Hospital Cost Function

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Dedication

This paper is dedicated to my parents, Yossi and Orit Hadash, for their everlasting support in my life adventures and education journeys. Additionally, this paper is also dedicated to Professor Gerard McCullough for the countless hours of support, friendship, and mentorship that cannot be measured in words.

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Introduction

Of all the active institutions in the modern economy, the hospital may be the most appreciated and least understood. Besides serving as a care facility for the sick, it is often times a research laboratory, an educational institution, and a major employer. The recent transformation of hospitals to complex, highly technical, and revenue generating organizations is accompanied by the growth of the insurance industry. Availability of medical insurance removed cost constraints from hospital charges by distributing premium charges among a growing pool of insurers. Additionally, the passage of Medicare as Title XVIII under the Social Security Act of 1965[1] provided the growing elderly population significant hospital and medical benefits, and also quadrupled expenditure on hospitalization in just a few decades. Additionally, the nature of the programs diminished the traditional social role of hospitals as voluntary institutions, and they became profit centers, focusing on profit maximizing departments and reducing less lucrative practices.

The fierce competition to survive the economic downfall and the emergence of insurance giants has forced structural reform in hospitals with reduced labor and staffing, while still maintaining a patient friendly environment. These accelerated changes give health systems a greater incentive to grow, diversify, and establish greater market power by acquiring new hospitals. This allows the hospital systems to charge more for their services. But this growth comes with associated risks: acquisitions of low performing hospitals, investments in new businesses, maintaining patient safety, regulatory compliance, and improving quality of care. Additionally, constant concern for patient satisfaction and customer retention is crucial in times where costly technological improvements are demanded by the governing bodies. Therefore, the current financial state of hospitals is ambivalent. This creates a dichotomy between very

[1] Center for Medicare & Medicaid

successful health systems that can operate as monopolies and individual hospitals in great financial distress that are willing to take on risky business decisions.

In recent decades, refinement of the hospital cost function by means of improved structural methods and data access induced policy implications. The health-care industry attempted to empirically develop a testing method for analyzing production efficiency by utilizing econometric disciplines. Standard economic theory assumes cost minimizing and profit maximizing behaviors by the firm. Hence, the hospital supposedly selects inputs to the production process to yield outputs at a given quality. But, hospital quality of care is multidimensional and difficult to quantify. Therefore, my intent is to construct, under a set of hospital behavior assumptions, an econometric study that analyzes the structure of costs and production of a set of hospitals.

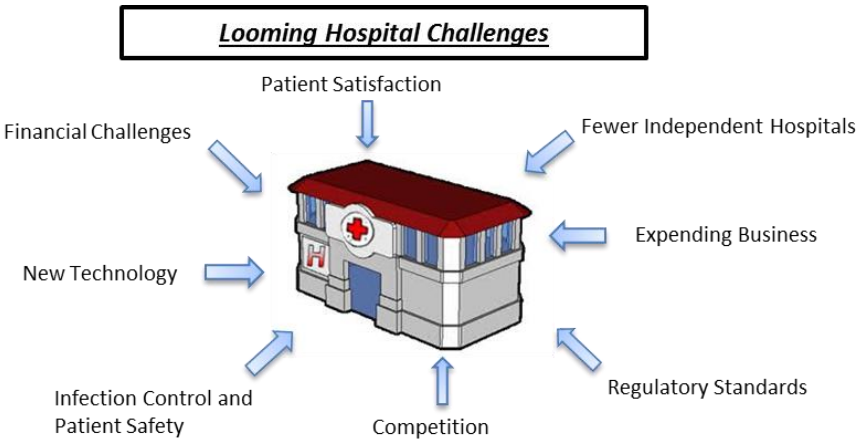


Figure 1: Hospital Challenges

Research Objectives

Information on hospital costs is available to health decision makers and researchers for two purposes: the assessment of hospital efficiency and the assessment of cost effectiveness of different health interventions. Econometric analysis explains how total cost changes in response to different inputs, prices, and scale of operation. The cost function is specified non-linearly, this

allows the study to explore the relationship between costs and quantities in a flexible statistical model. Previous studies have used micro data to estimate hospital cost functions in two ways: cost minimization functions and behavioral cost functions. The latter explains the variation in cost per unit of output, using determinants that have a causal relationship to hospital costs such as length of stay, occupancy rate, and bed size. However, the literature on cost minimization has described the minimum cost of providing a given volume of output as a function of an exogenous vector of input prices and the volume of outputs. When testing the hypothesis of cost minimization, the explanatory variables are typically comprised only of output quantities and input prices. The remaining variables used in the behavioral cost function specification are not part of the cost minimization question, but can be used to explain deviation of observed unit costs from the theoretical minimum functions (e.g. possible reasons for inefficiency).

The cost function is the research tool best equipped to explore the potential trade-off between quality and cost. As mentioned above, calculating cost is relatively straightforward, but quality of medical care is an elusive unknown that is almost impossible to quantify. This is because it is challenging for hospitals to gather data on hospital outcomes. If quality is an important determinant of hospital costs, routinely ignoring it in cost function estimation can be a serious problem.

It is often argued that health care institutions are not expected to be efficient, as they do not adhere to neo-classical firm optimization behavior. However, given the vast amount of resources that go towards funding such institutions, there is a great and growing interest in examining efficiency in hospitals with the driving force being profit.

Finally, the flexible form of the cost function can shed light on the marginal effect of hospital production, its return to scale, and market power. This related concepts can be computed

by manipulating the results of the cost function. The purpose of analyzing marginal effects is to determine at what point an organization can achieve economies of scale. Consequently, a variation in the calculation can reveal a firm's return to scale, which can have great policy implications. In addition, market power illustrates how and if imperfectly competitive markets differ from perfect competition. Theoretically, a key determinant of market power is demand elasticity or the Lerner index. The Lerner index can predict where a firm's market power is located between perfect competition and monopolistic power.

This section provided a short summary on the technical capabilities of the cost function, but in order to keep a narrow scope for the paper, this study will only apply a few of the techniques. The remainder of the paper is structured as follows: The next section provide a brief background of the U.S healthcare system, and Section 3 offer an in depth view of the literature on cost function and past research in the field of hospital cost. Additionally, this section will show how the cost function model can be used to analyze aspects of hospital technology that are relevant to the recent debate over hospital regulations. Section 4 describes the data and presents the regression results. Section 5 develops the policy implications of these results. The last two sections will present the research limitations and will summarize the paper conclusions.

Background

The United States health care system is unique in that it is predominantly privately financed and supported through public reimbursements available for the elderly and the indigent through Medicare and Medicaid respectively. Hospital systems are made up of several ownership structures, such as non-federal public hospital, private not-for-profit (NFP), or private for profit organization. Private US hospitals (Both NFP and for profit) receive payments through various channels: private insurers, Medicare, Medicaid, private out of pocket funds, and charity care.

However, hospital payments are based upon Diagnostic Related Groups (DRG's) which are determined prospectively. Therefore, insurers growingly organized their structure as Managed Care Organizations to negotiate prices and quantity of procedures. This type of organization places pressure on hospital payments because it is price competitive due to the Prospective Payment system and Managed Care Organizations.

US public hospitals are financed either federally or locally, which allow for leveled budget allocation and treatment of a greater pool of people. Enacting Medicare and Medicaid in 1965[2] radically increased the role of government in financing health care. Medicare, which covers the elderly population, has multiple parts to its bill. First, hospital care is financed by a payroll tax on the working population. Second, 75% of physicians' services are funded by federal taxes and 25% are financed by premiums paid by the elderly. Lastly, the bill also covers Managed Care Options and Prescription Drug Benefits. These two programs are predominantly voluntary and are funded by the federal government. However, unlike Medicare, Medicaid programs are administered at the state level and only 50% of the its funding comes from the federal government, while the rest comes from state programs in the form of cash assistance.

Hospitals are the largest segment of the not-for-profit sector, accounting for nearly 50%[3]of all hospitals. Amongst not-for-profit hospitals there is a clear distinction between educational institutions, religious organizations, and community owned hospitals. It is important to note that a large number of not-for-profit hospitals actively compete with profit-maximizing firms, which directly affects hospital behavior. A study by Cutler and Horwitz (2000)[4] suggests that a not-for-profit hospital in a local market affects the behavior of private hospital

[2] Center for Medicare and Medicaid Service Website
[3] American Hospital Association – "The Economic Contribution of Hospitals Often Overlooked"
[4] "Converting hospitals from not-for-profit to for-profit status, why and what effects? The Changing Hospital Industry: Comparing Not-for-Profit and For-Profit Institutions"

corporations. However, one should also consider the impact of competitive markets on the not-for-profit hospitals. Furthermore, since hospital ownership is endogenous, research should consider whether the presence of for-profit hospitals or other factors also drive behavioral differences. In a market with few for-profit hospitals, the very factors that cause for-profit firms to enter particular markets may simultaneously lead other hospitals to behave differently from hospitals of the same ownership type.

An additional question to consider is the impact of geographical location on economic costs of a hospital. The difference in the composition of markets (monopoly, resource limitations, etc) between rural and urban areas is driving the differences between the types of hospitals. Few simultaneous forces place pressure on the current economic condition of rural hospitals. According to the American Hospital Association, 30% of all Americans live in rural areas, and if we consider the current relocation trends to urban centers by the young and migration of the elderly to retirement in rural areas, the pressure on rural hospitals is greater than ever. In addition, nearly 50% of all rural hospital has fewer than 25 beds, despite the fact that they need to maintain a broad range of services. Thus, with fewer patients over which to spread expenses, cost per patient tends to be much higher. On the contrary, hospitals in metro areas are forced to invest in specialization departments, technology, and high paid employees to compete in the market.

Literature Review

Studies of cost function form one of the cornerstones of empirical microeconomics. A large number of studies have analyzed the production properties of a wide range of industries

and provided considerable evidence for policy considerations. The unique characteristics of the hospital industry opens the door for a large number of studies, which are largely driven by different data features. These studies also reflect different approaches to measuring variables hypothesized to influence cost. These are just a few of the reasons why most of the cost function studies are inconclusive in terms of scale economics and produce mixed results.

Hospital cost function encompasses a wide variety of models. In the 1970's, there was a rise in hospital cost analyses, mainly researching demand variability and economics of scale. Lave and Lave (1970) argued that economics of scale do not exist in the hospital industry and that the rate of cost in hospitals increases over time. The instrumental factor in their paper was the use of nonstandard market characteristics, such as hospital type and organizational structure. On the other hand, Baron (1971) and Leland (1972) transitioned to research demand variability, showing that hospital outputs do not go in parallel to input expenditures. This implicitly referred to the hospitals non-traditional profit maximizing behavior. Aside from these instrumental papers, others studies in the 1970's dealt with hospitals' optimal size and services.

In their paper, Multiproduct Short-Run Hospital Cost Function, Cowing and Holtmann(1983) marked a new wave in hospital cost function research. They estimated a multi-product, short-run hospital cost function with a cross-section data on 340 hospitals, which they defined as:

$$CV = G(Y, p', K, A) \qquad (1)$$

Where CV is the total variable cost, Y is a vector of outputs, p' is a vector of non-capital inputs, K is capital inputs, and A is the number of physicians in each hospital. Since the hospital is assumed to be a multi-product firm, the output vector includes inpatient care and outpatient visits. The authors concentrated extensively on the importance of input prices, while assuming

that they are fixed across all hospitals. The authors argued against the notion of economics of scale in hospital services and argued against specialization in the market place. Much like today, policy at the time supported merging smaller hospitals with large institutions to provide an array of services. This was philosophically based on economies of scope theory. Cost savings from joint production can encourage the use of a short-run model resulting from the over investment in capacity and equipment. Furthermore, the authors argue that economies of scope affect efficiency because not-for-profit hospitals may expand their services to reduce profit or increase costs to accommodate diseconomies of scope.

On the other hand, Breyer (1986) provided an overview of the empirical estimation of hospital cost functions while presenting a new approach to the theory of hospital cost function. As overly emphasized in his work, opinions in the field are divided on how to best measure hospital output because of its ambiguity and complexity. The two distinct types of specifications presented initially by Breyer are ad-hoc forms and the flexible functional forms. Cost function models explain the variation in costs per unit of output given different hospital characteristics. These characteristics include the following: hospital capacity (bed number), average occupancy rate, length of stay, wage levels of employees, and market features such as regional income level, physician density, and hospital bed density. On the contrary, a flexible functional form uses Taylor approximation to allow for differentiability in the function. Breyer's unique approach is using number of procedures, patient days, and number of staffed beds to measure hospital outputs.

The 1990's demonstrated a shift in cost function analysis. Economist attempted to incorporate care quality in response to the mounting costs of health care. Their fear was that the inherent tradeoff between resources and quality would force administrators to squeeze cost

savings by reducing investments in labor and capital. In "On Measuring the Hospital Cost/Quality Trade-off", Burgess and Kathleen examine the relationship between hospital costs and quality of care using data from the Department of Veterans Affairs. Their paper explores the inherent problems with estimating cost function without accounting for quality measures and suggests alternative methods to overcome the difficulties. The authors explore proxy measure such as readmission and mortality rates for quality. Results were interpreted both as a proxy effect, where quality measures adequately adjusted for procedure severity, and a hybrid model.

Since the turn of the century, most of the work in the field of hospital cost function analysis focused on efficiency measures, accounting for the changing map of health care cost, various governmental interventions, and insurance limitations.

Papers that utilize and research the flexible functional forms of the cost function started to receive considerable attention in the 1970's. This method appealed greatly to researchers because of the unique characteristics of the transcendental logarithmic cost function (or translog) that allows jointness and input-output separability as testable hypotheses. In addition, the concept of multiproduct scale economics was developed to relax the assumption that hospital production is strictly one dimensional (single output). In particular, Conrad and Strauss (1983) estimated a translog function with four inputs and three outputs, proving that hospitals present a constant return to scale in production. Following Conrad and Strauss, Grannemann et al. (1986) estimated a long run tranlog cost function, focusing on the real cost of capital to the hospital. Following the works of Grannemann, Conrad and Strauss, and Cowing and Holtmann, countless publications utilized the translog cost function to embark on the test of understanding hospital cost structures and the implications of its policy.

Methodology

Economic theory implies that if certain conditions are met (non-negativity, non-decreasing in outputs, concave and continuous in prices, etc), there exist cost and production functions that are dual to each other. Meaning that technology levels can be reached, using a production function or a cost function. The choice should be made based on statistical grounds. Production function estimation is preferred under the assumptions of profit maximization behavior, whereas cost function estimation is preferred under the assumptions of exogenous outputs and input prices. The behavioral nature of the non-profit hospital forces the researcher to utilize a cost function to measure industry productivity.

The restriction that the Cobb-Douglas model imposes on unitary elasticity of substitution is restrictive in understanding hospital operation. Therefore, in this study we use the translog cost function, which is a flexible functional form that can be used to approximate any twice-differentiable function without placing a-priori restrictions on the production technology. Its origin is the second order Taylor Series of the Cobb-Douglas. This functional form allow for elasticity of factor substitution, using the cross products and the quadratic terms. The multiproduct functional form allows for a complete description of differentiated marginal costs, productivity growth, and potential economics of scale.

Although the industry operate in an undefined ground between competitiveness and goodwill, its safe to claim that firms are trying to compete for services. Hence, maximize their potential profit, and compete for their inputs (capital and labor), and therefore, input prices are exogenous as well. It follows then that it is reasonable to estimate a cost function rather than a

production function. In addition, given the multi-product characteristic of a hospital, cost function estimation has an empirical advantage, because it incorporates multiple outputs.

Modeling hospital cost function require aggregation of outputs, which implies that an hospital chooses an allocation of outputs independent of the inputs needed to run the operation. In essence, hospitals serve patients demand for care, which in turn imply exogenous multi-product outputs. Therefore, since the study uses cross sectional data, and the luck of evidence for hospitals behavior in long-run, the study analyzed a short-run multiproduct cost function.

$$VC = f(Y, I_i, K, G) \qquad (2)$$

Where each variable is defined as follows. VC is short run variable cost, Y is a vector of outputs represented by: Inpatient Days, and Out Patient Visits. The variable I_i is a vector of input prices represented by: labor price Index, medical device cost per discharge, medical supplies cost per discharge, and drug cost per discharge. K is fixed capital, and G represents three control variables; urban dummy, teaching facility dummy, and profit maximizing hospital dummy to distinguish between the types of hospital ownerships.

This model assumes a cost minimizing behavior, given vectors of exogenous inputs and outputs. The cost minimizing behavior of a hospital can be questioned, but it's a necessary assumption in order to understand cost relationships. The multiproduct can be written

$$\ln VC\,(y,i) = \beta_0 + \sum_I \beta_I \ln I_i + \sum_k \alpha_j \ln y_j + \sum_c C_k \ln t_k + \sum_{ik} \beta\alpha_{ij} \ln I_i \ln y_j + \sum_{ik} \alpha\alpha_{ij} \ln y_i \ln y_j \qquad (3)$$

Data

The paper primary data source is the American Hospital Directory (AHD), a publicly available source for financial, structural, and operational information on hospitals. The American

Hospital Directory (AHD) gathers and analyzes data on roughly 6000[5] hospitals in the United States. It collects its data from public sources such as hospital cost reports, commercial licensors, and the center for Medicare and Medicaid. The information used in the analysis of the cost function is a cross sectional dataset that include 282 observations where every line describes financial and operational information of one hospital.

The original dataset include 346 variables that are subdivided to groups of financial and operational performance indicators. Each variable group describes the performance of multiple departments. An example of a group that was bundle together is "Inpatient Routing Service Cost Centers", which indicate the financial performance of 9 units; General Medical and Surgery, Intensive Care Unit (ICU), Coronary Care Unit, Surgical ICU, Neonatal ICU, and others. There are three groups that describe the financial performance of Cost Centers, four groups that describe Ancillary Service Cost Centers, Four groups that describe Salaries and Other Costs, a group for Staffing, and four groups that present the financial reports for 2012.

The variables of the model are summarized in table 1:

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Ln (Total Operating Expense)	282	8.06	0.513	6.55	9.24
Ln (Total In Patient Days)	282	4.44	0.55	2.55	5.62
Ln (Out Patient Visits)	282	3.87	1.58	0	5.71
Ln (Total Patient Surgeries)	282	6.04	2.42	0	8.96
Ln (Total Emergency Room Visits)	282	6.74	2.75	0	9.73
Ln (Labor Price Index)	282	-1.02	0.52	-2.38	0.3
Ln (Fixed Assets)	280	7.62	0.679	5.1	9.02
Ln (Case Mix Index)	282	1.53	0.337	0.81	3.39
Ln (Medical Supplies Charged Per Discharge)	276	2.92	0.299	1.13	4.15
Ln (Medical Device Charged Per Discharge)	250	2.95	0.477	0.52	4.21
Ln (Drugs Charged Per Discharge)	282	3.12	0.204	2.54	3.92
Dummy (Urban)	282	0.84	0.363	0	1
Dummy (Teaching Facility)	282	0.34	0.477	0	1

Table 1: Data Description

[5] American Hospital Directory Website

The dependent variable in the cost function model is Total Operating Expense, taken from the income statement section in the data. Variable cost is defined as a cost that will increase in amount with higher level of production. Total Operating Expense may include supplies, miscellaneous operative supplies, hourly administrative personnel, legal services, accounting services, and more. The items listed above represent the majority of items on an average hospital's Operating Expense detail listing and are all representative of variable costs. For example, if a hospital's operations grew to offer more surgical services, which resulted in added surgical rooms, more of the operative supplies listed above will be purchased and expensed. Additionally, this expansion in operations will likely result in the hiring of more administrative personnel to manage and organize the greater scope of services offered in the hospital, while added services will result in greater legal exposure and will drive legal costs to increase as well. Furthermore, the additional costs for adding surgical rooms, such as doctors' services, depreciation on machinery and equipment, and valuable materials used in procedures also impact Total Operating Expense, and can be considered variable cost. Therefore, one can assume that Total Operating Expense is a variable cost and can be utilized as the dependent variable in the cost function model.

As pointed out in the literature review, economists consistently contemplate with the challenge of determining what hospital outputs are, how to quantify them, and predict quality of care. This paper uses In Patient and Out Patient statistics as the base for understanding care in the hospital. Outputs in this paper cost function included inpatient days, outpatient visits, surgeries performed, and emergency room visits. It is important to note that the variable total surgeries performed, is an aggregation of inpatient surgeries and outpatient surgeries. Similarly, emergency room visits describe non-admitted and admitted patients. This study understands the

variety of ways in which patient days, admissions, and procedures are obtained for a facility or location. Our attempt is to standardize the measurement in a way that will capture our basic hypothesis. As a result, my results only include inpatient days and outpatient visits as outputs due to collinearity difficulties.

In order to account for technology difference among hospitals, the regression analysis includes Case Mix Index. Implemented October 1983[6], Case Mix Index (CMI) is a relative value given to a Diagnosis Related Group (DRG) of patients in the hospital. This measure determines the allocation of resources to treat patients in the group. Each DRG has an official weight that determines payment. For instance, a DRG with a weight of two is paid twice as much as a DRG of one. A high CMI means that the hospital performs complex services and therefore receives more money per patient. Hospital CMI account for the variety of illnesses treated in the hospital, therefore the cost bound to differ. Cost per patient will reflect reported charges per case in a treated year, which imply that CMI >1 has adjusted cost per procedure that is lower than the market. Conversely, CMI <1 has adjusted cost that is higher than market price.

Hospital inputs are instrumental in developing a viable cost function. Due to use of variable cost as the dependent variable, fixed capital measure was included in the regression. The capital measure was taken from the accounting data, and it describes expenses on property, plant, and equipment. It's important to note that this variable account for depreciation over time. Additional input is labor price index, calculated by dividing the direct salaries of employees (per occupation) by the total amount of paid hours. The index created by taking a numeror hospital to create a bench-mark, and multiplying the rest of the hospitals by the number.

Three other inputs that are included in the regression are; Medical supplies charged per discharge, Medical device used per discharge, and drugs charged per discharge. All the three

[6] Center for Medicare and Medicaid

were obtained from the Medicare cost reports, and are normalized to account for the different in expenditures per hospital size. It is important to emphasis here that medical device charged per discharge and medical device charged per discharge have missing values, therefore 34 hospitals were not included in the regression.

Three binary variables are included in the model. Urban, describes the geographical location of the hospital, and can explain market power effects and the role of government subsidies in hospital profitability. Teaching facility explore the financial impact of allocating resources to educating young staff. These facilities traditionally have greater resources and are larger in size, but can also present economic challenges because of the costs associated with maintaining teaching facilities. Lastly, Profit maximizing facility dummy can reveal the cost effectiveness and productivity of non-for-profit organization. A note to emphasis here is that the study divided all type of hospitals to for profit organizations and not-for-profit organization, where public hospitals are included in the not-for-profit organization because they take upon themselves high concentration of uncompensated care, and they provide non-profitable medical services.

This study does not incorporate the demand for hospital services, therefore the model overlook variables such as hospital bed size that predict capacity or density. There have been numerous studies of the structure of hospital costs, and the majority of these studies treats demand as known to the hospital, or argues that demand cannot be predicted. I will assume that service firms with high fixed costs have a service capacity which is fixed over the short or medium run. This means that if demand exceeds capacity at any given point in time, the excess demand cannot be served. For example, in certain industries it is essential that firms have sufficient capacity to keep the likelihood of excess demand below some desired level. Telephone

companies have enough lines and switching equipment to keep the probability of a customer being unable to get a line to a low level. Likewise hospitals have enough beds, equipment, operating rooms, and staff to treat many more patients than flow to them on average over the course of a year.

It is important to note that the marginal effect of the results was taken to allow for a continuous interpretation of the coefficients. Marginal effect calculation is as follow:

$$MC = \frac{\partial C^*}{\partial Q} \qquad (4)$$

Where $C^*$is total variable cost, and Q is output quantity,

$$\frac{\partial lnVC}{\partial \ln(output)} = b_i \qquad (5)$$

Where $output$ indicate either Inpatient Days or Outpatient Visits, and b_i is the regression estimate on output i

$$\frac{\partial VC}{\partial output} * \frac{output}{VC} = b_i \qquad (6)$$

Algebraic manipulation results in,

$$\frac{\partial VC}{\partial output} = b_1 * \frac{VC}{output} \qquad (7)$$

Where $\frac{\partial VC}{\partial output}$ equal the marginal cost of a hospital. As implied from the marginal effect structure of the translog regression, interpretation will be at the sample mean for the average hospital. Moreover, as typically applied in econometric work, interpretation of the coefficients assumes ceteris paribus.

Empirical Results

The parameter estimates for the cost function are presented in Table 2 and the full translog results are in the Appendix.

Regression results for Hospital Cost Function		
Ln (Operating Expense)	Estimate	T-Stats
Constant	3.58	(17.76)***
LN (In Patient Days)	0.486	(16.85)***
LN (Out Patient Visits)	0.014	(2.52)**
LN (Labor Price Index)	0.108	(5.11)***
LN (Fixed Assets)	0.187	(8.92)***
LN (Case Mix Index)	0.178	(3.53)***
LN (Medical Supplies Charged per Discharge)	0.062	(2.26)**
LN (Medical Device Charged per Discharge)	0.065	(3.45)***
LN (Drugs Charged per Discharge)	0.164	(4.56)***
Dummy (Urban)	-0.017	(-0.86)
Dummy (Teaching Facility)	0.041	(3.30)***
Dummy (Profit Max Organization)	-0.032	(-2.34)**
R^2	0.96	
Adjusted R^2	0.96	
Observations	248	
*, **, *** indicates significance at the 90%, 95%, and 99% level, respectively.		

Table 2: Empirical Results

Coefficients that can be directly interpreted have positive signs. The model R-squared is high, which is explained by the marginal power of each event. As the theory validates, low variability in the explanatory variables increase the power of the R-squared, meaning that all inputs and outputs in the cost function are linked.

All estimates other than the binary variable on geographic location (Urban) are significant and consistent. Based on hospital operating technology, one can expect to have structural differences between urban and rural hospitals. Although the insignificance of the urban variable indicates that there is no correlation between geographic location and hospital cost, I suspect that geographic location (Urban) is not significant because of the correlation with the

parameter for teaching facilities. This can be explained by the superior financial capabilities of large urban hospitals, and the costs associated with having education programs. Teaching hospitals are typically affiliated with medical schools and provide clinical education to students and residents. Most teaching hospitals are voluntary not-for-profit institutions or government public hospitals located in large urban areas. This finding can be interpreted as: a 10% increase in expenditure on teaching facilities implies a 4.1% increase in variable cost.

Although stating the obvious, teaching programs are expensive to maintain, insure, and provide resources for. The influence of these medical institutions on medical sciences and technology can be seen in surgical procedures, drugs, and sophisticated computerized systems. Medical education aimed at in-depth expertise or highly sophisticated fields of medicine greatly increased the overall sophistication of hospital practice. Consequently, the costs associated with these expensive operations may prove beneficial to specific teaching hospitals, their surrounding communities, and potentially the whole country. Further research is needed to quantify the pros and cons of teaching hospitals.

One might be concerned whether not-for-profit organizations provide care services that are superior and therefore more costly than proprietary profit-maximizing hospitals. The results show that proprietary hospitals have significantly lower costs than not-for-profit hospitals. In fact, empirical evidence suggests that both the care quality and quantity of procedures are higher for not-for-profit hospitals. The idea that the quality of care is higher and the diagnostic services provided are more diverse is supported by the fact that the dummy variable representing teaching facilities is also significant. Teaching activities are linked to higher variable costs in all regression experiments that excluded the type-of-hospital variable. Thus, both teaching status and not-for-profit status may reflect quality differences in hospital services.

When analyzing the result of the CMI variable, one can see that a 10% increase in the Case Mix Index implies a 17.8% increase in variable cost. One may ask why the impact is so great on cost. The answer is ambivalent. The CMI is used to adjust for average cost per patient, so if the CMI is high, DRG payments are larger. But does it imply anything about the health of the institution? High Case Mix is no guarantee that the facility is highly profitable. A cardiac surgery department may have a high CMI and still go bankrupt if the population it cares for is unfunded or uninsured. On the contrary, a specializing department that does very few procedures may have a really low CMI, but if it can streamline processes and attract payers whose reimbursement is greater than those expenses, it can be extremely profitable.

It is important to emphasize that the Case Mix Index is a quantifiable tool that predicts income, explains cost of treatment, and suggests viability of services to the specific population. In other words, it characterizes the underlying technology of a hospital. Therefore one can expect a lower CMI score for proprietary profit maximizing hospitals because of their tendency to eliminate procedures that are costly and not profitable. In my data set, the profit-maximizing hospitals have, on average, .1 points lower CMI score than the non-for-profit hospitals.

Considering the output elasticities, I find that the two primary diagnostic categories, Inpatient Days and Outpatient Visits, to be positively related to total variable cost. As I added output specifications to the model such as Outpatient Surgeries or emergency room visits, the power of the variable Outpatient Visits declined and was insignificant. The elasticities for additional services (outputs) were stable in numerous regressions and the t-statistics fell as the number of outputs increased. Thus, I suspect that the insignificance is attributed to collinearity difficulties.

Taking this into consideration, a 10% increase in Inpatient days implies a 48.6% increase in variable cost. On the contrary, a 10% increase in Outpatient Visits only implies a 1.4% increase in variable cost. These results highlight the difference in cost associated for the hospital services, and furthermore, that inpatient treatments account for the largest proportion of health care spending.

Analyzing input prices requires creative interpretation of the results due to the unique role the hospitals play in selling goods. As mentioned above, these ancillary costs are normalized by patient discharge to eliminate the scale effect of a large hospital system. With that in mind, one can see that the hospital operates as the "middle man" between the producer and the end client. For instance, a hospital system negotiates prices with a medical device company and sells it to the sick for a premium pay. Therefore, purchasing medical supplies, medical devices, and drugs involves logistical management, negotiation, and understanding of scale operation to run efficiently. Hospitals operate in a just-in-time inventory, and are flexible in introducing new products, but don't tend to do so because of reasons that will be explored in the next two paragraphs. The last point to emphasize is that all three input price variables work in different competitive markets, where each has his own unique characteristics.

Medical device companies tend to operate in oligopolistic markets, with few competitors. Not all buyers pay the same price for a given product, and disclosure of prices is protected by law. Prices for devices differ greatly by hospital resulting from the bargaining power a hospital system has. Buyers repeatedly lack comparative information and face high switching costs because of a relationship with a specific manufacturer. Perhaps, more importantly, in many cases the hospital is not the real buyer of a device. Rather, the purchasing decisions on a device type and its quantity is driven by a physician who will implement the device. This point gets to the

core of the cost problems in hospitals. Health care institutions care about their patient volumes (demand), while seeking to minimize cost per case given the reimbursement money they receive from payers. On the contrary, attending physicians are concerned with their time per case, their income, and procedure outcomes. Therefore, physicians often seek newer technology in treating their patients, a venture that is more costly. One can see that large manufacturers of medical devices have exploited the divergence between physician and hospital goals. Examples of that can be seen in payment for facilities, direct payments to physicians, or practice support via sales representatives. The result is that doctors may have greater loyalty to their sales representative, which increases the hospital cost. A solidification of the above can be shown by the regression result. A one percent increase in medical devices charged in the hospital implies a 6.5% increase in total variable cost. Hospitals are the eventual buyers of most medical devices produced, and the rising costs of producing the devices imply a direct cost for hospitals.

From beds and mattresses to nursing supplies, the operation of a busy institution is costly and demands a great investment in supplies. Therefore, a 10% increase in medical supplies charged implies a 6.2% percent increase in total variable cost. This can be explained by the large investments hospitals are making in purchasing medical goods and maintaining a competitive technology level.

In contrast to the other two input prices, drug charges are a source of contention in the new health reform because the federal government still prohibits Medicare from negotiating drug prices. Although the reasoning for it is the cost of developing a new drug, the relative costs of brand name drugs are increasing every year. Generous patent protection, oligopoly power, and lack of price regulation grant drug giants the privilege of inflating prices. On the contrary, in regulated markets worldwide, governments negotiate prices levels with pharmaceutical

companies that cover their manufacturing and distribution costs, but cover much less of their research expenses. In other words, companies are agreeing to sell their product cheaply elsewhere knowing that the U.S market will cover the research and development process. Therefore, the impact drug charges have on variable cost is considerably higher than the other two input prices. The analysis results show a 10% increase in drugs charged implies a 16.4% increase in total variable cost of the hospital. These results suggest that health care charges can be reduced dramatically by regulating the industries, or allowing for hospitals to negotiate prices.

On the contrary, expenditure on property plant and equipment involves a constant need to improve technologically and therefore one can expect a larger impact on variable cost. Since it's a cross sectional study, and 2012 is a year where hospitals had a mandate to invest in sophisticated technologies such as Electronic Medical Records systems, one can possibly anticipate a greater effect on costs. A 10% increase in expenditure on labor in the hospital implies a 10.8% increase in the hospital operating expense. One can expect a negative elasticity for the capital stock variable, but as we see this coefficient is positive, implying that the average hospital is not reaching its optimum long-run equilibrium. Additionally, it can suggest that hospitals hold too much capital, because one can expect variable cost to decrease (to be negative) if the investment in equipment and plant (hospital expansion) is reduced.

Lastly, the variable Labor Price Index result proves the importance wages play in hospital costs. According to a report by the American Hospital Association in 2012[7], growth in labor costs is the single most significant factor driving hospital costs. Therefore, in times that hospitals statewide face critical staff shortages (also cut positions) and demand for hospital services is on the rise, one can anticipate added cost pressures on hospitals. This Labor Price Index is a measure of the average prices paid by hospitals for a "market basket" of employees in one year,

[7] American Hospital Association – "The Cost of Caring" Published 2012.

therefore limiting the significance of it over time. Employee productivity, staff retention and the quality of work are issues that require overtime quantification. But, the study result does shed light on the importance labor trends play in understanding cost. A 10% increase in labor price index implies a 10.8% increase in variable cost. The last point to emphasize here is that although the cost share appears to be smaller than comparable literature, this result emphasizes the weight placed on labor cost and helps in the quest of understanding hospital allocation of resources.

Marginal Cost

The multi-product functional form of the cost function allows for a complete portrayal of marginal costs. Marginal cost is the change in total cost that comes from producing one additional item. The purpose of analyzing marginal cost is to determine at what point an organization can reach its optimal point of production and potentially achieve economies of scale.

Marginal cost:

$$\frac{\partial lnVC}{\partial lnQ} = b_j \qquad (8)$$

Where b_j is output estimated from the regression results, leading to;

$$\frac{\partial lnVC}{\partial lnIPD} = b_j * \frac{VC_i}{Q_{ipd}} = MC_{ipd} \qquad (9)$$

$$\frac{\partial lnVC}{\partial lnOPV} = b_j * \frac{VC_i}{Q_{opv}} = MC_{opv} \qquad (10)$$

Where Q_i is output quantity with respect to the two outputs. MC_{ipd} indicates marginal cost for the output inpatient days and MC_{opv} is the marginal cost for the output outpatient visits. The results indicate the average marginal cost of hospitalizing an Inpatient for one additional day (in 2012 real $ value) is $2308. This amount is the cost incurred by the hospital in accommodating the patient. Moreover, the average marginal cost of a patient visit to an outpatient clinic is $188. This cost does not include outpatient surgeries. When analyzing outpatient procedures and outpatient visits to a clinic the average price of a visit that is incurred by the hospital is $711.

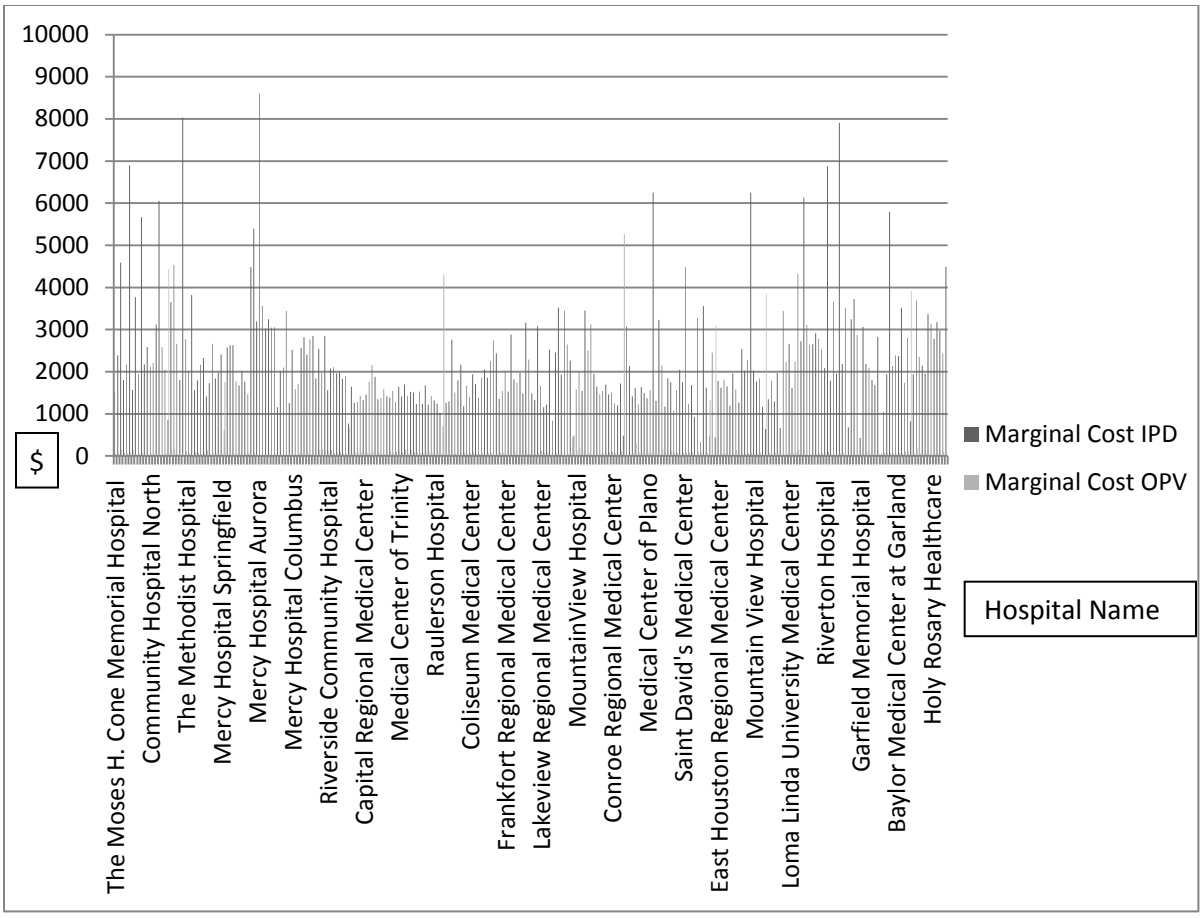


Figure 2: Marginal Cost per Hospital

Economies of Scale

The elasticity of cost output is the ratio of marginal to average cost. Therefore, if the marginal cost ratio is above the average cost, the average marginal cost is rising over time. If the elasticity of this parameter ratio is above one, then any scale effect that exists will run out at sufficiently high output levels. If the other parameters are such that the output elasticity of cost is less than one at low output levels, then we have a U-shaped average cost function. These results indicate economies of scale with respect to variable costs in the short-run, i.e., Marginal Cost ratio = 0.889 suggesting that a proportional increase in all input prices, with capital and labor price index held constant, would lead to less than a proportional increase in short-run costs for

the average hospital. In addition, the second-order output parameters are positive, implying a U-shaped short-run average cost curves. For hospitals with levels of service greater than the mean, expanding all outputs without expanding fixed inputs must eventually lead to diseconomies. Thus, we can expect continuing scale economies from concentrating services in fewer hospitals, past some optimal point, at least in the short-run.

A caveat in implementing the translog cost function is that in order to properly understand costs and hospital operation, the second derivative cannot be used to investigate economies of scope in hospital production. This would require an evaluation of costs when output level is zero, which logs cannot do.

When measuring return to scale:

$$RTS_i = \frac{1}{\frac{\partial VC}{\partial IPD} + \frac{\partial VC}{\partial OVC}} \qquad (11)$$

Where $\frac{\partial VC}{\partial IPD}$ is the marginal cost of inpatient days, and $\frac{\partial VC}{\partial OVC}$ is the marginal cost of outpatient visits. The mean result in the sample is 1.101, which in turn provides strong evidence for increasing return to scale in production. Interestingly, an in-depth analysis show that small rural hospitals experience decreasing return to scale in production of hospital services. This possibly occurs because rural hospitals serve small markets, and don't have the capacity to expand their operation.

Market Power

The Lerner's index measures the hospital market power using elasticities. The index is equivalent to the inverse of the elasticity in its absolute value. In order to calculate the Lerner index properly, the output price estimates were calculated: $\frac{Rev_{ipd}}{Q_{ipd}} = P_{ipd}$ and $\frac{Rev_{opv}}{Q_{opv}} = P_{opv}$,

where Rev_{ipd} is the revenue for the inpatient day variable; similarly Rev_{opv} is the outpatient visits revenue, and Q is the quantity of days for each output. Lerner index:

$$L = \frac{P_{ij} - \widehat{MC_{ij}}}{P_{IJ}} = \frac{1}{|\varepsilon|} \qquad (12)$$

Where P_{ij} is the estimated price per output, and MC_{ij} indicates the estimated marginal cost per hospital taken from equations 9 and 10, respectively. This index will always be between 0 and 1: the lower the result, the closer it is to perfect competition. On the contrary, the closer it is to 1, the higher monopoly power the firm has. A note to emphasize here is that the Lerner Index is a measure of market power, and not a measure of profitability. What the Lerner Index can demonstrate is that profit margins depend on the elasticity of demand faced by the monopolist.

Lerner Index	**Mean**
Lerner Index (In Patient Days)	0.530
Lerner Index (Out Patient Visits)	0.986

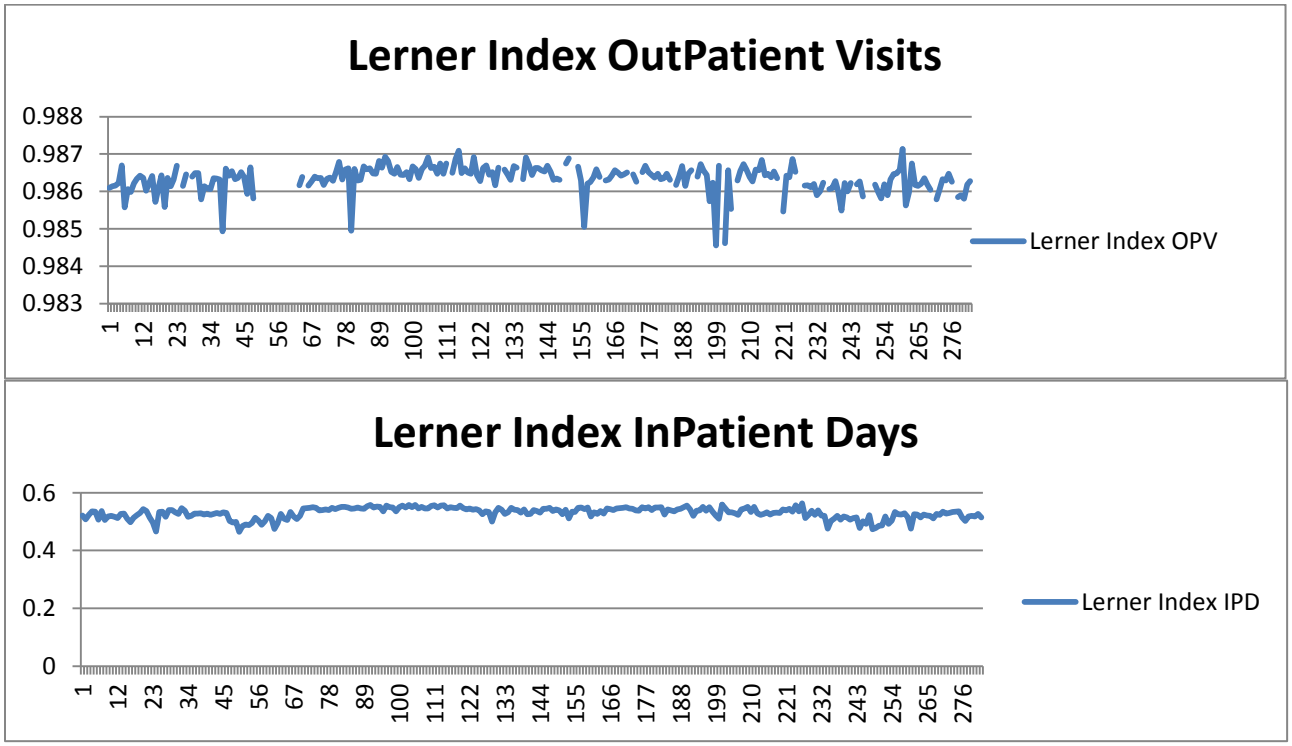
Table 3: Lerner Index Results

The results of the Lerner Index indicate that hospital inpatient care has lower monopoly power then outpatient treatment. Outpatient care has very inelastic demand, which typically implies high price to cost margins. Inpatient care also exhibits high market power. These results indicate that charges can vary widely within markets, and that there is no correlation between price of care, quality of care, and hospital profitability.

The relationship between prices and elasticities is supposed to emphasize the market power differences between profit maximizing firms and not-for-profit hospitals. In reality, the measurements show no behavioral differences. This result raises an important question, can market power in health care dictate patient behavior or demand for care? In my opinion, the

patient's inability to shop around for price differences limits their motivation to choose a cheaper/better/more equipped hospital. In other words, the patient's decision to choose a hospital is strictly based on geographic location and/or referral for a specific physician or treatment. This argument is presented in figure 3.

Figure 3 : Lerner Index Distribution



Discussion

The results discussed above propose significant policy implications. In a time where the market trend is hospital consolidation, meaning smaller hospitals are bought by large multi-state health systems, the paper results indicate a move toward the opposite direction. The paper shows that consolidation of existing hospital services may damage hospital efficacy and consequently increase the cost of operations. In general, the results on scale effect indicate that specialized hospitals are more cost effective. Future policy makers should look at dividing large hospital

systems (that provide an array of services) into multiple separate specialty centers in one geographic location.

Economies of scale in production also highlight the relative inefficiency of not-for-profit hospitals. Not-for-profit hospitals increase costs not only by expending their services beyond the operative efficiency; they also increase the scope of their services. In other words, the hospital personnel are asked to offer more services, leading to lower quality of care and higher costs.

Assessing the effects on hospital costs involves identifying the market forces that will compete with the current consolidation trend. Some suggest that economies of scale in production (of hospital services) may outweigh the damage of mergers and acquisitions to competitive markets. Can this problem be solved by government intervention? Or will market forces resolve this issue organically? A potential solution could be to mandate hospitals to set competitive market prices, or create a regional/local governing body to oversee these prices. The questions presented prove the need for further research on the incentive mechanisms placed by the regulator to reduce health costs. In other words, how can one hospital remain profitable while providing efficient and affordable care to its patients?

Another related problem to consider is the inflating cost of hospitalization. Increased public interest in the impact of hospital costs is driven by the prices of labor and material inputs. The results of this paper indicate that hospitals will be adversely affected if the price of labor continues to rise because they account for a large share of total variable costs. Hospitals can potentially have a great deal of flexibility in substituting administrative staff with clinicians, but that needs to be formally tested. Moreover, if life expectancy keeps rising we should assume that demand for clinical services will keep increasing, and therefore we can anticipate continued rising hospital costs.

Lastly, from a welfare economics perspective, monopoly power negatively affects health care due to lack of competition, which is a direct form of market failure. The prices charged are not economically efficient; they lead to higher premiums, and they place an upward pressure on government agencies (Medicare and Medicaid) to keep their prices higher than they would be otherwise. Therefore, an argument should be made that hospital market power may have negative spillover effects, leading to higher taxation. These added taxes are primarily financed by the greater population in paying the Medicare bill. Hence, a question arises: Are free markets a desirable feature for health care systems? One could argue that this question cannot be answered by economic theory alone. It is an issue that requires a greater understanding of the philosophy, culture, and beliefs of the system. A holistic review and understanding of hospitals is necessary to properly address this issue in the future.

Research Limitations

This paper presented multiple data restrictions that should be addressed in future research. Hospital panel datasets that span multiple years need to be utilized to allow for time series analysis. These datasets could be collected from the American Hospital Directory and American Hospital Association databases. This usually gives the researcher a large number of data points with time factor included. Panel data increases the degrees of freedom and reduces the collinearity problems among explanatory variables while improving the efficiency of the econometric estimates.

An additional factor that could benefit a future study is to compile data on admitting physicians. Currently, it is challenging to understand the relationship of a physician to a hospital because of their employment terms. Physicians can be employed by the hospital institution, or on a contract bases (meaning that they provide services in multiple hospitals) where there is a

division between Inpatient surgery and Outpatient surgery. Lastly, physicians can be organized under a collective union by a state or region. This lack of employment continuity creates difficulties in the understanding of procedure costs and salaries. Data on the number of physicians and the cost associated with their work can provide information on the demand for their services, the marginal cost of adding another physician, and the overall impact of their work on cost.

Another factor that could benefit future research is the addition of claims data. This would allow the researcher to match procedure expenditures to insurers' payments. This addition will aid in understanding hospital demand, and the claims information will help indicate hospitalization trends.

Conclusion

From a methodological perspective, the study results show that it is possible to use public data and established econometric techniques to estimate hospital cost effects. The results were obtained by estimating a multi-product translog cost function that includes operational outputs in the form of inpatient days and outpatient visits. The work suggests that expansion of the cost model is needed in order to capture the full impact of the function on hospital cost.

From a policy perspective, I recognize that there may be a trade-off between allowing hospitals the autonomy they need to realize their technological capabilities and protecting the market from monopoly power abuses. This paper does not question the wisdom of regulating health care systems or hospitals, if anything the results of this paper provide conformation that hospitals behave in a monopolistic environment that needs to be regulated.

In conclusion, I will argue the following: the fierce pressure to survive the current economic challenges placed by the health care system caused many hospitals to rethink their

patient services. Hospitals now face the almost impossible task of making facilities, services, and resources user friendly while implementing staffing reduction and organizational changes designed to maintain their economic viability. Caught between rising cost and failing revenues, hospitals have been seeking ways to cope with market condition, by engaging in multihospital deals of mergers and acquisitions to artificially increase market share and potentially gain economies of scale. Although financial outcomes vary by location, there is little evidence that large hospital systems meet market expectations. At the same time, costly new technology, demand for new services, increase in pharmaceutical charges, and competition from specialty hospitals and diagnostic centers reduced the operating margins of hospitals. Furthermore, there is a need to advocate for a system in which information about the cost and benefit of diagnostic tests is readily available to patients and providers at the point of care. If we fail to do so, the health care system will risk not only its patients but also the important breakthroughs on disease diagnosis and cure.

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Appendix

Regression results for Hospital Cost Function		
Ln (Variable Cost)	Estimate	T-statistic
Constant	9.56	(5.00)***
LN (In Patient Days)	-.688	(-1.21)
LN (Out Patient Visits)	.025	(0.20)
LN (Labor Price Index)	.809	(2.27)**
LN (Fixed Assets)	.034	(0.09)
LN (Case Mix Index)	.215	(1.72)*
LN (Medical Supplies Charged per Discharge)	-.198	(-0.42)
LN (Medical Device Charged per Discharge)	-.087	(-0.43)
LN (Drugs Charged per Discharge)	-.813	(-0.96)
Dummy (Urban)	.020	(1.00)
Dummy (Teaching Facility)	.025	(2.19)**
LN (In Patient Days)^2	-.002	(-0.05)
LN (Out Patient Visits)^2	.011	(1.87)*
LN(Fixed Assets)^2	-.018	(-0.60)
LN(Labor Price Index)^2	.076	(2.38)**
LN (Case Mix Index)^2	.043	(0.39)
LN (Medical Supplies Charged per Discharge)^2	.133	(2.06)**
LN (Medical Device Charged per Discharge)^2	.031	(1.73)*
LN (Drugs Charged per Discharge)^2	.127	(0.83)
LN In Patient Days * LN Out Patient Visits	.023	(1.22)
LN Labor Price Index *LN Fixed Assets	-.018	(-0.33)
LN In Patient Days * LN Labor Price Index	-.080	(-0.85)
LN Out Patient Visits * LN Labor Price Index	-.009	(-0.39)

LN In Patient Days * LN Fixed Assets	.129	(2.12)**
LN Out Patient Visits * LN Fixed Assets	.022	(1.89)*
Drugs/Discharge * Med Device/Discharge	.158	(2.17)**
Drugs/Discharge * Med Supplies/Discharge	.097	(0.60)
Med Device/discharge* Med Supplies/Discharge	.077	(1.59)*
R^2	0.97	
Adjusted R^2	0.97	
Observations	248	

Table 4: Translog Results