I. Introduction

As the growth rate of health care expenditures has been accelerated in recent years, efficient allocation of health resources has become an issue of heated dispute in health policy in Korea and it is recognized that inefficiency of health care institutions is an important contributor to the growth of health care costs. Public hospitals are believed to be so inefficient that the local governments are considering closing them. From a policy standpoint, hospital efficiency implies that the health care system can achieve cost efficiency if the same number of patients are treated in the most productive hospitals rather than in the least productive hospitals (Chilingerian, 1995). In line with this, to improve efficiency in the hospital industry is becoming a concern of researchers and public policy makers in Korea.

The main purpose of this research, therefore, is to measure and analyze how efficient the Korean hospitals are and what factors determine their efficiency. This research concentrates on technical efficiency, which measures the average productivity attainable at the most productive scale size and is a prerequisite for cost efficiency (Banker, *et.al*., 1984). Thus understanding technical efficiency will provide meaningful insight into the optimal allocation of hospital resources. In this study, explicit attention will be given to examining the effects of market concentration and hospital size on technical efficiency.

This paper places a particular focus on general hospitals for three reasons. First, the structure of the Korean health care market has been steadily concentrated into larger hospitals from smaller hospitals and clinics.[1] Second, these larger hospitals are playing a leading role in increasing non-insurance services and thereby possibly creating a price inflation. Not all health services are covered by the National Health Insurance in Korea. Most of these non-covered services are new or expensive high-technology-related medical services and are driven by larger hospitals.[2] Third, the quantity of resources used to care for the same number of patients has been found to vary by more than 50% in larger hospitals (Kwak, 1992). Variations in the utilization of hospital resources may result from inefficient decision making, regardless of case-mix, hospital characteristics or the institutional setting (Eisenberg, 1986). Inefficient decision making may be one of the basic causes of high costs and low productivity in the hospital sector(Ellis and McGuire, 1986). In general, Korean general hospitals are known to be inefficient due mainly to poor management and high profit.

The first step of the analysis in this research begins with measuring the technical efficiency of individual hospitals in terms of efficiency scores, based on Data Envelopment Analysis (DEA). The prior research on hospital efficiency has a shortcoming in that it relies on single-input, single-output analysis, despite the fact that hospital production is a multiple-input, multiple-output situation. Furthermore, analytic methods have been directed at the central tendencies of hospitals rather than identifying frontiers of the best results observed in practice (Seiford and Thrall, 1990). In this regard, DEA is a relatively easy method of handling multiple inputs and outputs. In DEA, the efficiency scores are defined as a weighted sum of outputs for a given weighted sum of inputs.

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[1] As of 1994, net sales(consumers' expenditures) of general hospitals was estimated to take the lion's share of 80.1% for inpatients and 28.6% for outpatients, while that of hospitals is estimated to take 11.0% for inpatients and 6.5% for outpatients and that of clinics is estimated to take 8.9% for inpatients and 64.8% for outpatients, respectively (Korea Institute of Health Services Management, 1995). Furthermore, Korea's big business conglomerates began to enter into the hospital industry with nationwide hospital chains. In the near future, their shares in the market are expected to increase.

[2] Medical institutions have been permitted to provide uninsured services using expensive technology and drugs. The extent and level of insurance coverage are determined by the government. Most outpatient services and high probability inpatient services are covered by health insurance. However, certain low probability but high cost services are excluded.

The efficiency score of each hospital is thus expressed as a single value which ranges from a maximum score of 1 for the efficient hospital to a score of less than 1 (above 0) for the inefficient hospital.

Having calculated the efficiency score, the explanatory variables were regressed on the efficiency score, by means of two-part model. The approach employed here is somewhat different from the conventional approaches used by Chilingerian (1995) and Kooreman (1994), who analyzed physicians in a single hospital and nursing homes in The Netherlands, respectively. A probit or the Tobit model was used to analyze the efficiency scores in their papers. However, this research depends on the econometric specification of the two-part model, which separates the factors that affect the probability of a hospital's being efficient from the factors that determine the degree of its efficiency.

This paper is organized as follows: the concepts and measurement of efficiency and the models are briefly outlined in Section II and the data is discussed in Section III. In Section IV, three different versions of DEA scores are calculated and then the econometric analysis of DEA scores is presented. Section V concludes the paper with six main findings from the study.

II. Models

1. Measurement of efficiency

Efficiency can be classified into four categories: overall technical efficiency, pure technical efficiency, scale efficiency, and allocative efficiency. In this study overall technical efficiency was broken down into pure technical efficiency and scale efficiency. Simply put, technical inefficiency refers to the extent to which a hospital fails to produce maximum output from its chosen combination of factor inputs, and scale inefficiency refers to sub-optimal hospital size (Chilingerian, 1995). In the real world, many hospitals operate apart from their own production function and at less or more than optimal size. Technically inefficient hospitals use a relatively excessive quantity of inputs when compared with peer group hospitals operating with the same size and outputs. Some hospitals are not operating with the most productive quantity of patients. In empirical studies, however, the measurement of these efficiencies has been controversial in multiple-input, multiple-output cases. The DEA model provides an easy method to deal with this problem.

In DEA, the production frontier, which is the set of hospitals that are producing a given number of outputs with the fewest number of inputs, is identified and the maximum score of 1 is assigned to hospitals on the frontier. Then efficiency scores for the hospitals which are not on the frontier are calculated by the ratio of inputs used by an efficient hospital which produces comparable outputs, to the inputs used by the nonfrontier hospital.[3] Thus the score of a nonfrontier hospital is less than 1 (above 0).

Although there are a number of alternative econometric techniques for measuring efficiency, DEA has been gaining in popularity. For example, DEA was recently identified by several researchers as a primary method for measuring and partitioning X-inefficiency (Leibenstein and Maital, 1992), for measuring production efficiency in hospitals (Valdmanis, 1992), and for

[3] In this step, we can measure the amount of inputs(outputs) of the nonfrontier hospital, that should be reduced (augmented) to become efficient.

measuring both technical and scale efficiency of physicians (Chilingerian, 1995) and that of nursing homes in the Netherlands(Kooreman, 1995).[4]

2. DEA model

The DEA model to measure overall technical efficiency was initially developed by Charnes, Cooper, and Rhodes(1978). This model, which assumes constant returns to scale (CRS), is considered a sensitive model for measuring technical efficiency. Following the work of Banker, Charnes, and Cooper (1984), a second DEA model, which assumes variable returns to scale (VRS), was developed to separate pure technical efficiency from scale efficiency.[5]

(1) CRS model

The following CRS model measures overall technical efficiency for each of the sample hospitals. The objective function is to maximize the efficiency score E for hospital k, subject to the constraints that no hospital will be more than 100% efficient and the coefficient values are positive and non-zero, when the same set of u and v coefficients (weights) are applied to all other hospitals being compared.

$$
\begin{array}{lll}
\text{Max.} & E_k = \Sigma\, u_r Y_{rk} & r = 1, \ldots, s \\
\text{s.t.} & \Sigma\, v_i X_{ik} = 1, & i = 1, \ldots, m \\
 & \Sigma u_r Y_{rj} - \Sigma\, v_i X_{ij} \leq 0 & j = 1, \ldots, n \\
 & v_1, \ldots, v_s > 0 & \\
 & u_1, \ldots, u_m > 0 &
\end{array}
$$

where E_k is the efficiency score for hospital k.

Input and output variables are as follows:

- Y_{rk} : the actual amount of output r produced by hospital k.
- X_{ik} : the actual amount of input i used by hospital k.
- u_r : the weight to output r, computed in the solution by DEA model.
- v_i : the weight to input i, computed in the solution by DEA model.

(2) VRS model

The following VRS model, though similar to the CRS model, measures pure technical efficiency and returns to scale for each of the sample hospitals. Scale efficiency can be measured by dividing the CRS efficiency score by the VRS efficiency score. From the VRS model, it is possible to analyze whether a hospital's production indicates increasing return to scale, constant return to scale, or decreasing return to scale by the sign of the variable w. Increasing returns to scale exists if the value of w_k is greater than zero ($w_k>0$), constant returns to scale if the value of w_k is equal to zero ($w_k=0$), and decreasing returns to scale if the value of w_k is less than zero ($w_k<0$). Thus, we can analogize the existence of economies of scale similar to ray economies of scale, confirm the most productive scale size (minimum efficient scale) of a hospital and estimate the number of hospitals operating at the efficient scale.

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[4] Among the DEA studies, studies of hospitals, physicians, nursing home care, medical drug reimbursement, nursing service, bank branches, electric utilities, transportation, army recruitment, community colleges, equal employment opportunity, and Kansas farmers are included.

[5] Both models are used to estimate divergence from most productive scale size and return to scale

$$
\begin{aligned}
\text{Max.}\quad & E_k = \Sigma\, u_r Y_{rk} + w_k && r = 1, ..., s \\
\text{s.t.}\quad & \Sigma\, v_i X_{ik} = 1, && i = 1, ..., m \\
& \Sigma u_r Y_{rj} - \Sigma v_i X_{ij} + w_k \le 0, && j = 1, ..., n \\
& v_1 , ..., v_s > 0 \\
& u_1 , ..., u_m > 0
\end{aligned}
$$

3. Two-part Model

The second step of the analysis is to relate the efficiency scores to a number of explanatory variables, including observed characteristics of the hospitals. The efficiency scores derived from the VRS model are relevant in this step because pure technical efficiency is of interest. The explanatory variables may include number of beds, number of beds squared, ratio of labor to bed, utilization of expensive technology, proportion of insured patients to total patients, length of stay, ownership and location.

If efficiently operating hospitals have certain common characteristics, this allows us to identify possible causes of inefficiency. Since, by definition, the DEA scores take on values between 0 and 1, and since some of the data tend to concentrate on these boundary values (*i.e.*, censored at 1), the regression cannot be estimated by ordinary least squares. Therefore, some empirical studies used the Tobit model (Chilingerian, 1995; Kooreman , 1994).

However, a two-part model was used in this study. The two-part model is composed of a logit model and a truncated (linear) regression model. The logit model separates efficient hospitals from inefficient hospitals and the truncated (linear) regression model indicates a relationship between the level of inefficiency in inefficient hospitals and its influencing factors. In the regression model, the logarithm of a dependent variable was used because the statistical distribution of dependent variable in censored data usually follows a log-normal distribution.

(1) Logit model

$$
\begin{aligned}
& \Pr(Y=1) = 1 / [1 + \exp(-(\beta_1 + \beta_2 X_2 + \beta_3 X_3 + ...)] \\
& \text{where,}\quad Y = 1 \quad \text{if efficiency score(E)} = 1 \\
& \qquad\qquad\; Y = 0 \quad \text{if efficiency score(E)} < 1
\end{aligned}
$$

(2) Truncated regression model

$$
\mathrm{Ln}(E) = \beta_1 + \beta_2 X_2 + \beta_3 X_3 + ... + \varepsilon_i \quad \text{for the data}\quad E < 1.
$$

where ε_i is the usual disturbance term.

The basic advantage of the two-part model over Tobit is that it allows the parameters that determine whether or not hospitals are efficient (efficiency score of 1) or not to be different from those that determine the level of efficiency, given that efficiency scores are less than 1. Since the efficiency scores are not observed but generated within the model, the direction of influence between the efficiency score and explanatory variables is not mutual but one-way. Therefore, simultaneous bias does not exist in the two-part model.

III. Data and Indicators

The data set used in this research is based on two surveys conducted in 1995 (thus the data is for 1994) among all 560 hospitals in Korea. All the hospitals are required to participate in surveys held annually by two nonprofit organizations. Hospital data for health staffing, cost and non-insured health services tend to be somewhat exaggerated in the survey responses, due mainly to legal requirements and taxation in Korea. Measurement errors, on the other hand, are likely to be minimal, because the survey forms have been filled out by the administrative staff of the hospitals, who are assumed to be well-informed about their hospitals. Specifically, the DEA model does not use the data related to costs, which is sensitive to hospital staff and not valid, but uses the data for the size of the hospital labor force, the number of beds, the number of patients, and hospital specific characteristics which are relatively reliable.

In this study, from a total of 102 general hospitals which provide services for 15 specialties, 62 general hospitals were selected, based on a stratified random sampling which is a way to avoid the multi-product problem. The services for 15 specialties include internal medicine, pediatrics, neurology, psychiatry, dermatology, general surgery, orthopedic surgery, neuro surgery, obstetrics & gynecology, ophthalmology, radiology, dentistry, and emergency care. These general hospitals usually have more than 300 beds.

Variables and operational definitions for measurement are shown in Table 1. Output and input variables are for the DEA model and explanatory variables indicate independent variables in the two-part model, where the dependent variable is the calculated efficiency score. The maximum number of input variables and output variables in DEA largely depends on the capacity of computer software as well as the purpose of analysis.

In this study, outputs of a general hospital were divided into 15 kinds of services for 15 specialties. An output for each specialty is measured by an adjusted number of patients, which is defined as a weighted sum (Q) of outpatients and inpatients. That is, Q = number of outpatient visits per day + 2.5∗(number of inpatient days per day). The weight 2.5 was estimated from production cost and has been conventionally accepted in the Korean hospital industry.

Input variables in the DEA model include physicians, registered nurses, nursing aides, pharmacists, technicians, administration staff, other personnel, and the number of beds as an indicator of hospital capital.

As an explanatory variable for the efficiency score in the two-part model, the number of CAT scanners was selected because all the sample hospitals have them and the revenue from them provides the lion’s share of total revenue from high-technology equipment. It is expected that the greater the number of CAT scanners, the less efficient a hospital is. The proportion of insured patients to total patients was included as a proxy variable for the impact of price control policy on efficiency. When facing price control, a hospital’s behavior is expected to become more productive. A dummy variable for location indicates a proxy variable for market concentration. Large hospitals located in small cities where the market concentration rate is likely to be high compared with that in big cities, are assumed to be insensitive to productivity and not well-informed. Other explanatory variables were chosen as expected from the literature.

Table 1. Definition and Measurement of Variables

variables	measurement
Outputs	
Y_1	adjusted number of patients per day for Internal Medicine
Y_2	adjusted number of patients per day for Pediatrics
Y_3	adjusted number of patients per day for Neurology
Y_4	adjusted number of patients per day for Psychiatry
Y_5	adjusted number of patients per day for Dermatology
Y_6	adjusted number of patients per day for General Surgery
Y_7	adjusted number of patients per day for Orthopedic Surgery
Y_8	adjusted number of patients per day for Neuro Surgery
Y_9	adjusted number of patients per day for Plastic Surgery
Y_{10}	adjusted number of patients per day for Obstetric and Gynecology
Y_{11}	adjusted number of patients per day for Ophthalmology
Y_{12}	adjusted number of patients per day for Otorhinolaryngology
Y_{13}	adjusted number of patients per day for Urology
Y_{14}	adjusted number of patients per day for Dentistry
Y_{15}	number of patients per day for Emergency Medicine
Y_{16}	adjusted number of patients per day for screening test and others
Inputs	
beds	number of beds
physicians	number of medical doctors including residents and interns
RNs	number of registered nurses
ANs	number of nursing aides
pharmacists	number of pharmacists and assistants
technicians	number of technicians and assistants
administration	number of administration staffs and engineers
others	number of other staff
Explanatory Variables	
beds	number of beds
beds squared	number of beds squared
labor intensity	number of staff divided by 100 beds
high-tech indicator	number of CAT scanners per 100 beds
length of stay	average length of stay per admission
proportion of insured patients	percent of insured patients to total patients (%)
ownership	1, if private hospital 0, otherwise
location	1, if hospital is located in metropolis(6 largest cities) 0, otherwise
teaching	1, if teaching hospital 0, otherwise

Table 2. Descriptive Statistics (n=62)

variables	Mean			S.D.
Outputs (per 100 beds)	adjusted total	outpatient visits	inpatient days	adjusted total
Y_1 (Internal Medicine)	98.4	48.1	21.0	45.9
Y_2 (Pediatrics)	44.4	24.6	7.9	27.5
Y_3 (Neurology)	6.6	3.1	1.4	3.2
Y_4 (Psychiatry)	14.5	5.2	3.7	8.3
Y_5 (Dermatology)	7.8	7.3	0.2	2.8
Y_6 (General Surgery)	31.8	9.0	8.9	9.5
Y_7 (Orthopedic Surgery)	56.7	13.4	17.3	22.9
Y_8 (Neuro Surgery)	33.9	6.9	10.8	20.1
Y_9 (Plastic Surgery)	7.8	2.5	2.1	2.7
Y_{10} (Obstetric & Gynecology)	32.5	15.2	6.9	18.3
Y_{11} (Ophthalmology)	11.7	8.2	1.4	5.6
Y_{12} (Otorhinolaryngology)	16.8	11.8	2.0	9.4
Y_{13} (Urology)	8.7	4.4	1.7	5.1
Y_{14} (Dentistry)	8.5	6.7	0.7	5.7
Y_{15} (Emergency care)	11.6	11.6	-	6.2
Y_{16} (Screening test and others)	20.0	10.5	3.8	16.2
total	410.8	88.9	188.5	71.4
Inputs (per 100 beds)				
beds		502.1		180.7
physicians		25.4		10.5
RNs		33.1		12.8
ANs		15.2		8.9
pharmacists		3.5		1.2
technicians		12.7		4.5
administration staff		18.3		12.7
others		15.6		7.4
Explanatory Variables				
labor intensity		123.8		36.6
high-tech indicator		0.362		0.226
length of stay		13.7		4.1
proportion of insured patients (%)		73.1		21.2
private hospitals (%)		79.0		-
hospitals in metropolis (%)		63.6		-
teaching hospitals (%)		35.4		-

notes: 1) adjusted number = outpatient visits + 2.5(inpatient days).
2) Standard deviation for dummy variables are not presented.

The summary of sample statistics is shown in Table 2. The adjusted number of patients per 100 beds is 410.8 per day, which is made up of 188.5 visits for outpatients and 88.9 days for inpatients. Specifically, the adjusted number of patients per 100 beds is 98.4 for internal medicine, 44.4 for pediatrics, and 6.6 for neurology.

The average size of the sample hospitals is 502 beds, ranging from 289 beds to 1508 beds (the average occupancy rate is 88.9%). The average staffing totals approximately 123.8 persons per 100 beds, and is made up of 25.4 physicians, 48.3 nurses (RNs & ANs), 3.5 pharmacists, 12.7 technicians, and 33.9 administrative staff & others, respectively. The ratio of nurses to physicians is 1.9

The sample hospitals have on average 0.362 units of CAT scanners per 100 beds, which means that each hospital with an average of 400 beds is operating approximately 1.5 units of CAT scanners. The average length of stay per admission is 13.7 days, with 12.9 days in teaching hospitals and 14.1 days in other hospitals. Insured patients make up 73.1% of total patients, in terms of an adjusted number of patients. Of general hospitals, 63.6% are located in Korea's 6 largest cities (Seoul, Pusan, Taegu, Taejeon, Incheon, and Kwangju). Of private hospitals, the percentage in the largest cities is 79%.

IV. Results

1. Efficiency scores

The results of running the two DEA models(CRS model and VRS model) are shown in Table 3, Table 4, and Table 5. Table 3 indicates the average efficiency scores and standard deviations which determine the level of efficiency and its distribution in Korean general hospitals. Table 4 shows how many hospitals operate in increasing returns to scale, constant returns to scale, or decreasing returns to scale. Table 5 compares the efficiency of private hospitals with that of public hospitals.

With respect to overall efficiency, the CRS model showed that 16 hospitals (25.8%) are efficient. This result indicates that chronic inefficiency is still substantial in Korean general hospitals. Regarding pure technical efficiency, the VRS model found 23 hospitals(37.1%) efficient. The frequency distribution of pure technical efficiency scores is shown in Figure 1 which looks like a lognormal distribution. As for scale efficiency, 19 hospitals (30.6%) were efficient and some were very close to being so, for example, 99% efficient.

From the efficiency scores, we find that scale inefficiency is also one of the main factors which reduces overall efficiency in the hospital industry. For example, a hospital not presented in this paper got a pure technical score of 1, but its overall efficiency score was as low as 0.67, due to a low scale efficiency score of 0.67.

Table 3. Summary of efficiency scores

	Overall Technical Efficiency (CRS)	Pure Technical Efficiency (VRS)	Scale Efficiency (CRS/VRS)
Mean	0.8643	0.9107	0.9538
S.D.	0.1030	0.0829	0.0914
Minimum	0.5642	0.6316	0.5718
Maximum	1.0000	1.0000	1.0000
Hospitals on frontier	25.8%	37.1%	30.6%

Table 4. Returns to scale

	Increasing Returns to Scale	Constant Returns to Scale	Decreasing Returns to Scale
No. of hospitals	27	14	21
(%)	43.5 %	22.6 %	33.9 %

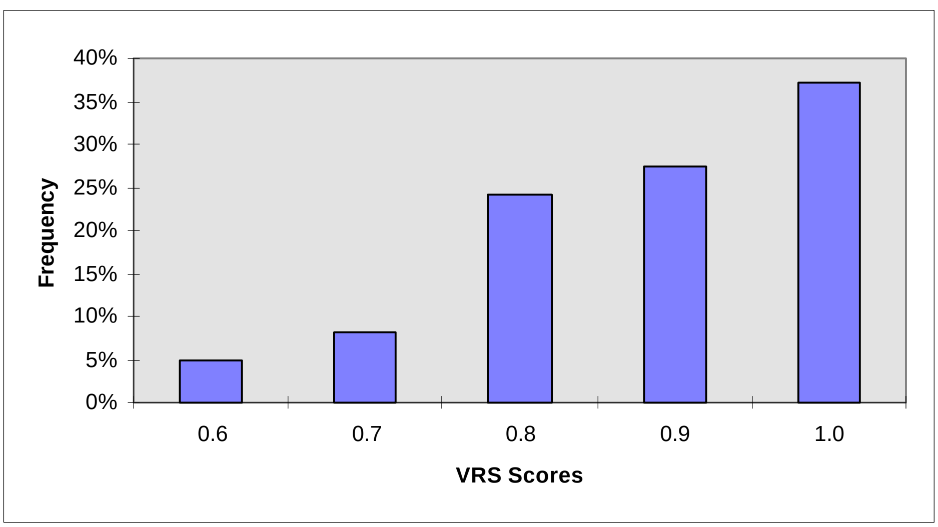

Figure 1. Distribution of pure technical efficiency scores

According to the results from the VRS model, approximate 44% of the 62 hospitals are operating in increasing returns to scale in production, 23% in constant returns to scale, and 34% in decreasing returns to scale (Table 4). This indicates that approximately 80% of hospitals are of inefficient size (bigger or smaller than optimal) and need to adjust their capacity in order to enhance efficiency. From a policy point of view, the government needs to be able to regulate the size of hospitals whenever they give permission to build a new hospital or expand the capacity of the existing hospital.

Compared with private hospitals (Table 5), public hospitals were found to have much lower levels of both technical and scale efficiencies. Likewise, variations in inefficiency scores of public hospitals are greater than those of private hospitals, although Korean public hospitals are homogenous in terms of staffing, facilities, organization, and output, regardless of location. Figure 2 shows that efficiency scores are more dispersed in public hospitals than in private hospitals. This reflects a widely-recognized fact that managerial performance of public hospitals in Korea has usually been dependent on the leadership of the hospital manager.

Table 5. Efficiency Scores of Private and Public Hospitals

	Overall Technical Efficiency	Pure Technical Efficiency	Scale Efficiency
Private Hospitals(n=49)			
Mean	**0.9273**	**0.9402**	**0.9511**
S.D.	0.1206	0.1603	0.1478
Min.	0.7781	0.8219	0.8386
Max.	1.0000	1.0000	1.0000
Hospitals on frontier	**28.6%**	**37.1%**	**32.6%**
Public Hospitals(n=13)			
Mean	**0.7519**	**0.8672**	**0.8214**
S.D.	0.2688	0.2261	0.2165
Min.	0.5642	0.6316	0.5518
Max.	1.0000	1.0000	1.0000
Hospitals on frontier	**15.3%**	**30.7%**	**23.0%**

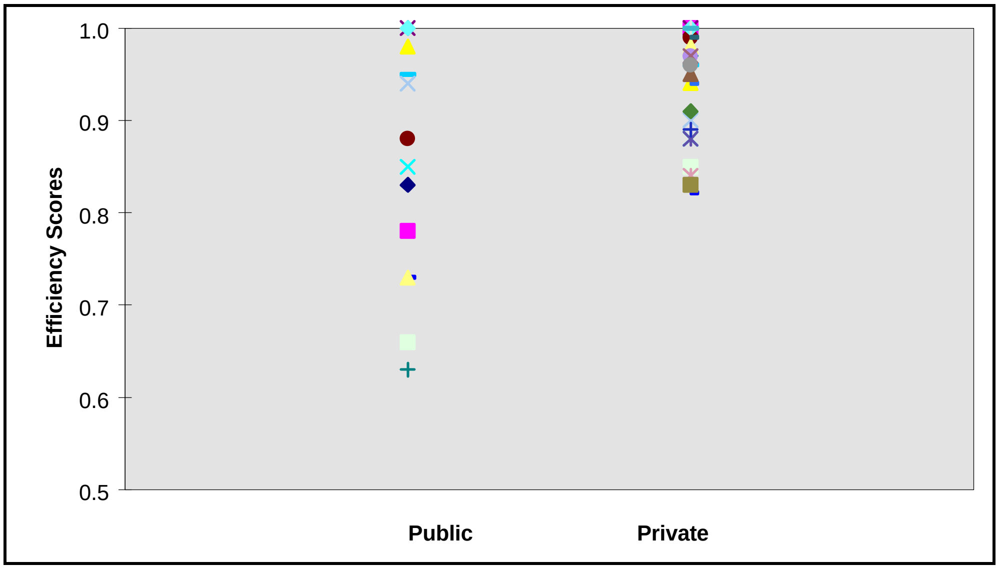

Figure 2. Efficiency scores(VRS) by ownership

The plot chart of the CRS efficiency scores and bed size indicates that inefficiency scores in small hospital groups are very high and volatile but they are getting higher and narrower as hospital size increases up to around 700-900 beds and then they decrease again(Figure 3). The high volatility of efficiency scores in hospital groups with 300-600 beds means that these groups may not have optimal sizes to provide at least 15 specialty services.

It has usually been expected that the larger the hospital, the less efficient it will be. However, the result in this study are quite different from the conventional view. It seems that the minimum optimal scale in general hospitals is larger than expected from the literature. Although the result in Figure 3 does not exactly imply the existence of a minimum optimal scale, it may be inferred that general hospitals are likely to be efficient at a range of approximate 700-900 beds.

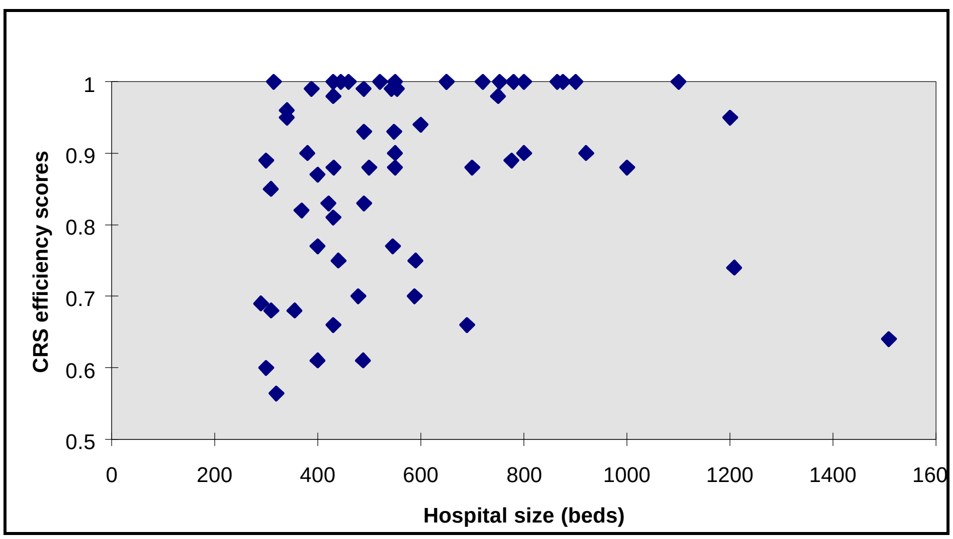

Figure 3. Hospital size and CRS efficiency scores

2. Factors affecting hospital efficiency

The empirical results for the two-part model using the efficiency scores as the dependent variable are presented in Table 5 (Logit model) and Table 6 (Truncated regression model). The results of the two regressions are significant at a 1% significance level. The signs of the coefficients of most variables are in close agreement for the Logit model and the Truncated regression model and those of most of the coefficient estimates are as expected from the literature. However, the significance of the individual coefficients are somewhat different in the two models.

Comparing the results of the two models, we find that labor intensity, location and the portion of insured patients are significant factors in determining hospitals' efficiency (Table 6), while high-tech indicators, ownership, and the proportion of insured patients are more significant variables in explaining the degree of inefficiency among the selected hospitals with a level of efficiency of less than one (Table 7). The proportion of insured patients is clearly a significant variable in both models.

The results of the two-part model show that the variables determining whether hospitals are efficient (efficiency score of 1) or not (efficiency score of less than 1) are different from those that determine the degree of efficiency, given that efficiency scores are less than 1.

(1) Probability of being efficient (Logit model)

Since the CRS model assumes constant returns to scale in production, the scale variable (number of beds) is probably an important explanatory variable in a model where CRS efficiency scores are used. It should not be significant, however, in a model where pure technical efficiency scores are used because VRS model measures efficiency conditional on a given size. The insignificant size effects in both models show that pure technical efficiency scores from the VRS model effectively eliminate the effects of size on efficiency.

Table 6. Estimation results for Logit model

variables	coefficients	s.e.	z-value
constant	-15.68548	16.73675	-0.937
beds	0.017770	0.014101	1.260
beds squared	-0.000013	0.000011	-1.209
labor intensity	-0.095806	0.048350	-1.982*
high-tech indicator	-4.736238	6.144884	-0.771
length of stay	0.341514	0.591704	0.577
proportion of insured patients	0.256927	0.127928	2.008*
ownership	-0.137933	0.467980	-0.286
location	2.229168	1.155782	1.992*
teaching	-0.912301	1.223094	-0.746
$\chi^2(9) = 44.92$, $P<0.01$.			

*: $p<0.05$.

The ratio of labor to beds in hospital production has a negative effect on the efficiency score, as expected. A production process in the hospital industry tends to have a fixed-input coefficient of labor and capital. Since inefficient hospitals usually have excessive labor, average productivity in hospital production can be increased until staffing is reduced to an optimal combination of labor and capital. This is short term adjustment.

The proportion of insured patients to total patients has a positive effect on the probability of a hospital's relative efficiency. A 10% increase in the proportion of insured patients is estimated to increase the probability of efficiency by 2.6%. The prices of health care services covered by health insurance are strongly controlled by the government and are usually lower than market prices. Thus hospitals are expected to make efforts to improve productivity according as the share of insured patients in total patients increases. This suggests the effectiveness of price control policies on technical efficiency in a health care system using national health insurance with a fee-for-service payment system.

The location of hospitals has a strong effect on the probability that a general hospital is efficient. The probability that hospitals in the 6 largest cities are efficient is higher than the probability in other areas by 2.2%. This may be interpreted to indicate with fewer general hospitals in small cities, and a resulting higher market concentration, geographical markets become less competitive which, in turn, makes their hospital staff less productive and less sensitive to the efficient allocation of resources. Alternatively, an excess capacity of hospitals in small cities may significantly result in a low occupancy rate, which would be followed by low productivity. If either or both of these hypotheses are true, it is desirable to control the number and size of hospitals in small cities.

Most cross-sectional analyses find a weak but statistically significant link between market concentration and profitability (Schmalensee, 1986: Tirole, 1992). Recent studies also show that hospitals located in less competitive markets are able to secure higher prices (Melnick, *et.al.*, 1992) and that price elasticity for physician services grows with the number of physicians (Wong, 1996).

High-tech indicator, length of stay, teaching, and ownership are considered to be not significant variables. However, the sign of the coefficients of these variables are mostly identical with the literature.

(2) Level of efficiency (Truncated regression model)

Regarding the inefficient hospital group (Table 7), the high-tech indicator, ownership and the percentage of insured patients become more significant factors in deciding the level of efficiency. The impact of the share of insured patients on efficiency scores are as described above.

The high-tech indicator, which is measured by the units of CAT scanners per 100 beds, has a negative effect on the level of hospital efficiency. This can be interpreted into two ways; first, economies of scale may exist in the use of a CAT scanner, which means the average productivity of a CAT scanner increases as hospital size (and thus number of patients) increases. Second, excessive units of CAT scanners can be a proxy variable of poor skills in hospital management which result in inefficiency.

From the estimated coefficient of the ownership, we can find that the efficiency of private hospital is higher by 5.7% than that of public hospital. This is consistent with the fact that efficiency scores less than 1 are distributed more widely in public hospitals than in private hospitals. Again, this indicates that public hospitals have much room for improvement through organizational change.

The other explanatory variables including hospital size, labor intensity, length of stay, location, and the teaching variable have no sensitive effect on the level of efficiency within technically inefficient hospitals. However, the insignificance of these variables does not necessarily indicate that they have no effect on the technical efficiency. It may simply mean that these variables are poor proxies for technical efficiency or are in multicollinearity.[6]

Table 7. Estimation results for Truncated regression model

variables	coefficients	s.e.	t-value
constant	0.147509	0.189522	0.778
beds	-0.000011	0.000027	-0.405
beds squared	1.41×10^{-8}	4.83×10^{-8}	0.292
labor intensity	-0.001111	0.000627	-1.772
high-tech indicator	-0.279792	0.114861	-2.436*
length of stay	-0.022273	0.012506	-1.781
proportion of insured patients	0.002419	0.001178	2.053*
ownership	0.056223	0.020671	2.720*
location	0.013739	0.018887	0.727
teaching	-0.014892	0.015533	-0.959
$F(9, 29) = 8.396$, $p<0.01$, $R^2 = 0.7499$,			

*: p<0.05

V. Conclusion

From the above findings, we can make the following conclusions and recommendations;

1) the Korean general hospitals are even more inefficient than expected, compared with the results of other studies. Only 25.8% of 62 general hospitals were efficient in overall technical efficiency. The chronic shortage of physicians, a fee-for-service payment system, the overwhelming share of the private sector in the supply of health care services, and market-oriented health care delivery systems have all been known to be major sources of high profits and thus widespread inefficiency in the Korean hospital industry for the last decades.

Accordingly, an increase in the number of physicians along with price controls for medical markets can form an alternative health policy to improve technical efficiency in Korea. The expansion of health insurance coverage to uninsured services means the strengthening of price controls in the health service market, because fees for insured medical services are determined by the government in Korea. This may be an effective health policy which will encourage hospitals to improve technical efficiency.

[6] For example, the length of stay which has a close correlation with occupancy rate seems to have a negative relationship with efficiency. The shorter the length of stay is, the higher the turn-over ratio of beds is. The high turn-over ratio of beds means the full mobilization of hospital capacity, which increase productivity. However, it is statistically not significant.

2) The larger the hospital, the more efficient it is. The optimal scale in terms of overall technical efficiency seems to be attained at a range of around 800-900 beds. This scale is much larger than those shown in empirical studies. However, some hospitals in small cities tend to be under-utilized. Therefore hospital size needs to be adjusted according to the size of the geographical health service market.

3) As noted in this paper, market concentration into larger general hospitals may result in high profits and inefficiency in these hospitals. Government policy for improving market performance in the hospital industry should focus on market structure as well as on market conduct, so as to increase competition in the market.

4) Considering the inefficient health care delivery system, the government should control the imports of expensive medical technology. Most of this equipment is not covered by health insurance and is being overutilized, resulting in financial burden to the consumers. An alternative strategy would expand insurance coverage to this medical technology, while the government controls the prices of the insured services at marginal cost.

5) Public hospitals that are less efficient than private ones should be reorganized to correct widespread inefficiency. We can expect that public hospitals' productivity could be improved through performance evaluations and incentives that encourage directors and staff. Incentives include a variety of performance-based personal benefits such as promotions, salary raises, and extended fringe benefits. Although hospital autonomy is sometimes considered an alternative solution, empirical studies of hospital autonomy in developing countries show that it cannot be an effective policy to improve technical efficiency in hospitals (Govindaraj and Chawla, 1996).[7] Furthermore, the results of these studies indicate that equity and access issues have either worsened or not improved after autonomy.

6) Labor intensity seems to be excessive in the Korean general hospitals. Suboptimal combinations of hospital staffing and hospital beds can be avoided, in the short term, by reducing the number of hospital staff to the most productive level.

[7] A study of hospital autonomy in developing countries shows that "there was no change in the traditional efficiency indicators, like bed occupancy rates and average length of stay..... At the same time autonomy has little or no impact on personnel decisions."(Govindaraj & Chawla, 1996).

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