Technology Investment by Hospitals in Korea*

Bong-min Yang
Seoul National University
Young-hee Park
Ji-san Health Science Junior College

There has been a rapid influx of high cost medical technologies into Korean hospital market. While some of the technologies prove to be beneficial, the government, the public and the hospital sector are concerned about the adverse impact the adoption of new technologies might have on the health care system. This study attempts to: i) explain why the issue of medical technology is important in Korea: ii) identify the factors that facilitate the aggressive import of foreign technologies: and iii) investigate the capital investment behavior of Korean hospitals. Empirical findings indicate that hospitals, especially private hospitals, aggressively acquire technologies and they seem to compete based on the acquisition of new technologies. Under cost-plus fee-for-service system, they purchase technologies even when they are not financially sound. This indirectly implies that unless some measures are to be taken by authorities, the health care sector is likely to be less efficient.

I. Introduction

In recent years, there has been a rapid influx of high cost medical technologies into the Korean hospital market. Data show that several major technologies are more available in Korea than in some industrialized countries. For example, there are 0.74 open-heart surgery units per million persons in Germany (1987) compared to 0.90 units per million in Korea (1988). Korea has 12 Lithotripters (ESWL), in comparison with 4 such units in Canada (1989) and 1

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unit in the whole U.K. (1988). As of 1986, 96% of all Korean hospitals with more than 200 beds had at least one CT Scanner. This diffusion of high cost medical technology has raised concerns about the changes it will bring for the Korean health care sector. Some have questioned this diffusion will necessarily have positive effects on the health of the overall population. The increasing dependence of medical care on technology affects efficacy, dependence on existing methods, cost, safety, and benefits, in both developed and developing countries. Medical technology (MT) raises additional issues about high costs that influence the setting of priorities both at the local and national levels, about equal access to health care for all, and about social justice (Ishay 1989).[1]

There are four theoretical stages in the process of development and diffusion of MTs: basic research stage, applied R&D stage, clinical investigation and testing stage, and diffusion stage (Office of Technology Assessment 1978). As Korean hospitals depend heavily on imported final-product MTs, public intervention to control MT focuses on the diffusion stage of specific technologies. However, relatively little is known about the environment in which medical technology diffusion occurs. So far, not much research on this topic is found in the Korean or in the international literature. This study investigates capital investment behavior of Korean hospitals and examines the circumstances that underlie their behavior. Better understanding of the issue will help the health sector in effective management of the adoption and use of MTs.[2].

This paper first discusses why the issue of MT is important in Korea and explains the circumstances under which the rapid and excessive diffusion of MTs occurred in the hospital sector. Based on these arguments, some testable hypotheses are proposed. The following section describes data on MT diffusion in Korea and presents some preliminary findings. Multiple regression analysis is performed in section IV, and major empirical findings are discussed in relation to the proposed hypotheses in the same section. Concluding comments and policy implications are made in the final section.

[1]Ishay (1989) argues further that the sophistication of technology and its high cost complicate basic issues, such as informed consent and the autonomy of the patient, the patient-physician relationship, and the profile of the doctor of tomorrow.

[2]Effective management of MT diffusion means that hospitals will be forced to choose among benefical technologies, providing some to the fullest extent, others to a limited extent, and still others not at all (Banta and Kemp 1982).

TABLE 1
ANNUAL GROWTH RATE: 1975-85

(Unit: %)

Gross Domestic Product	23
Health Care Expenditure	28
Medical Equipment and Technology	32

Source: 1. Korea Medical Insurance Corporation (1989).
2. The Bank of Korea, *Input-Output Table*, 1975-85.

II. Diffusion of Medical Technology in Korea

A. Why is the Issue of Medical Technology Important?

The issue of MT adoption bears growing importance in the administration of the Korean health care system. It is a complex issue pertaining to efficiency, equity, and medical ethics. Within the Korean health care system, the following arguments can be advanced as reasons why MT diffusion is a significant social issue.

First, as additional resources are being poured into the health sector in Korea with the newly inaugurated NHI (National Health Insurance) system,[3] policy makers and health professionals are concerned about the effectiveness of the resources used. In particular, they are concerned whether the ongoing trend of rapid diffusion and widespread use of MTs will bring about reasonable benefits for the health of the population.

Second, as shown in Table 1, investment on MTs was a principal contributing factor to rising health care expenditures in Korea during the last decade. Not only did it surpass the growth rate of GDP, its share out of total health expenditure grow continuously throughout the period.

Third, adoption of MTs is becoming a source of health sector inefficiency. Investments in medical facilities and high technology equipment have been actively undertaken recently by the private sector. Many of the new technologies are rarely utilized but add

[3]The government of Korea implemented the first stage of its compulsory social security program for health care in July 1977, by enforcing the scheme for corporations hiring 500 or more workers. With the introduction of Rural Health Insurance in 1988 and Urban Insurance in July 1989, expansion of the government-initiated compulsory health insurance program has been completed. Korea, like several industrialized countries, has now entered the "era on NHI".

considerable costs to hospital operations (Korea Development Institute 1989). Newspapers have called such wasteful hospital behavior: "high technologies for display, but not for use." This results in part from the fact that most of the MTs are adopted without going through appropriate in-advance assessment procedures. Jennett (1986) claims that inappropriately deployed technologies do much more harm than simply to waste money or to divert resources from more worth while endeavors. They expose patients to unjustified hazards, discomfort, or even disfigurement.

Fourth, there is a potential problem of increasing inequity with the adoption of expensive technologies. Utilization of many of the expensive high technology services are not covered by health insurance schemes. Examples of technologies not covered by national health insurance system are CT Scanner, MRI, Radiotherapy, EKG, and Lithotripters. As a result, the rich can afford expensive high technology services while the poor cannot. This produces a gradual evolution of classes in health service utilization.

Fifth, most medium and high cost MTs are cost-increasing, not cost-saving, innovations. The diffusion of such MTs, as a consequence, requires additional resources invested in the hospital sector. A potential problem is that the purchasing and operating cost of MT investment will spread out toward other MT-unrelated services, causing general increases in health care fees. Hospitals demand higher rates of government-set reimbursement fees as they demonstrate financial difficulties, stemming from technology adoptions. Inflation in health care prices could impose an enhanced barrier to the use of health services, especially for the poor.

Sixth, there could be demand inducement by providers with new technologies. This is particularly so when the technologies are deployed excessively compared to the needs of the population. Because use of MTs involves a high proportion of fixed costs and a small portion of variable costs, insufficient demand for services by MTs directly implies unavoidable loss to the providers. When faced with insufficient demand, the profit-seeking providers have an incentive to generate demand so that at least a break-even financial point can be reached. However, such financial burdens, and therefore provider-induced services, are less obvious in the public hospitals whose operations are largely controlled by public authority.

B. What Facilitates the Rapid Diffusion of MTs in Korea?

Proliferation of MTs in Korea has been produced by various incentives for hospitals and clinics to adopt newer technologies. Some of the incentives were created by profit-seeking behaviors of providers while others were supported by the financing mechanism of the health care system. The following factors have worked to promote the rapid adoption of MTs in recent years in Korea.

First, competition among hospitals to attract specialized professionals and to increase prestige in the group of equivalent hospitals is a force promoting adoption of new high cost technologies. Hospitals appear to be competing on the basis of the availability of new technology. In addition, a hospital often regards the possession of MTs as a critical determinant of its status among other competing hospitals (Yang 1988).

Second, unlike other goods and services, demand generation by suppliers is technically feasible in health care. Since demand is manipulable to a certain degree, uncertainty about the investment outcome is less with MTs than with other investment projects. With reduced uncertainty, one is more likely to undertake a certain investment project.

Third, employed physicians who strive for professional prestige through using new technologies put pressure on hospital administrators to purchase MTs. The growing number of young physicians emerging from medical schools since 1974 began their professional careers in large hospitals and had a strong preference for new technologies. They exert rising pressure on hospitals to adopt and use sophisticated technologies (Yang and Huh 1989).

Fourth, the fee-for-service (FFS) reimbursement system combined with the government fee control mechanism plays a role in boosting the diffusion of MTs. Under Korea's retrospective cost reimbursement system, the government sets fees on a cost-plus basis at a level which allows most hospitals to earn profits. By investing in new cost-inducing technologies, hospitals increase costs. Although most of the charges stemming from utilization of high priced MTs are not under government control, except several well known hospitals, this increase in costs affects negatively the overall profitability of hospitals that purchase MTs. When hospitals as a group negotiate new fee schedules with the government each year, the declined profitability due to MT acquisition is used by hospitals as means of claiming general fee increase. Such claims are often accepted, and therefore, hospital investments on highly expensive MTs are rewarded as the government allows another regulated fee increase. The current cost-plus reimbursement mechanism, consequently, helps rather than discourages the rapid diffusion of MTs.

Fifth, utilization of many of the expensive technologies (such as the CT Scanner, MRI, Radiotherapy, EKG, Lithotripters) are not covered by health insurance schemes, as noted above. Since the government does not control the fees charged for the services generated by these technologies, hospitals tend to charge the market-determined fees. As the market is far from the norm of perfect competition with factors such as asymmetry of information, entry barriers, moral hazards, and uncertainty, the market-determined fees normally carry a substantial amount of monopoly profits. For example, the average charge for a CT scan is over $250 in Korea compared to $75 in the United States. The fact that the price of high technology services not covered by insurance is much higher than it would be in a regulated system provides hospitals with an added incentive to purchase more high technology products and equipment.

Sixth, government plays a pivotal role between the technology importers and hospitals in the process of MT diffusion and has several tools at their disposal for controlling the process. To alleviate the duplication of facilities and excess capacity in the hospital sector, the CON (Certificate of Need) law was enacted in 1977. However, the law has been rather ineffective because hospitals have quickly found ways to circumvent it. The legislation could not limit the purchase of expensive equipment by private clinics or by private hospitals.

Seventh, patients play roles in the diffusion of some technologies. Patients ask providers to use certain tests or treatments that have been well publicized in the media. It is also true that patients regard the existence of certain equipment as an indication of high quality of care. Providers, to meet patient taste, adopt and use such MTs.

Other than the seven factors mentioned above, there are additional determinants that may affect the acquisition of MTs by hospitals in Korea. For example, the character of a hospital, whether it is public or private, can be a determinant of the rate of MT diffusion. Facing greater demands generated by larger population size and higher income level, hospitals in urban areas are more likely to adopt newly invented technologies. Hospital size may well be a determining factor of MT adoption. It is also conceivable that new technologies are more easily adopted by teaching hospitals.

C. Testable Hypotheses

Due to data limitation, all of the arguments in the previous section can not be tested. However, one can formulate the following nine testable hypotheses on hospital behavior.

1) Does hospitals' investment behavior reflect their financial status?
2) Is hospital size a critical determinant of technology investment?
3) Is hospitals' investment behavior the result of competition among hospitals for prestige and higher status?
4) Does the geographic location of hospitals explain any of the variability in the adoption of MT?
5) Do teaching hospitals lead other hospitals in the possession of MTs?
6) Do employed physicians exert some leverage in technology adoption?
7) Are outpatients sensitive to the presence of MTs in seeking health services?
8) Is the use of inpatient services influenced by the MTs? What is the major force that influences the utilization of inpatient services?
9) Do hospitals invest more in technologies whose uses are well supported by government fee schedules than those that are not?

III. Data and Descriptive Analysis

A. Data

All 187 general hospitals (with 80 beds or more) in Korea are covered in the data. The data was collected from computer files at the Korea Medical Insurance Corporation (KMIC). Ten technologies whose uses are covered by health insurance schemes are investigated.[4] These technologies are selected for study because they are the ones for which data can be found. No claims are made for these ten as being a representative sample of technology availability overall. However, they certainly represent a part of MTs actively used by hospitals.

[4]Data for technologies that are not covered by national health insurance are difficult to obtain. Therefore, they are excluded from this study.

A) Dependent Variable: 12 Medical Technologies and Their Combinations

Y_1: Auto blood analyzer
Y_2: C-arm type equipment
Y_3: Angio injector
Y_4: Gamma camera
Y_5: Linear accelerator
Y_6: Hyperbaric oxygen machine
Y_7: EEG (electro encephalo gram)
Y_8: Ultrasonic equipment
Y_9: Impedance audiometry
Y_{10}: Laser equipment
Y_{11}: Renal dialysis machine
Y_{12}: Spiro meter
$Y_{13} = Y_1 + Y_2 + Y_3 + Y_4 + Y_5 + Y_6 + Y_7 + Y_8 + Y_9 + Y_{10} + Y_{11} + Y_{12}$ (all of the above equipment weighted equally)
$Y_{14} = Y_1 + Y_7 + Y_8 + Y_9 + Y_{12}$ (technologies primarily used for outpatient diagnosis)
$Y_{15} = Y_2 + Y_3 + Y_5 + Y_6 + Y_{10} + Y_{11}$ (technologies primarily used for inpatient treatment)
$Y_{16} = Y_1 + Y_4 + Y_5 + Y_6 + Y_{10} + Y_{11}$ (expensive high technologies)

B) Independent Variable

BED : Number of beds, measures size of a hospital
OD : Hospital ownership dummy, 1 if public and 0 otherwise
*LD*1: Geographic location dummy, 1 if a hospital is in metropolitan area (population size $>$ 200,000) and 0 otherwise
*LD*2: Geographic location dummy, 1 if in medium and small cities (population size of 50,000~199,999) and 0 otherwise
THP : Teaching hospital dummy, 1 if a hospital is affiliated with educational institutions and 0 otherwise
PHY : Physician density in a hospital, measured as number of physicians per 100 beds
PHS : Squared *PHY* variable
LPH : Logarithms of *PHY* variable
OCC : Bed occupancy rate, measures average percentage of beds occupied per year
NOP : Number of outpatient visits per day

TABLE 2
GENERAL INFORMATION

Hospital Characteristics		Number
Ownership	Public	20 (10.7)
	Private	167 (89.3)
Location	Metropolitan	105 (56.1)
	City	62 (33.2)
	Rural	20 (10.7)
Teaching Hospital	Yes	34 (18.2)
	No	153 (81.8)
Hospital Size (Beds)	80-149	55 (29.4)
	150-249	35 (18.7)
	250-399	45 (24.1)
	400-	52 (27.8)

Note: Numbers in parentheses are percentages out of total 187 hospitals.

B. Descriptive Analysis

In 1975, two years before Korea's health insurance program started, 34.5% of all hospitals were public. Thirteen years later, the share dropped to 10.7% and the rest (89.3%) are now owned and operated by the private sector. Table 2 presents in part how hospital resources were divided into public and private sectors in 1987. A majority of hospitals (89.3%) is located in urban areas where 65% of the population reside. Of all 187 hospitals, 34 hospitals are affiliated with medical schools.

A recent accounting study on the profitability of medical technologies in Korea (Jung 1986) indicates that the currently used government fee schedules provide adequate reimbursement for some technologies (for example, impedance audiometry (IA), ultrasonic equipment (UE), and EEG) while others are poorly reimbursed (for example, laser equipment (LE)). Whether a service is adequately or poorly reimbursed is judged based on accounting cost calculations, incorporating labor, capital and material costs. Table 3 shows the effect of the level of reimbursement on the adoption of certain technologies. A couple of points from the table are worth elaboration.

First, hospitals in general adopt less of the poorly reimbursed technologies (LE) and more of the well reimbursed ones (IA, UE, EEG). However, it is difficult to assess whether the result is due to the reimbursement level alone or to other reasons such as the pre-

TABLE 3
LEVEL OF REIMBURSEMENT AND TECHNOLOGY ADOPTION

Type of Hospital	Total Number	Poorly Reimbursed	Well Reimbursed		
		Laser Equipment	Impedance Audiometry	Ultrasonic Equipment	EEG
Public	20 (100)	8 (40.0)	11 (55.0)	19 (95.0)	14 (70.0)
Private	167 (100)	31 (18.6)	84 (50.3)	156 (93.4)	143 (85.6)
Teaching	34 (100)	24 (70.6)	29 (85.3)	32 (94.1)	31 (91.2)

Note: Numbers in parentheses are percentages out of total number.

valence of disease pertaining to the technology in question.

Second, compared to public hospitals, a much lower percentage of private hospitals possess poorly reimbursed technology. Such a difference in the adoption rate between private and public hospitals is hardly found in the case of well reimbursed technologies. This implies that profit-oriented private hospitals may well take the prospect of profit generation into consideration in their investment decision on medical technologies.

Third, teaching hospitals lead other groups of hospitals in the adoption of technologies. The fact that more than 70% of teaching hospitals are equipped with technology of low profitability (LE) indicates that profitability of a technology is not a determining factor in their investment behavior. This result is consistent with the findings of other studies with regard to the role of teaching hospitals in technology diffusion.

The reimbursement level plays an important role in MT diffusion for non-teaching hospitals. This is particularly so in the case of private hospitals which dominate Korea's hospital sector. Technology diffusion among hospitals can be partially regulated by manipulating the reimbursement levels, an important policy option that the government holds.

IV. Multiple Regression Analysis

A. Model for Estimation

Since investment can be measured by the presence or absence of a technology in a hospital at a particular date, the study uses the presence of a unit of technology as the dependent variable. The regression analysis takes the well-known Probit form, with the dependent variable measured as the odds of having a technology the hospital has invested.

A financial variable, which measures a hospital's financial ability to make an investment, is included in each equation. In general, hospitals generate revenues from two sources: from outpatient visits and from inpatient service flows. The financial capability of a hospital, therefore, can be captured by two different measures. One is the number of outpatient visits per day *NOP* to a hospital's outpatient department. In actual estimation, *NOP* is used only when the presence of outpatient technology is the dependent variable. The other measure is the bed occupancy rates of a hospital (*OCC*). This variable calculates the average percentage of hospital beds occupied by inpatients per year. It is assumed that higher *OCC* will put a hospital in a better financial situation. *OCC* is used as a proxy for a hospital's financial status when estimating investment in the inpatient technologies.

Non-linear relationship between physician density (*PHY*) and hospital investment is hypothesized. This represents the circumstance that technology and physician manpower are substitutable each other so that increasing physician density may reduce technology acquirement by hospitals. The functional form of estimating equations for Probit regression is

$$Y_i = f(BED,\ OD,\ LD1,\ LD2,\ THP,\ PHY,\ PHS\ (LPH),\ OCC\ (NOP))^5$$
$$i = 1, 2, \ldots, 12.$$

Estimation results from Probit regressions are reported in Table 4.

[5] Notes that 1) *OCC* is an explanatory variable when Y_i is inpatient technology, 2) *NOP* is an explanatory variable when Y_i is outpatient technology, 3) *PHS* or *LPH* is included to describe the non-linear relationship between physician density and technology investment.

TABLE 4
PROBIT REGRESSION FOR HOSPITAL INVESTMENT IN 12 TECHNOLOGIES

	Y_1	Y_2	Y_3	Y_4	Y_5	Y_6	Y_7	Y_8	Y_9	Y_{10}	Y_{11}	Y_{12}
C	−0.8143	−2.1570	−1.7606	−5.7912	−4.9702	1.0031	−0.3348	0.9252	−2.5773	−3.0684	−4.1985	−1.1581
BED	0.0057	0.0070	0.0044	0.0063	0.0025	0.0028	0.0032	0.0027	0.0049	0.0051	0.0065	0.0020
	(3.93)	(6.10)	(5.31)	(6.44)	(2.63)	(3.02)	(2.62)	(1.75)	(4.69)	(4.58)	(6.05)	(2.39)
OD	2.7219	0.2165	0.9642	0.1647	0.0510	2.3606	−0.9646	0.2369	−0.3087	0.5257	−0.2317	0.6375
	(1.34)	(0.56)	(2.50)	(0.37)	(0.11)	(1.71)	(2.54)	(0.41)	(0.79)	(1.06)	(0.53)	(1.58)
*LD*1	−0.3319	−0.1541	0.1079	0.0636	1.8521	−1.1395	−0.0072	0.8676	−0.0913	0.2222	0.8431	0.4214
	(0.75)	(0.40)	(0.29)	(0.15)	(0.84)	(2.14)	(0.02)	(1.80)	(0.24)	(0.35)	(1.42)	(1.16)
*LD*2	−0.6286	0.2307	−0.0154	−0.2669	1.4869	−1.2170	−0.2954	0.6119	0.0339	−0.3714	1.1818	0.4063
	(1.39)	(0.60)	(0.04)	(0.64)	(0.67)	(2.25)	(0.74)	(1.32)	(0.09)	(0.59)	(2.02)	(1.14)
THP	0.0070	0.7330	0.5947	0.6599	0.5254	0.0779	−0.4173	−0.6316	−0.0146	1.1867	0.0788	0.7578
	(0.01)	(1.36)	(1.51)	(1.54)	(1.35)	(0.19)	(0.90)	(1.28)	(0.04)	(2.94)	(0.19)	(1.69)
PHY	0.1060	0.0355	0.0315	—	0.0278	0.0001	0.0894	−0.0497	0.1316	0.0737	0.0265	−0.0030
	(1.92)	(0.69)	(0.69)		(0.52)	(0.00)	(1.70)	(0.67)	(2.95)	(1.36)	(1.57)	(0.07)
PHS	−0.0023	−0.0012	−0.0004	—	−0.0004	−0.0002	−0.0018	0.0018	−0.0027	−0.0014	—	0.0006
	(1.76)	(0.94)	(0.36)		(0.37)	(0.19)	(1.51)	(0.86)	(2.65)	(1.21)		(0.50)
LPH	—	—	—	0.3656	—	—	—	—	—	—	—	—
				(1.68)								
NOP	0.0001	—	—	—	—	—	0.0007	−0.0012	0.0011	—	—	0.0010
	(0.18)						(0.85)	(1.51)	(1.84)			(1.62)
OCC	—	0.0098	−0.0012	0.0049	0.0112	0.0023	—	—	—	−0.0081	0.0099	—
		(2.31)	(0.28)	(0.95)	(1.51)	(0.55)				(1.21)	(1.87)	
Log Likelihood	−68.1103	−77.9323	−91.4678	−65.1266	−47.0760	−82.7837	−68.9183	−39.2805	−86.7322	−44.8615	−64.2408	−99.4938
Cases = 1	152	119	87	67	25	147	157	175	95	39	68	114
Cases = 0	35	68	100	120	162	40	30	12	92	148	119	73

Note: Numbers in parentheses are t-values.

Multiple regression analysis is used for combinations of technologies (Y_{13}, Y_{14}, Y_{15}, and Y_{16}) that are simple additions of single technologies of a certain kind. However, one needs to exercise caution in using the conventional ordinary-least-squares (OLSQ) estimation.

It is true that a hospital's decision on technology investment is partially determined by the financial status of the hospital (proxied by *NOP* in the case of outpatient technologies and by *OCC* in the case of inpatient technologies). It is also true that *NOP* (or *OCC*) could be influenced by the possession of related technologies. This is the case when patients choose a particular hospital because of its use of certain technologies. In other words, the causality can run in both directions between technology investment and hospital performance measures (measured by *NOP* or *OCC*). One of the independent variables, either *NOP* or *OCC*, is simultaneously determined with the dependent variable, grouped technologies. This is a built-in simultaneity problem within the equation, and therefore, use of OLSQ is not recommended.[6]

To incorporate the simultaneity nature of the above relationship in the estimation procedure, a system of equations is constructed and estimated, using two-stage-least-squares estimation technique (TSLS). TSLS provides coefficient estimates that are consistent and efficient. The functional form of multiple regression equations thus constructed are

$$Y_i = f_1(BED,\ OD,\ LD1,\ LD2,\ THP,\ PHY,\ PHS,\ OCC\,(NOP)),$$

$$i = 13, 14, 15, 16$$

$$OCC = f_2(PHY,\ THP,\ Y_i), \text{ when } i = 13, 15, 16$$

or

$$NOP = f_2(PHY,\ THP,\ Y_i), \text{ when } i = 14.$$

Estimation results of the above simultaneous model are shown below in Table 5.

B. Empirical Findings

In general the findings are consistent with *a priori* expectations. With reference to the proposed hypotheses, key findings are summa-

[6]Multicollinearity among explanatory variables is checked and found no threat to the valid estimation of the regression analysis. Even theoretically, two variables with similar character or similar trend of incidence are not existent.

TABLE 5

TWO-STAGE-LEAST-SQUARES REGRESSION FOR HOSPITAL INVESTMENT IN COMBINED TECHNOLOGIES

Dependent Var. / Explanatory Var.	All Technologies		Outpatient Technologies		Inpatient Technologies		Expensive Technologies	
	Y_{13}	*OCC*	Y_{14}	*NOP*	Y_{15}	*OCC*	Y_{16}	*OCC*
C	1.2859	46.5671	1.9040	−608.96	0.0302	48.385	0.1964	49.205
BED	0.0097	—	0.0028	—	0.0053	—	0.0050	—
	(11.31)		(3.10)		(10.53)		(10.11)	
OD	0.0645	—	−0.1663	—	0.2886	—	0.1609	—
	(0.15)		(0.65)		(1.09)		(0.63)	
*LD*1	0.2893	—	0.2157	—	−0.0262	—	−0.1130	—
	(0.59)		(0.75)		(0.09)		(0.40)	
*LD*2	0.1385	—	0.2001	—	0.0321	—	−0.2674	—
	(0.29)		(0.71)		(0.11)		(0.96)	
THP	0.9840	3.8371	0.0649	42.524	0.8411	4.9334	0.7448	5.6796
	(2.11)	(0.54)	(0.25)	(0.55)	(3.04)	(0.66)	(2.78)	(0.77)
PHY	0.1533	0.9818	0.0908	4.1162	0.0644	1.0213	0.0847	1.0508
	(2.54)	(3.92)	(3.05)	(1.37)	(1.80)	(4.22)	(2.44)	(4.08)
PHS	−0.0032	—	−0.0018	—	−0.0013	—	−0.0016	—
	(2.58)		(2.84)		(1.82)		(2.26)	
NOP	—	—	0.0004	—	—	—	—	—
			(0.35)					
OCC	0.0170	—	—	—	0.0060	—	0.0058	—
	(1.63)				(0.96)		(0.97)	
Y_{13}	—	0.3247	—	—	—	−0.1536	—	—
		(0.25)				(0.07)		
Y_{14}	—	—	—	242.35	—	—	—	−0.6608
				(5.28)				(0.26)
R^2	0.6484	0.1804	0.3471	0.1152	0.6263	0.1742	0.6303	0.1686

Note: Numbers in parentheses are t-values.

rized below.

1) The financial status of a hospital is a weak determinant of investment decisions on technologies. Hospitals' MT investment decisions do not necessarily correspond to their financial resources.
2) Hospital size is a strong determinant of technology investment. The coefficient of the variable is statistically significant in all single and combined-technology equations. The larger a hospital is, the more likely it is to adopt and use MTs.
3) The question of whether a hospital's investment behavior is the result of interest in gaining prestige and higher status cannot be answered directly from estimation results. However, there are two related findings that suggest hospitals pursue higher status through technology investment: i) coefficients of financial variables are not statistically significant in many of the equations, and ii) the variable representing a hospital's status (*THP*) is highly significant in both the least-profitable-technology equation (Y_{10}) and the expensive-technology equation (Y_{16}). These results together suggest that hospitals purchase technologies even when they are financially less sound, and furthermore, teaching hospitals invest in technologies regardless of their profitability or capital costs.
4) The geographic location of a hospital explains very little of the variability in MT diffusion.
5) Teaching hospitals lead other groups of hospitals in the possession of MTs. There is a significant difference in the adoption of MTs by teaching hospitals relative to other hospitals.
6) The physician density variable is statistically significant in all combined-technology equations. The number of physicians per bed has some influence on a hospital's investment decision in technologies. A striking result is that the relationship between physician density and technology adoption is strictly non-linear, with its maximum reached when there are 25 physicians per 100 beds. This might suggest that hospitals increase technology adoption up to the point of 25 physicians per 100 beds, and then substitution between technology and physician manpower takes place within a hospital. A logarithmic relation between the two variables, implying that technology adoption increases continuously with physician densities but at a decreasing rate, is obtained only in the case of Gamma Camera technology.
7) As quantities of MTs increase, so do outpatient visits, but MTs do not significantly affect inpatient service flows. Instead, inpatient

service flows are strongly influenced by physician densities. This result is consistent with the conventional notion that many of the outpatient visits are patient-generated and most of the inpatient services are physician-generated. A patient initiates an original visit and his (her) choice of a hospital is influenced by the hospital's possession of technologies, but not by the number of physicians. However, he (she) is more likely to be hospitalized in hospitals with higher physician densities than those with lower densities.

8) Private hospitals invest in technologies whose per case uses are well supported by government controlled fees. The level of reimbursement is an important determinant of a private hospital's MT investment decisions.

VI. Concluding Remarks

The empirical findings of this study show a marked proliferation of technologies in Korea's teaching and big size hospitals. Physician density also plays an important role in technology acquisition by hospitals. Private hospitals aggressively acquire profitable technologies, and they seem to compete based on the acquisition of new technologies.

Several policy implications can be drawn directly or be implied indirectly from the above analysis. First, technology diffusion among hospitals can be partially regulated by manipulating the reimbursement levels. Because private hospitals (89% of all hospitals in the study) react sensitively to the level of reimbursement, the government can use the fee control system as a potential modulator of technology diffusion.

Second, there is need for a corporate body to take responsibility or establish principles of management with regard to technology diffusion. Such an organization would ensure that technology assessment keeps pace with the introduction of new modalities. In this way, adoption of medical technology can be regarded as part of the rule rather than the exception.

Third, technology acquisition by leading hospitals should be closely monitored either by the government or the hospital association authority. Followers in the same group of hospitals or hospitals in lower level groups will be less pressured to acquire equipment when leading hospitals are prudent in technology acquisition. Careful planning of the procurement and maintenance of equipment by the leading hospitals is thus important.

Fourth, a health care network for using existing technologies is necessary, at least at the regional level, so that the appropriate use of MTs can be ensured. The potential benefits of medical technologies can be realized only if the technologies are not abused or underused.

Korea is aware that MTs need to be prudently used and effectively controlled by society, but no practical policies have been adopted or implemented yet. There does not seem to be any rational long-term planning, as can be found in some industrialized countries. Many western countries have taken steps toward controlling the expansion of technology in medicine. For example, Canada, Sweden, and the U.K. successfully limit MT acquisition through controls over the level of funding for hospital services and ambulatory settings. France created a quite detailed system of planning and regulation of technologies in 1970. In the Netherlands, the government has some control over investments in technologies through the Hospital Provision Act (Banta and Kemp 1982). Findings from this study of Korea should provide the government, which has the power of control as well as the legal mandate (such as the existing "Certificate of Need" law), with useful information for effective management of MTs in the future.

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