Exploring Appropriate Utilization Level and Bed Size on Revenue, Cost, and Profit

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I. Introduction

The modern general hospital produces a wide range of services including inpatient care, treatment in outpatient departments and emergency rooms, diagnostic and pharmaceutical services and home care (Ruchlin and Leveson, 1974). In specific, the expanding roles of hospitals on the provision of outpatient services and recent changes in hospital reimbursement policy have increased the importance of knowledge about the structure of hospital cost in the US. For example, hospital decisions on whether to expand or contact outpatient services in response to imposition of fixed rates for inpatient care may hinge, in part, on whether there are efficiency advantages from producing such services jointly (Grannemann, Brown, and Pauly, 1986).

In Korea, all physicians working in general hospitals are employees of the hospital and have staff position. There is no relationship between hospitals and clinics - that is, there exists no doctor's privilege concept for hospitalization. Therefore, all general hospitals have their own outpatient departments, and revenue from outpatient departments occupies about 35%~40% of the total revenue of a hospital. Because a hospital gives salary to all physicians in the hospital, provision of all kinds of outpatient services is important way to maintain productivity and operational efficiency for the hospital with same salary level. All physicians in the general hospital provide outpatient and inpatient services simultaneously.

Identical to the hospitals in the US, the hospitals in Korea experienced increasing cost and pressure of reimburse rate from the government, and thus they focused on profit maximization through cost minimization to improve their operational efficiency. The hospital cost function literature contains an extensive variety of empirical models. The majority of these fall into one of two categories. One type estimates average cost per patient or per patient day (most often using AHA-adjusted data) as a function of various regressors that are considered to affect costs. This widely used set of behavioral cost function is often accused of being ad hoc and of lacking foundation in the usual assumptions of production technology (Vitaliano, 1987; Kroneman, Siegers, 2004). Behavioral cost function studies mainly focused on the relationship between input such as bed size and financial outcome such as total cost or average cost using output variables such as admission, outpatient visits, length of stay as intervening variable. Through these analyses, behavioral cost function researchers

estimate hospital behavior change such as increasing admission or increasing length of stay to maintain production efficiency such as increasing output and to reduce average cost (Cowing, Holtmann, 1983; Vitaliano, 1987; Kroneman et al., 2004).

Another group of models, following the work of McFadden (1978), employs flexible functional forms that regress total costs on output levels and input prices, and hence are more consistent with the characteristics of the standard economic theory of production. The most popular of these forms is the translog cost function. The advantage of these models is that they are better suited for calculation of scale and scope economy measures that apply to multiple output production. However, they have been criticized for the large numbers of parameters that must be estimated, and for excluding many factors that are known to be significant in explaining variation in costs of complex, modern hospitals. Some recent work estimates hybrid cost functions that incorporate a number of desirable features from both types of models (Grannemann, Brown, and Pauly, 1986; Vita 1990). Grannemann et al (1986) reported that total cost function was influenced by cubed, squared, and linear acute inpatient day and outpatient visits, and squared and linear number of discharge. Hadley and Zucherman (1990) expand the literature with a dynamic model designed to capture the process of adjustment to Prospective Payment System; however, a consensus has not been reached on the appropriate form of the hospital cost function. Carey (1994) reported that total cost significantly related to number of discharge, outpatient visits, length of stay with the pattern of positive, negative, and positive for quantity, quantity-squared and quantity-cubed.

Unlike the aforementioned models, the other research model is to decide the input level such as bed size depending on patient flow such as queuing time using simulation model or stochastic model, then to set appropriate output level such as occupancy rate and length of stay on customer or policy maker perspective (Harrison, 2001; Harrison and Shafer, 2005; Cochran and Bharti, 2006). Using this method, many researchers suggested target occupancy rate (Brecher and Speizio 1995; New York State Department of Health 1993; Green, 2005). Brecher and Speizio(1995) reported that the most commonly and historically used occupancy target has been 85%. New York State Department of Health (1993) reported that the target occupancies for adult acute care beds in New York State have been 85% for urban counties and 80% for rural counties. Green (2005) reported that target occupancy in New York State was 79%, and this target could be varied by specialty and hospital bed size. This and other related target occupancy levels were originally developed at the US federal government level in the 1970's as a response to accelerating

health care costs and the perception that more hospital beds resulted in greater demand for hospital care (Brandeau, Sainfort, and Pierskall, 2004). These occupancy targets were the result of analytical modeling for typical hospitals in various size categories and were based on estimates of acceptable delays (McClure, 1976).

Over the past 30 years, a number of researchers have attempted to explore operationally and econometrically the hospital cost functions and production activities. Despite the existence of this voluminous literature on the hospital cost function and efficient production estimation, however, no consensus has emerged on the appropriate research strategy for exploring hospital cost and production relationships. Most of researchers considered that most of hospitals are not-profit organizations, and they do not play the role of revenue or profit center. However, hospitals have focused on cash flow because they must invest for their facilities, equipments, and manpower to keep up with customer needs. Therefore, efficient operation and high productivity are important to maintain high financial performance.

Previous studies estimated the relationship between average cost and bed size, and found appropriate bed size to minimize average cost. However, previous studies on the relationship between cost and output did not suggest appropriate output level. In addition, studies on revenue and profit to bed size and output were rather rare, and thus studies on exact appropriate bed size and output level to maximize revenue and profit are scarce as well as the studies on exact appropriate output level to minimize cost.

Therefore, the purposes of this study are 1) to estimate the relationship between financial performance such as revenue, cost, profit, and output performance such as operation ratio, 2) to calculate exact operation ratio at turning point in cost, revenue, and profit, and 3) to execute sensitivity analysis to test validity to compare gaps between estimated financial performance at specific operation ratio point from economic model and actual financial performance at specific operation ratio point from real data.

II. Empirical Methodology

As a construct instrumental in making this comparison, the researchers consider the revenue-based method used by the American Hospital Association (AHA) to summarize hospital output in a single utilization measure. Specifically, this measurement converts non-inpatient services to inpatient day equivalents. The inpatient days are multiplied by an adjustment factor to yield "adjusted inpatient days,"facilitating measurement of costs, revenues, and profits by capturing output in a single dimension. The desired adjustment factor can be expressed as

Adjustment factor = TR/IR (1)

where TR represents total revenue and IR represents inpatient revenue.

Lacking a desegregated measure of inpatient costs, the AHA substitutes revenues for costs in this calculation. The adjustment factor therefore provides a useful summary of the hospital's chosen allocation of revenues.

A better measure of output would use a desegregated measure of actual revenue in expression (1). Assuming that total costs are the sum of inpatient revenue and outpatient revenue (OR), the adjustment factor can be expressed as

Adjustment factor=TR/IR=1+(OR/IR) (2)

where one plus the ratio of desegregated revenues. Adjusted inpatient days are determine as

adjusted inpatient days = actual inpatient days × [1+(OR/IR)] (3)

The adjusted inpatient days in the formula above consider outpatient and inpatient utilization simultaneously.

To have the operation ratio of a hospital, full producible utilization is necessary. Using formula (3), inpatient days are total occupied bed days, and inpatient days are related to occupied bed concept. Full producible utilization is full producible adjusted inpatient days.

Full producible adjusted inpatient days= (bed×365) × [1+(OR/IR)] (4)

where bed is operated bed size in a hospital. Full product adjusted inpatient days means the quantity of utilization when it is assumed that a hospital fully used its capability in both of the outpatient and inpatient services.

Using formula (3), and (4), the researchers have the operation rate. The operation rate is

Operation rate = (adjusted inpatient days / full producible adjusted inpatient days) ×100 (5)

To find exact relationship between outcome variables and operation rate, outcome variables are total profit per bed, total revenue per bed, and total cost per bed. In addition, this study used the number of employees in a hospital, average length of stay, population of area surrounding the hospitals, and MSA/none-MSA as control variable.

Formula of model to estimate on profit, revenue, and cost are as follows

Total profit per bed = F (operation rate, number of employees ALOS, X) (6)

Total revenue per bed = F (operation rate, number of employees ALOS, X) (7)

Total cost per bed = F (operation rate, number of employees ALOS, X) (8)

where X is a vector of exogenous variables such as population size and MSA/none-MSA.

To use formula (6), (7), and (8), the researchers can have 'optimal' operation rate in the function of total profit, revenues, and costs.

For the analysis, this study used micro economical methodology to explore the relationship between financial performanceand operation ratio and the relationship between financial performance and input resources.

III. Data

1. Dataset

The majority of data used in this

analysis comes from Korea Foundation for the Promotion of Private School (KFPPS). T

2, variables

This dataset includes revenues separating inpatient and outpatient revenue, total cost aggregating outpatient and inpatient and total profit without separating inpatient and outpatient, bed size, and as erogenous variables, community population, MSA by governmental administrative definition, and ownership type categorizing private and government facilities.

Data were obtained for the years 2000-2003. Variables used in this study were averaged to reduce the effect of time. The variables in this study were means for 4 years. Summary statistics describing the sample of hospitals are listed in table 1.

IV. Results

1. Result of the Descriptive Analysis

The average operation ratio of hospital is 81.90%. Among the study Hospitals, 29 (80.6 percent) are located in Metropolitan Statistical Areas (MSAs) and 7 (19.4 percent) are located in none-MSA. See Table 1.

Table 1. Description of Dependent Variables

Variables	Mean(Standard Deviation)	N
Total Profit per bed	\5.54million(9.24)	36
Total Income per bed	\109.25million(30.43)	36
Outpatient Income per bed	\36.50million(12.13)	36
Inpatient Income per bed	\70.71million(18.48)	36
Total Cost per bed	\103.71million(26.09)	36
Average Length Of Stay	9.79(1.22)	36
Hospital Bed Size	684.39(260.34)	36
Hospital Employee	1162.74(689.70)	36
Population of Market	1611612.25(792318.28)	36
Operation Ratio of Hospital	81.90%(7.61)	36
Variables	**Categories**	**Number of Group(%)**	**N**
Location	MSA	29(80.6%)	
	None-MSA	7(19.4%)	

2. Result of Regression on Total Profit per bed, Total Revenue per bed, and Total Cost per bed

The regression model of total cost per bed was significant, with an F-statistics of 6.291 and an R-square of 0.565. The total profit per bed was positively related to number of hospital employees. However, operation ratio was not significant influence on the total cost per bed. See Table 4.

Table 2. Result of Multiple Regression on Total Profit per bed

Variables	Total Profit per bed	
	β coefficient (S.E)	*t-value*
Intercept	176.303(71.472)	2.470*
None MSA (reference: MSA)	0.121(3.655)	0.033
Hospital Employee	0.003792(0.002)	1.896
Population of Market	0.000001897(0.000)	1.041
Operation Ratio of Hospital	-4.691(1.786)	-2.627*
(Operation Ratio of Hospital)^2	0.03243(0.011)	2.833**
Length of Stay	-1.569(1.070)	-1.466
R^2	0.545	
Adj R^2	0.451	
F-statistics	5.792***	

*P<0.05, **P<0.01, ***P<0.001

Table 3. Result of Multiple Regression on Total Revenue per bed

Variables	Total Revenue per bed	
	β coefficient (S.E)	*t-value*
Intercept	212.074(187.336)	1.132
None MSA (reference: MSA)	4.816(9.581)	0.503
Hospital Employee	0.0246(0.005)	4.767***
Population of Market	0.00001117(0.000)	2.338*
Operation Ratio of Hospital	-4.127(4.680)	-0.882
(Operation Ratio of Hospital)^2	0.0395(0.03)	1.132
Length of Stay	-4.784(2.806)	-1.705
R^2	0.712	
Adj R^2	0.653	
F-statistics	11.960***	

*P<0.05, **P<0.01, ***P<0.001

Table 4. Result of Multiple Regression on Total Cost per bed

Variables	Total Cost per bed	
	β coefficient (S.E)	*t-value*
Intercept	35.572(197.346)	0.180
None-MSA (reference: MSA)	4.695(10.093)	0.465
Hospital Employee	0.01939(0.005)	3.567**
Population of Market	0.000009271(0.000)	1.842
Operation Ratio of Hospital	0.0564(4.930)	0.114
(Operation Ratio of Hospital)^2	0.001523(0.032)	0.048
Length of Stay	-3.216(2.956)	-1.088
R^2	0.565	
Adj R^2	0.476	
F-statistics	6.291***	

*P<0.05, **P<0.01, ***P<0.001

3. The Relationship between Operation Ratio of Hospital and Total Profit per bed.

Regression equation of Total Profit per bed was used to estimate the exact relationship between operation ratio of hospital and total profit per bed.

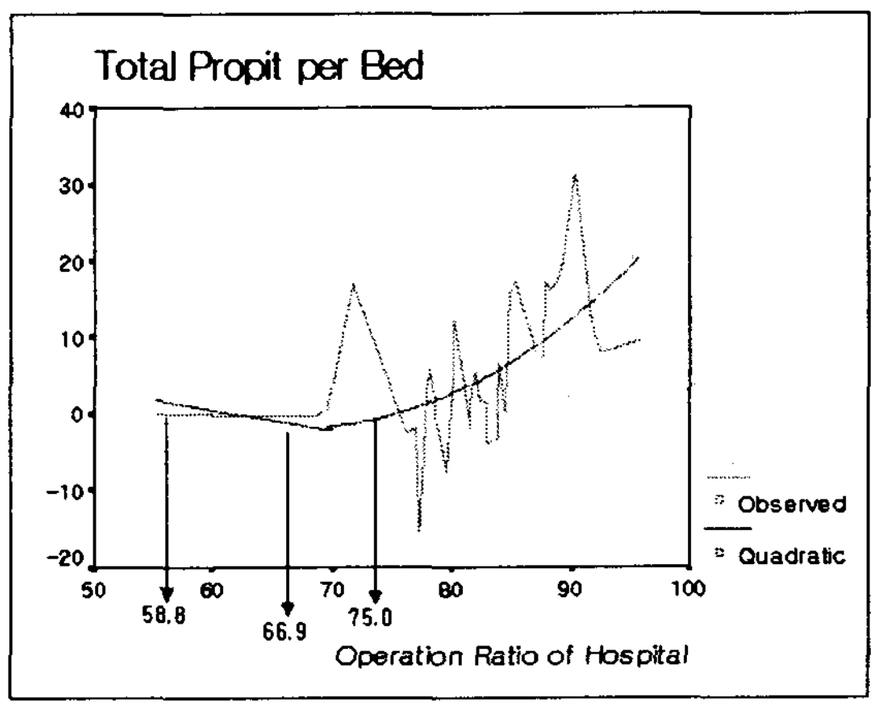
Total profit per bed = 0.03243×(Operation Ratio of Hospital)2 + -4.691 × (Operation Ratio of Hospital) + Constant

The relationship between operation ratio for a hospital and total profit per bed is a quadratic equation with concave (U shape)suggesting that the regression coefficient of (operation ratio of hospital)2 in total profit per bed model was positive.

The results showed that there was a turning point in operation ratio of hospital relating to the total profit per bed. Total profit per bed decreased when operation ratio of hospital increased, passing the turning point in operation ratio of hospital, total profit per bed increased when operation ratio of hospital increased. Moreover, when operation ratio of hospital passed a certain ratio, total profit per bed was below the zero. Profit per bed was above the zero again when operation ratio passed a certain larger ratio.

Applying differential method on the above equation, the exact operation ratio was estimated to be minimum profit point. For the minimum profit per bed, the turning point in operation ratio is 66.9% in both of outpatient and inpatient. Therefore, profit per bed decreased until point of operation ratio 66.9% and it means profit per bed is bottom at operation ratio 66.9%.

Using the equation, the researchers try to find the operation ratio which total profit per bed equals 0 with tracing method (where numbers are continually substituted in order to find where profit becomes 0). Finally, when operation ratio is58.8%, total profit per bed is zero, and changed from surplus to deficit, and when operation ratio is 66.9%, total profit per bed is bottom. And when operation ratio is 75.0%, total profit per bed is zero again, and then changed from deficit to surplus (See Figure 1).



<Figure 1. The Relationship between Total Profit per Bed and Operation Ratio>

V. Discussion and Conclusion

This study estimates the relationship between financial performance such as revenue, cost, profit, and output performance such as operation ratio and to calculate exact operation ratio at turning point in cost, revenue, and profit. As a result of analysis with economic methodology based on real data from 36 private university hospitals in Korea for a period of 4

years, the relationship between total profit and operation ratio was significant. When operation ratio was between 58.8% and 75.0%, total profit per bed was negative, and the profit increased when operation ratio was above 66.9%. Therefore, it is recommended to maintain operation ratio above 75.0% for an effective financial performance for hospitals. The relationship between total revenue, cost, and operation ratio was not significant. However, the result between operation ratio and revenue is similar to that of the studies of Harrison, Shafer (2005), Harrison (2001), Cochran, and Bharti (2006) where appropriate occupancy rate is above 80% by estimating optimum occupancy rate. In general, input resources in proportion to revenue and cost (Jacobs, 1991; Folland, Goodman, Stano, 2004). Therefore, this study analyzed the relationship between actual operation ratio and revenue, cost, and profit rather than input resources.

This study determined that revenue and cost of a hospital are affected positively by input resources such as the number of employees, while profit is affected by operation ratio. In addition, revenue is affected by input resources as well as demand such as the number of residents in a community. The results of this study are as follows; 1) it is necessary for general[1] hospitals to focus on efficient utilization of input resources for effective management of revenue and cost while considering external environment to maintain revenue, and 2) general hospitals must continuously improve operation ratio in order to ensure their profit. In this study, maximum profit is shown when operation ratio is maximized due to the National Health Insurance System, and this requires careful interpretation.

VI. Limitation of the Study

The analyses in this study were conducted only on private university hospitals excluding national and public hospitals, and thus the results of this study may have limitations on generalization for all types of hospitals in Korea. However, this study made its first attempt in the field both in Korea and outside to determine the relationships among financial performance (i.e. revenue, cost, and profit), care performance (i.e. operation ratio), and input resources.

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