_{i.}$ Stevenson (1980) addressed this issue by specifying a truncated-normal distribution, which is a generalization of the half-normal distribution. Since the half-normal distribution is a special case of the truncated-normal distribution where $\mu = 0$, the appropriateness of using the half-normal distribution was assessed

Table A3. Parameter Estimates for the Frontier Cost Function.

Variable	Coefficient	Asymptotic *t*-Ratio
INTERCEPT	9.4842	4.9725*
ADMITS	0.8301	3.3221*
ADMITS-SQ	0.1024	4.5492*
OPV	−0.8676	−4.4902*
OPV-SQ	−0.0405	−2.8767*
OTHERDAY	0.0940	0.7400
OTHERDAY-SQ	0.0130	7.6494*
Pk	−2.2069	−4.1743*
Pk-SQ	0.1848	2.0768**
ADMITS*OPV	−0.0111	−0.3564
ADMITS*OTHERDAY	−0.0433	−3.4044*
OPV*OTHERDAY	0.0380	3.1961*
Pk*ADMITS	−0.1221	−3.4369*
Pk*OPV	0.2151	7.6417*
Pk*OTHERDAY	−0.0281	−1.5049
MCMI	0.5374	24.5486*
COTH	0.2690	21.1126*
OTHERTEACH	0.0514	6.4525*
ER%	−0.0004	−1.1837
OUTSURG%	0.0165	11.2775*
HITECH	0.0031	1.5505
MORTINDEX	0.0692	4.2313*
YEAR	−0.0035	−1.0866
Inefficiency – Effects		
Δ_0	−2.3017	−6.0462*
HHI	−0.9980	−5.0994*
HMO%	0.0033	2.4983**
FP	−0.8731	−4.5752*
GOVT	1.2966	9.7477*
MEDICAID%	0.0224	8.1284*
MEDICARE%	−0.0132	−5.8407*
YEAR	−0.0168	−0.3223
Sigma-squared	0.3440	8.1334*
Gamma	0.9312	80.5542*
Log likelihood function = 851.3885		

* $p < 0.01$.
** $p < 0.05$.

by testing H_0: $\mu = 0$.[13] As Table A2 summarizes, this hypothesis could not be accepted, and the truncated-normal distribution was used in the final model.[14] However, it should be noted that although the mean estimated efficiency may vary under different assumptions, relative inefficiency or rankings are not affected very much. In this study, the simple correlation of the inefficiency scores estimated with the two distributions exceeded 0.98. This is consistent with results from a variety of other industries (Kumbhakar & Lovell, 2000) and hospital studies (Rosko & Mutter, 2007).

Finally, the hypothesis, $\delta_1 = \ldots = \delta_8 = 0$ could not be accepted. This implies that the exogenous inefficiency variables, as a group, have a significant impact on cost-inefficiency. As result of the hypothesis tests, the preferred model was a translog cost function, which assumed the composed error followed a truncated normal distribution. The hypothesis tests also support the inclusion of the inefficiency-effects variables in the simultaneous estimation procedure. This model, applied to cross-sectional data, was the preferred model identified by Rosko and Mutter (2007) in their review of empirical issues surrounding the use of SFA in the hospital industry.

A.6. Results

The maximum-likelihood estimates for the preferred model described above are presented in Table A3. The implications of these estimates were discussed in the main text.

CHAPTER 8

COMPETITION AND MARKET CONCENTRATION

Nazmi Sari

1. INTRODUCTION

The health care industry has been influenced by changes in the market structure and new technological developments during the recent decades. With the new technological developments in medicine, some less complex care moved out of the hospitals that led to decrease in demand for inpatient services. This recent change in hospital care created excess capacity in hospital markets, and therefore hospitals started to explore potential financial gains through horizontal consolidations. This has resulted in a wave of mergers in 1990s, which transformed the US, Canadian and European hospital markets. This, in turn, created concerns among policy makers and researchers in terms of its welfare implications.

Hospital markets in the US became highly concentrated due to increasing numbers of mergers during the last decades (for an extensive review see Gaynor & Haas-Wilson, 1999). Within 2 years, from 1994 to 1996, more than 40% of all hospitals were involved in mergers, acquisitions, joint ventures or partnerships. Only in 1997, there were more than 200 hospital mergers (Haas-Wilson & Gaynor, 1998). Between 1990 and 2003, market concentration increased by about 50% in US hospital markets. By 2003, almost 90% of people living in larger metropolitan statistical areas (MSAs)

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faced highly concentrated markets (Town, Wholey, Feldman, & Burns, 2006). During the same period, the Canadian hospital industry showed a similar trend. In Ontario, Health Services Restructuring Commission has been created in 1996 to direct public hospitals to ''amalgamate, transfer or accept programs, change volumes, cease to operate, or make any other changes considered to be in the public interest'' (Health Services Restructuring Commission, 2000, p. 11). In 1996–1997, there were about 33% reductions in the numbers of hospital corporations operating in Ontario due to wide ranging site closures and program transfers (Preyra & Pink, 2006).

Increase in concentration in hospital markets has raised concerns among researchers and policy makers because of potential anticompetitive consequences of mergers. It is expected that profit maximizing firms exercise market power if the numbers of competitors in the market decrease. However, it is also likely that mergers may enhance social welfare by creating efficiency gains due to economies of scale and scope. This can be achieved through a decrease in redundant services and investments, and reductions in management and administration costs. Efficiency gains can be quite substantial in small markets if there are significantly large numbers of expensive service duplications such as magnetic resonance imaging (MRI) and computed tomography (CT) scans. Horizontal consolidations in hospital markets can also affect service quality. As the focus is placed more and more on the impact of market concentration on hospital pricing and cost efficiency, potential quality consequences of market concentration has been neglected or not received enough attention from the researchers and policy makers. Horizontal consolidations may result in better treatment outcomes since in some services there may be significant learning effects. An earlier study showed that the mortality rate after open-heart surgery, vascular surgery, transurethral resection of the prostate and coronary bypass decreased with an increase in hospitals' surgical volume (Luft, Bunker, & Enthoven, 1979). On the other hand, hospitals may not have financial incentives to invest in quality enhancing activities if the quality is costly investment and not observable or imperfectly observable, therefore not contractible. As a result, net impact of mergers on social welfare is ambiguous due to opposite effects of hospital prices, cost and quality.

In this chapter, I examine competition and concentration in hospital markets and their public policy implications. In the following two sections, I review the recent literature on market concentration in hospital markets and its efficiency and quality consequences using evidence from related economics literature. Due to methodological variations including differences in the definition and measurement of relevant geographical markets, the literature provides contradictory evidence. In Section 4, I briefly review the antitrust guidelines and link it with the empirical literature reviewed in earlier sections by emphasizing methodological issues related to definition and determination of relevant markets for merger litigations. The last section presents the conclusions, and suggestions for further research on market competition and concentration in hospital markets.

2. PRICING, COST EFFICIENCY AND MARKET CONCENTRATION

In the US hospital markets, there has been a shift away from non-price competition towards intensive price-competition in the late 1980s due to major changes in hospital reimbursement schemes. In 1982, California became the first state to pursue health care reform through market-based procompetitive policies, and adopted a law to encourage increased price competition in the health care sector by allowing insurance companies to selectively contract with providers. This drastic change in policy led to a shift from patient-driven to payer-driven competition. There have been a large number of studies investigating the impact of this policy change on hospital pricing and costs. In this section, I summarize the findings from this literature by reviewing related research on horizontal consolidations in hospital markets.

2.1. Market Power and Concentration in Hospital Markets

The types of competition in hospital markets have changed from patient-driven to payer-driven competition after deregulation in the markets. During the regulated pricing period, providers placed more emphasis on the services and amenities they offered than on the prices they charged. This feature of hospital competition, known as the *medical arms race* (MAR), suggests that having more hospitals operating in the same market would increase investment in unnecessary duplication of expensive capital equipment such as MRI and CT scans, and higher advertising and promotion expenditures in order to attract patients and physicians. This type of market competition implies that higher competition may have unintended consequences in the form of higher, rather than lower, prices and costs.

Many studies have based their analysis on California hospitals. The California Office of Statewide Health Planning and Development (OSHPD) maintains a variety of datasets on various aspects of health care in California. Each non-federal hospital in California is required to submit the annual discharge data, the annual financial data and the quarterly financial data to the OSHPD. The detailed financial data make it possible to calculate the required price and cost variables for hospital behavior models. The richness in the OSHPD data encouraged many researchers to investigate the cost and pricing behaviors in California hospitals (Dranove, Shanley, & White, 1993; Gruber ,1994; Lynk, 1995; Melnick, Zwanziger, Bamezai, & Pattison, 1992; Zwanziger & Melnick, 1988). The studies examining the effects of market concentration on hospital pricing behavior have different conclusions, since they investigate different hospital markets in different time periods (for an extensive review, see Dranove & White, 1994; Gaynor & Vogt, 2000).

In a review article, Gaynor and Vogt provide a summary and effects of a standard merger on price using the estimated coefficients from 10 studies. In their analysis, they assumed that a standard merger is a merger between two hospitals located in the same market with other three hospitals. They also assume that each hospital has equal market share, and the new hospital after the merger will have a market share of 40%, while others continue to have 20% market share each. Except in three studies, their simulation shows that the effects of a merger on price range from +2% to +17% with a strong correlation between the effect size and the recency of the data used in the studies. The simulation from three studies suggests that the price effect is in fact negative; −3% based on Lynk and Neumann (1999) and −1% based on Lynk (1995) and Noether (1988).

Some of the papers reviewed in Gaynor and Vogt (2000) examine the association between concentration and price by hospital ownership. Among these, Lynk (1995) became one of the most influential studies on antitrust practice. A district court judge in September 1996 based his decision on a finding from Lynk (1995), and proposed not to block a merger of two non-profit hospitals in Grand Rapids, Michigan. Lynk used a 1989 hospital discharge data set from California and concludes that after a merger non-profit hospitals are less likely to use their market power. Using the findings from Lynk (1995), Gaynor and Vogt estimate that a standard merger would increase the price by +17% for a merger between two for-profit hospitals, while this effect will be −1% for a merger between two non-profit hospitals. In response to Lynk (1995), Dranove and Ludwick (1999) and Keeler, Melnick, and Zwanziger (1999) examine price effects of mergers by types of hospital ownership. They also use data from California and conclude with an opposite result: mergers, even non-profit mergers, are associated with higher prices. According to simulations in Gaynor and Vogt (2000), Keeler et al. (1999) and Dranove and Ludwick (1999) imply that a standard merger between two non-profit hospitals would increase price by 6% and 17%, respectively.

Using a structural model of demand and pricing in California hospital markets, Gaynor and Vogt (2003) also examine effects of competition on prices by ownership type. They simulate the effects of a merger in San Luis Obispo County that would create a monopoly. Their results show that prices increase by up to 53%, and the predicted price increase would not be substantially smaller even if the hospital were not-for-profit. Similarly, a recent study using data from New York State also provides evidence to support this argument (Zwanziger & Mooney, 2005).

New York State was one of the last two states resisted to the use of price competition in hospital markets in controlling healthcare costs until mid-1990s. In 1996, New York enacted new legislation that opened the hospital markets to price-based competition. With the Health Care Reform Act of 1996, all private payers were allowed to negotiate the prices they pay to the hospitals. Using data for the period of 1995–1999, Zwanziger and Mooney (2005) study the impact of new legislation on prices in the New York hospital markets. They conclude that hospitals in more competitive markets after 1997 were paid less. Their results show that one standard deviation increase in market concentration index at the mean (approximately 20%) was associated with a 10.4% increase in prices. This result is also consistent with economic theory that in more competitive markets hospitals do not have extensive market power, and therefore, accept lower prices offered by the insurance companies. With few exceptions, evidence from empirical studies also supports the view that market concentration leads to higher prices in hospital markets (see also Capps, Dranove, & Satterthwaite, 2003; Vita & Sacher, 2001).

2.2. Efficiency Gain and Market Competition

As payer driven price competition has become the norm in hospital markets in the US and UK, the providers have started to explore possibilities for mergers and acquisitions to overcome financial pressures. Horizontal consolidation in hospital markets would lead to higher prices as reviewed in previous section, but it may also create efficiency gain. As antitrust agencies emphasize detrimental impacts of potential market power due to horizontal consolidations, efficiency gain is also recognized in merger guidelines as a mitigating factor to be considered to evaluate the welfare consequences of a merger (i.e. Competition Bureau, 2004). However, cost savings would be harder to determine for antitrust agencies since the merging firms themselves provide such information and they have financial incentives to overstate cost savings. Policy makers also are concerned that consolidations create hospital market power without any, or not enough offsetting reductions in hospital costs. In other words, a merger may have both positive and negative impacts on social welfare due to efficiency gain and higher prices. Net impact as shown in Fig. 1, depends on the magnitude of these two aspects of a merger.

Fig. 1 presents the pre- and post-merger common average cost and the demand curve for two hospitals. Total output and price before the merger are shown with Q_1 and P_1. Suppose that a merger between two hospitals creates both market power (price increases to P_2) and efficiency gain (average cost AC_1 decreases to AC_2). The net change in social welfare depends on these two opposite effects. Although output decreases to Q_2 and price increases to P_2, the merger may still enhance social welfare if the welfare loss (area of triangle L) due to market power is less than welfare gain (area of rectangular G) due to efficiency. This issue has been an important empirical question, and received attention in the economics literature.

In order to examine potential efficiency gain due to horizontal consolidation, recent studies have focused on effects of mergers on hospital costs. For instance, Dranove and Lindrooth (2003) study the US hospital

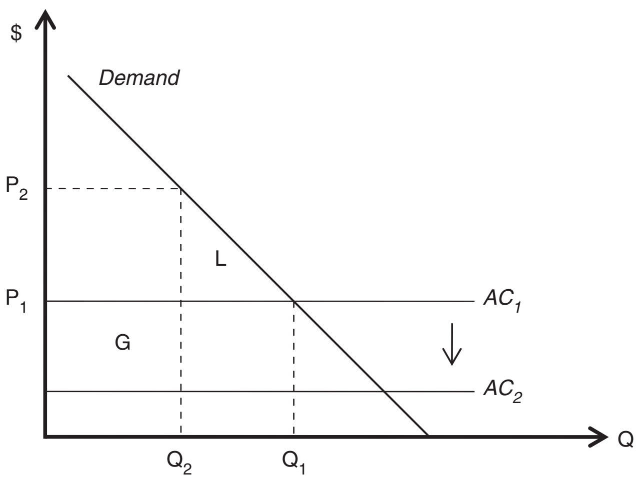

Fig. 1. Welfare Implications of a Merger.

markets in the period of 1988–2000 in order to investigate the impact of mergers which took place between 1989 and 1996. By comparing hospitals that actually merged with those that have the same characteristics but did not merge; the authors conclude that there is significant and persistent savings for mergers after consolidations. Their results are also aligned with the earlier studies (i.e. Connor, Feldman, & Dowd, 1998; Spang, Bazzoli, & Arnould, 2001). As indicated by Dranove and Lindrooth, hospitals may also create multi-hospital systems, which are the consolidations of two or more hospitals in the same geographic market that have common ownership, but maintain separate physical facilities, separate licenses, and keep separate financial records. Dranove and Lindrooth conclude that system acquisitions did not create similar savings. This implies that system acquisitions may have detrimental impacts on social welfare as it has potential positive impacts on both prices and costs. However, it is still not clear whether hospital consolidations enhance social welfare since the net impact depends on the amount of efficiency gains, specifically the area of rectangular G versus the area of triangle L in Fig. 1.

Another line of empirical research has focused on estimating the amount of inefficiency in production and costs. Following the pioneering work by Farrell (1957), others developed alternative models to estimate cost or production efficiency (i.e. Aigner, Lovell, & Schmidt, 1977; Cornwell, Schmidt, & Sickles, 1990; Schmidt & Sickles, 1984). Aigner et al. (1977) develop a stochastic frontier approach, which is based on the argument that not all deviations from the frontier such as deviations due to luck, climate, and poor machine performance cannot be under firms' control; therefore they should not be counted as a part of firm inefficiency. Using the methodology introduced in Aigner et al. (1977), Frech and Mobley (2000), among others, study hospital markets to identify the effect of differences in inefficiency on growth and market concentration. Similarly, Zuckerman, Hadley, and Iezzoni (1994) use a stochastic frontier cost function to estimate hospital inefficiency, and examine efficiency outcomes of profit motives, market forces and other hospital characteristics. Although this chapter includes severity of illness measures, output quality, and patient outcomes in the cost function estimations, as argued in subsequent studies, inefficiency estimates in cross-sectional studies can be biased due to hospital specific unobservable variables including imperfectly observable quality in hospital services (Dor, 1994; Skinner, 1994).

As an alternative to cross sectional studies, several studies used panel data models. Among several others (see Linna, 1998; Gerdtham, Löthgren, Tambour, & Rehnberg, 1999; Rosko, 2001), Sari (2003) applies panel data models using data from Florida hospitals in the period of 1990–1997, and estimates the effect of market competition on hospital efficiency. Sari emphasizes the potential bias due to unobserved quality differences among hospitals. Unobserved output quality may create bias since observed correlation between market concentration and inefficiency can be due to negative association between market concentration and high quality. After controlling for potential bias due to unobserved quality, the results in Sari (2003) reveal that the association between cost inefficiency and market concentration depends on the level of competitiveness in the market. Hospital cost inefficiency has an inverse U-shaped association with rising market concentration, implying that there is an immediate efficiency gain due to mergers in a competitive market. The source of the savings in mergers can be either exploration of economies of scale (i.e. increasing utilization of expensive equipment) or economies of scope (i.e. operating a single information system for various products) or both. As mergers combine scale and scope effects, the total impacts would even be larger. For instance, a joint information system creates savings due to spreading the fixed costs over increased volumes within output categories, as well as sharing the same information system across output categories. This finding is also consistent with the earlier results that the horizontal integration promotes cost efficiency by decreasing excess capacity in the health care markets (Connor, Feldman, Dowd, & Radcliff, 1997). However, Sari also suggests that mergers do not create efficiency if the level of market competition is moderate. The results suggest that once potential efficiency gain is exploited through mergers in competitive markets, further concentration does not create cost savings until the market becomes almost a monopoly.

It is clear that welfare consequences of market concentration in hospital markets are heavily influenced by potential efficiency gains. Net impact on social welfare depends on the relative magnitude of efficiency gain as opposed to welfare loss due to market power. So far there is no study in the literature which combines the welfare effects of consolidations due to higher prices, quality and efficiency gains.

3. HOSPITAL QUALITY AND COMPETITION

In the economics literature, there has been an ever growing interest on the impacts of market concentration on hospital pricing and cost efficiency, while quality consequences of market concentration have not received enough attention from researchers or antitrust enforcement agencies.

Until recently, empirical literature on quality issues has been limited (see Dranove, Shanley, & Simon, 1992; Robinson & Luft, 1985). Economic theory does not help either since it provides ambiguous conclusions in terms of the quality consequences of market concentration. The theory suggests that hospital competition leads to higher quality under price regulation if the regulated prices are higher than the marginal cost. In regulated markets, hospitals compete by providing higher quality in order to attract more patients. As briefly noted in the previous section, this type of competition may also create incentives for the hospitals to invest in activities that are not necessarily quality enhancing, such as unnecessary tests, duplication of more expensive services and technology (Robinson & Luft, 1985). Since the regulated prices or hospital budgets are adjusted based on the earlier prices and costs under retrospective reimbursement systems, hospital competition increases the cost with or without affecting quality.

In unregulated markets, hospital competition can turn out to be price, quality and price and quality competition. Hospitals in competitive markets have a higher incentive to invest in quality enhancing activities and provide higher quality as long as the marginal gain from providing higher quality exceeds the marginal cost. Spence (1975) studies behavior of a monopolist in setting both price and quality. He concludes that the monopolist either oversupplies or undersupplies the quality relative to the social optimum. A profit-maximizing monopolist firm, as demonstrated in Spence (1975), takes marginal valuation of quality – the dollar benefits of the product to the marginal consumer – into account. On the contrary, a surplus-maximizing social planner chooses a level of quality, where the marginal cost of quality equals to the average valuation of quality. Depending on the difference between the marginal and average valuations, the quality of care provided by the monopoly may be higher or lower than the social optimum.

In healthcare industry, quality is imperfectly observed by patients and their physicians. In particular, adverse treatment outcomes cannot be identified perfectly because they are either related to severity of patients' illnesses or poor quality of hospital care or both. Since adverse outcomes in treatment do not necessarily reflect treatment quality, it is difficult to argue that quality can be a contractible input into the production of health for the patient (McGuire, 2000). If the quality is imperfectly observable by the patients and it is a non-contractible input, then it is unlikely that hospitals will have any incentive in providing higher quality. An exception would be the situation in which the hospital aims to develop credibility and reputation in the market by providing high quality hospital services. The incentives to supply high quality services are determined by patients' ability to infer the quality after receiving care, their beliefs about future quality, and the effects of present reputation on the future market share (for a theoretical discussion, see Shapiro, 1983). This implies that the impacts of competition on quality in deregulated hospital markets are ambiguous.

Relatively few empirical studies explore quality consequences of market concentration and competition. And the empirical evidence provided in this literature supports the economic theory that the results can be in any direction. For instance, Ho and Hamilton (2000) assert that consolidations in hospital markets had no impact on mortality but increased the readmission rates. However, Kessler and McClellan (2000) conclude that competition in hospital markets has significantly reduced adverse health outcomes after 1990.

Ho and Hamilton (2000) compare the quality of hospital care before and after mergers in California between 1992 and 1995. They use inpatient mortality for heart attack, 90-day readmission for heart attack patients and discharge within 48 hour for normal newborn babies. They conclude that the recent mergers have not had a measurable impact on inpatient mortality, but readmission rates and early discharges increased due to the mergers. Although the authors argue that the recent mergers have not had a detrimental impact on quality, they suggest that additional research needs to be conducted to improve our understanding about the quality consequences of consolidations in hospital markets.

Kessler and McClellan (2000) develop a model to estimate the effects of hospital competition on costs and health outcomes for all non-rural Medicare patients who were hospitalized for a treatment of a new heart attack in the period of 1985–1994. They construct competition indices using a hospital choice model, in which each individual's potentially relevant geographic market includes all nonfederal hospitals within 35 miles of her residence or within 100 miles for large and teaching hospitals. In their model, the hospital market competition is assumed to be a function of predicted patient flows from a hospital choice model. They conclude that before 1990 the competition did not have a strong positive impact on adverse health outcomes. However, after 1990 the adverse health outcomes decreased significantly due to competition. Gowrisankaran and Town (2003) apply a similar methodology to estimate the effects of competition on quality in Southern California in the period of 1989–1993. Their outcome variables are the risk-adjusted hospital mortality rates for pneumonia and acute myocardial infarction. Unlike other studies, the authors construct competition measures for each hospital and payer type. They conclude that competition reduces risk-adjusted hospital mortality rate for HMO patients while increasing it for Medicare patients. Based on their results, they argue that the impact of competition on quality depends on hospitals' control over reimbursement rates. If the reimbursement rates are too low, hospitals may not have incentives to compete for Medicare patients through better quality. They conclude that the competition for HMO patients improves social welfare since it reduces price while enhancing quality. However, this conclusion may not hold for Medicare patients since the competition reduces quality, therefore may not be welfare improving. Kessler and Geppert (2005), however, reach an opposite conclusion in terms of welfare implications of competition for Medicare patients. They estimate the effects of hospital competition on quality of care and hospital expenditures for elderly Medicare beneficiaries in the US, who had a heart attack in the period of 1985–1996. The authors find that high-risk patients in competitive markets receive more intensive treatment than in uncompetitive markets, and they also experience better health outcomes. On the other hand, low-risk patients receive more intensive treatment in highly concentrated markets, but they do not experience better health outcomes. Based on this finding, the authors conclude that competition improves health outcomes and at the same time creates savings.

In a study using alternative quality indicators, which are directly based on treatment outcomes, Sari (2002) also examines the impact of market concentration on hospital quality. The quality indicators in this study capture various dimensions of quality by identifying in-hospital complications and inappropriate procedures directly from patient discharge records. This study contributes to the literature by using more comprehensive quality measures and data from up-to 16 states in the US for the 1992–1997 period. The results of this study suggest that quality consequences of hospital mergers are substantial. For instance, a hypothetical merger, which increases hospital market share by 10%, increases complications by 7.6%, and increases wound infections by 8.3%. Hospitals with higher market share also utilize more inappropriate procedures. If the hospital's market share increases by 10%, it is likely that inappropriate surgical utilization increases by 5.4%. The results also support that the complication rates and inappropriate surgeries are 1.4% and 1.02% higher in concentrated markets compared to competitive markets.

While the results in Sari (2002) support positive associations between market competition and higher quality, there are other papers which find contrary results (see Mukamel, Zwanziger, & Bamezai, 2002; Propper, Burgess, & Green, 2004; Volpp et al., 2003). Contrary to the theoretical expectation, the evidence is also ambiguous in price-regulated markets (see Gowrisankaran & Town, 2003; Kessler & McClellan, 2000; Kessler & Geppert, 2005; Tay, 2003). These contrary findings can be explained by the possible variations in the price-cost margin in various geographical regions. They can also be explained by differences in quality and output measures, or methodological differences including differences in the definition and measurement of relevant geographical markets. Some of these important empirical issues are extensively discussed in the earlier literature and in this book by Burgess (2007). It seems that the most important aspect in merger litigations would be the definition of relevant market and the identification of potential competitors. This has also been an important empirical issue in the hospital competition literature. In the next section, I will review the antitrust guidelines and link it with the empirical evidence by emphasizing methodological issues related to definition and determination of relevant markets for merger litigations.

4. MERGER GUIDELINES AND ANTITRUST POLICIES

In market economies, policy makers protect consumers and other producers against anticompetitive actions of the merging firms by using antitrust policies. The merger guidelines are essentially similar across countries. For instance, *U.S. Horizontal Merger Guidelines* define the sound merger enforcement as enforcement that "must prevent anticompetitive mergers, yet avoid deterring the larger universe of procompetitive or competitively neutral mergers" (U.S. Department of Justice and the Federal Trade Commission, 1997, p. 1). In its *Merger Enforcement Guidelines*, Canadian Competition Bureau has the same objective. In these guidelines, a merger is assumed to be anticompetitive if it is likely to prevent competition, and the action is motivated by the economic interest of merging entity. In other words, the mergers are anticompetitive if they are likely to create, maintain or enhance the ability of the merged entity to exercise market power. The exercise of market power creates a transfer of surplus from consumers to producers due to the ability of the merged entity to maintain price above competitive levels for a significant period of time.

The guidelines are implemented by different enforcement agencies in various countries through a similar routine sequence of steps. U.S. Department of Justice and the Federal Trade Commission, and Canadian Competition Bureau Guidelines clearly define these steps as: determining product and relevant geographic markets, identifying competitors in the market, estimating pre- and post-market concentration index, identifying potential competitive effects, and considering any factors that mitigate anticompetitive effects (i.e. cost efficiency).

A market is defined as the smallest group of products, and the smallest geographic area in which a hypothetical monopolist would impose and sustain a significant and non-transitory price increase above the pre-merger price level. This definition is based on substitutability and focuses on demand responses to changes in relative prices. The ability of a firm to raise price depends on buyers' willingness to pay the higher price, and therefore depends on availability of alternative options at a lower price in the same market. This implies that identifying the relevant market and potential competitors plays a crucial role in determining anticompetitive implications of a merger.

Most of the empirical studies on hospital concentration and competition define the relevant markets using one of the three approaches: geographical areas such as counties or metropolitan statistical areas, areas based on distances between hospitals such as area covering a 15- to 30-mile radius around each hospital, or areas based on patient migration or patient flow. Once the appropriate market is determined, the studies calculate aggregate market concentration, most commonly, using *Herfindahl-Hirschman Index* (HHI), which is a summation of market share for each hospital in a given market, ranges from 0 (highly competitive market) to 10,000 (monopolist). The guidelines also acknowledge HHI as an appropriate index and define the markets with post-merger HHI below 1,000 as the antitrust safety zone. In other words, these are considered to be unconcentrated markets in which adverse competitive effects from mergers are not expected. Therefore mergers in these markets do not require further attention from antitrust agencies.

It is obvious that defining the relevant market and potential competitors is extremely important in applying antitrust regulations, and estimating potential welfare gain or loss due to the market concentration. The assumption that the geographical boundaries or fixed distances would be appropriate measures in determining the relevant market implies that the distance is the only relevant product characteristics for consumers in making decisions to get treatment from hospitals. In other words, substitution among different hospital products depends only on physical distance. This assumption does not seem appropriate since individuals may even travel to another country in order to get better treatment. The differences in the hospital quality or even perceived quality are important factors in determining the patients' choices, implying that the relevant market needs to be determined using patient flows. This feature of healthcare markets has been recognized by researchers and whenever patient migration data are available, the markets are defined using patient migration or flow data. Despite improvements with this alternative approach, it is likely that higher quality hospitals attract patients from longer distances; hence the measured market area for them will be larger than that of neighboring lower quality hospitals. This even implies that higher quality hospitals have more competitors and less market power compared to lower quality neighboring hospitals (Tay, 2003). As a solution, subsequent studies used predicted patient flows, which are estimated using a hospital choice model, rather than the actual flows (i.e. Kessler & McClellan, 2000). This suggests that hospital quality plays a critical role in competition for patients, as well as in expanding market area.

Although the guidelines are primarily concerned with the prices and efficiencies after any merger, there is still some emphasis on the effects of mergers on other dimensions of competition such as quality, product choice, service and innovation (Competition Bureau, 2004; U.S. Department of Justice and the Federal Trade Commission, 1997). Quality consequences of mergers have recently received more attention in the economics literature. However, due to difficulties in observing and measuring hospital quality, antitrust agencies have not sufficiently emphasized quality implications of mergers in merger litigations (Hammer & Sage, 2002). Even if there is efficiency gain after a merger, it is likely that the saving could be through quality distortions. Under this scenario, it is difficult to argue that the merger enhances social welfare even if post-merger prices stay the same. Further research focusing on the impacts of market concentration on efficiency and quality, and their welfare implications would shed light on the anticompetitive implications of recent mergers.

5. CONCLUSIONS

This chapter provides important insights for antitrust implications of concentration in hospital markets using evidence from recent economics literature. Hospital markets have become concentrated due to mergers, acquisitions, joint ventures and partnerships. They have also been influenced by changes in market structure due to an increasing role of managed care in the United States. These changes in the market structure transformed the hospital competition from non-price competition towards intensive price-competition. The literature supports the view that an increase in concentration in hospital markets leads to higher prices; therefore it has negative welfare consequences. As noted by the antitrust agencies in their merger guidelines, achieving cost efficiency is a potential mitigating factor that needs to be considered in examining welfare implications of a merger in hospital markets.

The cost savings through concentration can be achieved due to economies of scale and scope. However, it is also likely that quality distortion can be an alternative source of the savings. There are some studies supporting the view that concentration creates efficiency gain, while some others argue that concentration has a negative impact on health outcomes and quality. It is, therefore, not clear whether the net impact on social welfare would be positive since the result depends on efficiency gain, market power, and quality consequences of concentration. Since they have been motivated by the economic theory, the guidelines recognize these aspects of a merger. However, antitrust agencies have not sufficiently emphasized quality implications of mergers in merger litigations due to the difficulties in observing and measuring hospital quality. While recent empirical literature attempts to overcome the shortcomings of earlier studies by introducing alternative measures and methodologies – new output and quality measures, various market definitions and modeling, structural models, etc. – there is still no study demonstrating combined welfare effects of horizontal consolidations due to market power, efficiency gain and quality. Additional research that would provide new empirical evidence by taking several aspects of consolidations into account will enhance our understanding about the consequences of mergers and will guide the competition policy, and future merger litigations.

In this chapter, I restrict the discussions to the welfare implications of horizontal consolidations in hospital markets. However, another striking development in the US healthcare industry has been the formation of strategic partnerships between hospitals and physician groups that may also have important welfare consequences. As noted in Gaynor (2006), vertical integrations between physicians and hospitals can have anticompetitive impacts due to a foreclosure effect in both hospital and physician markets. It is possible that vertical integration could foreclose rival hospitals and physician groups from access to hospital and physician services. This can increase market power in both physician and hospital markets. Vertical integrations may also result in higher prices due to an increase in bargaining power of the integrated unit with insurers. Further research in this important area that received recent attention in the literature (Ciliberto & Dranove, 2006;

Cuellar & Gertler, 2006) will also be helpful in formulating and applying future antitrust policies.

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CHAPTER 9

EFFICIENCY AND PRODUCTIVITY CHANGES IN LARGE URBAN HOSPITALS 1994–2002: OWNERSHIP, MARKETS, AND THE UNINSURED

Gary D. Ferrier and Vivian G. Valdmanis

1. INTRODUCTION

Based on the Current Population Survey, 46.6 million Americans did not have health insurance in 2005 (Center on Budget and Policy Priorities, 2006). Lack of insurance is often associated with lower utilization rates, which may in turn adversely affect health status (Ayanian, Weissman, Schneider, Ginsburg, & Zaslavsky, 2000). Since universal health insurance is not provided for in the US, uninsured individuals must either self-pay or rely on charity care provided by hospitals and health clinics. The majority of charity care is produced in the public sector, either at the state, county, or local level (federal hospitals primarily serve a particular segment of the population – e.g., veterans in the case of Veterans Administration hospitals). Public hospital provision of "safety net" hospital services is particularly prevalent in large urban areas (Lipson & Naierman, 1996). These safety net hospitals are defined by the Institute of Medicine as having an "open door policy to serve all patients regardless of their ability to pay and provide substantial levels of

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care to Medicaid, the uninsured, and other vulnerable patients" (IOM, 2000). Private not-for-profit (NFP) hospitals also provide charity care but to a lesser extent than public providers, especially since the imposition of cost cutting measures both by Medicare and Medicaid (federal programs that fund health care for the elderly and indigent, respectively) and by managed care. Given that approximately 15% of US GDP is allocated to health care, cost cutting measures are laudable; however, care still needs to be provided for individuals who cannot afford it, and the burden of providing this care has to be borne somewhere in the health care system.

Private and public hospitals co-exist in the US, particularly in large urban areas. Historically, public hospitals have taken on the safety net role, permitting private hospitals, even the NFP sector, to pursue other objectives such as technological expansion, financial viability, and prestige building. This relationship between public and private hospitals began in the early 1900s and continues today (Opdycke, 1999). To help maintain the safety net (in part by providing an incentive to private hospitals to participate in it), the federal government has implemented Medicare and Medicaid legislation, established disproportionate share payments for hospital that provide care for the poor, and instituted allowances for teaching functions at hospitals. In spite of these programs, wide gaps in coverage still exist, as evidenced by the millions of uninsured. Absent universal coverage, the piece meal provision of hospital care and the need for safety net hospitals continue.

Reductions in lengths of stay have created excess bed capacity at many hospitals, putting further financial pressure on hospitals (Friedman, 1997). Private hospitals' excess capacity makes Medicaid patients more attractive to them as they attempt to increase utilization rates, even though reimbursements for these patients are less than for privately insured patients (Bovbjerg, Marsteller, & Ullman, 2000). However, even in the face of excess capacity, access for the uninsured to private sector hospitals is not easily gained. Not only is payment an issue, but the health status issues these patients present (such as drug/substance abuse, AIDS, and mental illness) are often difficult and costly to treat (Brecher & Spiezio, 1995). Furthermore, these patients often consume loss-leading services (Vaknin, 1996).

Unless universal health care coverage is implemented in the near future, hospitals and their governing overseers will need to continue to develop policies on care for the uninsured. However, the financial constraints faced by local governments have made this task increasingly onerous. For example, California requires that each county ensures that health care is available for the medically indigent, primarily through the public hospital system (Friedman, 1997). Recent economic woes in California have the reduced number of public hospitals, increasing the burden for those that remain. For example, the county of Los Angeles (LA) considered closing the LA County-University of Southern California (USC) medical center; closure was prevented only by the intervention of the Clinton administration, which provided the necessary funding to keep it open (Friedman, 1997). This action was deemed necessary because it was unlikely that the private sector would have or could have absorbed the amount of uncompensated and Medicaid care provided by LA County-USC.

Over its long history, the New York City public hospital system has responded to financial pressures by aligning with private hospitals, forming affiliations with medical schools, and taking other actions to overcome the threats of closure (Opdycke, 1999; Brecher & Spiezio, 1995; Rorer, 2000). Similarly, for financial reasons the public hospital in Boston – Boston City Hospital – merged with the Boston University Medical Center. Recently, public hospitals in Detroit and Washington, DC, were closed because of financial hardship. Furthermore, Philadelphia, the fifth largest city in the US, has not had a public hospital since the closure of Philadelphia General in 1977. Without the presence of public hospitals to serve as safety nets hospitals, the financial burden associated with safety net services falls upon private hospitals.

Rosko (2004) studied the impact of uncompensated care on hospitals in Pennsylvania and found a discernible effect on hospitals' financial viability when large amounts of charity care are provided. This finding may not bode well for hospitals in Washington, DC, since DC General Hospital was one of the highest providers of charity care in the US (Fagnani, 2001). Furthermore, the burden on all hospitals operating in Arizona, Texas, and California looms large, since these three states have the highest rates of uninsured individuals (Sorelle, 2000).

The presence of public hospitals follows the typical economic role of public provision in the face of market failures since the private sector will not provide the socially optimal level of services. In the case of hospitals, market failures include a discrepancy between costs and payment (creating moral hazard), free-ridership, and positive as well as negative externalities. Unless laws and public policies are changed, re-allocating the patient load to the private sector would in all likelihood result in increased burdens on the private sector as well as broader costs (Vaknin, 1996). Without adequate compensation, hospitals – whether private or public – treating large numbers of uninsured patients may risk financial distress that could result in closure which, would in turn, reduce access to care in the surrounding community.

In spite of the role public hospitals play as safety net providers, which reduces this burden on private hospitals, some still contend that public hospitals may not be necessary (Brecher & Spiezio, 1995). One argument is that given the excess capacity in private hospitals, efficiency could be increased by re-allocating funding of charity care to the private sector. Hampering this type of re-allocation is the 1997 Balanced Budget Act (BBA), which limited the amount of added allowances from Medicare to hospitals providing charity care, thereby making the uninsured patient even less desirable, from an economic standpoint, to private hospitals.

In addition to serving as safety nets, public hospitals offer other benefits to their communities as well, including the training of future medical practitioners (particularly physicians) and the provision of trauma care. The percent of care provided via the emergency room represents the ability to treat cases in urgent or emergent conditions that must be attended to irrespective of ability to pay. Hence, the benefit of public hospitals is difficult to dispute from a social welfare standpoint; nonetheless, it is important to consider the costs of obtaining these benefits by examining the relative efficiency and productivity of public hospitals (Vaknin, 1996). Privatization proponents claim that the conversion of public hospitals would improve both efficiency and access (Tradewell, 1998). Under this scenario, the public role in the provision of hospital care would be one of contracting with the private sector rather than the direct production of care (Bovbjerg et al., 2000).

Given the issues briefly outlined above, there are two related empirical questions we seek to address. First, are public hospitals necessarily less efficient or productive than their private sector counterparts? Second, are private hospitals' efficiency and productivity affected by the presence, or lack thereof, of a public hospital in their communities? We aim to address these two questions by measuring the efficiency and productivity of hospitals in the largest urban US standard metropolitan statistical areas (SMSAs) from 1994 through 2002 and comparing the results across public and private hospitals in all markets and across private hospitals in markets with and without public hospitals.

This analysis will be carried out using data envelopment analysis (DEA) and the Malmquist index of productivity. We are interested in the dynamics of hospital performance over time, since this will provide a better idea of the long-term viability of hospitals – public or private – as well as determine how the changes that occurred in US hospital markets throughout the 1990s and early 2000s have affected hospitals. We do not directly address the access of uninsured patients to hospitals or the utility functions of hospital decision-makers by ownership form (for a review of this issue, see Duggan, 2000).

Instead, we focus on the operational front; i.e., we examine how hospitals' efficacy in converting inputs into outputs, given certain market characteristics, affects their continued provision of all types of patient care. Indirectly, we can draw some inferences from this perspective, namely that if private hospitals in the Philadelphia, Detroit, and Washington, DC – markets without public hospitals – lag behind their peers in the other large urban areas with a public hospital presence, welfare losses that occur would need to be furthered studied at the specific local level. We also disaggregated the sample to address how private and public hospitals' efficiency and productivity changes may differ in markets with high proportions of uninsured individuals versus markets with lower proportions of uninsured individuals. We contend that hospitals in high uninsured markets would be particularly affected by a public hospital closure (Rosko, 2004). Conversely, concentrating the uncompensated care burden in the public hospitals may deter productivity especially if care cannot be provided in an efficient manner (Bovbjerg et al., 2000).

As stated above, we are interested in gauging whether the presence of a public hospital affects private sector hospitals' productivity over a 9-year sample period. Whether or not a hospital provides charity care, while important from a social standpoint, is not the primary issue we address; rather, we examine whether the presence of a public hospital provides positive "spillovers" for private sector hospitals operating in the same SMSA. The methods we use will be briefly described in the next section; technical details are provided in Appendix A. Data and variable definitions are given in Section 3, followed by the findings and results in Section 4. The chapter concludes with a summary and discussion.

2. METHODS

Technology governs the process by which inputs are transformed into outputs. Efficiency and productivity provide information on how effectively the inputs are transformed into outputs. Over time, there are two sources of productivity change; productivity can change due to changes in technology itself (i.e., technical change) or due to changes in the efficiency with which technology is applied (i.e., technical efficiency change). To gauge how hospitals' productivity changes over time, we calculate the input-oriented Malmquist index of productivity change and its components (see Färe, Grosskopf, & Lovell, 1994).

A graphical representation based on two time periods, 1 and 2, and just a single input and a single output illustrates the dynamics of efficiency and productivity (see Fig. 1).

Technology can be depicted by a ray from the origin – technology is given by T^1 in period 1; but, assuming technological progress, it shifts to T^2 in period 2. Points along a technology represent input quantities that are just sufficient to produce the associated level of output (i.e., points along the ray represent the efficient use of input – more output can not be produced from the given level of input for the observed "state" of technology). Points to the left of the technology ray are not feasible – there is not enough input to produce the associated level of output; on the other hand, points to the right of the ray are inefficient – given the technology, a lesser amount of input could have been used to produce the associated level of output.

Consider the production of output level u^1 during the first period using technology T^1. Point E represents an efficient use of resources (i.e., it lies on the technology ray), while point D^1 represents an inefficient use of resources (i.e., it lies to the right of T^1); point F is simply not feasible in period 1 (i.e., it lies to the left of T^1). Since "hospitals" at points E and D^1 both produce output level u^1, but hospital D^1 uses x^2 unit of input while hospital E uses only x^1 units of input, hospital D^1 is inefficient relative to hospital E. Hospital D^1's efficiency score is given by λ, which is found by solving $x^1 = \lambda \times x^2$; i.e., the efficiency of D^1 is given by the proportionate reduction in its input level needed to make it "just able" to produce u^1. Alternatively, the efficiency of

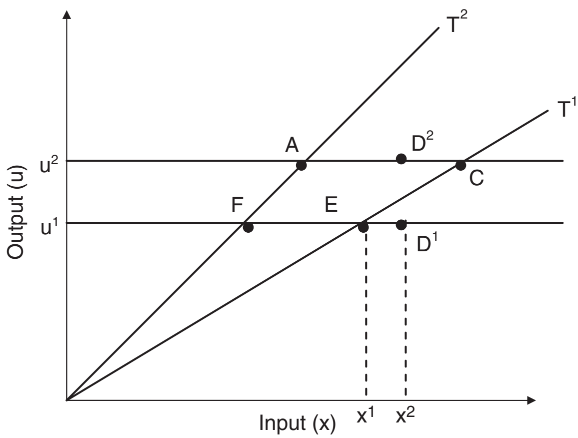

Fig. 1. Measuring Efficiency and Productivity.

hospital D is given by the ratio x^1/x^2. D^1 would be more productive if it were to emulate E and operate on the "frontier" – i.e., the boundary between feasible and infeasible production possibilities; D^1's productivity gain in this case would be due to a "change in efficiency."

Now consider time period 2. A better means for transforming inputs into output now exists – relative to T^1, technology T^2 is more productive. Along T^2 the same level of output (say u^1) could be produced using a smaller amount of input than was previously feasible given T^1 (e.g., compare points E and F). Suppose that hospital D moves from D^1 in period 1 to D^2 in period 2 – using the same level of inputs (x^2), more output is created (u^2 in period 2 versus u^1 in period 1). Operating at point D^2 was not feasible given T^1, the state of technology in period 1, but it is a feasible production point in period 2 given T^2; i.e., technical change has taken place. Unfortunately for hospital D, it is still inefficient – it operates at point D^2, but hospital A uses a lower level of input to produce the same level of output (u^2). While hospital D benefited from "technical change" – the shift of technology from T^1 to T^2 – it has not taken full advantage of the new technology. Hospital D's productivity change between periods 1 and 2 can be calculated using the Malmquist index (*MI*) of productivity change. It is given the by ratio of hospital D's technical efficiency in period 2 relative to its technical efficiency in period 1; i.e., $MI^D = TE^{D_2}/TE^{D_1}$.

Remember that hospital D had two ways in which it could improve its productivity between periods 1 and 2 – first it could change the efficiency of its operations, second it could take advantage of the change in technology that took place. To determine the contribution of each of these two possibilities, the Malmquist index for hospital D (or, more generally, for any hospital) can be decomposed into two pieces – a component to due a change in efficiency and a component due to a change in technology; i.e., $MI^D = \Delta TE^D \times \Delta Tech^D$. The first term captures the change in technical efficiency (a change in how well available technology is utilized); the second term captures the change in technology (a change in the technology itself). Measures of *MI* or its components that are greater than one indicate that improvements have been made; measures equal to one imply that no changes were made; and measures less than one mean that performance has deteriorated. A change in efficiency measures the degree to which an observation is "catching up" with best-practice technology; while a shift in the frontier itself measures "true" technical change (see Nishimizu & Page, 1982). Appendix A (Technical Appendix) at the end of this chapter provides detail on how the Malmquist index and its components can be calculated using data on (multiple) input and (multiple) output quantities across multiple time periods.

3. DATA AND VARIABLES

In this chapter we use data for the years 1994 through 2002 as reported in the American Hospital Association's (AHA) *Annual Survey of Hospitals*. We focus on large urban SMSAs with populations greater than 1 million and follow only hospitals that were operating for all 9 years. The specific urban areas in our study include: Atlanta, Boston, Chicago, Dallas, Detroit, Houston, Los Angeles, Long Island, New York City, Philadelphia, Riverside, CA., St. Louis, Sand Diego, and Washington, DC. We included hospitals whose ownership form included non-federal public hospitals ($N = 64$), private not-for-profit (NFP) hospitals ($N = 425$), for-profit hospitals ($N = 95$) and Veterans Administration (VA) hospitals ($N = 16$). The total number of hospitals in our sample is 5,400 (600 hospitals observed in each of 9 years). VA hospitals were included in order to ascertain their efficiency and productivity since there have been policy suggestions that these hospitals could produce health care services for the uninsured (Moskowitz, 2004).

It should be noted that the decision to include in our sample only hospitals that were in operation throughout the study period may introduce self-selection bias into our analysis; however, this likely under-estimates productivity improvement due to the closing or merging of hospitals within a market. Moreover, we considered it to be appropriate to exclude hospitals that closed or changed their status for two reasons. First, we did not want to alter our sample size since that would necessarily affect the efficiency findings due to the curse of dimensionality (essentially a degrees of freedom problem – as the number of observations changes relative to the number of specified inputs and outputs, efficiency scores may change), and we did not want to confound our findings by potential outlier effects because of hospitals that closed due to poor financial conditions. This concern regarding closings for fiduciary reasons is an accounting concern, whereas we are primarily interested in taking an economic view of the production process in order to ascertain social costs.

Large urban areas were selected since these markets may be particularly vulnerable to large populations of uninsured patients with costly conditions requiring specialized services not found in smaller communities (e.g., AIDS populations, large numbers of homeless, and those requiring trauma care).

Recall that the Malmquist index is constructed using DEA, which permits the use of multiple inputs and multiple outputs – we specified our efficiency and productivity; in our analysis we specify five inputs and seven outputs. Inputs include the number of staffed beds to account for size and capital; labor inputs included the numbers of full time equivalent registered nurses

(RNs), licensed practical nurses (LPNs) other staff (OTHER) as well as the number of medical residents and other trainees. We included medical residents and trainees as inputs since they provide direct patient care as well as represent the teaching commitment on the part of the hospital which is another social benefit. Further, teaching commitment is also permitted an additional allowance via Medicare. Even though the allowances were changed in the BBA, we are interested in ascertaining staffing mixes in private and public hospitals that provide medical education. The number of physicians was not included as an input due to data limitations – because private sector hospitals in the US do not directly employ the doctors who work in them, our data source did not contain information on numbers of physicians.

The seven outputs in our model include the number of inpatient days by type of payment – Medicare inpatient days, Medicaid inpatient days, and other inpatient days; the total number of inpatient surgeries, the total number of outpatient surgeries, the total number of emergency room visits, and the total number of outpatient visits. The differentiation of patients on the basis of payment source and type of service provided should offer an adequate description of a hospital's case mix, which often is a determinant of resource use (Wilson & Burgess, 1996; Grosskopf & Valdmanis, 1993). Of course, patient outcomes would be a preferable measure of the true benefit of hospital care; however, we rely on the assumption that care provided will lead to better health outcomes, ceteris paribus, than would no care at all.

Descriptive statistics of the input and output data, for the full 9-year sample period, are presented in Appendix B. Over the 9-year sample period there were some discernable trends in the data. Most notably, the number of beds, on average, decreased. This change was most pronounced for the VA hospitals; however, the associated decrease in the inpatient services was offset by an increase in the number of outpatient visits. This trend was mirrored in the non-federal public hospitals and, to a lesser degree, in the private hospitals. The average number of FTE staff remained relatively stable, even in the hospital sectors that reduced their numbers of beds.

In terms of outputs, the numbers did not fluctuate, which is interesting since some researchers hypothesized that given excess capacity in the private sectors, Medicaid patients would be increasingly treated in private hospitals rather than public hospitals. This conjecture was not found in any of the hospitals operating in our sample of hospital markets. (Specific findings of payer mix by hospital ownership by SMSA are available from the authors.)

4. RESULTS

We first examine the differences in the provision of social goods across by hospital ownership types between 1994 and 2002 to determine whether hospitals' commitments to their communities have changed. Social goods are proxied by emergency room visits as a percentage of all outpatient services (% ER) and teaching commitment (residents/bed) (Fig. 2).

Throughout the time period of our study, the commitments to providing these two social goods have remained relatively stable across ownership type. On the whole, the two public ownership forms – non-federal public and VA hospitals provided the most teaching, while the private for-profit hospitals had the highest percentage of ER visits (followed closely by the NFP and non-federal public hospitals).

We next turn to our examination of efficiency and productivity changes through time by ownership form. The purpose of this part of our study is to

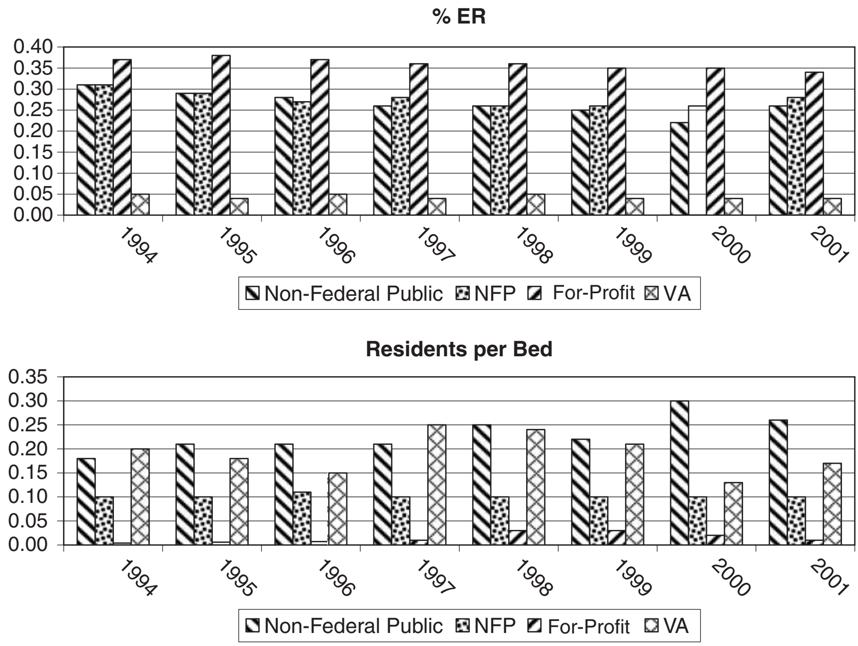

Fig. 2. The Provision of Emergency Room Care (% ER) and Teaching Commitment (Residents per Bed) by Hospital Ownership – 1994–2002.

directly address the issue of the economic performance of public hospitals. These findings are illustrated in Fig. 3.

During the time period from 1994 to 2002, we find that the Malmquist index, efficiency, and productivity changes were generally greater than 1, on

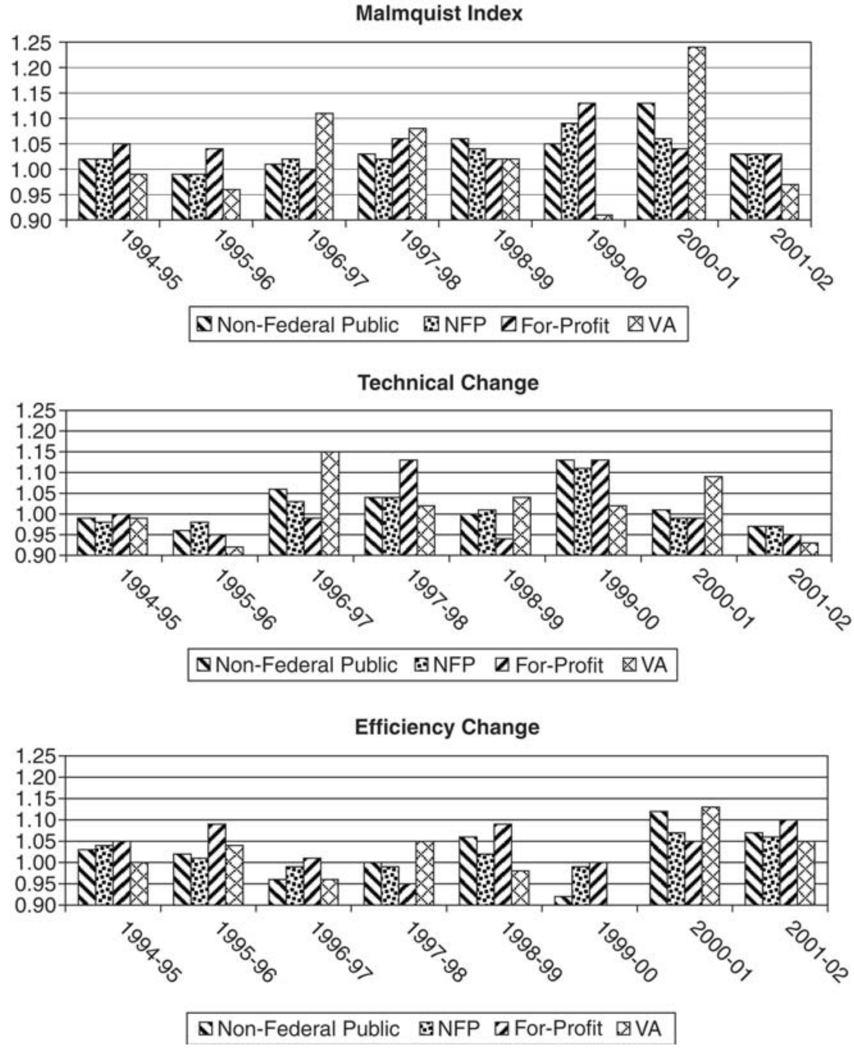

Fig. 3. The Malmquist Index, Technical Change, and Efficiency Change by Hospital Ownership – 1994/1995–2001/2002.

average, indicating improved performance for each hospital ownership type, though VA and for-profit hospitals posted the biggest gains. In general, technical change outpaced efficiency change. The improvements in performance were unsteady, however. For example, VA hospital productivity initially declined (1994/1995 and 1995/1996), then steadily improved (1996/1997 to 2000/2001, before declining again at the end of the sample period (2001/2002). The VA hospital gains followed a concerted effort to improve their flagging performance (Waller, 2006). Improvements by for-profit hospitals came about in part because of the need to demonstrate net revenue gains to their stockholders. Both VA and for-profit hospitals may be notably different than their non-federal public or NFP counterparts. VA hospitals treat a specific population for which they may be able to anticipate demand (this supposition is supported by the low percent of ER care provided by VA hospitals). For-profit hospitals tend to be smaller and focus their activities on services that are most attractive to private pay patients (Woolhandler & Himmelstein, 1999). It is important to note that non-federal public hospitals were not significantly out-performed by the private NFP hospitals, indicating that public hospitals were not necessarily ineffective in their maintaining efficiency or productivity advances.

From the findings above, it appears that, as a whole, hospitals exhibit relatively similar behavior. We next assess the impact of a public hospital's presence by contrasting the Malmquist index and the technical efficiency and productivity changes for hospitals in markets with and without public hospitals.

As in the case of the general findings above that compared performance across hospital ownership categories, we did not find consistent significant productivity differences in hospital markets with and without a non-federal public hospital presence. Recall that we hypothesized that public hospitals relieved private hospitals of (some of) the burden of providing charity care, thus leaving private hospitals with more resources to invest in performance enhancing activities. Given the results illustrated in Fig. 4, we little evidence that hospitals in markets with a public hospital can achieve greater levels of technical efficiency change and technological change than those without a public hospital. There were only two time periods where productivity change was statistically significant. In 1998/1999, hospitals in markets without public hospitals outperformed hospitals in markets with public hospitals; however, in the following time period, 1999/2000, the opposite situation arose, essentially offsetting the previous period's effects. This offset may indicate some type of "catching up" phenomenon. The reverse direction of the efficiency and technological changes may also reflect this type of catching up,

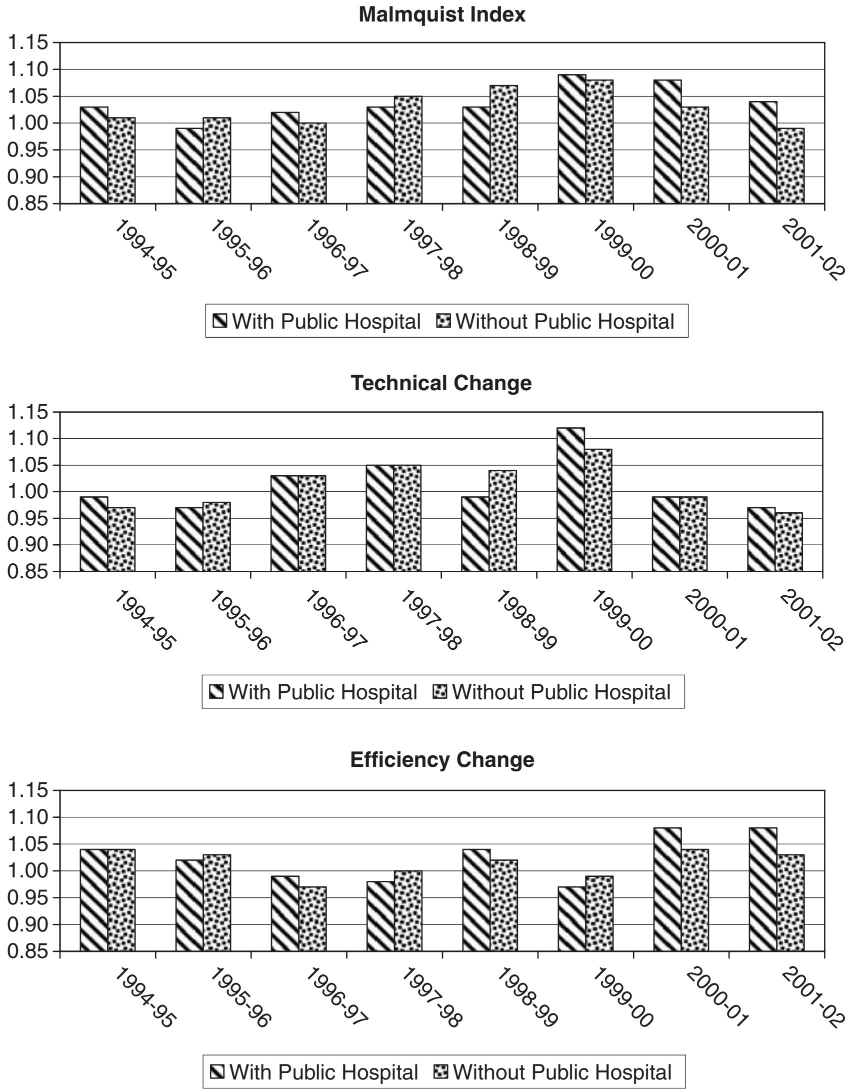

Fig. 4. The Malmquist Index, Technical Change, and Efficiency Change for Hospitals in Markets with and without Public Hospitals.

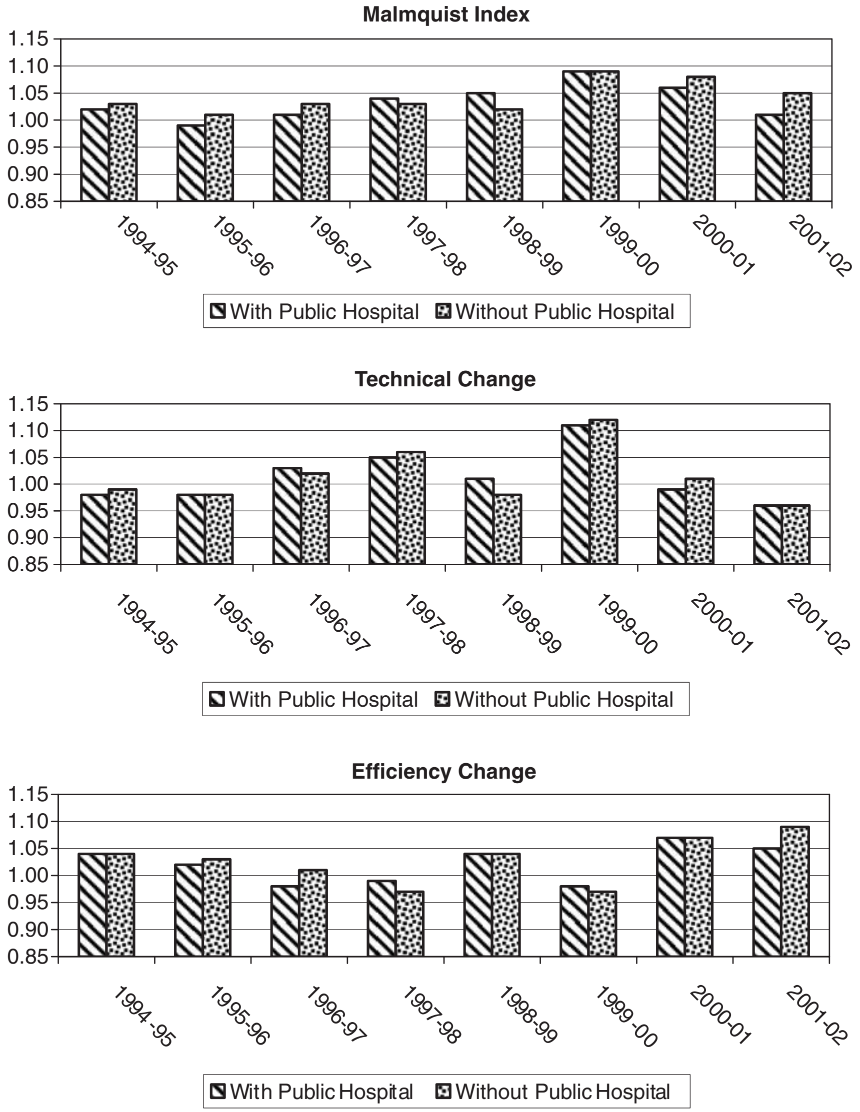

Fig. 5. The Malmquist Index, Technical Change, and Efficiency Change for Hospitals in Markets with High and Low Proportions of Uninsured.

particularly for hospital care where technological advances as well as health care policy may induce changes in the treatment of patients.

One piece of the uncompensated care issue, the effect of the presence of a public hospital, was addressed above; we now turn to the second piece, namely whether the markets in which these hospitals operate contain a high proportion of uninsured residents. This part of the analysis enables us to directly gauge the total charity care need in a community and its possible impact on hospitals' technical efficiency and productivity changes. In communities that have high levels of uninsured individuals, it has been suggested that hospitals will fall behind technologically since more resources will be used in the provision of charity care, limiting the hospitals' ability to put resources into productivity enhancing activities. We define "high" uninsurance markets as those urban areas in our sample as SMSA's with a proportion of uninsured greater than 24.1%.[1] We pay particular attention to the sample hospitals operating in Texas and California (two states with among the highest proportions of uninsured individuals) and the sample hospitals in Minnesota (whose population has one of the lowest proportions of uninsured individuals).

Regardless of whether hospitals operated in a market with high versus low proportions of the uninsured, their performance in terms of the Malmquist index, technical efficiency change, and productivity change were quite similar (Fig. 5). Exceptions to this finding occurred in 1998/1999 and 2001/2002, when hospitals operating in markets with a high proportion of uninsured people had significantly higher levels of technological change and in 1999/2000 when hospitals in markets with a lower proportion of uninsured individuals had higher technological change. Interestingly all statistically significant differences occurred after the BBA of 1997 was implemented in 1998, indicating that this policy may not have had the feared negative repercussion for hospitals treating poor patients. We further note that the performances of hospitals operating in Texas and California (high proportions of the uninsured) and Minnesota (low proportion of the uninsured) were not significantly differently from that of other hospitals in our sample.

5. DISCUSSION

By 2008, it is forecasted that as many as 55 million people in the US may lack health insurance (Mechanic, 2006). The likelihood of any major reform, such as universal health care coverage, is low. While proposals for increasing health care benefits to targeted populations have been put forth

(Ayanian et al., 2000; Friedman, 1997), expansion of governmental programs will be limited. Therefore, responsibility for the care of the uninsured will continue to rest on uninsured themselves and the hospitals in their communities. Whereas the VA hospitals continue to care for their constituency[2] and those with private health insurance will be able to gain access to private hospitals, the poor and vulnerable will continue to depend upon safety net hospitals. The social welfare benefits provided by public hospitals are difficult to dispute. Furthermore, as we have shown, public hospitals do not lag private hospitals, particularly NFPs, in terms of efficiency and productivity changes. We have also offered evidence that private hospitals in markets without public hospitals appear to maintain their productivity levels while presumably providing a relatively greater share of uncompensated care vis-à-vis their counterparts in markets with public hospitals. To more fully address this issue, future research could more directly assess the pre- and post-public hospital closure performances of other hospitals and the effect of closure on access to care. From an organizational standpoint, however, we found that hospitals in markets with high proportions of individuals lacking health insurance did not appear to be statistically significantly different than hospitals in markets with higher proportions of their populations covered by insurance. Finally, even though VA hospitals performed as well vis-à-vis the other hospital ownership forms so far, it appears unlikely given the downsizing in this sector as well as political influence that these hospitals will produce care for the non-Veteran population in the future.

From a societal standpoint, we have found that for 9 years, from 1994 to 2002, the hospitals in our sample made modest gains in their economic performance by improving their technical efficiency and by adopting more productive technologies. Our findings suggest that, on average, various hospitals ownership forms provided care to their communities with relatively similar levels of efficiency and productivity. What we do not know is how this economic performance translates to accounting performance in terms of bottom-lines and financial viability. The close call for the LA County-USC hospital, suggests that more, not less, fiduciary support may be needed in the future.

NOTES

1. This figure was selected as the median of the proportion of uninsured in our sample SMSA, therefore for those SMSA's with a higher proportion than 24.1% were deemed high uninsurance markets.

2. However, this supposition may change as wounded soldiers/veterans return from the War in Iraq. If supply in the VA hospitals/clinics are not increased there may be an additional influx of demand affecting non-federal hospitals.

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APPENDIX A. TECHNICAL APPENDIX

To gauge how hospitals' productivity changes over time, we calculate the input-oriented Malmquist index of productivity change and its components (see Färe et al., 1994).

Hospital technology is represented by the input requirement set, $L(y)$ – i.e., the set of all inputs that could potentially be used to obtain a specific set of outputs using the technology available at the time. Then, allowing for both multiple inputs and multiple outputs, the technical efficiency of each observation (TE^n, $n=1,\ldots,N$) relative to the best-practice technology can be calculated by determining the proportion λ of the observed input vector that is technologically required to produce the observation's given output vector. That is,

$$TE^n(x,y) = \min\{\lambda : \lambda \cdot x_n \in L(y)\},$$

where $TE^n(x, y)$ is the Farrell (1957) input-oriented measure of technical efficiency. Using data envelopment analysis (DEA), $TE^n(x,y)$ is the solution, λ^*, of the following linear program:

$$\begin{gathered} Min\ \lambda \\ subject\ to \\ y_n^o \leq z \cdot M \\ \lambda \cdot x_n^o \geq z \cdot K \\ z_n \geq 0, n = 1, \ldots, N. \end{gathered}$$

Note that the constraints in the above linear program are simply the input requirement set (i.e., the technology that governs the transformation of inputs into outputs).

The Malmquist index, *MI*, can be expressed in terms of Farrell efficiency scores. The Malmquist index of productivity change between any two adjacent years is given by:

$$MI(t, t+1) = \frac{TE^{t+1}}{TE^{t}}.$$

The decomposition of the Malmquist index is given by:

$$MI(t, t+1) = \Delta TE(t, t+1) \times \Delta TECH(t, t+1).$$

The first term of the decomposition captures changes in technical efficiency; the second term describes technical change, which measures shifts in the best-practice technology. Measures greater than one indicate that improvements have been made; measures equal to one imply means that no changes were made; and measures less than one mean that performance has deteriorated. The shift in the frontier measures "true" technical change, while the changes in efficiency are measures of how well an observation is "catching up" with best-practice (see Nishimizu & Page, 1982).

In terms of Farrell efficiency scores, the decomposition of the Malmquist index is given by:

$$MALM_{t_0}(t, t+1) = \left[\frac{TE_{t+1,t+1}}{TE_{t,t}}\right] \times \left[\frac{(TE_{t,t+1}/TE_{t+1,t+1})}{(TE_{t+1,t}/TE_{t,t})}\right]^{\frac{1}{2}}.$$

The first term in the subscripts on the technical efficiency measures denotes the time period to which the reference technology belongs, while the second term in the subscripts the time period to which the input and output data belong. Not that the change in technical efficiency only involves "same period" measures of efficiency – i.e., technology and the inputs and outputs share a common time period for the; the change in technology term, however, sometimes involves "cross-period" calculations – technology from one period, but inputs and outputs from another period.

APPENDIX B. DESCRIPTIVE STATISTICS OF THE INPUTS AND OUTPUTS ($N = 5{,}400$ [600 HOSPITALS OVER 9 YEARS])

Variable	Mean	Std. Deviation	Minimum	Maximum
INPUTS				
Beds	280.56	226.02	7.00	2,278.00
Registered Nurses (RNs)	324.98	324.07	1.00	3,111.00
Licensed Practical Nurses (LPNs)	32.42	34.82	0.00	436.00
Medical Residents	50.55	132.33	0.00	1,118.00
Other FTE	945.19	1,004.03	14.00	11,0622.00
Other Trainees	2.36	18.38	0.00	830.00
OUTPUTS				
Medicare Inpatient Days	28,116.92	25,954.70	0.00	213,696.00
Medicaid Inpatient Days	13,699.27	24,060.34	0.00	252,531.00
Other Inpatient Days	28,667.50	35,860.13	18.00	406,541.00
ER Visits	30,654.01	26,771.54	0.00	289,719.00
Outpatient Visits	125,265.30	165,823.47	0.00	2,185,630.00
Inpatient Surgeries	3,302.95	3,166.56	0.00	41,685.00
Outpatient Surgeries	4,707.33	4,390.56	0.00	70,702

PART IV:
MANAGEMENT POLICY AND MTA

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CHAPTER 10

BENCHMARKING FINNISH HOSPITALS

Miika Linna and Unto Häkkinen

1. INTRODUCTION

One common feature facing diverse health care organisations is a need to compare performance across geographical areas, institutions or individual practitioners. In all health care systems, comparative data help the central government formulate policies for distributing central grants, clinical education, public health, research and tackling disparities. Good comparative data also provides an important resource for decision-making by local managers and clinicians. Through the process usually known as *benchmarking*, institutions can explore which of their peers are performing best, and seek out detailed qualitative and quantitative information on the context and processes contributing to good performance. Benchmarking also helps local managers set targets and rewards, and permits local electorates pass judgment on their local governments. The central theme of this chapter is to describe how the national hospital benchmarking system (BMS) was implemented in Finland, focusing on the use of BMS for managerial purposes and its impact on hospital care.

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1.1. Background

In Finland, some 432 local governments (municipalities) annually decide how much of the budget will be devoted to the provision of health care services. The source for this budget is via local taxes and state subsidies. Specialist care is provided by 21 hospital districts, which are federations of geographically grouped municipalities. Each hospital district has a central hospital as well as in some districts, care is supplemented at local hospitals. Hospitals are mainly publicly owned by the district government, are non-profit, and have been enjoying relatively monopolistic positions in their catchment areas. However, recently the public hospitals have been threatened by private and for-profit – and even multinational – firms entering the health care market. In addition, the buyers of hospital services (the municipalities) are increasingly comparing the prices charged between public hospitals within the same geographical area.

In the absence of nationally set regulations or even guidelines, each hospital district determines the pricing methods used to reimburse its hospitals. Because pricing methods are district based, they may vary from district to district. The trend of pricing has been consistently moving away from the bed-per-day price towards case-based prices, and presently most hospitals use some kind of case-based payment (Häkkinen & Linna, 2006).

The 1993 state subsidy reform in Finland reduced central government control and increased local autonomy in the provision of health services. This decentralisation offered special challenges for national information strategy and the solution to counterbalance the devolution of central planning was to introduce new means for "information management". In the 1990s, a number of studies were carried out on the productivity of Finnish hospitals at the National Research and Development Centre for Welfare and Health ("STAKES").[1] The studies showed large differences in the productivity of hospitals which could not be explained by patient case-mix or other characteristics measured at hospital level (Linna & Häkkinen, 1998). However, it was soon recognised that these first attempts in productivity measurement did not provide information which would be specific enough for managerial decision-making or in the operative planning.

There was a clear need to explore the productivity and efficiency differences further and a natural starting point was the initiation of collecting for more detailed information necessary for hospital comparisons within the national discharge registry. Despite the comprehensiveness of this data collecting scheme, it was facilitated by the fact that all hospitals operating in Finland already had well established data collection and integration processes to update annually the patient-level national register of discharges for all inpatient admissions. Moreover, the existence of hospital patient administration systems (PAS) offered good opportunities to explore sophisticated definitions for output or utilisation (e.g. extending the definitions from diagnosis related groups (DRGs) to episodes of care), since each patient had been coded using the personal identification number and the register covered the whole country (Linna, 1999).

2. IMPLEMENTING THE HOSPITAL BENCHMARKING SYSTEM (BMS)

In 1996, ''STAKES'', in co-operation with six hospital districts launched a piloting study project. The main purpose of this process was to provide hospital managers with benchmarking data for improving and directing activities at hospitals (Järvelin, Linna, & Häkkinen, 2003). Members of this project were voluntary, jointly financed and it was decided that the information in the BMS were confidential. The project designed and implemented an internet-based information system supporting a continuous data gathering and processing, as well as displaying benchmark measures at the desired level of aggregation. The project took advantage of the existing information systems in hospitals (the patient administration systems, cost accounting and pricing/reimbursement data and cost administration) to collect patient-level data on produced services and their costs. One of the specific aims was to develop a new measure for output (the episode of care) that could be used in the productivity and efficiency calculations alongside with the traditional measures such as DRG admissions and outpatient visits.

2.1. The Pilot Phase of BMS

The pilot study proved to be promising despite the many problems and inconsistencies in the preliminary data sets. In fact, by 1998 all hospital districts in the country were participating in the voluntary BMS project. We provide descriptions of the characteristics of different phases in the development of the BMS in Table 1. In the pilot phase of the BMS, data quality and credibility issues were discussed frequently, especially when hospital-level efficiency scores were published. Despite considerable curiosity and enthusiasm among the hospital management and administrative personnel there was little use of BMS data in the management.

Table 1. A Description of Different Phases in the Development of BMS in Finland.

Time Period	Pre-BM Era	Pilot Phase	Production Phase	Maturity	Public Information
	1993–1995	1996–1998	1999–2002	2003–2005	2006
Reporting in the BMS	Hospital efficiency scores	Hospital, specialty and DRG level reporting	District, hospital, specialty and DRG level reporting	The core reporting simplified	Public access to the main reports
Developments in methods or data	DEA and SFA used to estimate efficiency	Patient level outpatient data included, episodes as output definition	Episodes reaching the patients use of services over different hospitals	Psychiatric care included	DRG style grouping of outpatient care (NordDRG FULL grouping)
Main critique on the BMS	The sources of inefficiency not revealed, too aggregated for managerial actions	Problems with data quality, considerable disbelief in the reported BMS indicators	Data quality (diagnosis coding and DRGs) and comparability, complexity of indicators, difficult to deduce managerial actions needed	Sensitivity and capability to measure changing technologies, quality of coding, the lack of outcome measures	Reliability of DRG weights, the lack of detailed cost accounting and resource data

Response of potential users in the management	Some interest, problems to understand methods	Interest to develop data collection and indicators, results only seldom disseminated to clinical managers	BMS data exposed increasingly to clinical managers which find the concepts too difficult	BM approach accepted among the majority of hospital management, clinical use still modest	Productivity indicators widely accepted in the strategic performance measurement frameworks (e.g. BSC)
Managerial use	–	Inform hospital managers	Changes in the treatment practices, e.g. by downsizing ward capacity	Contracting negotiations, cost comparisons, first implementations in the strategic measures	Cases or benchmarking processes, learning from others, the evaluation of restructured actions, wide use in consultancy
Other use	Research, informing the ministry of welfare and health		Various health care system level evaluations for the ministry	Data delivered to Statistic Finland to be used in the National accounts	Piloting hospital BM in the Nordic countries including Sweden, Norway and Denmark

In addition to data discussions, during the pilot phase of the BMS project performance was assessed from the producers' viewpoint at the hospital level as well as from patient group level (episode or DRG groups). In the first application the users compared the length of stay, volumes the use of outpatient visits and average costs in the most significant DRG or episode groups. BMS was used to sort out the most efficiently treated patient groups and to assess the theoretical savings potential in resource usage by these groups.

To reduce systematic bias in the average DRG costs, hospitals were classified into three different groups according to their grade of specialisation: university hospitals, central hospitals and other (local) hospitals. Comparisons were made only within each group, i.e. university hospitals were compared to other university hospitals, central hospitals to other central hospitals and local hospital to other local hospitals.

2.2. The Production Phase of BMS

In the production phase, comparability was enhanced further by excluding activities such as psychiatric care and long-term care from the data due to the inherent variability in resource use by these services. However, hospitals' teaching and medical research activities using a considerable amount of resources were included and by adjusting resource use, i.e. deducting their cost from total costs, measures of teaching and research outputs, could also be included in the assessment of productivity.

Since there were over 500 DRG groups, cost weights were used to aggregate outputs in efficiency analysis. These relative cost weights were calculated from those hospitals that had high-quality patient-level cost accounting. The comparability of costs were improved through more detailed definitions from cost data collection. Since 1998 all hospitals have followed the national standards and recommendations for cost accounting rules for public institutions.

In productivity calculations there were 521 output categories (DRGs) in inpatient care and 28 output categories in outpatient care. The outpatient output included separate groups for visit types (emergency visits, scheduled visit) in each medical specialty (e.g. internal medicine, surgery, etc.).

In the production phase, the BMS was extended to allow comparisons of DRG use and costs across geographical areas using the codes indicating patients home municipality. The episodes of care could be extended to take into account patients' use of services in all hospital districts and all hospitals

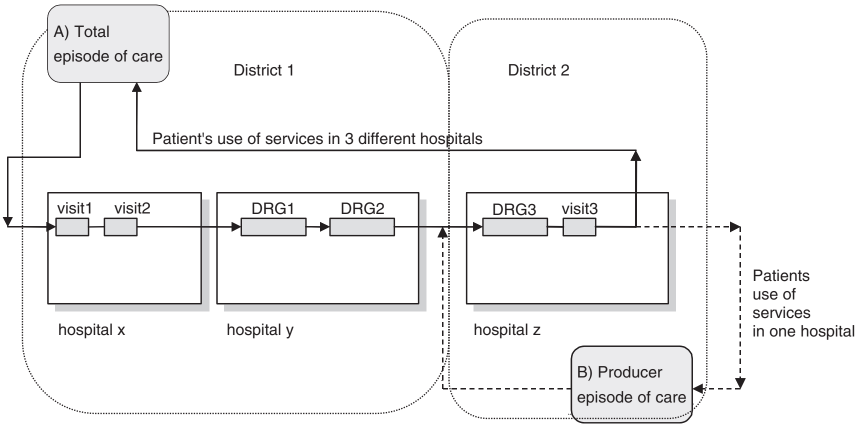

Fig. 1. An Episode of Care Consists of All the Admissions and Outpatient Visits of a Patient Due to One and the Same Illness.

in the country (Linna, 2005). Fig. 1 shows the definitions for and differences between the producer specific and regional episodes of care.

Since 1999 the BMS data have been frequently presented in the hospital districts. Surprisingly, in the beginning the clinical managers were only moderately interested in these data. The concepts and productivity calculations were considered difficult. It was also during this period that few clinicians were familiar with the DRGs. Even though there was little implementation of the system, the debate over data quality continued and one of the important applications of BMS data was to reveal mistakes and missing data in the original data sets produced by hospital data administration.

Despite the slow adoption of the BMS at the local or district level, the BMS data were often used in various health system-level evaluations and studies conducted by the central government (Linna, Häkkinen, & Magnussen, 2006; Linna & Häkkinen, 2006). Productivity and efficiency comparisons were illustrated in two books published by the Ministry of Treasury and Stakes (Linna & Häkkinen, 2003; Junnila, 2004). The standard BMS reporting includes only cross-sectional productivity indices (simple weighted ratios) and productivity changes in time-series. According to BMS data, the productivity change was positive in the first three years (1998–2000) and after 2000 neutral or slightly negative. More sophisticated analysis assessing the economics of scale and scope as well as the explanations for efficiency differences are currently being conducted by "STAKES" but the results have not been published yet.

2.3. The Mature Phase of BMS

During the mature phase of BMS, DRGs were already relatively well known in the hospital management. However, new concerns arose about the validity of productivity indicators. There were doubts by some hospital managers about how the grouping methods would account for the changing technologies in the treatment. In addition, a more detailed grouping for the outpatient visits was deemed necessary. First experiments using the sc. NordDRG FULL grouping system were started to include better case-mix information on outpatient care. It was demonstrated by this experiment that there was increasing evidence of varying coding practices both in the inpatient and outpatient data (e.g. the use of secondary diagnoses in the patient records). As part of the process of fully implementing an advanced BMS, reports on the differences in the coding practices were included as were reports for hospital case-mix. Confidentiality issues were also often discussed.

The public interest towards hospital cost and efficiency differences was rising and soon there were proposals among the BMS participators to make the system open to all users. The worst performing hospitals responded by increased criticism against the used methods and data quality in the BMS.

The core reporting in the BMS was simplified at the request of the users. BMS reporting was designed and positioned to serve mainly the hospital managers and the clinical management while the description of the most detailed production processes (e.g. operation room processes) had to be obtained from other information systems. The users often expressed their interest in productivity and efficiency analyses that revealed more detailed explanations for efficiency differences.

In 2002 the benchmarking project group at "STAKES" launched a survey to hospital management to ask what are the main strategic priorities and indicators needed in the management. The most frequently mentioned issues were:

1) cost-effectiveness of treatment and the lack of quality/effectiveness indicators,
2) improvements in productivity and indicators to aid in resource and manpower management,
3) tackling regional variations in the access and use of services (equity), and
4) securing a stable financing of hospital production and investments.

The lack of quality and effective measures were addressed at "STAKES" by initiating a new project for the development of register-based cost-effectiveness.

Preliminary results will be reported during 2007 and these indicators will be implemented in the BMS system in 2008.

3. HOW THE BENCHMARKING DATA HAVE BEEN USED?

As shown in Table 1, the use of BMS information in hospital management was rather modest and sporadic in the early phases and remained quite low for a long period of time.

In 2001, in order to evaluate the significance and impact of BMS system, questionnaires were sent to all hospital districts/areas (the largest district divided into 7 areas +2 foundation-based hospitals, $N=29$). In the questionnaire the users were asked to indicate the extent and reason the BMS had been used.

According to the survey, most districts had been using the BMS data in operative planning, follow-up/evaluation or for other purposes. Typical applications included:

- Comparisons revealing poor areas of performance;
- Supplemental information in operative planning;
- Predicting the total use of DRGs for resource management;
- Supportive evidence in the negotiations with the buyers;
- Performance measures presented to the health boards.

However, most districts underlined that the BMS data were not used systematically and only seldomly were actual decisions based on BMS data. In most cases the BMS data were only used to increase awareness of potential problem areas. For example, compensation or resource allocations within hospitals were not based on productivity or efficiency information.

Referring back to the information provided in Table 1, the indications revealed a slow adaptation of BMS data for managerial purposes. Since 2003, findings applying the BMS showed that the hospital and specialty level productivity scores have been implemented in the common strategic performance measurement framework used by all university hospitals (Balance scorecard). The BMS data also were used in the contracting negotiations between the hospitals and the municipalities increasingly often. Demand of BMS data was rapidly growing for various consultancy projects by public and private organisations. Hospital efficiency and productivity scores have been used widely to evaluate the effects of the few hospital mergers as well as major reorganisations in hospitals or specialty units.

In the later periods there have been cases where the BMS information has initiated true benchmarking processes. BMS data have been employed to point out marked differences in resource use between specialties among hospitals. After visits to the best performing organisations resources have been reallocated and care processes restructured (e.g. the balance between outpatient and inpatient care or between hospital and long-term care).

The interesting question is how the BMS system has affected the efficiency of hospitals during the period when BMS data has been available. It is very difficult to prove which factors have contributed to changes in efficiency and the BMS system alone may have had only a minor effect in efficiency. However, incentives for efficiency improvements may have increased simply due to active monitoring of hospital performance. Therefore, indirectly, the BMS may have had an impact. This outcome is demonstrated by the fact that using the BMS data indicators the efficiency differences have slowly diminished in all hospital categories, which may be due in part to improved coding and data quality. The hospitals using DRGs in billing seem to be using more frequently the secondary diagnoses which also affect the measured case-mix but so far there has not been any indications of systematic strategic behaviour in the coding.

4. HOSPITAL BENCHMARKING IN THE FUTURE

The main reason that efficiency analyses are not regularly used by policymakers and managers appears to stem from concern about data reliability and relevance. Most of these concerns are expressed at the hospital and specialty (clinical DMUs) level. This example from Finland on productivity and efficiency benchmarking indicates that it takes time for managers to learn to use performance information in their decisions.

Typical concerns about efficiency measures are that they are not related to outcomes. There is wide agreement that productivity indicators cover only one aspect of performance measurement and that a balanced measurement would also include information on health outcomes. This has led to the launch of seven disease-based pilot projects which measure the effectiveness of care. Each of the pilots deal with one health problem: heart attack, hip fracture, schizophrenia, stroke, breast cancer, very low birth weight infants and hip and knee replacements. Thus for managerial purposes, the disease-based approach will have great potential and when it is linked with the bottom-up approach, it motivates data collecting and the use of BMS for improving the treatment practices.

Another problem with the existing BM system is that the total episodes of care do not take into account the patients contacts in primary care. The main reasons for that are (1) health centrer in primary care do not need to collect patient-level information for national registers, (2) the tradition of coding "diagnoses" or reasons for visits and the procedure/activities is very young among the organisations in primary care and (3) there is no national standard yet for grouping primary care services in Finland, although readily available grouper exists.

In the future there are good possibilities to extend the total episodes of care to include primary care and nursing home services as well. In Finland, there are plans to gather performance data from the emerging electronic client and patient systems, which are increasingly available in the social and health care facilities in primary care. It has been suggested that data gathering into national registers should be continuous and based on protected electronic on-line data collection. It is to be hoped that these improvements will bring more timely, accurate and comprehensive data on patients, health services and their costs to be used in the management. BMS data can be linked to clinical guidelines and recommendations to increase its use among the clinicians. Since the role of DRGs continues to grow in the hospital billing, comparative information on costs, efficiency and productivity via BMS will become a necessary tool for hospital management.

NOTE

1. It is a government institution (and belongs to the Ministry of Welfare and Health) responsible example for policy relevant health services research and evaluation.

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CHAPTER 11

EFFICIENCY IN GOVERNMENT-FUNDED HEALTH CARE SERVICES: THE USE OF NON-HEALTH SECTOR MECHANISMS TO ENCOURAGE EFFICIENCY

Abby L. Bloom

OVERVIEW

Increasing the productivity of publicly funded infrastructure and human capital is an imperative faced by every nation, especially in the health sector, where most nations are struggling with almost continuous increases in the proportion of national budgets spent each year on health and health care. Efficiency is one aspect of the broader issue of productivity within the health sector. This case study examines how a generic Government-funded body, with no specific health or health care mandate, can stimulate improvements in efficiency in Government-funded hospitals and healthcare and thereby contribute to improved productivity in these vital services.

The chapter examines the aim, structure, operation and health care efficiency-related activities of the Productivity Commission of Australia, and sheds light on how such a mechanism can influence broader policy and

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funding patterns. The benefits and constraints of the mechanism are considered, and the chapter concludes with a discussion of the potential use and impacts of such a mechanism in other countries.

The Productivity Commission: Aims, Structure and Mechanisms

The Productivity Commission is a semi-autonomous Australian Government agency, funded by Australia's national Government. Its main role is to conduct and report on commissioned inquiries and publish reports on issues of microeconomic reform at the request of the Australian Government (Productivity Commission, 1998b). Its second major role is to provide the secretariat to the inter-Governmental Steering Committee for *The Review of Government Service Provision* (Productivity Commission, 2006b). This latter role is the main focus of this chapter.

The Productivity Commission has played a key role in policy development and reform since its formation in 1998 (Productivity Commission, 1998a) but its roots go much deeper. It is the lineal descendant of the Industry Commission and, before that, the Industries Assistance Commission (IAC), which was established 30 years ago. In turn, the IAC was created from the Tariff Board, which was founded in 1921 (Productivity Commission, 2003). The Commission is charged with advising the Australian Government on all aspects of microeconomic reform in all sectors of the economy.

The Statutory functions (Productivity Commission, 2007) of the Commission are to:

1. Hold public inquiries and report on matters related to industry and productivity;
2. Provide secretariat services and research services to government bodies such as the Council of Australian Governments;
3. Investigate and report on complaints about the implementation of the Australian Government's competitive neutrality arrangements;
4. Advise the Treasurer on matters related to industry and productivity as requested; initiate research on industry and productivity issues; and
5. Promote public understanding of matters related to industry and productivity.

The Commission also provides the Chair and Secretariat for the Review of Government Service Provision ("The Review"), an inter-governmental exercise that aims to stimulate improvements in efficiency and effectiveness (productivity) of Government services, by reporting on the comparative performance of government services provided by all of Australia's states and territories.[1] The Review operates under the auspices of the Council of Australian Governments (COAG, the peak intergovernmental forum in Australia).

Most of the analysis and discussion in this chapter will focus on the "Report on Government Services", the annual publication of the Review of Government Service Provision. It is colloquially known as "the Blue Book" after the colour of its covers.

The aims of the Report are:

1. To provide ongoing comparisons of the performance of Government services;
2. Report on Government services reforms that Governments have implemented, or are under consideration (Steering Committee for the Review of Government Service Provision, 2007).

The Report is designed to inform (State) Governments on performance and priorities, and to give (State) Governments an incentive to improve performance, including efficiency. For those unfamiliar with the Australian health system, the Report also provides an outstandingly clear description and analysis – with an emphasis on the role of Government in what has become over time a confusing mix of public and private funding and provision.

Underlying the Report is a philosophy of performance measurement that has been accepted and acted upon by all Australian State and Territory Governments:

Performance measurement can:

- Help clarify government objectives and responsibilities;
- Promote analysis of the relationships between agencies and between programmes, allowing governments to coordinate policy within and across agencies;
- Make performance more transparent, allowing assessment of whether programme objectives are being met;
- Provide governments with indicators of their performance over time; and
- Inform the wider community about Government serviced performance.

The three main reasons for reporting comparative performance across jurisdictions are:

1. To verify good performance and identify those agencies which are "getting it right";

2. To allow agencies to identify those agencies that are delivering better or more cost effective services; and
3. To generate additional incentives for agencies to address substandard performance (Steering Committee for the Review of Government Service Provision, 2007).

The Report on Government Services covers 12 Government sectors, including health. The sectors reviewed comprise approximately 11% of Australia's total GDP, and cover about 30% of all Government recurrent expenditure. While the Report covers a range of Government services, the remainder of this chapter focuses exclusively on health.[2]

Each Report focuses on several specific areas that account for a significant proportion of overall health expenditure and hence efficiency. The performance of public hospitals is central, as Government funding of public hospitals accounts for a substantial amount of funding, and hence performance, of Government investment in the health sector.

As shown in Fig. 1, the Review structure has two levels:

1. A Steering Committee – effectively the Board of Directors of the Review is chaired by the Chairman of the Productivity Commission. The Steering Committee's members are very senior State, Territory and Australian Government officials, such as Deputy Secretaries of Treasuries and

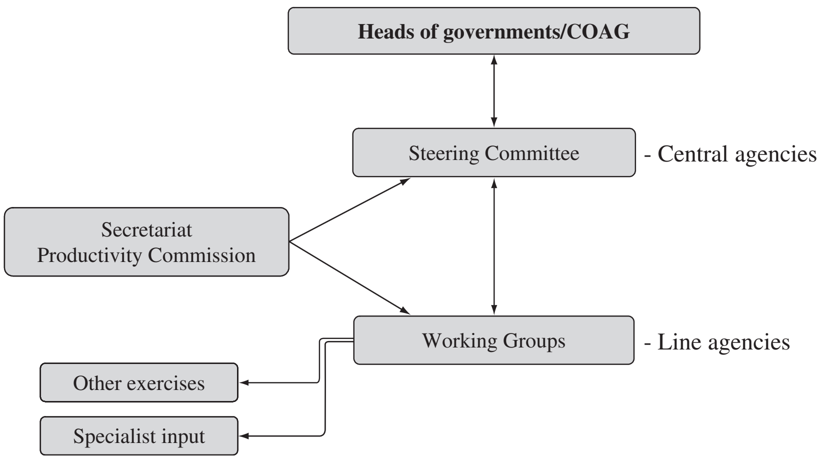

Fig. 1. Structure of the Review of Government Service Provision. *Source:* Review of Government Service Provision, Productivity Commission 2006.

Premiers' Departments. The Steering Committee decides what will be included in Review publications.

2. A Working Group for each of the 12 service areas covered by the Report on Government Services, including health: Each Working Group, whose members include line agency staff (for example, form health departments) and data experts, is chaired by a member of the Steering Committee.

The role of the Productivity Commission ("Commission") is to chair the Review and provide the secretariat; the Commission has no overarching authority in what is basically a consensus process. This structural feature is one of several deliberate measures designed to support the role of the Commission as a neutral convenor, guide and engine.

At its inception the Steering Committee articulated clear guiding principles for the Review: outcomes, completeness, comparability, progressive data availability, timeliness and iterative improvement. Progressive data availability and iterative improvement are illustrated by the gradual evolution of the Commission's health sector reviews: the Commission's first review of Government Services (1995) had a single chapter on health (public acute care hospitals), whereas the most recent Review has three chapters devoted to health care: public hospitals, primary and community care and system wide health management issues.

Each Report summarises improvements made in indicators and in data since the previous report in a section entitled "Developments in Reporting". For example, the Report published in 2007 for the first time reported on the availability of dentists, and, at the request of Governments, included further details on incidence of preventable diseases and chronic conditions amongst Australia's indigenous population. Data were included on breast cancer detection and management, and data improvements were made in specialised mental health services (Steering Committee for the Review of Government Service Provision, 2007).

Fig. 2 illustrates the general framework applied to each service area. The framework is designed to link social and economic policy objectives, specifically equity, effectiveness and efficiency to appraise performance on the basis of outcomes. While the aim of the Review is to focus on outcomes, these are often difficult to measure, and shortcomings in data have meant that many indicators continue to focus more on outputs than outcomes.

Equity indicators measure access to the service by the general population and by specified "special needs groups." Effectiveness indicators measure how well the service achieves its objectives in as measured by access,

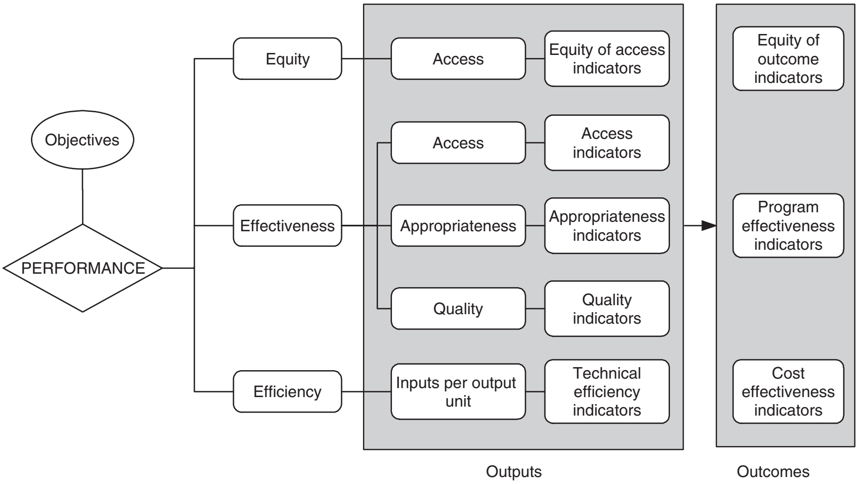

Fig. 2. Indicator Framework. *Source:* Review of Government Service Provision, Productivity Commission 2006.

appropriateness and quality. Efficiency indicators measure how well organisations utilise their resources, and are measured by the ratio of Government-funded inputs to outputs.[3]

The annual Report on Government Services has a consistent structure: the health section commences with a preface that describes the broad health system-wide issues and outcomes addressed by the following sections of the Report. Three chapters follow, each providing (1) context as well as descriptive information; (2) a framework of indicators; and (3) the data and guidance on how to interpret each indicator. In its annual Report, the Review has compiled increasingly sophisticated health service indicators. For example, in the most recent report, indicators were added to quantify patient satisfaction, pre-anaesthetic consultations and sentinel events (see Appendix Fig. A1 for a full list of public hospital indicators and Appendix Fig. A2 for health services indicators).

The Productivity Commission's other Activities that Contribute to Increased Efficiency of Hospitals and Health Care

In addition to providing the Secretariat for the Review, the Productivity Commission undertakes research into a broad range of economic and social issues affecting the welfare of Australians, including: competition policy, productivity, the environment, economic infrastructure, labour markets, trade and assistance, structural adjustment and microeconomic reform. This research can take the form of public inquiries requested by the Australian Government, or self-initiated research initiated by the Commission. Since late 2006, for example, the Commission's reports have included ''Men Not at Work'' (Lattimore, 2007) and a report on the productivity impact of increased competition enabled by regulatory reform (Productivity Commission, 2006a).

Since 1995, the Productivity Commission has conducted research and issued influential reports on several aspects of health care provision (including hospitals which are operated by the States, and co-funded by the Commonwealth). Areas of inquiry include:

- The efficiency of health care services
- The health workforce
- Medical technology
- ''Managed competition''
- Supplier-induced demand for medical services
- Improving decision-support tools in relation to health policy and socio-economic status in Australia
- A broad-ranging review of the comparative productivity of health care with other Government services, and
- A series of reports on ageing and aged care.

All Reports are available on the Commission's website, www.pc.gov.au.

The Review of Government Service Provision: The Process of Compiling and Comparing Data

The process of acquiring, compiling and comparing data that could be used to measure efficiency and other outcomes is not straightforward. According to participants interviewed, the working group, comprising representatives of numerous jurisdictions, is supportive of collecting data in part because they wish to redress the acute lack of evidence-based and comparative measures that can be fed back to health professionals, including doctors, to influence their practices and decision-making. Not surprisingly, there is said to be active debate about the quality and accuracy of the indicators and associated data. Further, the comparisons across jurisdictions made in the annual Report can be politically sensitive.

Some participants would object to the use of available data for the comparative Report, on the basis that it was not sufficiently robust. But the Steering Committee would counter this view by emphasising the agreed principles of the Review: progressive data availability, timeliness and iterative improvement. Thus available data might be used even when it was acknowledged to be deficient, and the report would be heavily qualified with footnotes.

Some individual state health departments claimed that the Report was no longer necessary because individual States were already collecting and analysing the data. The Steering Committee has continued to include health in the annual Report on Government Services according to its terms of reference from governments. The rationale is that reporting on a state-by-state basis is not guaranteed over the long term, and would not necessarily enable, let alone foster, inter-jurisdictional comparisons.

International Approaches to Performance Monitoring – What Distinguishes the Review?

International approaches to performance monitoring highlight the uniqueness of the Review model. Performance reporting in other OECD countries, including the United States, tends to focus on a single agency's performance and does not compare performance with other agencies or across jurisdictions. Exceptions are New Zealand's reporting of indicators by regional council and territorial authority areas, the UK's comparison of the performance of local councils, and (at a more aggregated level) the OECD Factbook with its comparisons of countries.

United States of America

The Governmental Accounting Standards Board (GASB) of the Financial Accounting Foundation (FAF) has been studying the use of performance measurement by governments in order to improve standards of state and local governmental accounting and financial reporting. The GASB has been working on a Service Efforts and Accomplishments (SEA) programme, whose objective is to encourage "regular issuance of quality service efforts and accomplishments reports and help state and local governments effectively communicate performance to the public" (Performance Measurement for Government, 2007).

Unlike the comprehensive, national efforts of the Review, the US performance measurement reports are issued by individual (state and local) governments, and as expected, the forms and information of these reports vary. In the absence of a consensus approach, as illustrated by the Review, it is very difficult to make comparisons across jurisdictions.

New Zealand

The New Zealand government is preparing a broad suite of indicators covering social, economic, cultural and environmental outcomes. The Ministry of Social Development currently produces annually *The Social Report*, which provides information on the health and well-being of New Zealand society. Indicators are used to measure levels of well-being, to monitor trends over time, and to make comparisons with other countries. The website provides data for social report indicators by regional council and territorial authority areas. The Social Report covers nine "domains", but unlike the Blue Book, these domains do not directly reflect specific service areas (although there is sometimes a broad connection). A limited number of high level indicators are presented for each domain. There is no attempt to comprehensively address the full range of objectives of any specific government service (Ministry of Social Development, 2007).

Similarly, New Zealand's Ministry of Economic Development and the Treasury regularly produce "Growth through Innovation: Economic Development Indicators Report", which contains the latest data on New Zealand's economic performance compared to other OECD countries. The report includes a wide range of productivity and growth indicators, as well as data on core Growth and Innovation Framework themes: innovation, skills and talent and international connections. Additional indicators provide measures of labour utilisation and productivity, entrepreneurial activity, the quality of regulation and indicators of macroeconomic stability and performance (Ministry of Economic Development, 2007).

Neither of these reports enables comparisons across administrative or funding regions, so that jurisdictional variations in efficiency in Government-funded services cannot be appraised and compared.

United Kingdom

In 2002 the United Kingdom introduced regular web-based reporting against public service agreements, or commitments, by a selection of government departments. Public service agreements measure agency performance by setting out the aim of the department or programme, its supporting objectives, and the key outcome-based targets that are to be achieved during a specified period. Web-based reporting provides accountability and transparency, and allows the public to assess how the United Kingdom Government is delivering across all areas of government.

The Office of the Deputy Prime Minister maintains a Local Government Performance website, which allows the public to view key facts about local authorities and see how they are performing against regional and national averages, and against other authorities (HM Treasury, 2007). There are currently 90 Best Value Performance Indicators (BVPI) which cover services including education, social services, housing, waste, transport and community safety and well-being and fire. Performance appears to be published only in relative terms: for each indicator, local authorities are grouped into five categories and awarded zero to four stars according to their performance.

The Treasury publishes a website that enables the public to view each department's progress against their Public Service Agreement (PSA) targets, Departmental Reports and Autumn Performance Reports.

- PSA targets are three year agreements, negotiated between each of the main Departments and HM Treasury during the Spending Review process. Each PSA sets out a Department's high-level aim, priority objectives and key outcome-based performance targets.
- Departmental reports provide detail on what the department does and how it is performing against its commitments (including the efficiency programme). Departments publish these reports each spring.
- Autumnal performance reports provide an update of performance later in the year and complement Departmental Reports.

All of these reports measure performance against agreed targets, but do not permit comparisons of performance across jurisdictions.

OECD

The OECD Factbook (OECD, 2007) provides more than one hundred indicators that cover a wide range of economic activities and measures: economy, agriculture, education, energy, environment, foreign aid, health and quality of life, industry, information and communications, population/labour force, trade and investment, taxation, public expenditure and research and development (R&D). Data are provided for all OECD member countries and for selected non-member economies. The information is outcome-focused, and is not linked to specific service delivery agencies, so that it is not possible to attribute results to any agency's efforts or funding – or to Government-funded services as distinct from other factors. The information is provided by each participating country and, while there is some discussion of the comparability of data, the data are collected for purposes other than OECD reporting, so that comparability of data is not necessarily factored into data collection or reporting.

Discussion: Benefits, Constraints and Impacts

The Australian Review of Government Service Provision has established and maintained a unique, independent, consensus model and process for compiling, comparing and communicating useful, reasonably comparative data on Government-funded health services. By doing so, the Review has most unusually enabled comparisons across sectors and across jurisdictions on the three main aims of these services: equity, access and efficiency. In particular the annual Report on Government Services Provision has provided a means of comparing efficiency across jurisdictions and across services.

One of the main lessons of the Productivity Commission case study is the importance of reaching consensus on principles at the outset, and then evoking those principles to achieve progress. This lesson was sheeted home repeatedly and successfully to prevent deficiencies in data from impeding the process. The principle of iterative and continuous improvement of data enabled the Commission to start compiling and comparing (relatively) poor data, and tenaciously continuing to do so in the expectation that increasingly better data would be available for subsequent Reviews.

In 2007 the Steering Committee estimated that 46% of the indicators in its most recent report were "comparable"; however only 36% of the indicators entailing public (Government-funded) hospitals were comparable.

From its inception the Steering Committee supported the view that publishing the comparative data – even if it was imperfect and incomplete – was essential for three reasons:

1. To encourage agencies to put more effort into data collection;
2. To persuade Governments to reveal their data; and
3. To stimulate the use of comparative data to increase productivity of Government services.

The Steering Committee's rationale for publishing data known to be imperfect – with many caveats and cautions – was that once in the public domain even poor data stimulates people to improve the quality of data. More importantly, even imperfect data can highlight (comparative) differences in service outcomes, and motivate agencies and governments to investigate the reasons for those differences. The publication of data in the Report has often been a catalyst speeding up the collection and use of data to measure productivity.

There is another reason for collecting, comparing and promulgating the data. The "Blue Book" plays a significant role in "consciousness-raising" in Government and among the public (one of the statutory functions of the Commission), generating policy debate about relative performance of different jurisdictions.

By involving all State and Territory Governments, and appraising health as a sector on the same basis as all other sectors, according to the general framework, the Review's process avoids the appearance of a political agenda. It does not single out health or hospitals for special scrutiny or, on the other hand, special dispensation. This approach also conveys the message that *all* Government services are expected to be judged by the same fundamental measures – including health care.

Thus, the work of the Productivity Commission as the secretariat for the Review has given it credibility, guidance and leverage for its ambitious and highly regarded inquiries into areas such as the healthcare workforce, private health insurance and the ageing population. These inquiries, commissioned by the Commonwealth Government, have a broad impact on government policy in the health sector and the wider economy – what has been called "the pointy end" of national health care issues.

Has the Review's annual Report had an impact on efficiency in the health sector? It is difficult and probably impossible to isolate and quantify the impact of the Review. In the first instance, the Steering Committee does not "advocate" for action in response to the Reports – the Blue Book provides information, but does not make policy prescriptions. The fact that governments have continued to support the Report for over a decade, despite the costs involved (the costs of data collection, public servants' involvement with the Report and the occasional political discomfort that such transparency about performance brings) is reasonably persuasive evidence that the Report provides value to its main stakeholders.

The Steering Committee does use several means to appraise the impact of the Report, including collecting both systematic and anecdotal information. The Review periodically conducts a survey of Report readers. The last, in

2004, had a response rate of 16% (not especially low for a voluntary mail survey with no follow-up), but provided "generally positive" feedback on the review's "usefulness, credibility, relevance and timeliness". A somewhat higher proportion of readers from "central" agencies found the Report very useful compared with "line" agencies (100% versus 75%) – consistent with the fact that "central" agency staff use the report to assess the performance of line agencies. Results of a survey conducted in early 2007 are forthcoming.

The Review also identifies how often the Report is used in state and federal parliamentary submissions and debates, and in state-level inquiries and commissions. It tracks requests for reports, website use, and media reports – all in an effort to assess the utility of its own work. Over 1,500 copies of the 2006 Report were distributed by the secretariat, and in the first month of its release there were over 6,500 "hits" on the Report website. In the month following its release, the Report was referenced in 53 media releases by governments, oppositions and interested parties, and it was cited 134 times by the media (Steering Committee for the Review of Government Service Provision, 2006).

The Productivity Commission, through its Review of Government Service Provision, has had several substantial impacts on the performance of government services, including the efficiency of the health sector:

1. It established a consensus on a general framework for appraising the efficiency, as well as equity, access, and effectiveness, of *all Government-funded services*. It has emphasised that all services should be assessed according to the same principles, and the health sector is on a par with all others in this respect.
2. High level support and endorsement has been given to appraising Government services according to higher-level outcomes, as well as outputs.
3. It established a precedent, and widespread acceptance, that this general framework can and should be adapted to each service area, and the Steering committee has endorsed specific outcome measures for the health services covered by the Report.
4. It has encouraged independent state and territory Governments to participate in, and contribute to, this process, over a period now exceeding 12 years.
5. It demonstrated that the benefit of reporting comparative performance, as a complement to the gradual introduction of other measures that could be used for comparison, such as diagnosis related group-based data collection and reporting among the States.

6. It reinforced the importance of assessing and comparing efficiency, but as only one of several important measures. Because quality, effectiveness, equity and other measures were also included, the Report was not criticised for single-mindedly pursuing efficiency. According to one of the long-term participants, ''Everyone had a 'bit' they could hold on to'', leading to better acceptance of the process.
7. Anecdotal evidence suggests that the publication of annual reports has contributed directly to improvements in data quality among the states and territories.
8. Finally, and importantly, the Review has drawn attention of Government agencies, Parliamentarians and the general public to variations in efficiency of hospitals and other health services across different jurisdictions. The variations have focused attention and led to investigation of the determinants and, it is believed though difficult to prove, to actions designed to improve performance.

However, the Review process and Report are constrained by what was described as ''...a fact of life – it's a consensus-driven model...'' and therefore progress is slow. The advantage of a process built on consensus, however, is that it is sensitive to political reality. For instance, the process recognises that with the publication of the report each year, newspapers will seek out salient headlines – typically flagging where their local area is lagging in comparison with the rest of the nation. As one participant commented, ''Governments supply the data and take the blows''. By contrast, the Commission's other form of reporting, the in-depth inquiries (independent, academically rigorous and usually commissioned by the Australian Government), can publish critical appraisals and make specific policy recommendations without regard for consensus or the same concerns about political sensitivity. To a great degree the two mechanisms are complementary – both are necessary.

CONCLUSIONS

In conclusion, the Review of Government Service Provision, with a secretariat provided by the independent Productivity Commission, presents a useful model that may be of significant benefit to other nations. The example of the Productivity Commission Secretariat illustrates both the benefit and the difficulties of establishing a legitimate and respected independent body to foster and sustain the process over time. ''The Productivity Commission started the ball rolling, put a toe in the water'', according to one participant, "and that has led to improvements in data collection, data consistency among jurisdictions, and in numerous sectors – health and other". It has demonstrated that an independent, non-health sector-specific consensus model can stimulate improvements in, and a focus on performance of, government-funded health care, including hospitals. It does so first and foremost by forging consensus to measure, compare and publish agreed data for performance indicators, including measures of efficiency.

The process initiated by Heads of Government in Australia and supported for over a decade by the Productivity Commission Secretariat has been an important driver for national measurement and comparison. It has stimulated data collections by statutory health bodies, such as the national minimum data sets developed by the Australian Institute for Health and Welfare. As they have been developed over time, the minimum data sets have in large part taken over some of the functions of the Productivity Commission. In this way, it can be seen that, through the Review and complementary activities, the Commission has helped pave the way for what is now a routine and accepted process: the obvious but all too rare collection, compilation, analysis and comparison of data and indicators that enable policy makers and managers to assess the efficiency of Government-funded services across states and other jurisdictions.

NOTES

1. Australia is a country of over 20 million people, distributed among 6 states and 2 territories, the largest of which – New South Wales – has a population of 6.8 million, the smallest of which – Northern Territory – a population of 206,000.
2. Readers seeking information on other aspects of the Productivity Commission or the Review should refer to the Commission's website: www.pc.gov.au.
3. An instructive definition and discussion of these terms can be found in Steering Committee for the Review of Government Service Provision (2007), 1.13–1.18.

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APPENDIX

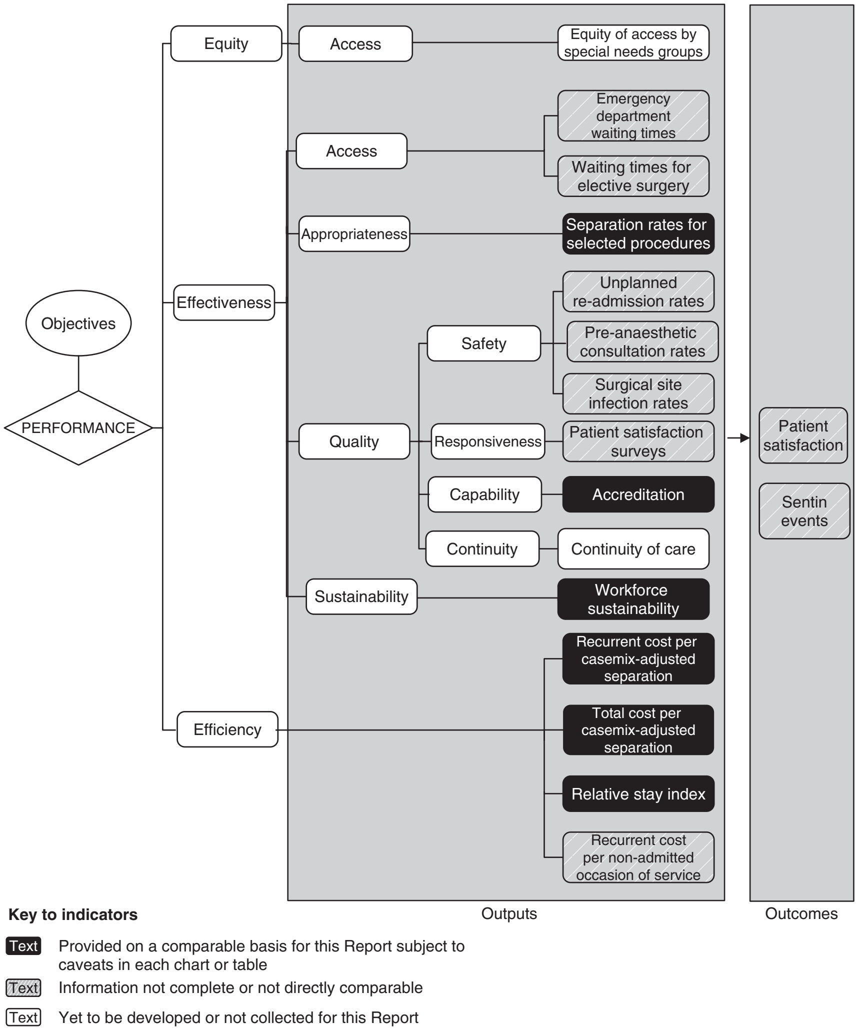

Fig. A1. Performance Indicators for Public Hospitals. *Source:* Productivity Commission. Report on Government Services, 2007.

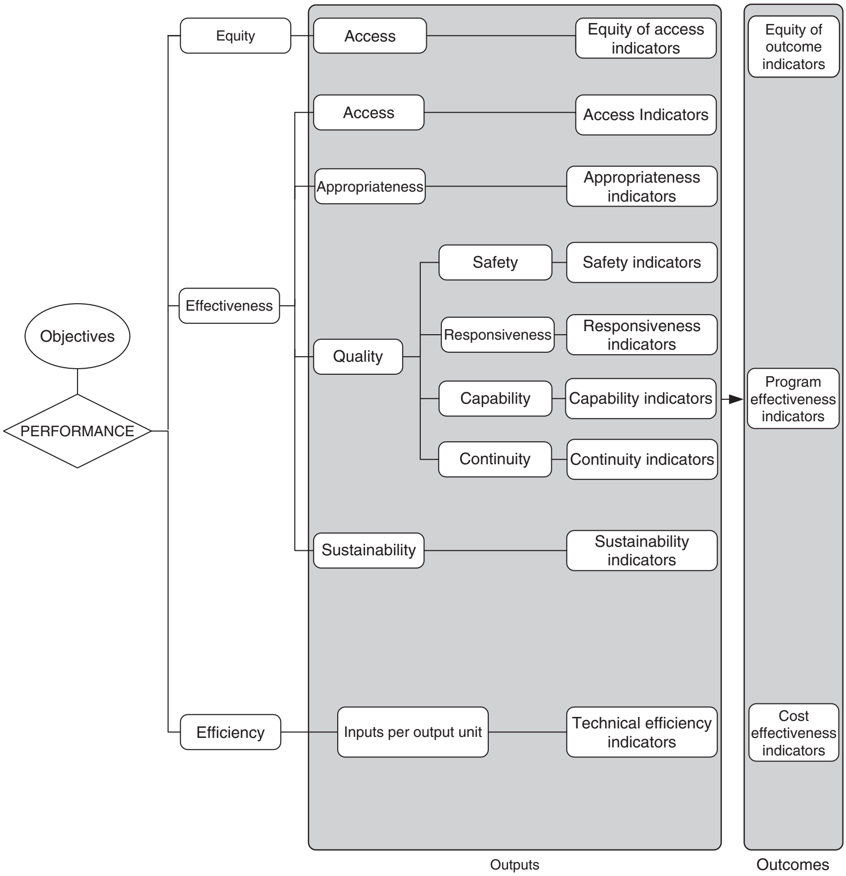

Fig. A2. Performance Indicator Framework for Health Services. *Source:* Productivity Commission. Report on Government Services, 2007.

CHAPTER 12

EVALUATING HEALTH CARE EFFICIENCY

Rolf Färe, Shawna Grosskopf, Mats Lundström and Pontus Roos

1. INTRODUCTION

The purpose of this chapter is to suggest a general framework for assessing the efficiency of health care in general, and health care interventions specifically. We begin with a three-pronged overview of assessing performance in health care which begins with what we call the budget or cost side model relating budgets and costs to treatments. Next we proceed to describing an intermediate outputs specification which relates hospital resources to medical outcomes, and we conclude with a final outcomes model which relates the medical outcomes to patient health outcomes. The third model is illustrated with an application to data from Swedish cataract patients.

The application in this chapter deals with the broader issue of deriving a credible index that allows us to relate patient medical conditions prior to medical intervention and their quality of life after intervention. Thus we are constructing an outcomes measure based on patient ability to pursue daily life activities that accounts for their medical status prior to intervention. This is in contrast to the more usual practice of measuring medical success purely in terms of medical status of the patient post intervention.

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To accomplish this we apply work by Amartya Sen concerning the measurement of individual well-being or quality of life. His basic argument is that measuring what the patient 'has' – health status, income, etc. – does not tell us about an individual's well-being. Rather we need to determine what the individual is actually 'doing' with what they 'have'. Thus we are seeking a way to relate medical status (what health status patients bring to the surgery) to the ability of the individual to go about daily life activities. This requires that we find a functional relationship and means of aggregating the multi-dimensional medical characteristics and multidimensional outcomes or daily life activities. Here we build on work by Roos and Lundström (1998) and Roos (2002) who borrow from economic index number theory, especially the work of Malmquist (1953) and a number of papers largely due to Diewert. All approaches rely on what economic production theorists call distance functions.

In our empirical implementation, we compare individual observations to a best practice frontier constructed from the individuals in the sample. The frontier is the boundary of what we call the capability set, relating inputs (medical status) to outputs (daily life activities). The idea is to see how much patients improve after the medical intervention relative to the frontier. Restricting the evaluation of particular interventions solely on a medical basis will miss possible co-morbidities as well as patient-perceived changes in health status. A model that accounts for multidimensional aspects of patients' health status is necessary in order to rationalize interventions in complicated cases. This chapter proposes a general framework which accounts for patient health status pre and post intervention as well as medical/physical and patient-assessed outcomes on health and daily life activities.

2. THE OVERALL MODEL

In this section we introduce our overall model which consists of the three parts, namely:

1. financial or budget constraint
2. intermediate model: production of medical services
3. final outputs: capabilities or health outcomes.

The financial part of the model we take to be the budget constraint faced by the institution involved in health care delivery. This may be a hospital, clinic, or a department such as intensive care or surgery. Introducing a budget constraint allows us to evaluate basic financial and economic issues: What is the best allocation of resources given input prices, the budget and available technology? Can we provide more or better services with the current budget? Can we provide existing service levels at lower cost?

Here we need information on inputs, such as personnel, which we denote by a nonnegative vector $x = (x_1, \ldots, x_N) \in \Re_+^N$ [1] and the corresponding prices denoted by $w = (w_1, \ldots, w_N) \in \Re_+^N$.[2] Then the total cost, C may be written

$$\sum_{n=1}^{N} w_n x_n = wx \leq C \tag{1}$$

In words, the total costs of, i.e., inputs multiplied by their respective prices cannot exceed the budget. The intermediate model is the medical model which shows what the health care unit actually does. For example, in cataract surgery the doctor replaces the patient's lenses which change the visual acuity of the patient. We model this as a production process, i.e., inputs are used to create outputs. Again the inputs are the health care unit is physical resources and the outputs are the medical outcomes which we denote as the vector $y = (y_1, \ldots, y_M) \in \Re_+^M$. The medical production process is described in general terms as the output set

$$P(x) = \{y : x \text{ can produce } y\} \tag{2}$$

Thus for any input vector $x = (x_1, \ldots, x_N) \in \Re_+^N$, the production process or technology P describes all possible outputs $y = (y_1, \ldots, y_M)$ that the input vector can produce or create.

This medical production model has been the focus of much of the previous work in the area of hospital performance in particular. Thus one may investigate whether a hospital is producing the medical outcomes as efficiently or inexpensively as possible.

The last piece of our overall model is the capability or outcomes that capture the resulting well-being or quality of life of the patients after their treatment. Thus the outcomes from the intermediate medical model are inputs into the capability model, and the outputs of the capability model are the patients' daily life activities such as working, reading, etc. We denote these activities as the vector $q = (q_1, \ldots, q_J)$, and let the transformation of outputs from the medical model, $y = (y_1, \ldots, y_M)$ be described by

$$Q(y) = \{q : y \text{ can produce } q\} \tag{3}$$

Thus the capability set $Q(y)$ consists of all daily life activities a patient can perform after treatment $y = (y_1, \ldots, y_M)$.

The three components of the overall model are clearly interrelated. The inputs $x=(x_1,\ldots, x_N)$ belong to the budget set

$$B(w, C) = \left\{ x : \sum_{n=1}^{N} w_n x_n = wx \leq C \right\} \quad (4)$$

These inputs are used to produce treatments y. These treatments impact the patients' capability sets $Q(y)$. Thus if the price w_n of some input changes, then the treatments may change which in turn affects the patients' capabilities or daily life activities.
Fig. 1 illustrates this interaction.

3. THE INTERMEDIATE MODEL

The intermediate model which describes the transformation of inputs $x=(x_1,\ldots, x_N)$ into outputs $y=(y_1,\ldots, y_M)$ has been applied at various levels of aggregation. For example, Färe, Grosskopf, Lindgren and Poullier (1997) used the model to make a cross country comparison of their relative health care performance. Grosskopf and Valdmanis (1987) among many others starting with Sherman (1984) used this model to study the relative performance of individual hospitals in the U.S. The aforementioned examples employed data envelopment analysis (DEA) and focused on technical efficiency. Many others used regression techniques to estimate

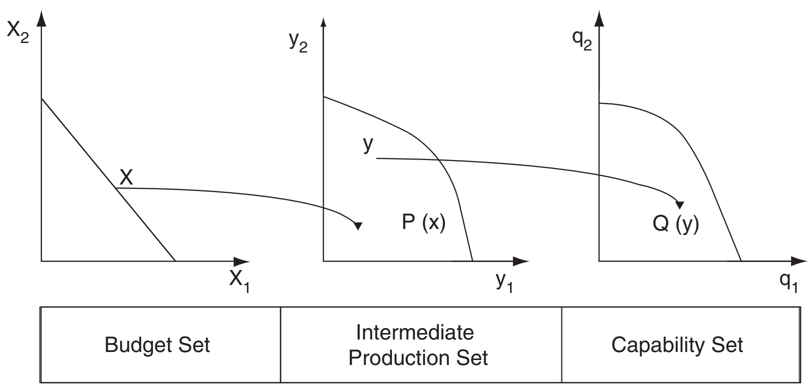

Fig. 1. The Overall Model.

hospital production or cost functions, where the latter bring in elements of the financial model. For a recent survey see Hollingsworth (2003).

In empirical applications, the technology $P(x)$ needs to be fleshed out in more detail. Here we impose basic axioms used in production theory, including

1. $P(0)=0$, i.e., there is no free lunch,
2. $P(x)$ is a closed and bounded set,
3. $x \leq x'$ implies that $P(x) \subseteq P(x')$, free disposal of inputs,
4. $y \leq y' \in P(x)$ implies that $y \in P(x)$, free disposal of outputs,

These axioms are satisfied by the standard activity analysis or DEA model, see Shephard (1970).

The first axiom tells us that there can be no output without using some input – health care treatments use resources. That the technology is closed and bounded models the idea that we can only achieve finite medical outcomes with finite resources – i.e., if resources are limited, so are medical outcomes. The last two statements allow for disposability, which allows for the possibility of wasted inputs or outputs.

The type of questions that can be addressed with this model include

1. Is a particular set of medical outcomes y^0 the best we can do with our resources x^0, i.e., are they technically efficient?
2. Is y^0 more efficient than y'?
3. How has the technology $P^{\tau}(x)$ changed over time $\tau = t,\ t+1$? Is there technical progress?

When the intermediate model is combined with the financial constraint, additional policy questions can be addressed, including

1. Are the treatments y produced as inexpensively as possible?
2. Has the budget $wx \leq C$ been used effectively?

The policy questions associated with the intermediate model are frequently analyzed with the help of a Farrell (1957) efficiency measure. Fig. 2 illustrates.

The intermediate model appears in the figure as the output set $P(x)$, which is bounded by the segments 0AB0. The output vector y^0 is interior to $P(x)$, which implies that with given inputs x, this observation should be able to increase outputs, for example, along the ray from the origin to the boundary of the output set, i.e., y^*. The distance between y^0 and y^* is a measure of its inefficiency. Next consider the observation y' which also uses input level x.

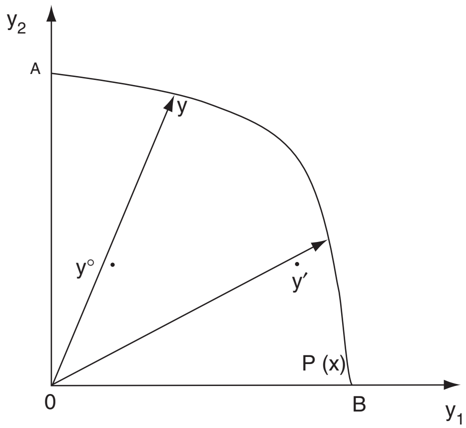

Fig. 2. Efficiency in the Intermediate Model.

Clearly it is more efficient than y^0 since it is closer to the boundary of $P(x)$ than y^0.

One can also analyze performance over time which involves comparing observations to the shift in the frontiers of the output sets over time. The tool best suited to this type of analysis in the health care sector is the Malmquist productivity index, which does not require information on prices. For a survey of this topic see Färe, Grosskopf and Roos (1998).

When the financial or budget constraints are introduced together with the intermediate model $P(x)$, one can compare minimum to observed cost, or alternatively one can study what we call the cost indirect output set, which we define as

$$IP(w, C) = \{y : y \in P(x) \text{ and } wx \leq C\}. \tag{5}$$

This set depends on input prices w and total cost C, including the original set $P(x)$, which is defined for a given level of input x. $IP(w, C)$ also includes all the additional output sets with input levels different from x which satisfy the budget constraint $wx \leq C$. As before one may ask whether an observed output vector y^0 is efficient relative to the boundary of this set. In addition, one may address the issue of whether inputs are optimally allocated, i.e., are we using the best combination of doctors and nurses in the hospital or clinic. This is achieved by minimizing costs relative to $P(x)$ or maximizing outputs in the indirect model.

4. THE CAPABILITY MODEL

Here we turn to the capability model which we use in our empirical example to follow. We appeal to work by Amartya Sen concerning the measurement of individual well-being or quality of life. He argues that measuring what the patient has – health status, income, etc. – does not suffice. We need to determine what the individual is actually able to 'do' with what they have.

In our case we are seeking a way to relate medical status $y = (y_1, \ldots, y_M)$ of the patients to their ability to go about their daily life activities. This requires finding a functional relationship in order to add up or aggregate the multiple medical characteristics and the multiple outcomes or daily life activities. Here we build on work by Roos and Lundström (1998) and Roos (2002). These have in common a reliance on what economic production theorists call distance functions, which are also typical measures of efficiency in the intermediate model. In our empirical example, these compare individual patient observations to a best practice frontier constructed from the individual patients in the sample. The frontier is the boundary of the capability set $Q(y)$ relating medical status to daily life activities. The idea is to measure how much patients improve relative to the frontier of $Q(y)$.

> A bicycle is treated as having the characteristics of 'transportation', and this is the case whether or not the particular person happening to possess the bike is able-bodied or crippled. In getting an idea of well-being of the person, we clearly have to move on to 'functionings' to wit, what the person succeeds in *doing* with the commodities and characteristics at his or her command. Sen (1985, p. 10)

In this chapter we are interested in the well-being of persons before and after cataract surgery. Thus the eyes are the bicycle in our example and the functionings are the ability to read, walk and go about life's daily activities.

The characteristics approach referred to in the quote above goes back to the framework developed by Gorman (1956) and Lancaster (1968), which we call the characteristics model. Here we take the characteristics of the eyes as the inputs which are used to produce the outputs of reading, walking and other daily life activities. This interpretation of the capability model is empirically tractable ... and 'the investigation is not of theoretical interest only, but also of some real practical import'. Sen (1985, p. 7)

We illustrate that real practical import for the case of patients undergoing cataract surgery. We look at patient capabilities as our means of determining the effect of surgery on their well-being. Specifically, the data we use in this study can be organized into two groups:

1. eye characteristics
   $y_1 =$ visual acuity, left eye,
   $y_2 =$ visual acuity, right eye,
   $y_3 =$ contrast vision,
2. self-assessed frequency of daily life activities related to vision; higher score indicates more activity or less difficulty
   $q_1 =$ reading
   $q_2 =$ walking
   $q_3 =$ watching television.

The data on visual acuity and contrast vision (y) and daily life activities (q) are collected through interviews with the patients before surgery as well as 4 months after surgery, which is discussed in more detail later in the chapter.

To illustrate our approach, suppose for the moment that there is only one eye characteristic, say visual acuity which we denote by y and one positive activity, say reading which we denote by q. This allows us to draw a two dimensional representation of what Sen would call the capability set. In our figure the capability set is denoted by T where

$$T = \{(y, q) : \mathrm{q} \in Q(y)\}. \tag{6}$$

Thus the set T consists of all pairs (y, q) that are feasible, whereas the set $Q(y)$ consists of those daily life activities q that a given set of medical conditions y can generate as shown in the figure. In other words, if visual acuity is y^0, the range denoted by $Q(y^0)$ on the q axis in Fig. 3, represents all the feasible activities that can be achieved with acuity level y^0. Thus T and $Q(y)$ contain the same information.

The question we wish to address is whether the well-being of the patient (as indicated by their daily life activities) has improved after medical intervention or treatment. Thus we compare daily life activities before and after treatment. Let us call these (y^0, q^0) before treatment and (y^1, q^1) after treatment.

In this chapter we differ from Roos (2002) by using a directional output distance function[3] rather than a Shephard (1970) type distance function. The latter was illustrated earlier in the intermediate model. We use the directional distance function instead to project (y^0, q^0) and (y^1, q^1) to the frontier of T in part because it facilitates aggregation from the patient level up to the clinic or hospital level for example. Recall from a description of

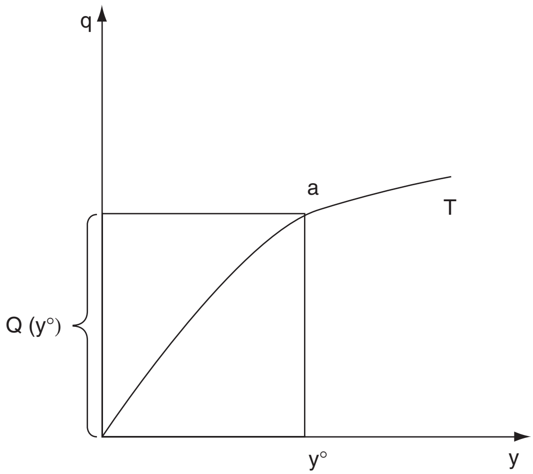

Fig. 3. Capability Set.

the intermediate model, we can compare y^0 and y^1 by measuring the distance to the frontier.

Given our capability set T and a directional vector $g=(0,g_q)$, the directional output distance function is defined as (see Chambers, Chung, & Färe, 1998 or Färe & Grosskopf, 2004)

$$\vec{D}_T(y, q; 0, g_q) = \max \beta \ \text{ s.t.}(y, q + \beta g_q) \in T \tag{7}$$

Fig. 4 illustrates.

The technology or capability set is T, the directional vector g projects in the direction of the vector $(0, g_q)$ indicating that y is held constant while q is expanded, i.e., given their vision characteristics, how much can we improve daily life activities? The distance function projects observed (y, q) onto the boundary of T northward along the direction g onto point a. Given the relationship between y and q, the best outcome possible is the highest level of q given y.

The distance function inherits the properties of T, and it completely characterizes that technology, i.e.,

$$(y, q) \in T \text{ if and only if } \vec{D}_T(y, q; 0, g_q) \geq 0 \tag{8}$$

For additional properties, see Färe and Grosskopf (2004).

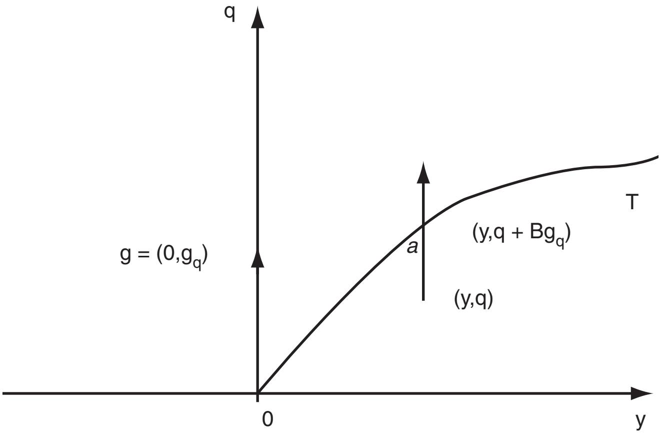

Fig. 4. The Directional Output Distance Function.

We can also include the relative changes over time. To evaluate the change from before treatment (y^0, q^0) to after treatment (y^1, q^1) we use the one period Luneberger productivity indicator introduced by Chambers (1996). The reference set is chosen to be from the initial period T^0, and the indicator is defined a

$$\mathrm{L} = \vec{D}_T^0(y^0, q^0; 0, g_q) - \vec{D}_T^0(y^1, q^1; 0, g_q) \tag{9}$$

which we illustrate in Fig. 5.

The two vectors (y^0, q^0) (medical outputs and activities possible in time 0) and (y^1, q^1) (medical outputs and activities possible in time 1) are projected north/south onto the boundary of T, i.e., in the capabilities direction, (0, g_q). If an observation is efficient, then the associated distance function takes a value of zero. Since (y^0, q^0) in the figure is inside the boundary of T^0, $\vec{D}_T^0(y^0, \mathrm{q}^0; 0, g_q) > 0$, i.e., we can increase q^0 given y^0. In contrast, (y^1, q^1) is outside T^0, so we must contract q^1 for it to become feasible, i.e., an element in T, which means that $\vec{D}_T^0(y^1, \mathrm{q}^1; 0, g_q) < 0$. The indicator takes the difference between the two distances to the boundary. Here the difference is positive, thus there has been an improvement in the patient's 'quality of life' between the two periods.

Although individual patient effects are of interest in their own right, we are often also concerned with performance in the aggregate of a department or clinic for example. For example, suppose that there are $k = 1, \ldots, K$

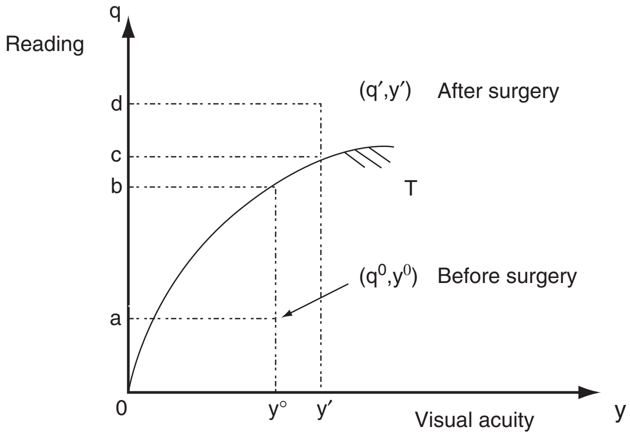

Fig. 5. The Luenberger Productivity Indicator.

patients (y_k, q_k) in our sample. How do we measure the total improvement in the sample? This is simply the sum of the individual results, i.e.,

$$L^{\text{Tot}} = \sum_{k=1}^{K} L^{\text{k}} = \sum_{k=1}^{K} (\vec{D}_T^0(y_k^0, q_k^0; 0, g_q) - \vec{D}_T^0(y_k^1, \text{q}_k^1; 0, g_q)) \quad (10)$$

If the distance function is additively separable, i.e., if it may be written as two separate components

$$\vec{D}_T^0(y, q; g_y, g_q) = \vec{D}_y(y; g_y) + \vec{D}_q(q; g_q) \quad (11)$$

then the Luenberger indicator decomposes into an eye condition y-indicator and a quality of life q-indicator, namely

$$L = (\vec{D}_y^0(y^0; g_y) - \vec{D}_y^0(y^1; g_y)) + (\vec{D}_q^0(\text{q}^0; g_y) - \vec{D}_q^0(\text{q}^1; g_q)) \quad (12)$$

5. ESTIMATION

Appendix A includes details as to how we may compute the changes in health status using activity analysis with patient level data.

We use the 'before' data to construct the capability set, or reference set. Data for each patient before and after surgery are then compared to this reference or capability set to determine whether and how much patients have improved in terms of visual acuity and daily life activities.

Our daily life activities or capability variables q_j, $j=1,\ldots, J$ are self-assessed, as well as ordinal. Thus we are interested in knowing what happens to our capability model T^0 if their numbering is changed; as we demonstrate in Appendix A, our model is unaffected.

6. CATARACT SURGERY

In an ongoing study, EyeNet Sweden is investigating the effect of cataract surgery on the well-being of a group of patients in Sweden, see Lundström, Albrecht, Nilsson, and Aström (2006). This study is investigating the gains of interventions on the quality of life of these patients, focusing on differences in gains from immediately sequential cataract surgery (ISCS) and delayed sequential cataract surgery (DSCS). Here we focus on the relation between medical condition and capabilities of the patients before surgery and after their cataract surgery.

Most cataract patients have cataracts in both eyes and benefit from bilateral cataract extraction. Medical studies such as Laidlaw et al. (1998) and Lundström, Stenevi, and Thorburn (2001) have shown that second-eye surgery adds quality of life (QoL) to such patients. The typical procedure is to perform bilateral cataract extraction one-by-one, i.e., what is called DSCS with an interval between the surgeries of weeks or months. However as described in Chang (2003) more than 6,000 cases of immediately sequential or simultaneous cataract surgery (ISCS) have been reported and described as favorable in Johansson and Lundh (2003), Sarikkola, Kontkanen, Kivelä, and Laatikainen (2004) and Smith and Liu (2001). The advantages include faster rehabilitation of the patient and lower costs for the patient and society. The disadvantage is risk of a serious bilateral complication such as corneal decompensation, macular oedema or endophthalmitis, see Smith and Liu (2001). Of course this may occur in sequential surgery as well. The risk of endophthalmitis is extremely small although as reported in Montan, Wejde, Koranyi, and Rylander (2002) endophthalmitis due to contaminated equipment has occurred. Another disadvantage of ISCS is that the possibility of recalculating the target refraction and changing the lens – available under the one eye at a time approach – is lost.

The relative gains of the two types of surgery will be captured in our study by the patient's self-assessed satisfaction with vision (here: reduced difficulty with reading, walking and watching tv), according to the Cataract Management Guideline Panel, 1993.

The data consists of a sample of 79 Swedish patients randomly selected to surgery either on both eyes on the same day or sequential surgery with a 2 month interval between the first and second eye surgery, these are from the ongoing EyeNet study, see Lundström et al. (2006). All patients were eligible for bilateral cataract extraction, i.e., all patients had cataracts in both eyes. As mentioned in previous sections we have data on these individual patients before their surgery (period 0), and after surgery (period 1). The pre-surgical examination was performed by one of two experienced registered ophthalmic nurses and one of two experienced cataract surgeons. The surgery and follow up examinations were performed by the same surgeon and ophthalmic nurse. The visual exam was repeated 2 months after the first surgery, i.e., after the first eye surgery for the DSCS group and after the both eye surgery for the ICSC group. This was done again after 4 months. The patients' self-assessed visual function was studied using the Catquest questionnaire (Lundström, Roos, Jensen, & Fregell, 1997; Lundström, Stenevi, Thorburn, & Roos, 1998), which contains questions about daily life activities and difficulties in performing daily life activities, cataract symptoms, satisfaction with vision, work, driving and degree of independent living. All patients completed the Catquest questionnaire before surgery and at the two post-surgical exams. There was no significant difference in demographic characteristics between the two groups of patients.

In our estimation of the indicator we transformed the daily life activity data so that higher values are 'better'. This allows us to use the standard activity analysis model in estimating the indicator. We used the before surgery data '0' to model the reference technology, and we estimated the two distance functions for each $k' = 1, \ldots, K$ using the directional vector (0, 1). The two linear programming problems are detailed in Appendix A.

7. RESULTS

We begin with the data. In Table 1 we display summary statistics of the variables we use in our estimation. The basic story is that values of the three measures of vision improve after surgery, although the range of values does not. Similarly the daily life activity variables related to reductions in difficulty with reading, walking and watching tv improve after surgery with no change in the range[4]. This suggests that we should expect to see improvements in terms of our indicators as well. For example, the mean values of our acuity variables all improved 4 months after surgery as did the mean values with respect to reading, walking and watching tv.

Table 1. Variables.

	Pre-Surgery Period "0"			4 Months After Period "1"		
	Mean	Min	Max	Mean	Min	Max
Visual acuity (y)						
Right eye	.61	.2	1	.96	.6	1
Left eye	.66	.2	1	.94	.6	1
Contrast	1.65	1.35	1.95	1.82	1.5	2.1
Daily life activities (q)						
Reading	2.85	1	4	3.87	1	4
Walking	3.17	1	4	3.81	1	4
TV	2.91	1	4	3.87	1	4

Note: Larger value reflect better acuity or contrast and better ability to read, walk and watch tv.

Table 2. Summary of Results.

	Change from Pre-Surgery to Post Surgery			
	Mean	Std. Dev.	Min	Max
ALL (obs=79)				
Luenberger Ind.,vrs	.444	.528	0	2.00
Vision Acuity Ind., vrs	.229	.129	−.100	.480
Output Quantity Ind., vrs	.533	.577	0	2
DSCS (one eye at a time) (obs=35)				
Luenberger Ind.,vrs	.396	.518	0	2.00
Vision Acuity Ind., vrs	.248	.129	0	.480
Output Quantity Ind., vrs	.514	.562	0	2
ISCS (both eyes at once)(obs=40)				
Luenberger Ind.,vrs	.485	.536	0	1.89
Vision Acuity Ind., vrs	.213	.146	−.100	.430
Output Quantity Ind., vrs	.550	.597	0	2

Table 2 summarizes our results. If we look at the indexes for the entire sample we see that the values are on average greater than zero, representing an improvement after surgery. Recall that the Luenberger indicators account for changes in daily life activities given visual acuity. We also see improvements on average when we calculate separate indicators for vision (vision acuity indicator) and daily life activities (output quantity indicator).

Table 3. Frequencies.

	All obs (75)			One Eye (35)			Two Eyes (40)		
	Better	Worse	Same	Better	Worse	Same	Better	Worse	Same
Luenberger Ind., vrs									
# %	35	0	40	15	0	20	20	0	20
	47	0	53	43	0	57	50	0	50
Vision Acuity Ind.									
# %	70	2	3	34	0	1	36	2	2
	93	03	04	97	0	03	90	05	05
Output Quantity Ind., vrs									
# %	37	0	38	17	0	18	20	0	20
	49	0	51	49	0	51	50	0	50

Turning to the results for the two surgical alternatives, we find that the Luenberger indicator suggests that there is a greater improvement on average for the two eyes at a time surgery, .485 vs .396. The visual acuity indicator suggests the opposite result on average; one eye at a time surgery yields a higher average vision indicator, .248 vs .213. The indicator of daily life activities (output quantity indicator) suggests that operating on both eyes at once yields higher average improvements in daily life activities.

To provide a more complete picture of the distribution of our results, Table 3 displays frequencies. These are for improvements (better), declines (worse) and no change. Here we find that the Luenberger indicator is roughly evenly divided between improvements and no change, as is the output indicator. The acuity indicator shows almost uniform improvement, with only two cases which showed a decline and three no change in vision after surgery. These general results are consistent across the type of surgery as well; again the acuity indicator shows the most consistent pattern of improvement. This suggests that while patients do realize medical improvements no matter which type of cataract surgery they receive, only about half self-report a consistent reduction in difficulties in their ability to read, walk and watch tv, although we see a slightly greater share reporting improvements in the two eyes at a time surgery.

8. SUMMARY

In this chapter we propose a three-pronged approach to assessing efficiency of health care, including financial performance, performance in the production of (intermediate) medical outcomes and performance relating medical outcomes to patient health outcomes. Throughout we use frontier models which can be estimated in a number of ways, including DEA, stochastic frontiers and index numbers. We illustrate the health outcomes model with an application to cataract surgery patients in Sweden and use DEA as our estimator. Again, other frontier estimation methods as well as index numbers could be employed to explore other procedures' effectiveness and overall performance of services and/or hospitals and clinics.

NOTES

1. $\Re_+^N$ denotes all real nonnegative numbers.
2. Since health care is by nature a service, one may wish to include the patients (and their pre-intervention health status) as inputs as well.
3. This function was introduced by Luenberger (1992) under the name shortage function.
4. Note that our data on outcomes are integer data, thus the means are not values observed in the data.

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APPENDIX A

Suppose we have $k = 1, \ldots, K$ patients with data on y and q before and after a medical procedure. We denote these as (y_k^0, q_k^0) and (y_k^1, q_k^1) respectively.

We use the 'before' data to construct the capability set. The method we apply is referred to as activity analysis or DEA (Data Envelopment Analysis). The capability set T^0 is constructed as

$$T^0 = \{(y, q) : \sum_{k=1}^{K} z_k q_{kj}^0 \geq q_j, j = 1, \ldots, J,$$
$$\sum_{k=1}^{K} z_k y_{km}^0 \leq y_m, m = 1, \ldots, M,$$
$$z_k \geq 0, k = 1, \ldots, K\} \tag{A.1}$$

where z_k, $k = 1, \ldots, K$ are called intensity variables and serve to construct a convex cone from our set of data points. This model satisfies standard production axioms just as in the intermediate model. In addition since the intensity variables are only restricted to be nonnegative, T^0 is homogeneous of degree zero, i.e., $\lambda T^0 = T^0$, $\lambda > 0$, which is constant returns to scale. When in addition the intensity variables are restricted to satisfy $\sum_{k=1}^{K} z_k = 1$, we say that the model satisfies variable returns to scale.

Ultimately we estimate two linear programming models, the first that relates to the patient's acuity and daily life activities before the cataract surgery:

$$\vec{D}_T^0(y_{k'}^0, q_{k'}^0; 0, 1) = \max \beta$$
$$\text{s.t.} \sum_{k=1}^{K} z_k q_{kj}^0 \geq q_{k'j}^0 + \beta, j = 1, 2, 3$$
$$\sum_{k=1}^{K} z_k y_{km}^0 \leq y_{k'm}, m = 1, 2, 3$$
$$\sum_{k=1}^{k} z_k = 1,\ z_k \geq 0,\ k = 1, \ldots, K \tag{A.2}$$

and the second which compares the patients' daily life activities after surgery to the pre-surgery frontier: and

$$\begin{aligned}
&\vec{D}_T^0(y_k^1, q_k^1; 0, 1) = \max \beta \\
&\text{s.t.} \sum_{k=1}^{K} z_k q_{kj}^0 \geq q_{k'j}^1 + \beta, j = 1, 2, 3 \\
&\sum_{k=1}^{K} z_k y_{km}^0 \leq y_{k'm}^1, m = 1, 2, 3 \\
&\sum_{k=1}^{k} z_k = 1, z_k \geq 0, k = 1, \ldots, K
\end{aligned} \tag{A.3}$$

Our daily life activities or capability variables q_j, $j = 1, \ldots, J$ are self-assessed, as well as ordinal. Thus we are interested in knowing what happens to our capability model T^0 if their numbering is changed. There are two types of changes we would like to consider:

- scaling (multiplication)
- translation (addition).

If we start with scaling, we would construct a new variable

$$\hat{q}_j^0 = \lambda q_j^0, \quad \lambda > 0 \tag{A.4}$$

Does this change T^0? The answer is no since

$$\sum_{k=1}^{K} z_k \hat{q}_j^0 \geq \hat{q}_j \tag{A.5}$$

and

$$\lambda \sum_{k=1}^{K} q_{kj}^0 \geq \lambda q_j \tag{A.6}$$

so the λ cancels and we have our original constraint.

Next we construct a new variable through translation

$$\bar{q}_{kj}^0 = (q_{kj}^0 + \varepsilon), \varepsilon \in \Re \tag{A.7}$$

then

$$\sum_{k=1}^{K} z_k \bar{q}_{kj}^0 \geq \bar{q}_j \tag{A.8}$$

and

$$\sum_{k=1}^{K} z_k \bar{q}_{kj}^0 + \sum_{k=1}^{K} z_k \varepsilon \geq q_j + \varepsilon \tag{A.9}$$

If $\sum_{k=1}^{K} z_k = 1$, then again we have our original constraint leaving T^0 unaffected. Thus in our empirical work we further restrict the intensity variables so that the capability set satisfies variable returns to scale.

We transform some of our data so that small values are undesirable whereas the original data was coded with small values as desirable. In particular, let $\delta \geq \max\{q_1,\ldots, q_K\}$ and make the following transformation

$$q_{kj}^{*0} = (\delta - q_{kj}^0) \tag{A.10}$$

The model then becomes

$$\sum_{k=1}^{K} z_k q_{kj}^{*0} \geq q_{kj}^* \tag{A.11}$$

and

$$\sum_{k=1}^{K} z_k (\delta - q_{kj}^0) \geq \delta - q_{kj}$$

$$\delta \sum_{k=1}^{K} z_k - \sum_{k=1}^{K} z_k q_{kj}^0 \geq \delta - q_{kj} \tag{A.12}$$

thus if $\sum_{k=1}^{K} z_k = 1$, one needs to reverse the inequality since

$$-\sum_{k=1}^{K} z_k q_{kj} \geq -q_{kj} \tag{A.13}$$

and

$$\sum_{k=1}^{K} z_k q_{kj} \leq q_{kj} \tag{A.14}$$

PART V:
CONCLUDING REMARKS

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CHAPTER 13

EFFICIENCY IN HOSPITAL INDUSTRY: SUMMARY AND CONCLUSIONS

Jos L. T. Blank and Vivian G. Valdmanis

1. INTRODUCTION

It is well recognized that hospitals do not operate in a competitive market typically observed in the economics literature, but rather alternative measures of performance must be developed. In other words, health policy analysts, managers, and decision-makers cannot rely on determining efficiency via the typical profit maximizing/cost minimizing firm but develop techniques that address the issues germane to hospital productivity. What has been presented in this book demonstrates the research in both productivity and policy that must attend to this anomaly. In this introductory section, we briefly summarize the theoretical underpinnings of this book.

In Chapter 2, Balk defines the underlying productivity theory that the remaining chapters either directly or indirectly must address to improve hospital performance. First, Balk identifies the two main issues in production – changes over time and comparisons among hospitals. The first issue was demonstrated by the changes in hospital markets over time. Mergers, affiliations, networks, and markets had arisen over time in response to costs that had become unacceptable in terms of national budgets

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and private insurers. Confounding these types of market responses, hospital decision-makers, as Balk points out and the authors in several chapters key in on, is that quality of care cannot be compromised to the point of endangering patient well being. Burgess in Chapter 3 especially identifies how researchers of hospital policy and performance need to hone in on the appropriate data and performance indicators to answer appropriate questions. The Burgess chapter also directly addresses what Balk refers to as the accounting model – specifically one needs to have the appropriate enumeration of inputs and outputs (and prices, if available) in order to develop the kind of modeling that is required for a complete hospital performance analysis.

2. METHODOLOGY

2.1. Productivity and Efficiency Measurement

In a market environment a suitable overall performance measure seems to be profit, here defined as a production unit's revenue minus its cost. An alternative and mostly preferred measure is profitability, defined as a unit's revenue divided by its cost. Hospitals, operating in a non-market environment, are generally characterized by the fact that their revenue cannot be calculated since there are only regulated (non-market based) services' prices or no services' prices at all. An important component of profitability appears to be productivity. The most encompassing measure of productivity change or productivity differences is total factor productivity (total factor productivity –TFP) change or difference. TFP is nothing but the 'real' component of profitability change or difference. If there were no differentially changing prices then productivity change/difference would coincide with profitability change/difference. TFP includes all resources and services and is therefore an integral concept of productivity measurement. Therefore TFP is far to be preferred to so called partial productivity measures, such as the number of surgeries per full time equivalent of nursing staff.

Any measurement exercise must start with setting up an adequate accounting model. In such a model one must specify the resources and services, the quantities and the prices which must be observed, and the various concepts that play a role, such as revenue, cost, and profit(ability). One important issue in productivity measurement concerns the problem of decomposing any (nominal) revenue or cost change into the contributions of price change and quantity change. After revealing the 'real' component in profitability change a further decomposition is possible. Productivity change can further be decomposed into to technological change, scale effects, diversification effects, resource and services substitutability and efficiency change. Technological change refers to the improvement in equipment and/or organizations due to innovations.

Scale effects refer to the impact of the size of a hospital on productivity. Small hospitals may suffer from indivisibilities of means of production, whilst large hospitals face relatively larger cost due to bureaucracy and span of control. (Dis) economies of scale means that a hospital is capable of expanding services by proportionally more, or less, as it expands its resources. There is an extensive literature on this issue.

A related subject to economies of scale is system economies. Multi-hospital system economies are present if the cost of providing a range of services by a number of hospitals, that are centrally managed, is less (more) than the aggregate cost of independent owned hospitals. System owners may be able to provide hospitals services at lower costs by coordinating and allocating the treatment of patients across system members, by sharing facilities or collective purchases.

Economies of diversification are present if the cost of providing a range of services collectively is less (or more) than the collective cost of providing each service or a subset of services individually. Specialization in services or widening the scope of services may enhance total service provision. Not much (research) progress has been made on this topic.

The judicial relation between the central organizations and affiliated hospitals can vary from sponsor to ownership. The judicial construction of the system is therefore also a subject of research. In Chapter 5 Alam and Granderson gives an illustrative example of system economies. They show that the nature of the membership and the number of members do and in some cases do not affect hospital efficiency.

Resource and services substitutability are related to the allocation issue. Specialization in product services or a well chosen mix in personnel may contribute to higher productivity.

Technical efficiency is a residual concept, based on the remaining differences after correcting productivity change by the above mentioned factors. By extension, technical efficiency change therefore reflects a change in the "distance" to the best practice. In most applications efficiency is connected with managerial skills in a hospital. In this respect, it is also important to make a fair comparison amongst hospitals by identifying factors that are out of control of the management. These environmental factors should also be included in the productivity analysis.

In empirical applications various techniques are available to establish the various components of productivity change. Well known and popular techniques are Stochastic Frontier Analysis and Data Envelopment Analysis. Both techniques envelop the data to construct a "best practice" or frontier. In addition to the methodological issues raised by Balk and the contributors, we also must pay heed to the measurement of outputs/services provided by the hospitals. Appropriate dis-aggregation must be performed if the analysis is to be based on patient outcomes and hospital wide data can only be used when the hospital in its entirety is the unit of analysis.

3. MARKET FACTORS AFFECTING HOSPITAL PERFORMANCE

The relevance of productivity analysis follows from the possibility to investigate the relation between productivity change and policy or managerial instruments in order to improve productivity. This book contains a number of examples of instruments influencing productivity, such as market structures and hospital networks.

Bazzoli describes, in Chapter 4, that consolidation and integration may also impact primary markets including the wave of hospital construction and renovation along with development of specialty hospitals. Given the changes in renovations, Bazzoli recommends that hospital decision-makers consider how to organize services across their affiliated hospitals. The basic point raised by Bazzoli is that careful consideration be made in how best to allocate services among hospitals in order to maximize the utility of their existing space and labor force leading to more efficient patient through-put. The key issue raised in this chapter is that individual hospitals no longer 'go it alone' but in a more pressure-filled market with HMO and price discounts in contracts with both public and private insurers, hospitals must learn to cooperate if they are to be sustained.

Another aspect of hospital market efficiencies is the notion of hospital market concentration. Sari, in Chapter 9, assessed mergers, acquisitions, joint ventures and partnerships as a way of transforming hospital competition from non-price (cost increasing) competition to more intensive price competition. This is an important distinction since the literature has consistently supported the view that non-price competition leads to higher prices and negative consumer welfare. However, tradeoffs may exist between more efficiency via more concentration and lower levels of quality and thus poorer patient outcomes. Sari warns that policy makers, particularly in the area of anti-trust, have not focused enough on quality effects. In her findings, Sari demonstrated that concentrating services achieved better cost efficiency in highly competitive markets, i.e., more hospitals in a market area. This corresponds to mergers et cetera mitigating some of the non-price competition cost-increasing behavior.

However, in order to fully understand the multi-dimensionality of concentration effects in hospitals, Sari suggests that any analysis regarding either vertical or horizontal integration study quality changes. Combining the warnings of Sari and the measurement of hospital services by Burgess would be a promising step towards evaluating any future mergers.

4. TECHNOLOGICAL CHANGE

Of course there is a large body of literature concerning the medical effects of new treatments and medicine, the so called medical technology assessments (see e.g. Chapter 12). In many of this research attention is also paid to the direct cost of these new technologies. However, these studies are limited to medical treatment and do not focus, for instance, on process changes in the hospital. These studies neither focus on the cost consequences for the whole hospital (e.g. the use of medicine may affect the average stay of a patient). In hospital cost or productivity analyses not much attention is paid to the influence of technological developments and innovation on productivity. However, in particular in the hospital industry major technical changes may be expected. A clear insight in the relationship between technology and cost may provide policymakers and managers with pertinent information that could influence long term cost growth by controlling the availability and diffusion of new technologies. In Chapter 6 Blank illustrates the effects of a number of well-defined technology clusters on productivity. He shows that some technologies affect productivity in a positive way, whilst other technologies have a negative effect. In that case quality gains must be decisive in implementing these new technologies.

Economies of diversification are present if the cost of providing a range of services collectively is less (or more) than the collective cost of providing each service or a subset of services individually. Specialization in services or widening the scope of services may enhance total service provision. Not much (research) progress has been made on this topic.

5. HOSPITAL OWNERSHIP AND PRODUCTIVITY

Total factor productivity (TFP) as Balk describes can be focused on either the patient level as presented by Färe et al. (Chapter 12) along side with the types of benchmarking approach described by Linna in Chapter 10 and Bloom in Chapter 11. In these chapters the theories of productivity advocated by Balk and the measurement of hospital services pursued by Burgess fits into advancing patient-based research.

A second theoretical proposition described by Balk in Chapter 2 is the comparisons across units – i.e., comparing individual hospitals with other hospitals on the basis of total factor production (TFP). Specifically, relative efficiency (or productivity) can be ascertained by comparing each hospital's TFP among a set/sample to determine the "best practice frontier." On the organizational level, hospitals' productive performance may be affected by their ownership-status, how their response to competitive markets by concentrating services and finally how hospitals by ownership respond to markets and the care provided to the uninsured over time.

Mutter and Rosko (Chapter 7) demonstrated via the stochastic frontier approach that for-profit hospitals performed relatively more efficiently than either not-for-profit or government hospitals in operating in the US without any detraction from overall quality of care. The findings in this chapter correspond with the analysis of financial and net revenue ratios commonly used by hospital executives, but go further in determining the impacts by adjusting for case-mix indices of the patients reflecting illness/injury severity which dictates the use of more resources. By adjusting for case mix, hospitals, particularly, for-profit hospitals cannot appear more efficient simply by cream-skimming or serving less resource-intensive patients. From the results presented in this chapter, for-profit hospitals did appear to have a lower case-mix than other hospital ownership forms a finding that is consistent with property rights theory. However, by employing a more sophisticated frontier analysis, Mutter and Rosko found that for-profit hospitals were important in competing with not-for-profit hospitals thereby increasing hospital efficiency sector wide holding case mix constant.

As Balk described productivity analysis, two important dimensions were changes over time and comparisons among hospital performance. In Chapter 9, Ferrier and Valdmanis combined these two dimensions in analyzing hospitals operating in large urban areas in the U S. between 1994 and 2002, using a Malmquist approach, focusing on hospital ownership mix among markets. It has been hypothesized that public/government hospitals absorb the majority of uncompensated care in a market area freeing up their non-public counterparts either not-for-profit or for-profit to pursue more efficiency and technological change. Results in this chapter demonstrated that in markets with a public hospital both public and not-for-profit hospitals made gains in both efficiency and productivity changes. In markets without a public hospital, private not-for-profit hospitals maintain their productivity levels while absorbing more uncompensated care vis-à-vis their for-profit hospital counterparts. Hospitals serving in areas with large uncompensated care populations, were not find statistically significant different from hospitals in areas serving a higher proportion of insured individuals. However, the findings in this chapter do not suggest that safety-net hospitals be closed but rather more fiduciary support should be given to these hospitals to maintain operations in light of the growing uninsured population in the US.

6. BENCHMARKING

As Burgess aptly pointed out in Chapter 3, measuring hospital services relies on analyzing the appropriate data to answer the questions of efficiency, patient care quality, and outcomes. Linna and Häkkinen (Chapter 10) echo this concern. Specifically, these authors argue that the reason hospital efficiency analysis is not regularly used by policy makers and managers is due to their suspicions regarding data reliability and relevance particularly relating cost efficiency to quality. To quell this concerns, Linna and Häkkinen demonstrate the benchmarking approaches used in Finland. A pilot project focusing on seven diseases was launched and a 'bottom-up' approach, i.e., including hospital managers was used to demonstrate the usefulness of benchmarking – learning cost-effectiveness from their peers. Further, the benchmarking will be expanded to include post-hospital care including primary care and long term care which will be based on hospital grouping services. The data will be gathered and collated in a national registry and in the future linked to clinician guidelines so that medical personnel can also benefit from this information.

Finland is not the only country pursuing this type of information gathering, The Review of Government Service Provision in Australia also serves as another example of benchmarking that can be adopted in other countries. Bloom (Chapter 11) demonstrated that an specific consensus model can drive data collection improvements focusing on the performance of government-funded health services including performance indicators on quality and efficiency. The key aspect in the Australian approach is the functioning of the Productivity Commission to pave the way toward routine and accepted data collection and analysis, which will, as in the case of Finland, enable policy makers and managers to assess the efficiency of government services across states and market areas.

7. CONCLUDING REMARKS

There are two major conclusions that can be made regarding the work presented by the authors in this book. First, that hospital sustainability requires understanding the role of market, organizational, and methodological factors necessary for achieving and evaluation cost-efficiency. Balk and Burgess aptly point out the methodological and measurement concerns that must be addressed in order to carry out relevant evaluation of hospital performance. But as the chapters by Linna and Häkkinen and Bloom demonstrate, that this cannot be accomplished without cooperation at all levels of hospital management and decision-making without appropriate and acceptable data collection in order to demonstrate 'best practice' performance that can be copied or adopted by other hospitals in a state or market area.

Reliance on ratios which admittedly are easy to understand cannot be sustained given the intricacies of hospital care production. Mutter and Rosko demonstrated this by employing the use of sophisticated frontier analysis to include relevant measures such as case-mix severity of patients that necessitates the use of more resource-intensive treatment. Färe et al. go one step further in modeling the treatment of cataract surgery from organizational efficiency, to capability, to patient outcomes. These approaches can be easily adapted to more generalized questions such as how best to meet efficiency, effectiveness, and quality within the hospital sector. To meet such requirements, data collection as described by the benchmarking approaches is one positive development.

The second major conclusion derived from the chapters in this book is that there is not a single approach that is applicable to all hospitals everywhere. Mergers, acquisitions, and integration were shown to operate effectively when hospitals cooperate as shown by Bazzoli, but empirically Sari demonstrated that this type of hospital policy operates best in highly competitive markets. Market type approaches worked well in urban areas but different facets of managed care and contracting worked better in rural areas as modeled and analyzed by Alam and Granderson.

Within the hospital, technological advances while in some cases are strictly cost-increasing, they may be more than made up with better patient outcomes which in the long run reduce social costs. Blank wrote in Chapter 6, illuminated this point that in some cases and diagnoses, technological advances are met with marked patient improvement. This finding may lead some in the hospital policy area to re-think the centers of excellence approach with regards to quality or certificate of need regulation to concentrate highly technological advances ensuring that technologies are allocated to hospitals where best to meet patient care needs. However, in order to make these policy directives, hospital policy decision-makers and managers would need to be sure that any allocation decision is met with increased quality of care and patient outcomes.

Hospital ownership, particularly in the US, has also been an issue studied for years. Mutter and Rosko using the stochastic frontier rejected the null hypothesis that property rights theory is not applicable to the hospital sector. Whereas, Ferrier and Valdmanis, tracking hospital markets over time, showed that public hospitals' performance in both efficiency and technical gains were similar to not-for-profit hospitals. Whereas Mutter and Rosko raised the issue of quality assurance, Ferrier and Valdmanis pointed out that access, especially to the uninsured, poor, and underinsured also need to be a primary policy focus. Even though the conclusions reached in these two chapters appear to be in contrast, a missing data item that may rectify this difference could be health status of a patient upon admission or socio-economic status. This additional information may add knowledge regarding varying recovery rate, physiological effects of treatment and resource use that may clarify performance among hospital ownership forms.

Whereas there is no one single policy to pursue, it is evident from the chapters in this book that relying solely on market forces would lead to social welfare loss since necessary hospital services may be eliminated. Alternatively, relying solely on a regulated sector from a centralized government may not pass political muster particularly in the US where there is much political animus against a nationalized system. Rather, issues raised and lessons learned from the chapters in this book can point policy makers and managers towards meshing solutions towards a comprehensive approach to enhance hospital performance. This is particularly important since sustaining hospitals' costs at the current growth rate is untenable, governments, patients, and/or private insurers will be forced to cut back on reimbursements forcing hospital closure, conversion, or other drastic steps. Even though we concentrated on the supply of hospital services, the impact on demand could be debilitating especially in light of expected increases from an aging population or an unexpected increase in demand from either natural (pandemics) or man-made (terrorism) causes.

The contributors added to the discussion of hospital performance and how certain approaches and factors that should be taken into account. However, the list is not exhaustive. We wish to pursue the implications of the research presented here and invite researchers from other countries to contact the editors for future volumes covering this important health care policy. We make this call since lessons learned from different markets operating in the US as well as examples from other countries can provide innovative information. And, the issue of hospital efficiency is indeed a multi-country problem that policy makers world wide need to address. In conclusion, improving hospital performance in providing necessary services in the most efficient way to all individuals in need is the only way to maximize social welfare and Pareto Optimality – a worthwhile pursuit in evaluating any society's services to their population.

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