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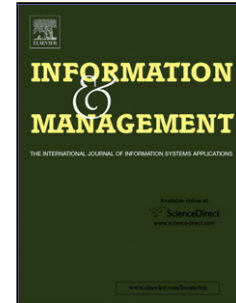
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Strategic Information Technology Outsourcing in Hospitals

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Highlights

- Outsourced IT has a considerable impact on the hospital productivity

- The optimal level of IT outsourcing is between 50% and 80% of overall IT spending.

- Hospital characteristics play an important role on hospital productivity

Abstract

This study examines the effects of outsourced information technology (IT) on hospital productivity by using California hospital data from 1997 to 2007. I estimated the parameters of a value-added hospital production function, correcting for endogenous input choices. I found that in comparison to in-house IT, outsourced IT has a more considerable impact on hospital productivity in the short run. However, in the long run, in-house IT has a more substantial impact on productivity than outsourced IT. I also found that hospitals that do not engage in "too much" IT outsourcing have considerable productivity gains from their outsourced IT. Moreover, hospital characteristics play an important role in the effects of outsourced IT on hospital productivity; for example, hospitals with a small number of beds and early adopters experience productivity gains from outsourced IT.

Introduction

The main objective of healthcare organizations is the diagnosis and treatment of patients[1]. Thus, health information technology (IT) has not been considered an essential part of healthcare organizations until recently when the shift has occurred. IT plays a critical role in the delivery of patient care, and therefore, healthcare organizations are becoming increasingly dependent on IT systems [1]. Health IT reduces healthcare costs and medical errors, meets the growing demand for quality care, copes with lower reimbursement rates, makes it easier to collect patient data, and improves efficiency [2-10]. With the recognition of these benefits, healthcare organizations are more interested today than ever before in adopting IT systems.

That said, IT adoption is not an easy task for providers. Providers must comply on the Health Insurance Portability and Accountability Act, which requires the establishment of national standards for IT transactions. This law made security and protection of patient data and privacy a priority [1]. Moreover, the Health Information Technology for Economic and Clinical Health Act requires providers to demonstrate the meaningful use of electronic medical records (EMRs) within a short period of time or suffer penalization [11]. Under these regulations, providers have been frustrated with IT strategies out of alignment with their core goals of patient care. The current environment has placed many hospitals in an increasingly untenable position.

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[1] The US payment system is changing to value-based reimbursement that ties payments to the quality of care delivered and rewards providers for both efficiency and effectiveness.

Many hospitals have recognized that they cannot build everything internally and therefore cannot ignore outsourcing approaches that reportedly have worked in other industries.

Outsourcing can be beneficial for organizations, allowing them to concentrate on core business and customers. Resources are conserved where they are the most effective and reduced where they are the least effective. Outsourcing can lower both costs and risks while improving efficiencies. Outsourcing involves an outsourced organization performing specialized tasks unrelated to the core business to improve production and service related to these tasks. As a result, organizations can expand their flexibility, innovative capabilities and opportunities through outsourcing [12]. Over the last two decades, there has been a rapid expansion of outsourcing in manufacturing and service industries. A notable internal function area representative of the growth in outsourcing is IT services.

Despite rapid growth in in IT outsourcing, the impacts of IT outsourcing on hospital productivity have not been documented. Whether IT outsourcing provides hospitals with the benefits seen in other industries is a relevant topic that should be investigated. This type of information will help healthcare organizations cope with environmental pressure and make informed decisions regarding adoption of IT outsourcing. As such, this study addresses the following research questions:

1) Does health IT outsourcing have an effect on hospital productivity?

2) Is outsourced health IT comparatively more effective than in-house health IT?

3) What are the optimal amounts of IT outsourcing to improve productivity?

4) How do the effects of IT outsourcing on productivity differ across hospital characteristics?

5) Are there learning spillover effects in IT outsourcing?

This study builds on the earlier research of Lee et al. [13] and makes some new contributions. First, this study focuses on IT outsourcing in the healthcare industry and highlights the effects of IT outsourcing on hospital productivity, which have not been studied in healthcare field research [15]. Second, it examines the comparative effectiveness, substitutions, and complements for hospital productivity between outsourced and in-house IT. Third, this study attempts to determine the most comparatively effective amount of outsourced IT by analyzing productivity. Fourth, it examines how IT outsourcing productivity varies depending on hospital characteristics and time trends. Finally, this study applies dynamic panel data (DPD) analysis to control common endogeneity problems in the production function, which have not been considered in previous IT studies.

Theoretical background

IT outsourcing offers potential benefits to healthcare organizations [15-23]. It often involves restructuring firms around core competencies through the delegation of noncore functions to specialized external vendors [24]. This restructuring involves decisions about whether to conduct routine tasks in-house or through outside providers. IT industry studies have highlighted three potential benefits of outsourcing: the reduction of direct operating costs, specialization in core competencies, and the substitution of noncore competencies with inputs from a specialist provider [25]. First, IT outsourcing could reduce direct operating costs such as wages and managerial administrative overhead [26]. Cost reduction plays a significant role in sourcing decisions [27]. Second, asset specificity is involved when specific investments are required to support transactions and realize least-cost performance. Vendors who are involved in asset-specific transactions have a cost advantage over others. Thus, when an organization needs to minimize costs, outsourcing activities are worth consideration [28]. Third, there are benefits

from the substitution of noncore competencies with inputs from a specialist provider. An organization engaged in outsourcing can devote more resources to develop its core competencies. Organizations that outsource tend to develop better systems as a part of their outsourcing contracts. Accordingly, customers may see improvements in performance and productivity, and consequently, companies benefit from larger margins [29-30]. Thus, an advantageous substitution effect arises when an organization replaces its noncore operations with inputs from specialists who have in-depth knowledge.

However, IT outsourcing can also have negative consequences. Organizations lose some control when outsourcing IT services, as there are no longer in-house experts. IT outsourcing requires services be contracted up front, with any deviations from the contracted services adding considerable costs [31]. The decrease of in-house expertise and loss of control may lead to other unintended consequences, such as a decrease in informational integration, which is one of the key factors of IT productivity. Hence, focusing only on cost reductions when outsourcing can backfire if the resulting contract does not consider these drawbacks [22, 32-33].

Literature review

Health IT systems were adopted primarily to provide billing and financial services. Subsequently, the role of IT has expanded to provide clinical services for hospitals [34]. Health IT, including EMRs, is designed to improve communication among providers by automating the collection, use, and storage of patient information [35]. Moreover, health IT is intended to facilitate guideline compliance and decision support [36]. Numerous studies at academic hospitals provide evidence that special EMR functions, such as clinical decision support or computerized physician order entry, improve the quality of patient care by reducing errors [2-4]. Other studies that use large samples of hospitals have found that overall spending on health IT is

associated with improved patient safety, higher quality of care, and reduced costs [5-9]. Further, more recent studies have found that health IT adoption is reported to improve outcomes, clinical care [10, 35], efficiencies [37], and care coordination [34].

It is interesting then that studies examining the relationship between IT and productivity found health IT to have a significant but small impact on productivity. For example, Lee et al. [13] found that health IT inputs increased by >210% recently, but health IT inputs contributed only 6% to production. In addition, Huerta et al. [38] measured hospitals' total factor productivity (TFP) and compared it to nine different stages of EMR adoption. They found that adoption of EMR systems has lowered TFP gains compared to those facilities without EMR and that the anticipated savings from increased EMR use may not be achieved in the short term. Moreover, Ko and Osei-Bryson [31] stressed some complementary factors that improve productivity. They found that the impact of IT on productivity is not uniform but is contingent on other complementary factors such as both IT- and non-IT-related investments.

Research that examined the relationship between IT outsourcing and financial performance began in general business. The results are mixed. Some studies report cost savings [32, 39], higher financial performance as captured by Tobin's q and return on equity [40], and positive effects on stock price [41]. Other studies found negative effect [42-43] or no effect [44-45] on financial performance. Recent studies found that the effects of IT outsourcing on the firm-level attributes are small, even when they are statistically significant. Most firms spend only 3% of their revenue on IT. Thus, IT outsourcing may not be a large enough proportion of the overall budget to be captured by profitability analysis [46].

Only a few studies have attempted to measure the economic impacts of IT outsourcing on productivity. At the industry level, Han et al.'s [14] study reported that purchased IT services

contribute to productivity improvements. In addition, the study used a production function to analyze the economic impact of purchased IT services in 61 private sector industries in the United States. The study also measured IT outsourcing by accounting for the amount of purchased IT services. The results indicated that purchased IT services lead to more productive labor and make substantial contributions to industry output growth when the intensity of the industry-level IT is high.

At the firm level, Knittel and Stango [47] investigated the productivity impact of IT outsourcing on the credit union industry sector. They also argued that IT drives productivity growth by reorganizing the production of IT services. Further, the benefits of IT outsourcing may stem from the vendors' scales of specialization and efficiency, which can be facilitated by complementary investments. The study also constructed an IT outsourcing measure with a vector of indicator variables based on whether a firm uses in-house IT, a vendor-supplied system run in-house, or a vendor-supplied system run by the vendor at a remote location. The research found that IT outsourcing has considerable benefits for credit unions, primarily through cost savings.

More recently, Chang and Gurbaxani [48] examined the impact of IT outsourcing on the productivity of firms that choose IT service delivery, focusing on the role of IT-related knowledge. The study uses the Harte Hanks Computer Intelligence Technology database, which provides data from a variety of technologies in Fortune 1000 firms between 1987 and 1999. The study found that IT outsourcing results in productivity gains for firms. The research also argued that IT-related knowledge held by IT services vendors enables these productivity gains.

In terms of health IT outsourcing, healthcare providers outsource IT services for billing and data collection. For example, many hospitals are working with vendors who help with coding preparation, such as the international classification of diseases 9 and 10 [49]. With a

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demand for sophisticated IT, providers must accept that they need to purchase most of the emerging software and learn to work more effectively with it [50]. For example, in medical billing, clearinghouses function as intermediaries that send claims information from providers to insurance payers. Medical billing services take care of data entry and claims submissions, follow-up on rejected claims, pursue delinquent accounts, and even send invoices directly to patients [50]. In-house medical billing centers consume a huge capital to build and/or expand. For example, the Profitable Practice [50], a content-based medical blog that provides advice for effective practice management, has run a comparative cost-effectiveness analysis between in-house and outsourced billing costs. This source reported that the average cost of an in-house billing department is $118,000 versus $4000 in outsourced costs, and that the cost of software and hardware is $7500 if done in-house and $500 if done through outsourcing. Given the degree to which providers depend on electronic workflow, IT outsourcing could ensure the long-term viability of their businesses by saving costs.

Thus, hospitals stand to obtain benefits in performance, margins, and productivity by engaging in IT outsourcing [29-30]. IT outsourcing could be a way to cope with the variety of pressures currently experienced by healthcare providers. Few studies have examined the relationship between IT outsourcing and productivity in healthcare fields. Thouin et al. [51] studied the effects of different firm-level IT characteristics on financial performance in the healthcare industry. They also found that IT budgetary expenditures and the number of IT services outsourced are associated with the increased profitability, whereas IT personnel is not associated with the increased profitability. In addition, they recommended that IT administrators increase IT budgetary expenditures along with IT outsourcing levels. However, this study assumed IT and IT outsourcing were complementary goods, not substitutes. In other words, they

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neither compared the productivity gains from outsourced and in-house IT separately nor tried attempting to determine the most comparatively effective amount of outsourced IT. Moreover, they simply applied the maximum likelihood estimation to account for extreme outliers, not considering the endogeneity problem in the production function.

Thus, to fill this gap in the current literature, this study examines the effects of IT outsourcing on hospital productivity using California hospital data between 1997 and 2007. Unlike previous studies, this study compares the productivity gain between outsourced and in-house IT, allowing for both complementary and substitute services to be considered. It also attempts to determine the most comparatively effective amount of outsourced IT by analyzing hospital productivity. In addition, this study looks at how productivity from IT outsourcing differs depending on hospital characteristics and time trends. Moreover, this study applies DPD analysis to control for endogeneity problems in the production function.

Methods

A number of studies in economics and information systems (IS) have examined the effects of IT investments on outcomes at firm, industry, and country levels [52-55]. The most common approach used to model the relationship between IT and outcomes is the production function framework. In the production function approach, IT investment is treated as an input, with other inputs such as capital and labor. Most of these studies have measured returns on IT investments focusing on IT capital [4]. Among the various production function forms, the Cobb–Douglas production function is widely used for its simplicity and fit to the data. This production function is commonly used in the IT productivity [13, 52, 56-57] and services outsourcing literature [58].

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Econometric Model

I modeled value-added output (Y_{it}) for hospital i in period t whose inputs are non-IT labor

(L_{it}), non-IT capital (K_{it}), IT labor ($L_{C,it}$), IT in-house capital ($K_{C,it}^I$), and IT outsourced capital

($K_{C,it}^O$)[2]. Therefore, hospital production can be expressed as follows:

$$Y_{it} = f(L_{it}, K_{it}, L_{C,it}, K_{C,it}^I, K_{C,it}^O) \tag{1}$$

The production function is estimated using the Cobb–Douglas specification, which is widely

used to represent the relationship of an output to inputs. Taking logarithms of the Cobb–Douglas

function yields an estimated linear regression. I used lowercase variables to denote logarithms of

inputs, and the vector x_{it} comprises the entire set of logged hospital inputs. Further, I employed

hospital and time fixed effects (FE) to account for time-invariant cross-hospital differences.

$$y_{it} = \beta_l l_{it} + \beta_k k_{it} + \theta l_{C,it} + \delta_1 k_{C,it}^I + \delta_2 k_{C,it}^O + \epsilon_{it} \tag{2}$$

In equation (2), β_l, β_k, θ, δ_1, and δ_2 are the output elasticities for each respective input. In this

regression, I am interested in the δ_1 and δ_2 terms that measure the contributions of in-house and

outsourced health IT to output. Hospitals may have information on ϵ_{it} when selecting their

inputs. Thus, I decompose this unobserved error term into four components:

$$\epsilon_{it} = \gamma_t + \eta_i + v_{it} + m_{it} \tag{3}$$

where γ_t is a year-specific effect representing a common technology shock, η_t is a time-invariant

hospital fixed effect, v_{it} is an unobserved productivity shock, and m_{it} is a serially uncorrelated

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[2] The output was measure as value-added, a common measure of output in productivity studies. That is, output was measured as operating revenues less intermediate inputs. This measure was selected for two reasons: First, hospitals produce multiple products and these must be aggregated into a single output measure; and second, production is heterogeneous across hospitals. The value-added production function accounts for quality reflected in market prices and quantities.

measurement error. Both γ_t and η_i may be correlated with the inputs. The unobserved

productivity shock, v_{it}, evolves according to an autoregressive process and may be correlated

with the observed inputs. Finally, m_{it} is a productivity shock that may be correlated with an

input choice and may evolve according to a moving average process.

Correlation between the inputs and ϵ_{it} implies that the standard approaches to the

parameter estimation are biased. Suppose that hospitals operate in perfectly competitive input

and output markets and that they perfectly observe error terms before choosing inputs. A

hospital's current choice of inputs would be correlated with error terms such as productivity

shock. The appropriate econometric approach involving the removal of the bias relies upon the

assumptions regarding the variation in γ_t, the evolution of v_{it}, and the timing of input selection

[59].

The primary model is the DPD approach used in the works of Arellano and Bond [60],

Arellano and Bover [61], and Blundell and Bond [62]. The DPD approach is suitable in the

context as it allows for a time-invariant fixed effect in the evolution of unobserved productivity.

Many hospital characteristics such as location or religious affiliation, are time-invariant, whereas

other aspects of hospital productivity (e.g., physician affiliation or reputation) evolve over time.

Thus, the DPD framework better fits the institutional setting and provides internally consistent

sources of variation that can be used to identify the parameters. Finally, the DPD approach is

more robust to input measurement error.

Assume v_{it} evolves according to the autoregressive process $v_{it} = \rho v_{it-1} + e_{it}$, where

e_{it} is an independent, identically distributed random shock. Then, the key assumption is that the

innovation in unobserved productivity, e_{it}, is uncorrelated with the independent variables. Even

though ϵ_{it} has a hospital fixed effect and a productivity component, it may be correlated with

other independent variables. Thus, solving v_{it-1} and substituting it into equation (2) yields the dynamic factor representation:

$$y_{it} = \rho y_{it-1} + \beta_l l_{it} - \rho\beta_l l_{it-1} + \beta_k k_{it} - \rho\beta_k k_{it-1} + \gamma l_{C,it} - \rho\gamma l_{C,it-1} + \delta k_{C,it}^I - \rho\delta k_{C,it-1}^I +$$
$$\eta k_{C,it}^O - \rho\eta k_{C,it-1}^O + \gamma_t - \rho\gamma_{t-1} + \eta_i - \rho\eta_i + e_{it} + m_{it} \qquad (4)$$

or

$$y_{it} = \pi_1 y_{it-1} + \pi_2 l_{it} + \pi_3 l_{it-1} + \pi_4 k_{it} + \pi_5 k_{it-1} + \pi_6 l_{C,it} + \pi_7 l_{C,it-1} + \pi_8 k_{C,it}^I + \pi_9 k_{C,it-1}^I +$$
$$\pi_{10} k_{C,it}^O + \pi_{11} k_{C,it-1}^O + \gamma_t^* + \eta_i^* + e_i^* \qquad (5)$$

where the common factor restrictions are $\pi_3 = -\pi_1\pi_2$, $\pi_5 = -\pi_1\pi_5$, $\pi_7 = -\pi_1\pi_6$, $\pi_9 = -\pi_1\pi_8$, and $\pi_{11} = -\pi_1\pi_{10}$. Moreover, $\eta_i^* = \eta_t(1-\rho)$ and $e_i^* = e_{it} + m_{it}$.

Ordinary least squares (OLS) and FE estimation will generate a consistent estimator under a restrictive assumption. However, the DPD model consistently estimates parameters under a less restrictive assumption than OLS and FE.

The DPD framework also allowed us to address the potential time-varying sources of endogeneity in competing hospitals' adoption of IT and to simultaneously estimate the equation of interest using both level and difference specifications where appropriate lags of the levels and differenced variables could be used as instruments. Lagged levels are used as instruments for the difference equation, whereas lagged differences are used as instruments for the level equation. All the independent and dependent variables were used as instrument variables for the difference and level equations. These simultaneous estimation strategies result in lower finite sample bias and increased precision.

This estimation strategy is especially useful when data are highly persistent because previous estimation methods, such as the first difference generalized method of moments (GMM) estimation, have been criticized for their weakness in capturing the contemporaneous differences

when data are highly persistent [61, 63]. Weak instruments could cause large sample biases, where the standard errors are more likely to underestimate the real variability of the estimators [64]. In the context of growth regression variables, such as human and physical capital, a differenced GMM procedure used to estimate autoregressive models is not likely to perform well [62].

The DPD approach herein used a specific moment condition as follows:

$$E = [\Delta x_{it-s}(\eta_i^* + e_i^*)] = 0 \text{ and } E = [\Delta y_{it-s}(\eta_i^* + e_i^*)] = 0, \text{ for } s \geq 1 \text{ and } t \geq 3 \tag{6}$$

$$E = [x_{it-s}\Delta e_i^*] = 0 \text{ and } E = [y_{it-s}\Delta e_i^*] = 0, \text{ for } s \geq 2 \text{ and } t \geq 3. \tag{7}$$

The values of *t* and *s* are determined by the assumption on the autocorrelation structure in m_i. This assumption can be validated by testing whether the first differenced residual exhibits the second-order serial correlation. In the analysis, the specification tests indicated that *s* = 3 removed the serial correlation; therefore, this value was used in the estimation. Further, because the model used over-identification to represent a larger number of instrument variables than endogenous variables, the over-identification of instrument variables was tested using the Sargan–Hansen test, a standard GMM test for over-identifying restrictions.

Data and variables

This study used California annual hospital financial data between 1997 and 2007 provided by the Office of Statewide Health Planning and Development (OSHPD). Approximately 324 acute care California hospitals were included for each of the 11 years, leading to 2904 hospital years. The data formed an unbalanced panel.

To assess the impact of IT outsourcing on hospital productivity, I estimated the parameters of a hospital's value-added production function using labor, capital, IT labor, in-

house IT capital, and in-house IT capital. For the purposes herein, value added is defined as a total operating revenue with less intermediate inputs. Total operating revenue is the sum of the revenue of daily, ambulatory, and ancillary hospital services, which are in the income statement. Intermediate input is defined as the total operating supplies in the trial balance worksheet and supplemental information sheet. Labor includes salaries; wages; employee benefits; professional fees; depreciation (not capital stock); rentals, leases, and other direct expenses of hospital services; ambulatory services; ancillary services; research; education; general services; fiscal services; administrative services; and unassigned costs less supplied materials. Excluded from labor, however, are salaries, wages, employee benefits, professional fees, and other expenses related to IT investment. Capital is defined as total assets including current assets; property, plant, and equipment; investment and other assets; intangible assets; and assets with limited use.

As the key explanatory variable, health IT is measured as a dollar amount in both capital and labor related to IT. The OSHPD data placed all IT expenditures within the data processing section of the financial statements. Health IT capital and IT labor are measured in dollars and are extracted from each hospital's balance sheet.

IT labor was categorized as expenditure in data processing and defined as:

L = Salaries and Wages + Employee Benefits + Professional Fees   (8)

Health IT capital was defined as:

K_I^C = Physical Capital + Other Direct Expenditure;   (9)

K_{IO}^C = Purchased Service + Lease and Rental   (10)

where physical capital represents hardware. The IT outsourcing variable was constructed based on the work of Lee et al. [13] and Han et al. [14], which included purchased services and leases

and rentals. The OSHPD data reported depreciation only of health IT physical capital. Thus, to reconstruct the actual physical capital, I used the 5-year straight-line method of depreciation [13].

The OSHPD reported the abovementioned four categories as IT outsourcing in trial balance worksheets and supplemental information sheets. However, the OSHPD did not provide more detailed information regarding cloud-based systems, off-campus systems, or other examples. However, based on their hospital financial data and the other literature [13, 50], IT outsourcing included all IT activities and services in hospitals, a more broad-based measure of IT outsourcing compared to prior studies [49-50].

Results

Descriptive Statistics

Table 1 provides descriptive statistics in 2007 dollar values. The mean values of value-added, IT labor, in-house IT capital, and outsourced IT capital are provided as both levels and shares relative to value added. Not-for-profit hospitals comprised 55% of the sample, whereas for-profit and government-owned hospitals comprised 25% and 20%, respectively. On average, for-profit hospitals are considerably smaller than not-for-profit and government hospitals.

<Table 1>

Total health IT labor increased by 213%, from $0.87 million in 1997 to $2.71 million in 2007. Health IT capital investment was heterogeneous. Outsourced IT accounted for 34% of overall IT investment, while in-house IT accounted for the remaining amount of overall IT investment. Outsourced health IT capital inputs increased by 458%, from $0.86 million in 1997 to $3.96 million in 2007, while in-house IT capital inputs increased by 264%, from $2.1 million

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in 1997 to $5.7 million in 2007. Further, I observed that IT investment was considerably

different across ownership structures[3].

Even though the raw value of IT capital investment increased, the share of in-house IT

capital investment in both for-profit and not-for-profit hospitals decreased over the sample period.

For-profit hospitals and not-for-profit hospitals reduced in-house IT investment by around 1%

and 0.4% points, respectively. However, government hospitals increased in-house IT investment

by 0.7% points.

On the other hand, the share of outsourced IT investment increased over time in each of

the three types of hospital ownership structures. For example, for-profit and not-for-profit

hospitals increased their share of outsourced IT investment by around 200% over the value added.

In contrast, government hospitals' share of outsourced IT investment increased by only 20% over

the value added. This suggests that ownership plays an important role in IT investment. Hospitals

across ownership structures have different production technologies, face different input costs,

and have different objectives in their utilization of health IT.

Production function estimates

To examine whether IT outsourcing has contributed to productivity in hospitals, I

estimated the Cobb–Douglas production function using the full sample of 2904 observations,

which comprised spending at 324 unique hospitals in California each of the 11 years. The

estimates are shown in Table 2.

<Table 2>

The first two columns present estimates of OLS and FE. Estimated parameters of the

DPD model are presented in column 3. The OLS and FE model estimates were almost all lower

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[3] Other variables, like general capital and labor, were explained in another paper (Lee et al., 2013)

than the estimates made using the DPD model. This was consistent with the existing literature

that estimated production function parameters and suggested that input choices are endogenous

[13]. The DPD estimates indicate that in-house and outsourced IT capital and IT labor are very

productive represented by coefficients that are significantly different from zero. Common factor

restrictions were not rejected for the DPD model but were rejected for the OLS and FE estimates.

The Hanson p-value was 0.47 indicating that the over-identification restrictions were not rejected.

Moreover, this DPD approach allowed for an AR(1) component in the production function. This

allowance for serial correlation was required to obtain valid lagged instruments for equations.

The p-values of the first- and second-order AR tests are 0.000 and 0.275, respectively. These

results indicated that the autoregressive parameter is only weakly identified from the first-

differenced equations, and that there was dramatic reduction in finite sample bias using

additional moment conditions [62]. The regression result showed that the output elasticity

estimate for IT outsourcing was significant, ranging from 0.006 to 0.014. This result indicated

that IT outsourcing made positive and significant contributions to production in California

hospitals between 1997 and 2007. The elasticity is relatively small in comparison to that found in

other research [28], which used industry-level data showing that the output elasticity estimate for

IT outsourcing was significant, ranging from 0.021 to 0.042. Finally, parameter estimates did not

reject a constant return to scale technology.

On the basis of the coefficients of in-house IT and outsourced IT, I calculated the short-

term marginal product. The outcome elasticity of K^c is defined as $E_{K^c} = \frac{\vartheta Y}{\vartheta K^c} \frac{K^c}{Y} = \theta \frac{Y}{K^c} \frac{K^c}{Y} = \theta$.

Then, the short-run gross marginal product is defined as $MPK^c = \frac{\vartheta Y}{\vartheta K^c} = \frac{\vartheta Y}{\vartheta K^c} \frac{Y}{K^c} \frac{K^c}{Y} = \theta \frac{Y}{K^c}$. The

short-run gross marginal product was approximately 50% higher than the marginal product of in-

house IT, 66.7% for in-house IT, and 100% for outsourced IT. These figures suggested that

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outsourced IT is more productive than in-house IT in the short run. However, in-house IT is a stock variable, which is measured at a specific point in time. Therefore, to measure the marginal product of in-house IT, the calculation of long-run effects was required. This calculation depends on the opportunity cost of capital (9%) and the depreciation rate over 4 years[4].

The long-run effects were simulated on the basis of the regression results. First, value-added production was calculated using the predicted values. Each of the exponents below represents elasticity estimated in the DPD model in Table 2.

$$y_{0\_it(base)} = \alpha * l_{it}^{0.776} * k_{it}^{0.147} * l_{C,it}^{0.019} * k_{C,it}^{I\ 0.018} * k_{C,it}^{O\ 0.014} * u_{it} \tag{11}$$

Second, I calculated the 4 years of value-added production based on the following formula:

$$y_{d\_it} = l_{it}^{0.776} * k_{it}^{0.147} * l_{C,it}^{0.019} * \left(1 + (1 - 0.25 * d)\right) * k_{C,it}^{I\ 0.018} * k_{C,it}^{O\ 0.014} * u_{it} \tag{12}$$

where d represents the depreciation year varying from 1 year to 4 years, meaning in-house IT capital depreciated up to 4 years, until the end of its useful life.

Third, I calculated present value (PV) by summing the difference between base value and productivity each year, multiplied by opportunity cost, as follows:

$$PV = \left(y_{1\_it} - y_{0\_it(base)}\right) * e^{-0.09} + \left(y_{2\_it} - y_{0\_it(base)}\right) * e^{-0.09*2} + \left(y_{3\_it} - y_{0\_it(base)\_}\right) *$$

$$e^{-0.09*3} + \left(y_{4\_it} - y_{0\_it(base)}\right) * e^{-0.09*4} \tag{13}$$

The average of PV represents the long-term effects of the marginal product of in-house IT.

On the basis of the previous calculation with straight-line depreciation, the long-run net marginal product of in-house IT ranged from 152% to 177%. The value of in-house IT capital would be substantially higher if it remained fully productive until the end of its useful life. In

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[4] I used the general measure of opportunity cost of capital as reported by Christiano et al. [87] and Lee et al. [13]. Outsourced IT was treated as flow inputs. I reached similar conclusions when varying the cost of capital (5% to 10%) or depreciating IT capital over a three- to five-year period. However, the overall conclusions were consistent with these alternative assumptions.

either case, the long-run benefits of in-house IT more than compensate for the short-run benefits of outsourced IT.

I also examined how the degree of outsourced IT was associated with hospital productivity because the amount of outsourcing in fact matters [65-68]. Table 3 presents the results of dividing the sample into three categories based on the proportion of outsourced IT out of total IT capital. The three categories were defined as ≤50%, >50% and ≤80%, and >80%. According to Lacity et al. [69], institutions should be careful in the process of deciding between outsourcing and in-house IT activities. While the outsourcing of IT activities can range between two extremes—total outsourcing or total insourcing—outsourcing activity should be a continuous variable, such as the percentage of outsourcing activities, as in the sample of hospitals in this study. Following Lacity et al., [69], I adopted a continuous measure of outsourcing IT.

<Table 3>

The findings show that hospitals that outsourced >50% and ≤80% of their overall IT had significant gains from in-house and outsourced IT. In particular, hospitals that engaged in outsourcing in this range were the only hospitals that saw productivity gains from outsourced IT. The other two categories of hospitals only had productivity gains from in-house IT.

Organizational characteristics and spillover effects

This subsection examines more ancillary questions to understand the mechanisms through which outsourced IT is associated with productivity. In particular, I examined how productivity is affected by ownership structure, hospital size, and spillover effects.

Table 4 presents production function estimates by hospital ownership structure. Several studies have reported that hospital ownership plays an important role in the organizational objectives of hospitals [13, 70-71]. In all three ownership structures studied, the regression results showed that in-house IT was positively associated with hospital productivity, but outsourced IT was not. Table 1 shows that hospital ownership influenced levels of investment in outsourced IT, but that these different IT adoption behaviors may not be associated with increased productivity.

<Table 4>

I also examined whether there was meaningful hospital-level heterogeneity with regard to the impact of outsourced IT on hospital productivity in Table 5. This heterogeneity may be related to hospital size or to IT adoption time. To examine this issue, I divided the sample into two groups on the basis of the number of staffed beds and the year. Then, I estimated parameters for each of the two sub-samples.

<Table 5>

Column (1) of Table 5 presents the results from dividing the sample in a median-sized hospital (173 staffed beds). Smaller hospitals (173 staffed beds or fewer) showed significant productivity gains from both outsourced IT capital and in-house IT capital. However, the size of the gain was larger from outsourced IT capital than from in-house IT capital. On the other hand, larger hospitals (>173 staffed beds) only showed productivity gains from in-house IT capital and none from outsourced IT capital.

Finally, I found that improvements in the productivity of health IT occurred over a considerable span of time. Thus, rapid innovation would lead us to underestimate the impact of future outsourced health IT investments. Accordingly, I tested for spillover effects by examining

whether the output elasticity of outsourced IT increased over the 11 years of the study data. I divided the data into two subsamples on the basis of the years of observation. The time periods of the samples were 1997–2001 and 2002–2007. Column (2) of Table 5 presents the production function parameter estimates for these two subsamples. Estimation results suggest that outsourced IT was more productive in earlier periods than in later periods. However, during the earlier period, in-house IT did not lead to a productivity gain.

Discussion

In hospital settings, IT outsourcing has the potential to create value. Despite much evidence to this end [22, 30-42, 77-78], the adoption of IT outsourcing in healthcare lagged behind other industries during the study period. IT capital investment itself accounted for only 1–2% of revenue in 2007 (OSHPD), which was substantially lower than that seen in other industries; 6.33% in retail trade, 3.39% in wholesale trade, 18.30% in finance/insurance, and 27.09% in information sectors [72].

Previous studies on the effects of IT outsourcing on firm performance have found that the value of IT outsourcing lies in cost reduction from vendors [73-74]. Vendors achieve these lower costs through economies of scale, economies of scope, and economies of specialization [75]. This cost structure changes output levels and productivity. Another study explained that the value of IT outsourcing is in new capabilities and fundamental transformations in customer organizations facilitated by vendors [76].

The objective function of hospitals is different from other general firms. For example, hospitals aim to optimize the quality and cost in the current payment system that is being shifted toward value-based reimbursement. Thus, the benefits of IT outsourcing in hospitals may differ

from the benefits in other industries because IT in hospitals was reported to improve quality and reduce cost [2-10]. Further, the theoretical effect of IT capital ownership on productivity is unclear in the context of hospitals. In-house IT assets will have consequences for long-term productivity, while outsourced IT will be more productive in the short-term with vendors' specialized technical skills because they will be largely responsible for upkeep, capital replacement, and other aspects of the trade. This situation might be particularly important for IT. Alternatively, a hospital might have greater incentives to use IT productively. Hospitals might also make more complementary investments with in-house IT than with outsourced IT.

This study focuses on the issue of hospital productivity and finds a positive effect of IT outsourcing on hospital productivity. Moreover, this study demonstrates the comparative effectiveness between outsourced IT and in-house IT, showing that outsourced IT is substantially associated with hospital productivity. Indeed, the short-term marginal product of outsourced IT is almost twice that of in-house IT. This implies that a hospital may invest in more outsourced IT to improve productivity in the short run. This finding is consistent with the work of Broedner et al., which argues that outsourcing improves short-run productivity [84]. In the long run, however, the marginal product of in-house IT is larger than that of outsourced IT. Thus, outsourced IT is comparatively more effective than in-house IT in the short run, while their productivity gains are opposite in the long run.

This result is consistent with the other IT industry literature [77-78]. These previous studies argue that as firms increasingly outsource IT, they may lose control of IT resources. As firms outsource more, they retain only a limited number of IT employees and are left with insufficient managerial and personnel skills to maintain control over ongoing IT projects [77]. In contrast, IT vendors make specific investments in physical or human capital, and are more likely

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to commit to specific computer systems and institutional environments [61, 66]. This particular

dynamic may lead to skewed relationships between firms and vendors because of the lock-in

effect. This environment may result in moral hazard among vendors. Moreover, the systems as

designed by vendors may not meet the information needs of the client firms [79]. These two-way

disadvantages ultimately result in many risks in IT outsourcing. For example, delayed delivery of

data and the slow implementation of IT projects have been reported [13]. In addition, other

studies found risky components of IT outsourcing, including the degradation of IS services and

vendor attitude problems [80-81]. Accordingly, I investigated how much IT outsourcing is

needed to maximize productivity and found that the amount of IT outsourcing plays a significant

role in production. Hospitals that do not engage in "too much" IT outsourcing have significant

productivity gains from their outsourced IT. This finding is consistent with previous studies.

Lacity and Willcocks [6] found that clients who outsourced >80% of their IT budgets had

success rates lower than 30%, but clients who outsourced less than 80% of their IT budgets had

success rates higher than 80%. Thus far, research on IT outsourcing has dealt with topics

including the decision to outsource [82], vendor issues [83], and the mitigation of out-sourcing

risks [84]. In line with these studies, the findings may help to determine the appropriate amount

of IT outsourcing for hospital managers.

Moreover, this study found that IT capital investment behaviors differ across ownership

structures. The share of outsourced IT considerably increased in for-profit and not-for-profit

hospitals between 1997 and 2007. Conversely, government hospitals increased their share of in-

house IT capital over the same period. However, this differing IT adoption behavior could not be

observed in the DPD parameter estimates. I also found that hospitals with fewer beds showed

production gains from outsourced IT. For many small- and medium-sized firms, IT is an

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attractive area for outsourcing because it is one of the most expensive areas for an organization to establish and maintain [85]. This result in the study was also consistent with that of Ang and Straub [86]; the size of the banking establishment had a considerable impact on the decision to outsource, with smaller firms more likely to outsource. Thus, IT outsourcing is potentially more cost-effective than adopting an in-house IT system. Finally, I found that early adopters have productivity gains from outsourced IT over in-house IT. The early period is a mitigating trial period because learning is slow and supplier capabilities are not fully tested. However, there may be a trade-off between the benefits from in-house and outsourced IT during this particular period of time [87].

Overall, this study found the following results: (1) the association between outsourced IT and hospital productivity was positive, and the short-term marginal product of outsourced IT was almost twice that of in-house IT, at 66.7% for in-house IT and 100% for outsourced IT. (2) In the long run, the marginal product of in-house IT is larger than that of outsourced IT; the long-run net marginal product of in-house IT ranged from 152% to 177%. Thus, outsourced IT was comparatively more effective than in-house IT in the short run, whereas productivity gains were opposite in the long run. The linear combined marginal product of in-house and outsourced IT was 167% in the short run and ranged from 218.7% to 243.7% in the long run[5]. (3) The optimal level of IT outsourcing was >50% and ≤80% of overall IT spending. (4) Hospitals with fewer beds showed production gains from outsourced IT. (5) Early adopters had productivity gains from outsourced IT over in-house IT. However, there were trade-offs between the benefits from in-house and outsourced IT.

Conclusion

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[5] p-value of linear combinations of variables was less than 0.01

This study examined the effects of outsourced IT capital investment on hospital productivity. The study found that IT outsourcing in hospital settings potentially creates value. This study makes some important contributions. First, it provided a better understanding of the economic value of IT outsourcing by focusing on productivity and the comparative effectiveness between outsourced and in-house IT. Second, it found that hospital productivity varied depending on hospital characteristics and time trends. Finally, this study applied a production function using the DPD equation to reflect the outsourcing decision process, which allowed me to estimate the productivity effects of IT outsourcing while controlling for potential endogeneity.

Adoption of IT outsourcing in the healthcare industry is problematic because there has not been clear evidence of an efficiency gain associated with investments in outsourcing IT. I believe that this study's findings will help managers of healthcare organizations in restoring IT adoption strategies. Smaller hospitals could achieve more productivity gain from IT outsourcing than larger hospitals could. IT outsourcing in the range of 50%–80% may be the best option to achieve meaningful productivity gain. Moreover, the largest gains from IT outsourcing will be seen early on with diminishing returns. Then, client hospitals should focus on in-house IT capital that complements provider capabilities. Because IT vendors may become better positioned to deliver IT services over time, hospitals should periodically evaluate their sourcing strategies.

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Table 1. Mean and standard deviation in $1000 and share of input as a % of value added

Entire Sample								
Variable	Total	Share	FP	Share	NFP	Share	GOV	Share
Value added (y)	133,895	100.0%	74,892	100.0%	164,548	100.0%	124,326	100.0%
	(181,806)		(71,881)		(208,531)		(180,735)	
IT Labor (L^C)	1576	1.2%	539	0.7%	2025	1.2%	1616	1.4%
	(3146)		(903)		(3793)		(2678)	
IT Capital, owned (K_I^C)	3636	2.7%	572	0.8%	5176	3.1%	3278	2.6%
	(8579)		(1297)		(10,500)		(6760)	
IT Capital, outsourced (K_{IO}^C)	1901	1.4%	734	1.0%	2646	1.6%	1330	1.1%
	(4040)		(982)		(5121)		(2230)	
1997								
Value added (y)	83,889	100.0%	35,110	100.0%	101,514	100.0%	81,528	100/0%
	(109,648)		(29,756)		(1101,840)		(134,698)	
IT Labor (L^C)	867	1.0%	247	0.7%	1108	1.1%	793	1.0%
	(943)		(268)		(2027)		(1228)	
IT Capital, in-house	2147	2.5%	404	1.9%	30,48	2.8%	1407	2.1%
	(4454)		(890)		(5469)		2535	
IT Capital, outsourced	866	1.0%	310	0.8%	1107.4	1.1%	739	1.0%
	(1385)		(564)		(1459)		(1538)	
2007								
Value added (y)	214,317	100.0%	115,876	100.0%	281,136	100.0%	159,184	100.0%
	(262,092)		(92,247)		(316,109)		(186,868)	
IT Labor (L^C)	2712	1.3%	914	0.8%	3507	1.2%	2794	2.1%
	(5140)		(1516)		(5616)		(4519)	
IT Capital, in-house	5662	2.1%	846	0.9%	8374	2.4%	4389	2.8%
	(12,842)		(1507)		(16,088)		(8427)	
IT Capital, outsourced	3967	2.0%	1486	1.5%	5817	2.5%	2154	1.2%
	(7344)		(1848)		(9257)		(3693)	

Note: NFP is not-for-profit, FP is for-profit, and GOV is government

Table 2. Comparison of production function parameter estimates among OLS, fixed effect, and DPD models.

	OLS	Fixed Effect	DPD
Labor	0.779***	0.602***	0.776***
	(0.030)	(0.072)	(0.046)
Capital	0.099***	0.089***	0.147***
	(0.014)	(0.015)	(0.026)
IT Labor	0.012***	0.011***	0.019***
	(0.003)	(0.003)	(0.007)
IT Capital, in-house	0.014***	0.012***	0.018***
	(0.002)	(0.003)	(0.005)
IT Capital, outsourced	0.006***	0.006**	0.014**
	(0.002)	(0.003)	(0.007)
Rho	0.809***	0.565***	0.693***
	(0.027)	(0.034)	(0.042)
Com Fac	0.000	0.000	0.092
AR(1)			0.000
AR(2)			0.169
Sargan–Hansen test			0.000/0.540

Note: DPD is dynamic panel data and standard errors are in parentheses

***: $p < 0.01$, **: $p < 0.05$, *: $p < 0.10$

Table 3. DPD estimates by the percent of IT outsourcing

	Percentage of outsourced IT over total IT		
	≤ 50%	50% < X ≤ 80%	> 80%
Labor	0.773***	0.665***	0.709***
	(0.028)	(0.037)	(0.038)
Capital	0.144***	0.192***	0.127***
	(0.020)	(0.0220	(0.025)
IT Labor	0.024***	0.014**	0.025***
	(0.007)	(0.006)	(0.005)
IT Capital, in-house	0.028***	0.012***	0.014***
	(0.004)	(0.005)	(0.003)
IT Capital, outsourced	0.004	0.014**	0.004
	(0.005)	(0.007)	(0.006)
Rho	0.605***	0.649***	0.656***
	(0.035)	(0.038)	(0.046)
Com Fac	0.013	0.000	0.067
AR(1)	0.000	0.000	0.000
AR(2)	0.608	0.395	0.192
Sargan test	0.000	0.000	0.000

Note: Standard errors are in parentheses

***: $p < 0.01$, **: $p < 0.05$, *: $p < 0.10$

Table 4. DPD estimates by ownership structure

	Profit	NFP	Government
Labor	0.927***	0.561***	0.471***
	(0.041)	(0.065)	(0.073)
Capital	0.062**	0.087***	0.109***
	(0.026)	(0.033)	(0.031)
IT Labor	0.030***	0.007*	0.040***
	(0.008)	(0.004)	(0.010)
IT Capital, in-house	0.011**	0.008**	0.018***
	(0.005)	(0.004)	(0.005)
IT Capital, outsourced	0.008	0.007	0.017
	(0.006)	(0.006)	(0.013)
Rho	0.664***	0.884***	0.873***
	(0.047)	(0.036)	(0.023)
Com Fac	0.413	0.007	0.000
AR(1)	0.000	0.000	0.000
AR(2)	0.669	0.473	0.038
Sargan–Hansen test	0.000/1.000	0.000/1.000	0.000/1.000

Note: Standard errors are in parentheses

***: $p < 0.01$, **: $p < 0.05$, *: $p < 0.10$

Table 5. DPD estimates by time frame, bed size, and IT outsourcing

	Number of beds		Year	
	Smaller (≤ 173)	Larger (> 173)	Early (≤ 2001)	Later (> 2001)
Labor	0.668***	0.826***	0.460***	0.784***
	(0.075)	(0.044)	(0.148)	(0.047)
Capital	0.139***	0.112***	0.220**	0.145***
	(0.033)	(0.026)	(0.093)	(0.027)
IT Labor	0.022***	0.007	0.012	0.020***
	(0.007)	(0.005)	(0.028)	(0.007)
IT Capital, in-house	0.009**	0.021***	-0.012	0.020***
	(0.005)	(0.004)	(0.017)	(0.004)
IT Capital, outsourced	0.013*	0.007	0.050**	0.016***
	(0.007)	(0.006)	(0.025)	(0.006)
Rho	0.827***	0.756***	0.878***	0.667***
	(0.051)	(0.040)	(0.100)	(0.042)
Com Fac	0.048	0.033	0.855	0.100
AR(1)	0.000	0.000	0.001	0.000
AR(2)	0.252	0.189	0.264	0.758
Sargan–Hansen test	0.000/1.000	0.000/1.000	0.018/0.746	0.000/0.361

Note: Standard errors are in parentheses

***: $p < 0.01$, **: $p < 0.05$, *: $p < 0.10$