HOSPITAL INVESTMENT IN INFORMATION TECHNOLOGY: DOES GOVERNANCE MAKE A DIFFERENCE?

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JEL Classification: I1, D8

Working Paper: November 2003

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Abstract:

We examine the adoption of patient care IT systems by US short-term acute care hospitals and the resulting impact these systems have in the productivity of hospitals. Of particular interest is the extent to which for-profit and non-profit hospitals obtain different results from the adoption of IT systems. We find that the marginal effect of IT on for-profit hospital productivity is to reduce the number of days supplied, while in non-profits the marginal effect of IT is to increase the quantity of services supplied. This evidence is consistent with the differing objectives of non-profit and for-profit hospitals

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I. INTRODUCTION:

The healthcare and information technology industries are two large sectors of the United States' economy undergoing rapid change. The healthcare provider community and, in particular, hospitals have consolidated in response to the market forces from managed care and other regulatory burdens. The IT industry spent most of the past decade growing , and was hailed by Alan Greenspan as one of the possible key factors contributing the US economy's productivity. However, healthcare delivery has been relatively untouched by the revolution in information technology that has been transforming nearly every other aspect of society. The challenges of applying information technology to health care, largely due to the economic and political complexities of the industry, should not be underestimated. Within US hospitals, medical data reside in a poorly organized and often illegible collection of paper records that are frequently inaccessible in a timely fashion, thus limiting the efficient and effective management of many illnesses that require frequent monitoring and ongoing patient support. Therefore, in an acute care hospital setting, the deployment of information technology is a substantial investment that a rational manager would undertake to maximize an institution's utility, which will vary by its governance structure.

The provision of hospital services is dominated by non-profit organizations. More than 80% of all short-term acute care hospitals in the US are non-profit. The for-profit and largely investor owned sector, however, has garnered increasing attention in recent years as they have purchased non-profit hospitals. Further, following the AHERF bankruptcy of 1997-1998, access to tax exempt debt has been significantly curtailed. Non-profit hospital financial solvency throughout the 1990s was ensured largely through investment returns, donations, and governmental support. In fact, the 2,500 non-profit hospitals generated little more than $410M in operating surplus between 1990 and 1998. The approximately 600 for-profit hospitals, by contrast, generated in excess of $10B in surplus during the same period. For non-profit hospitals to remain viable in an increasingly competitive marketplace they will require capital to replenish their existing stocks and invest in new technology. Their ability to configure their operations in an efficient manner is therefore important.

A logical question is whether the operating efficiency of non-profit hospitals may be improved by the use of information technology, or whether the use of information technology in these organizations has different productive implications than their for-profit counterparts given their different objective functions.

Despite their importance, little is known about how information technology is employed within non-profit organizations. Non-profit organizations do not have owners who are legally entitled to the residual claims. Thus, in contrast to for-profit organizations, there is a lack of ownership incentives, no stock-based compensation, no external market for corporate control, and no derivative lawsuits. A number of studies assume that the objective of non-profit hospitals is to fulfill a philanthropic objective to provide quality healthcare services to the community at large and charity care to the indigent. Prior studies assume non-profit hospitals maximize quantity of care subject to budget and quality constraints. In other studies, both quality and quantity are in the objective function [Newhouse (1970) and Feldstein (1971)]. Pauly and Redisch (1973), for example, argue that physicians gain *de facto* control over hospitals and manage the hospital to maximize their own utility.

This paper contributes to this important topic by examining the adoption and implications for information systems in US hospitals. In particular we estimate the marginal effect of IT in for-profit and non-profit hospitals. Given the different objectives and governance mechanisms of these organizations, we hypothesize that IT will have different effects in for-profit and non-profit hospitals. While others have estimated production functions for hospitals (see for example Jensen & Morrisey, 1986, Zuckerman, Hadley & Iezzoni , 1994, Hofler and Folland, 1995), they have not examined the marginal effect of a common technology adoption and the corresponding effect on productivity. We are able to form specific hypotheses about the effect of IT on hospital productivity based on the differing objectives of for-profit and non-profit hospitals.

Our principal findings are as follows. The presence of healthcare information systems in US hospitals appears to have an impact on productivity. The impact of hospital IT differs between for-profit and non-profit hospitals. IT systems in for-profits serve to reduce the total number of patient days supplied – a corollary of financial success in a world of prospective payment. IT systems in non-profits appear to increase the quantity of services, total discharges, consistent with a non-profit utility function valuing quantity. When viewed in light of past research, that suggests there is little distinction in the outputs (for example, charity care and the quality of care) and behaviors (for example, focus on financial performance) of nonprofit and for-profit hospitals.[1] Our evidence suggests IT systems do generate important operational differences consistent with their differing objectives.

The paper is organized as follows: Section II describes the existing literature; Section III describes the data, Section IV contains the empirical results; and Section V summarizes the findings and implications.

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[1] There is an extensive literature that compares the outputs of nonprofit and for-profit hospitals. Frank Sloan, Commercialism in Nonprofit Hospitals, in To Profit or Not to Profit: The Commercial Transformation of the Nonprofit Sector, edited by Burton Weisbrod, pp. 151-168, Cambridge University Press, Cambridge, 1998, provides a review of the more recent research in this area. The evidence is mixed and somewhat inconclusive. Non-profit hospitals have consistently reported positive profits, which in some years have been higher than the profits reported by for-profit hospitals. The general result seems to be that there is not much difference between for-profit

II. ROLE OF IT IN HOSPITALS

Because of the many different interpretations of technology in the health care industry, it is important to define different types of information technologies. Shea and Clayton (1999) offered that clinical information systems could be classified into four categories: improving access to medical knowledge, electronic patient/medical records, communication improvements among providers, and decision support systems.

The two major types of decision support systems are financial decision support systems and medical decision support systems. Financial support systems usually compile all types of information such as financial data, encounter information, and provider information. This information is then used to make planning decisions for the organization. Providers use medical decision support systems (DSS) to help make clinical decisions. An example of this type of DSS might be a clinical pathways program that uses provider inputs to provide information about a diagnosis and a recommended treatment. In our analysis, we focus on computer patient care systems such as computerized physician order entry systems. Patient care related IT systems are a necessary but not sufficient technology to improve medical decision-making. However, these systems provide an opportunity to improve the efficiency of a hospital by lowering the costs of clinical data collection and analysis. Because less time is required to track a patient through a hospital, it is possible to more efficiently treat patients at a lower marginal cost, while increasing the throughput of an institution in order to treat more patients.

Hammond, Prather, Date, and Kind (1990) found that a provider interactive medical record system can favorably influence both the costs and the quality of medical care. Parente and Dunbar (2001) found that hospitals with integrated information systems have higher total

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and private nonprofit hospitals in the provision of uncompensated care, in quality of care, and in the adoption of and operating margins than those hospitals that do not have integrated information systems. Neumann, Parente, and Paramore (1996) reviewed eleven studies and presented a consolidated analysis of each. They found that fully automating administrative functions could save between $5 and $8 billion annually.

The "Most Wired" report (Solovy, 2001) by Hospital and Health Networks and Deloitte Consulting shows that "most wired" hospitals have better control of expenses and higher productivity. The characteristics were measured in terms of greater access to capital as a reflection of credit ratings. They are more efficient as measured by lower median expenses per discharge and more productive as measured by full-time equivalent staff (FTE) per adjusted occupied bed, paid hours per adjusted discharge and net patient revenue per FTE.

With few exceptions, the health IT empirical analyses have been at the firm level. Thus, it has been difficult to generalize the impact of health IT to a specific sector of the health economy, such as hospitals. In one of the few national samples of hospitals examined, Parente and Dunbar (2001) examined a cross-sectional 1,400 hospital sample. However, their results were unable to disentangle the endogenous relationship between IT investment and profitability. They found hospitals investing in health IT had a higher total profit margin. However, it could also be the case that wealthier hospitals, with greater profits from operations and total assets, invested in IT. They noted that IT had no impact on operating margin, suggesting health IT had little effect on performance, and the presence of IT could simply be a wealth effect. Our analysis improves on this work by using a panel database of hospital IT investment and performance, as well as specifically identifying productivity improvements attributable to IT.

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technology according to Sloan 1998.

III. DATA AND MEASURES

The data for this study combines two databases. We use the Dorenfest database to measure technology investments by approximately 3,000 United States hospitals annually. The hospitals surveyed account for general hospitals with greater than 100 beds as of 1986. Dorenfest data surveys hospital IT purchases from 1986 to 2000. Included in the database is a list the type of health IT application as well as the vendor providing the application (if it is not home grown). We restrict our attention for the purposes of this analysis to patient care systems. [2]Patient care systems are the largest and most significant types of systems in which a hospital may invest[3]. The Dorenfest data does not state the cost of the investment made in any period but rather whether a system was in place. We are, therefore, limited in the detail that we can include in our analyses. We construct two measures: whether a hospital has the IT system in a given year and the total number of years the IT system has been in place. It is conceivable that the tenure of the IT system within the facility may influence the marginal productivity and impact on cost.

For this study, Dorenfest data for years 1990 through 1998 were combined with Medicare cost report data to create a nine-year panel of data. The cost reports provide detailed financial performance and operating characteristics of the hospitals annually. Approximately 70% of available hospitals from the Dorenfest database could be matched successfully with the Medicare cost report information. We further restrict our sample to hospitals for which we have a

[2] This restriction was made possible by a consistent identification of patient care information systems in the Dorenfest database. In later years of the sample, different terms were used to capture patient care systems, such order entry systems, but the term patient care was still carried from 1990 through 1998 to permit consistent development of the variable for a panel data analysis. Additional verification was obtained in the Dorenfest database by examining the patient care software vendors and their products to identify consistent identification of software product.

[3] While we categorize the remaining classes of IT investments, there is a high degree of correlation in the adoption of al systems, so the additional information associated with the adoption of other classifications is limited.

complete 9 year series of data. We therefore remove from our sample hospitals that closed or ceased their Medicare certification between 1990 and 1998. We further limit our sample to short term acute care non-government hospitals with greater than 50 beds having operating earnings between -$50M and $50M and an ROA from operations between -.5 and .5.

IV. RESULTS:

Table 1 presents summary statistics on our sample of hospitals by ownership type. Not surprisingly, non-profit hospitals were larger in terms of beds, FTEs, totals assets and patient volume. For-profit hospitals displayed better financial performance, and lower lengths of stay. Interestingly for-profit and non-profit hospitals were similar with respect to their median cost per day and admission. Non-profit hospitals adopted patient care IT systems to a greater degree and did so earlier in our study period.

Figure 1 presents a graph of the adoption curve for IT systems by for-profit and non-profit hospitals along with a plot of the mean ROA by hospital type. Throughout most of the study period the percentage of non-profit hospitals with the patient care IT system was greater than in the for-profit hospitals. In short, non-profits appear to be early adopters of the technology. It is also noteworthy that at this very general level there does not appear to be a relation between the financial performance of the hospital and adoption of the IT system. Throughout most of the 1990s, non-profit hospitals had negative operating ROAs[4], yet they invested in these expensive IT systems. It is noteworthy that both non-profit and for-profit hospital financial performance suffers materially from 1997 onward, largely the result of Balanced Budget Act of 1997 (BBA).

[4] This is not to say however that the nonprofits had no available capital to purchase the IT systems. After one accounts for the below the line sources of revenue from investment income, donations and government appropriations non-profits typically had marginally positive financial positions.

To better understand the factors affecting the adoption of the IT systems by these hospitals, we performed a logistic regression[5] of adoption on organizational attributes presented in table 2. The model suggests that for-profits are less likely to have an IT system, and when they do, it is positively influenced by the financial position of the hospital. Non-profits, on the other hand, are more likely to have an IT system, to adopt the system earlier (negative coefficient on the time trend), and are more likely to make the investment when they have poor financial performance. Full time equivalent employees per hospital bed (a crude measure of efficiency) were not related to whether the IT system was purchased. Hospitals which had higher case mix were more likely to invest in IT. These results largely confirm what was depicted in figure 1.

Table 3 presents OLS regression results in which five different dependent variables (FTE's per hospital bed, Length of Stay (LOS), Return on Assets (ROA), Casemix adjusted cost per patient day, and Casemix adjusted cost per discharge) were regressed on a set of organizational controls and a measure of IT investment. Hospital IT Tenure defined as the number of years that the IT system has been in place, captures not only the presence of absence of an IT system but also allows the effect IT to change as the organization has a longer history with the system. Naturally, there are many macroeconomic changes taking place in the hospital industry over time. To capture the time series changes in hospital performance dimensions, we have included a simple time trend. Panel A presents the results of the OLS estimation for non-profit hospitals, and Panel B presents the same estimation results for for-profit hospitals.

Turning our attention to Table 3, Panel A, it is noteworthy that in none of the models was IT significant. The remaining variables in the model have largely the appropriate signs. The time trend variable is suggesting that FTEs/bed are increasing over time, LOS is dropping, ROA

[5] A logistic regression in this context is equivalent to a discrete time hazard rate model given our data structure. The panel of observations for each hospital was truncated after their initial adoption of the IT system. We therefore have

is declining and that costs are increasing. None of the models has respectable explanatory power, however. This is in stark contrast to Panel B, in which the same models were estimated for for-profit hospitals. The models have a reasonable amount of explanatory power, ranging from an adjusted R-squared of .015 for the ROA specification to .283 for the cost per casemix adjusted day model. These models have greater explanatory power and significance of the model coefficients, despite the fact that there are roughly 20% of the observations seen in the non-profit models.

The time trend and casemix index control variables take on exactly the same sign as was observed in Panel A. While the IT variable was not significant in any of the non-profit specifications it is significant in each of the five regression models presented in Panel B. IT Tenure serves to reduce LOS and each casmix adjusted cost measure while having a positive effect on ROA and FTE's per bed. These signs are in the expected direction given the for-profit orientation of the hospital. In summary, IT appears to have a significant impact on multiple dimensions of for-profit hospital performance and no perceptible effect in non-profit hospitals.

To more accurately assess the impact of IT on hospital production we then estimated a translog production function. These production functions were estimated for both total inpatient days as well as total discharges and estimated separately for both non-profit and for profit hospitals. These specifications are most akin to the translog production functions of Jensen and Morrisey (1986). The objective here was to evaluate the full impact of IT on hospital production, allowing for the complementary and substitute effects IT may have for labor and hospital capacity (measured in this specification as hospital beds). This is clearly a reduced form estimation which does not incorporate other important dimensions of hospital inputs and organizational attributes. These will be incorporated in subsequent versions of the paper.

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varying numbers of observations depending on the year in which the IT system was adopted.

Table 4 presents the results of the translog production function estimation. The main effect of FTEs and Beds in both models for both for-profit and non-profit hospitals is positive as expected. Furthermore, in the case of for-profit hospitals the effect of FTE's and hospital beds is concave as would be expected. We include linear time trend in the production function. This is important given that our measure of IT linear, measuring the number of years since IT adoption. Without this linear time trend it is likely that many macroeconomic shifts in hospital output would load on the IT Tenure variable.

The main effect of IT on the productivity of labor is negative in both for-profit and non-profit hospitals. The tenure of the IT system serves to reduce the productivity of labor. Conversely, the marginal effect of IT on hospital capacity is positive in all models, suggesting that IT increases the marginal product of hospital beds. We compute the total marginal effect of IT by taking the derivative of the production function with respect to IT Tenure and evaluating the expression at the mean value.

The marginal effect on health IT is quite different between non-profit and for-profit hospitals. IT increases the discharges of non-profit hospitals, which is consistent with their functional objective to maximize the quantity of services provided within a community. For for-profit hospitals, IT has a negative effect on the number of patient bed days and the costs associated with staffing beds for those days. Given the duality of cost-minimization and profit-maximization, for-profit hospitals are maximizing profits by using IT to reduce inpatient stays. IT appears to have no statistically significant effect on the length of stay for non-profits hospitals and the volume of admissions within for-profit hospitals.

V. FINDINGS AND IMPLICATIONS

Our primary results find the marginal effect of health information technology investment consistent with the hypotheses that for-profit hospitals will invest in IT to maximize profits/minimize costs, and that non-profit hospitals will invest in IT systems to maximize volume. These results were obtained by using an estimated production function in a manner consistent with earlier empirical work focused on the hospital industry. While we see this analysis as a first step in the path of future analyses, the analysis does present a novel example of where the marginal effect of a common technology adoption in hospitals and the corresponding effect on productivity were considered.

This analysis has several limitations. First, we did not match all hospitals between the Dorenfest and HCFA database. However, we do know which hospitals did not match and can gauge some of the direction of the bias caused by this result. Since the analysis focuses only on hospitals with greater than 100 beds that were financially solvent through the 1990s, it may be that our subset is most pertinent hospitals to test the impact of health IT at the median hospital. However, our analysis does not consider the recent impact of health IT on smaller rural hospitals where anecdotal evidence has suggested significant returns on IT investment.

A second limitation may be that case-mix is absent from the production function. We have deliberately left it out at this stage of the analysis to develop a pure specification of production with only inputs. While case-mix could be considered a technology determinant of the hospital, we fear it could be correlated to other inputs in the translog function as currently specified, particularly health IT as seen from the logistic regression analysis.

Even with these limitations, the Dorenfest database is a unique resource that can be refined for future empirical analysis. One major new health IT application will be the use of hospital-wide computerized physician order entry (CPOE) systems. The Dorenfest data have the potential to not only track hospital investments in these systems, but also the physician and long term care affiliates' adoption of CPOE within an integrated delivery hospital system. A potential enhancement would be for the Dorenfest surveyors to request HCFA ID numbers to quickly boost the match rate.

Within the last three years, interest in the adoption of information technology by medical providers has been fueled by two Institute of Medicine reports documenting case studies of health IT successes. The first report, "To Err is Human" (1999) estimated the amount of patient fatal medication errors within hospitals ranged between 40,000 and 90,000 per year. The report's authors suggested, based on several well designed firm-level health IT studies, that these errors could be greatly reduced with the adoption of the patient care IT systems. A second report entitle "Crossing the Quality Chasm" (2001) outlined several recommendations that included providing incentives to hospitals to adopt CPOE systems and other IT innovations to improve the quality of U.S. medical care. Specifically, they stated: "Congress, the executive branch, leaders of health care organizations, public and private purchasers, and health informatics associations and vendors should make a renewed national commitment to building an information infrastructure to support health care delivery, consumer health, quality measurement and improvement, public accountability, clinical and health services research, and clinical education. This commitment should lead to the elimination of most handwritten clinical data by the end of the decade."

Our analysis provides evidence to address the business case for investing in these decisions and provides a national database demonstrating successful health IT implementation consistent with the goals of a for-profit or not-profit hospital. As a future extension of our analysis to address the quality issue raised in the IOM reports, we plan to model the inpatient mortality of hospitals in our sample as part of the production process. Initial descriptive analyses, focused on the 1996-1998 portion of our sample, show that laboratory and pharmacy order entry systems, which are usually embedded in the patient care systems examined in our analysis, are negatively associated with inpatient mortality (Parente & Peterson, 2001). We completed this analysis using Medicare claims data to identify hospital-specific inpatient mortality. Also, with the use of the date of death field in the Medicare beneficiary file, we were also able to identify six-month post discharge mortality. In the case of six-month post discharge mortality, we find an even greater negative impact associated with health IT systems. If modeled in our production function framework, we would expect the total marginal effect of health IT on mortality to be negative for both for-profit and non-profit hospitals, since both have an incentive to improve quality.

One enhancement to our production model specification is to allow for a multi-dimensional output space including measures of quality, such as mortality. As part of this analysis we explored using Cobb-Douglas and Data Envelopment Analysis to get a more robust specification of production with varying levels of success. We hope to employ a specification similar to Hofler and Folland's (1995) use of a stochastic frontier estimation to evaluate the efficiency of US hospitals based on visits or admissions in five patient categories taken from the 1985 AHA Survey. Additional explorations that could provide an opportunity to include case-mix will be examined. We also plan to investigate the use of incorporating random effects to account for the correlated error structure. Finally, we hope to be able to estimate acquisition and SFE equations simultaneously.

In summary, an exploratory examination of the adoption of patient care IT systems by US short-term acute care hospitals and the resulting impact of these systems on productivity has yielded some interesting first stage results. The national scope and recent panel data available for this analysis make it both policy relevant and timely, as the marginal value of health IT investments are being considered by healthcare managers. The finding that for-profit and non-profit hospitals successfully maximize their production objectives, though in different ways, helps focus the debate on the merits of these systems by the finding they are good for everyone, but in different ways depending on the organization. Extensions of this work will provide better specification and will examine the additional value of these systems on quality dimensions.

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Figure 1: Time Series Cumulative Adoption of Patient Care IT Systems by Hospital Type

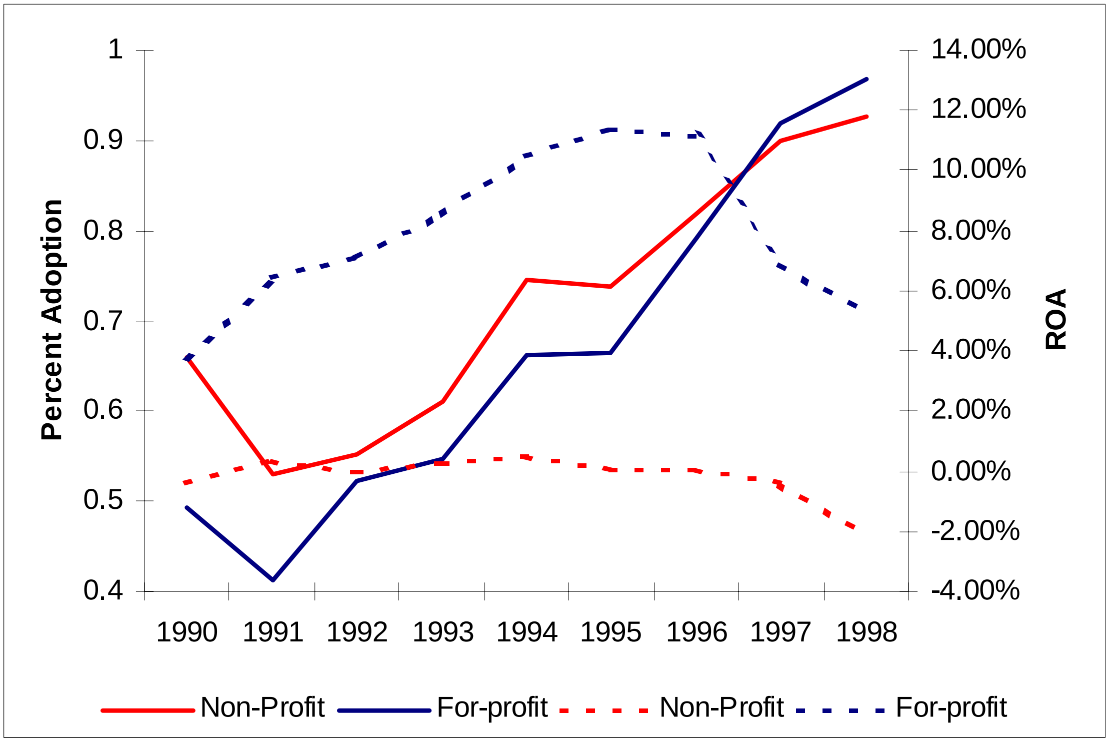

Table 1: Descriptive Statistics

The table below presents summary statistics on variables used in subsequent analyses. The information system (IT) variables are obtained from the Dorenfest annual survey of hospital IT. All other variables are computed from the Medicare Cost Reports for 1990 - 1998.

	Non-Profit		For-profit	
	Mean	Median	Mean	Median
Observations	7,688	7,688	1,513	1,513
Percent with Patient Care IT System	0.70	1.00	0.66	1.00
Mean IT Tenure	2.96	2	2.88	2
Total Inpatient Days	52,894	41,603	34,856	26,883
Total Hospital Discharges	9,485	7,832	6,637	5,402
Total Beds	247	211	208	172
Total Assets	104,061,117	69,189,243	55,102,656	40,939,255
Length of Stay	5.73	5.25	5.27	5.04
Medicaid Percentage	0.09	0.08	0.1	0.07
Medicare Percentage	0.45	0.46	0.43	0.43
Casemix Adj. Cost Per Day	3,086	1,103	1,208	1,121
Casemix Adj. Cost Per Adm.	8,225	5,839	6,024	5,577
ROA from Operations	0.00	0.00	0.07	0.07

Table 2: Logistic Regression of IT Adoption

The dependent variable is equal to one if the hospital in a given year had a newly acquired patient care IT system and zero in the preceeding years. All hospital years after adoption have been removed. The IT variable is obtained from the Dorenfest data, all other variables are obtained from the Medicare Cost Report data for the years 1990-1998. Standard Errors are in parentheses.

Observations	3,494	
Events	1,077	
	Parameter	Asymp-T
Intercept	0.041	0.105
	(0.393)	
For-profit Dummy	-2.476	5.250
	(0.472)	
Operating Return on Assets	-1.874	3.031
	(0.618)	
FP * Operating Return on Assets	2.139	2.369
	(0.903)	
FTE per hospital bed	-0.001	0.296
	(0.005)	
Time Trend	-0.226	9.287
	(0.024)	
FP * Time Trend	0.262	5.078
	(0.052)	
Medicaid Percentage	-2.807	5.201
	(0.540)	
Medicare Percentage	-0.624	1.833
	(0.340)	
Medicare Case Mix Index	1.269	7.221
	(0.176)	
Pseudo R- Sq	0.056	

Table 3: OLS Regression of Hospital Performance Measures on IT Tenure

Panel A and Panel B present OLS regressions of five dependent variables on organizational attributes and the number of years the patient care IT system has been in place for non-profit and for-profit hospitals respectively. The IT variable is derived from the the Dorenfest annual survey of hospital IT and the other variables are computed from the Medicare Cost Reports for the years 1990-1998. Observations are hospital year specific. T-statistics appear in parentheses.

Panel A: Non-Profit Hospitals

	FTEs per bed	LOS	ROA	Cost/ day CMA	Cost / adm CMA
Observations	7,669	7,669	7,669	7,669	7,669
Intercept	6.900	4.350	-0.004	-46,480	-45,131
	(0.6)	*(1.7)*	*-(0.4)*	*-(3.6)*	*-(3.5)*
Time Trend	0.511	-0.318	-0.002	1,413	1,687
	(0.9)	*-(2.5)*	*-(5.0)*	*(1.4)*	*(1.7)*
IT Tenure (years)	0.428	0.043	0.001	-566	-637
	(0.7)	*(0.3)*	*(1.4)*	*-(0.5)*	*-(0.6)*
Total Assets (100 millions)	-0.896	0.174	-0.001	994	1,106
	-(0.8)	*(0.7)*	*-(1.3)*	*(0.6)*	*(0.7)*
Medicaid Percentage	-13.763	5.446	-0.081	2,064	2,695
	-(0.9)	*(1.6)*	*-(7.0)*	*(0.1)*	*(0.1)*
Medicare Percentage	-15.489	6.586	0.009	77,320	79,306
	-(1.6)	*(3.0)*	*(1.2)*	*(4.5)*	*(4.6)*
Case Mix Index	0.465	0.737	0.019		
	(0.1)	*(0.6)*	*(4.6)*		
Adjusted R-Squared	0.000	0.002	0.016	0.003	0.003

Panel B: For-Profit Hospitals

	FTEs per bed	LOS	ROA	Cost/ day CMA	Cost / adm CMA
Observations	1,503	1,503	1,503	1,503	1,503
Intercept	1.634	4.590	-0.052	356	2,702
	(4.7)	*(12.1)*	*-(1.3)*	*(5.2)*	*(8.4)*
Time Trend	0.016	-0.164	-0.002	116	339
	(0.9)	*-(8.7)*	*-(1.2)*	*(20.0)*	*(12.5)*
IT Tenure (years)	0.032	-0.037	0.006	-31	-139
	(1.8)	*-(1.9)*	*(2.9)*	*-(5.2)*	*-(5.0)*
Total Assets (100 millions)	0.559	0.089	-0.016	-87	41
	(7.4)	*(1.1)*	*-(1.8)*	*-(3.9)*	*(0.4)*
Medicaid Percentage	-1.437	1.377	0.084	-648	-1,740
	-(3.6)	*(3.2)*	*(1.8)*	*-(4.9)*	*-(2.8)*
Medicare Percentage	-0.359	2.293	0.040	-481	435
	-(1.4)	*(8.2)*	*(1.3)*	*-(5.6)*	*(1.1)*
Case Mix Index	0.676	1.027	0.086		
	(3.4)	*(4.7)*	*(3.7)*		
Adjusted R-Squared	0.138	0.171	0.015	0.283	0.113

Table 4: Translog Production Function Estimation by Hospital Type

The table presents the results for two translog production functions estimated for total inpatient hospital days and total hospital discharges separately for non-profit and for-profit hospitals for the period 1990-1998. The marginal effect of IT is computed as the derivative of the production function with respect to IT. The IT variable employed is the number of years the patient care information system has been in place in the hospital. Standard errors are in parentheses.

	Non-Profit				For-Profit			
Dependent Variable	Log Days		Log Discharges		Log Days		Log Discharges	
	Parm.	t-stat	Parm.	t-stat	Parm.	t-stat	Parm.	t-stat
Intercept	2.4886	13.97	-0.7438	-4.07	-0.4729	-0.48	-0.3246	-0.32
	(0.178)		*(0.183)*		*(0.993)*		*(1.003)*	
Time Trend	-0.0333	-18.16	-0.0047	-2.51	-0.0305	-5.66	-0.0024	-0.44
	(0.002)		*(0.002)*		*(0.005)*		*(0.005)*	
Log FTE Hosp	0.4714	6.79	0.7783	10.91	0.6229	1.44	0.6662	1.52
	(0.069)		*(0.071)*		*(0.434)*		*(0.438)*	
Log FTE Hosp * IT Tenure	-0.2697	-12.98	-0.2707	-12.68	-0.0852	-0.75	-0.0971	-0.85
	(0.021)		*(0.021)*		*(0.114)*		*(0.115)*	
Log Hosp Bed	1.3179	13.54	1.5366	15.37	2.2903	3.77	1.5835	2.58
	(0.097)		*(0.100)*		*(0.607)*		*(0.613)*	
Log Hosp Bed * IT Tenure	0.3425	13.07	0.3389	12.59	0.0747	0.55	0.0862	0.63
	(0.026)		*(0.027)*		*(0.136)*		*(0.137)*	
Log FTE Hosp ^2	0.0641	15.41	0.0621	14.52	-0.0654	-1.61	-0.1180	-2.87
	(0.004)		*(0.004)*		*(0.041)*		*(0.041)*	
Log FTE Hosp ^2 * IT Tenure	-0.0092	-9.76	-0.0089	-9.17	0.0489	4.38	0.0635	5.63
	(0.001)		*(0.001)*		*(0.011)*		*(0.011)*	
Log Hosp Bed ^2	0.0376	2.43	0.0325	2.05	-0.2643	-2.5	-0.2674	-2.51
	(0.015)		*(0.016)*		*(0.106)*		*(0.107)*	
Log Hosp Bed ^2 * IT Tenure	-0.0753	-15.25	-0.0716	-14.13	0.0514	1.85	0.0678	2.41
	(0.005)		*(0.005)*		*(0.028)*		*(0.028)*	
Log FTE Hosp * Log Hosp Bed	-0.1582	-11.27	-0.2065	-14.32	0.1539	1.39	0.2591	2.31
	(0.014)		*(0.014)*		*(0.111)*		*(0.112)*	
Log FTE Hosp * Log Hosp Bed * IT Tenure	0.0710	16.84	0.0685	15.83	-0.0976	-3.13	-0.1280	-4.07
	(0.004)		*(0.004)*		*(0.031)*		*(0.032)*	
Marginal Effect of IT	0.0011	0.55	0.0060	2.83	-0.0111	-1.86	-0.0005	-0.09
	(0.002)		*(0.002)*		*(0.006)*		*(0.006)*	
Observations	7682		7681		1510		1510	
Adj R-Squared	0.8839		0.8593		0.7262		0.6828	