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The Effects of the Assimilation and Use of IT Applications on Financial Performance in Healthcare Organizations

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Abstract

This research examines the impacts of the assimilation and use of IT on the financial performance of hospitals. We identify two dimensions of IT assimilation and use. They are the IT applications architecture spread, which is the adoption of a broad array of IT solutions, and IT applications architecture longevity, which is the length of experience with use of specific IT solutions. We examine the extent to which these dimensions of assimilation within the business and clinical work processes impact hospital performance. Compared with the effects of IT applications architecture spread, we find that the IT applications architecture longevity has a more significant effect on financial performance. In addition, the effects of assimilation manifest differently across the business and clinical process domains. Our results enhance understanding about the manner in which the assimilation and use of IT contributes to the financial performance of hospitals.

***Keywords**: Health Care, Synergies, Enterprise IT Architectures, Financial Performance, IT Value.*

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1. Introduction

Information technology is regarded as a significant lever for enhancing the performance of healthcare organizations.[1] Therefore, policy makers in the US and other countries have taken steps to facilitate the effective assimilation and use of IT in these organizations. In an acknowledgement of the strategic importance of IT, researchers have begun to examine the relationship between IT investments and the financial performance of healthcare organizations (Menon, Lee, & Eldenburg, 2000; Menon, Yaylacicegi, & Cezar, 2009). Conceptualizations about the business value of IT have identified the different processes and mechanisms through which IT impacts firm performance (Sambamurthy, Bharadwaj, & Grover, 2003; Barua & Mukhopadhayay, 2000). However, there is a need for empirical research that provides a more detailed calibration of the impact of IT on healthcare performance.

Researchers have examined the effects of information technology on firm performance in other industries (Bharadwaj, Bharadwaj, & Konsynski, 1999; Melville, Kraemer, & Gurbaxani, 2004; Mittal & Nault, 2009). Results from these studies suggest that the impacts are based on the portfolio of IT applications being used by a firm (Aral & Weill, 2007; Dehning, Richardson, & Zmud, 2003). These studies indicate that the performance impacts of IT applications vary across different categories of applications. Other research has argued that the assimilation and use of IT has an important role in enhancing firm performance (Devaraj & Kohli, 2003). Assimilation refers to the extent to which information technologies are being used within the key processes and activities in organizations (Cooper & Zmud, 1990). Devaraj & Kohli (2003) argue that the performance benefits of IT may not fully materialize unless those technologies are actually being assimilated and used. Assimilation is particularly important not only because the levels of IT assimilation are generally low in most firms (Fichman & Kemerer, 1997), but also because it reflects an organization’s experience with managing and mastering the complex mutual adaptation processes for the organizational use of IT (Purvis, Sambamurthy, & Zmud, 2001; Leonard-Barton, 1995).

Our research examines how the assimilation and use of IT impacts the performance of healthcare firms. Earlier studies of assimilation have focused either on specific technologies (e.g., Fichman & Kemerer, 1997; Angst & Agarwal, 2009), or their degree of use in specific business processes and activities (Armstrong & Sambamurthy, 1999; Pavlou & El Sawy, 2006; Ray, Muhanna, & Barney, 2005). In contrast, our research focuses on the assimilation and use of a broad array of health information technologies. We draw upon the Ross, Weill, and Robertson (2006) conceptualization of enterprise architectures to examine the effects of two novel dimensions of IT assimilation and use. The first dimension examines the effects of adopting, assimilating, and using a greater number of healthcare information technologies. A broad array of IT applications is available to support the specific needs of clinical and business processes in hospitals. However, their adoption rates tend to vary due to the complex social contagion forces in play (Angst, Agarwal, Sambamurthy, & Kelley, 2010). Therefore, we examine the effects of a hospital’s ability to explore and use a large array of healthcare IT applications in its enterprise architecture in the form of a dimension termed the IT Application Architecture Spread (ITAAS). The second dimension captures the degree of experience with assimilating and using healthcare IT applications. Theories of technological assimilation argue that organizations develop knowledge about how to use IT by experimenting with the applications, routinizing their features, and making mutual adaptations among the applications and the work processes where they are applied (Leonard-Barton, 1995; Purvis et al., 2001). These mechanisms of assimilation take time to occur. Therefore, we conceptualize IT Applications Architecture Longevity (ITAAL) as the extent of experience that hospitals have with using specific IT applications in their enterprise architecture.

[1] For example, in 2008, the US Government established the position of the National Coordinator for Health Information Technology through an Executive Order. The National Coordinator is responsible for the development, maintenance, and oversight of a strategic plan for nationwide adoption of health information technologies.

We use a framework employed in the new product development literature (Katila & Ahuja, 2002; Rothaermel & Deeds, 2004) and archival data from HIMSS Analytics[2] to operationalize these two dimensions of hospitals' IT applications architectures. Further, since there is a distinction between the sets of activities that constitute business versus clinical processes in hospitals (Menon et al., 2009), we examine the effects of IT Applications Architecture Spread and Longevity in each of those two domains of a hospital's work processes.

The rest of this paper is organized as follows. In the next section, we present our theoretical and conceptual arguments and research hypotheses. Next, we describe the details of our data and analysis. Finally, we present our results and discuss their implications for future research and practice.

2. Conceptual Arguments

Prior research has examined assimilation in terms of the adoption and use of technologies by individuals (Agarwal, Animesh, & Prasad, 2009; Angst & Agarwal, 2009; Davis, 1989; Davis, Bagozzi, & Warshaw, 1989; Venkatesh & Davis, 2000; Hong & Tam, 2006) and by organizations (Lee & Mendelson, 2007; Bala & Venkatesh, 2007; Masetti & Zmud, 1996; also see Table 1 for a brief review). Though prior research has largely focused on the antecedents of the assimilation of information technologies, recent literature also emphasizes examination of the performance impacts of IT use (Mishra, Konana, & Barua, 2007; Devaraj & Kohli, 2003). Furthermore, prior research has usually restricted its focus to the assimilation and use of individual or a few specific organizational technologies, such as electronic switching technologies (Cool, Dierickx, & Szulanski, 1997), production and inventory control technologies (Cooper & Zmud, 1990), OOP technologies (Fichman & Kemerer, 1997), telecommunication technologies (Grover & Goslar, 1993), IBPS standards (Bala & Venkatesh, 2007), and ERP systems (Liang, Saraf, Hu, & Xue, 2007). Although these studies provide a nuanced understanding, a focus on the entire portfolio of information technologies provides a broader (enterprise architecture wide) view of assimilation and use (Mendelson, 2000).

Table 1. Select Studies Examining IT Assimilation and Use

Study	Context of Study	Guiding Theoretical Framework	Assimilation Constructs and Measures	Data and Method
Bala and Venkatesh 2007	Assimilation of IBPS standards in dominant and non-dominant firms.	Relational view of the firm, Institutional theory, and organizational inertial theory.	Four distinct stages of IBPS assimilation awareness, adoption (or rejection), limited deployment, and general deployment.	Data collected from multiple case sites on the assimilation of Rosettanet PIPs in the high-tech industry.
Liang et al. 2007	How top management mediates the impact of external institutional pressures on the degree of usage of enterprise resource planning (ERP) systems.	Institutional Isomorphism and IT assimilation.	Formative scale assessing volume (% of subset of business processes conducted through ERP), diversity (number of firm's business funtional area automated by ERP),and depth (vertical impact of ERP on business activities).	Survey of companies in China that have adopted ERP technologies.
Zhu and Kraemer 2005	Impacts of technological, organizaiotnal, and enviromental factors on technology use and value across developing and developed contries.	Resource based view, TOE (technological context, organizational context and environmental context) and E-business use	Percentage of use of e-business in providing online information, conducting business-to-business sales, etc.	Survey data from 624 retail firms across 10 countries.

[2] HIMSS Analytics (formerly The Dorenfest Integrated Healthcare Delivery System+ (IHDS+) database) gathers data on information technology usage via a survey of hospitals and maintains the data for 27,000 care delivery organizations (CDOs), including 3,989 hospitals in the U.S.

Swanson 1994	Three IS Innovations amongst organizations - data administration, the information center, and material requirements planning (MRP).	Dual core model of organizational innovation (Daft, 1978).	Adoption and evolution patterns of Type I, Type II, and Type III innovations.	Description of innovation adoptions across firms from a large scale survey.
Grover and Goslar 1993	Use of telecommunication technologies in organizational contexts.	Theory of innovations (Kwon & Zmud, 1987).	Initiation adoption and assimilation of telecommunication innovations.	Survey-based measures.
Meyer and Goes1998	A six-year field study investigating the diffusion of medical innovations in community hospitals.	Literature on Innovations (e.g., Aiken & Hage, 1971; Daft & Becker, 1978; Baldridge & Burnham, 1975; Kimberly & Evanisko, 1981; Downs & Mohr, 1976; Dewar & Dutton, 1986).	Guttman Scale to conceptualize innovation assimilation.	Field interviews, questionnaires, organizational documents, and secondary data sources.
Cooper and Zmud 1990	Implementation of a production and inventory control information system (material requirements planning: MRP).	Innovation and diffusion literature (e.g., Ginzberg, 1981; DeSanctis & Courtney, 1983; Markus, 1983; Kwon & Zmud, 1987).	Dichotomous measure of MRP adoption and infusions.	Telephone Interviews.
Fichman and Kemerer 1997	Assimilation of Software process innovations, specifically object-oriented programming languages (OOPLs).	Organizational learning and innovation diffusion theory (e.g., Attewell 1992).	Assimilation is defined as the process spanning from an organization's first awareness of an innovation to potential acquisition and widespread deployment. Guttman scale used to assess assimilation.	608 information technology organizations.
Purvis et al. 2001	Assimilation of knowledge platforms in organizations.	Knowledge-based view of the firm, institutional theory, and technology assimilation.	Knowledge embeddedness measured as planning knowledge, analysis knowledge, design knowledge and construction knowledge.	176 firms in a large-sample questionnaire survey with purposive sampling.

Enterprise IT architectures facilitate the establishment of long-term, process-based capabilities in organizations (Ross et al., 2006). Further, they evolve over time as organizations learn and modify their business processes and IT applications. Ross et al. (2006) define IT applications, data, technology, and process to be the four key aspects of enterprise IT architectures. Amongst these components, IT applications have been of special significance for examining the performance impacts of IT (Aral & Weill, 2007; Dehning et al., 2003). As a result, we examine the assimilation and use of IT applications throughout a hospital's enterprise IT architecture (Ross, 2003; Ross et al., 2006).

Prior studies have categorized IT application architectures according to the class of the technology. For example, Aral & Weill (2007) classify enterprise IT into strategic, informational, transaction, and infrastructure asset classes. Dehning et al. (2003) examine the impacts of three types of IT applications, i.e., those aimed at automation, information, and transformation, on firm value. Extending their focus on the differentiated IT architectures, we examine the dimensions of IT application architecture based on a hospital's pattern of assimilation and use.

The first dimension of assimilation and use, Information Technology Application Architecture Spread (ITAAS), refers to the range of information technologies adopted to digitize work processes in organizations. Organizational work processes vary in aspects such as sensory requirements, relationship requirements, synchronism requirements, and identification and control requirements, and all are not easily digitized (Overby, 2008). Spread captures the extent to which a hospital has been able to identify and adopt suitable IT solutions for its work processes. The second dimension refers to the longevity of information technologies (ITAAL) in an enterprise's IT architecture. Prior research has examined how adopting organizations learn to identify the specific features of an appropriate technological solution (DeSanctis & Poole, 1994; Attewell, 1992), mutually adapt the technological solution to their work domain (Leonard-Barton, 1995), and trigger institutional efforts to routinize the use of these technological solutions (Jasperson, Carter, & Zmud, 2005). Thus, the longevity of IT application architecture use provides organizations with time and opportunities to adapt and assimilate information technologies into their work domains.

ITAAS and ITAAL signify two different dimensions of IT application architecture usage within a hospital. Figure 1a depicts the portfolio of work processes in a hospital, of which each one could be a candidate for digitization due to the availability of appropriate IT solutions. Figure 1b illustrates the IT applications architecture spread as a count of the number of IT applications that have been adopted for the work processes. A greater number of shaded processes represents a higher spread. In contrast, Figure 1c illustrates the height of the shaded area for each digitized process as the length of time that the application has been in use, with greater height signifying IT application architecture longevity. Suppose a hospital has only recently digitized many of its work processes. This hospital has a high ITAAS but limited ITAAL (Figure 1b). In contrast, another hospital that has been using a few IT applications for a long period of time will have a high ITAAL but limited ITAAS (Figure 1c). Figure 1d represents high ITAAS and ITAAL simultaneously, i.e., a pattern of a wide scope of IT use and deep experience in using these. As Table 2 illustrates, these two dimensions capture four different scenarios of IT applications architecture in hospitals.

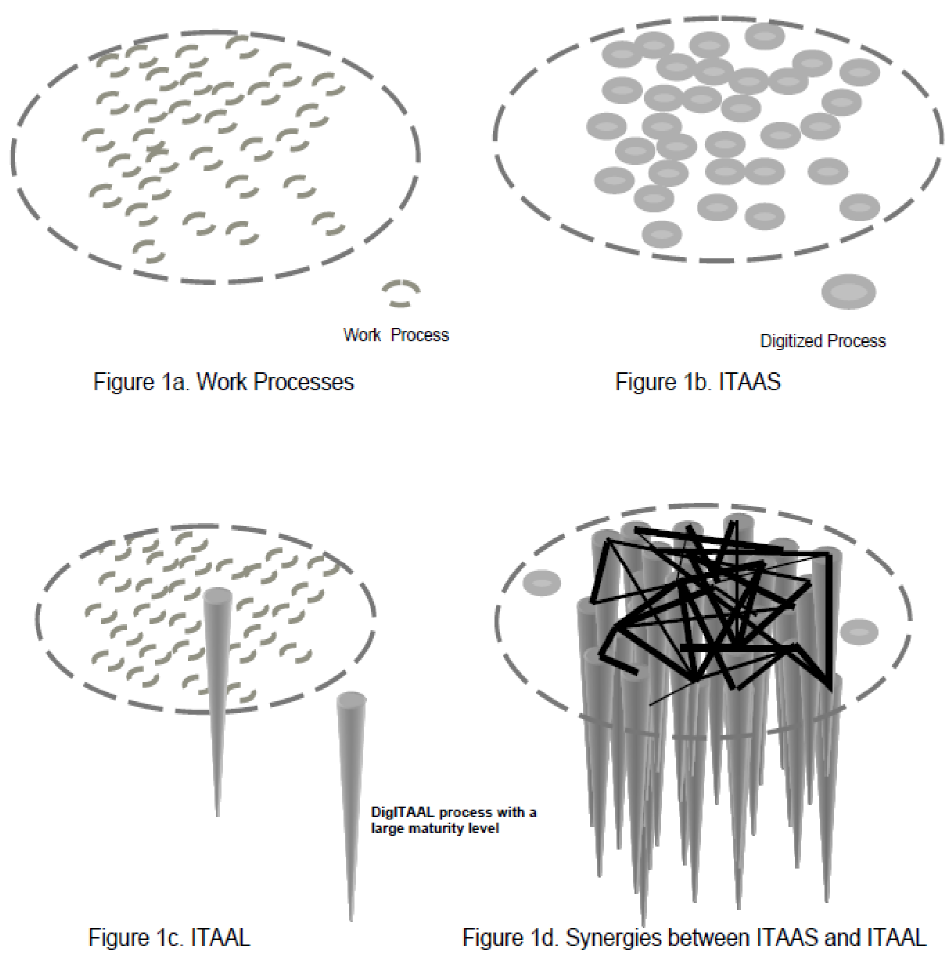

Figure 1. Patterns of IT Application Architecture

Table 2. IT Assimilation Patterns Across Hospital Application Architecture

		IT Applications Architecture Longevity (ITAAL)	
		LOW	***HIGH***
IT Applications Architecture Spread (ITAAS)	***LOW***	A newly and sparsely digitized hospital (figure 1A)	A hospital with limited IT use for a long period of time. (figure 1C)
	HIGH	A newly but extensively digitized hospital (figure 1B)	A hospital with full scale digitization over a long period of time. (figure 1D)

3. Research Model and Hypotheses

The activities and work processes in hospitals span two distinct domains, referred to as business and clinical domains. While the clinical domain entails the actions of medical professionals, such as nurses and doctors in patient care, the business domain entails the actions of the administrative personnel in patient registration, billing, and staff scheduling. Though both the domains are important, the nature of the activities is different and revolves around professionals with different skills. Therefore, the available IT solutions are also distinct and different between these two domains (Menon et al, 2009). Clinical IT applications, such as cardiology information systems, pharmacy management systems, and laboratory information systems assist physicians in patient treatment. Business IT applications, such as costing systems, patient billing, nursing staff scheduling, and credit collections are used by hospital managers to ensure efficient administration and cost management. In this research, we assess the impacts of ITAAS and ITAAL across the business and clinical domains of a hospital's work processes. Figure 2 presents our research model.

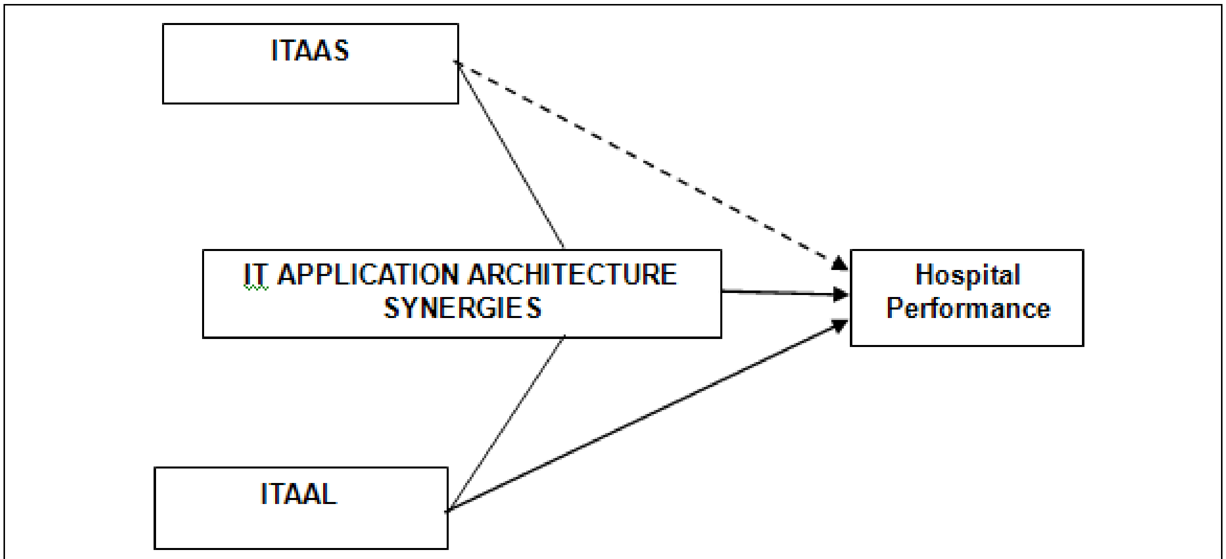

Figure 2. Research Model

IT applications architecture spread (ITAAS) is likely to have a positive impact on performance because the exploration and adoption of a larger number of information technology solutions may improve transaction processing efficiency, decision-making speed and accuracy, and organizational intelligence (Huber, 1990). A higher spread could enhance the reach and range of business processes and help coordinate work within and across hospital boundaries at a lower cost (Keen, 1991). Since information technologies are associated with lower internal and external coordination costs, higher ITAAS should lead to overall lower costs of operations (Gurbaxani & Whang, 1991). For example, a higher level of ITAAS in the clinical domain implies that a hospital has adopted a larger number of clinical applications that cumulatively would enhance the ability to gather, store, and disseminate clinical information across doctors and treatment facilities. In addition, the adoption of more clinical applications could also improve decision-making support for doctors by allowing them to anticipate adverse medical interactions and consider prior treatment history.

Although they appear intuitive, the positive impacts of ITAAS are not automatic because the mere adoption of IT may not be enough (Cooper & Zmud, 1990). Beyond adoption, extended periods of assimilation are needed to change and digitize the existing work practices. In the case of a failure to assimilate the innovation, the hospital may even be worse off if it loses its existing set of successful routines (Mitchell & Singh, 1993). Therefore, greater ITAAS alone may not be sufficient to warrant improvements in performance. As a result, we do not offer a hypothesis about the direct effects of IT applications architecture spread on hospital performance. To further examine the impact of ITAAS on hospital performance, it is imperative to examine the role of ITAAL.

As opposed to ITAAS, which is unlikely to have a direct effect on hospital performance, IT applications architecture longevity (ITAAL) is likely to have direct performance effects for three reasons. First, the users of a technology must make sense of the technology's features and understand how to apply these features in their work (DeSanctis & Poole, 1994). Users often experience significant knowledge barriers in making sense of the technology and learning how to apply it for their work (Attewell, 1992). With time, they gain experience and are able to leverage these technologies effectively. Second, although hospitals could facilitate assimilation by providing resources in the form of training, management support, or rewards and incentives, these factors alone are not enough (Orlikowski, Yates, Okamura, & Fujimoto, 1995). The digitization of work processes happens over extended time as users develop the needed experience and competence with the technology solutions through repeat trials and usage (Fichman & Kemerer, 1999). Finally, the efficient use of the technology requires mutual adaptation of its features and the work processes to which it is being applied (Leonard-Barton, 1995). Through a recursive process, healthcare personnel may discover how to "fit" the features of the technology to the "adapted" tasks and activities such that the technology features are being used efficiently. Prior research has found evidence that greater time since adoption enhances the organizational assimilation and use of information technologies (Purvis et al., 2001) and that higher levels of assimilation and use enhance the performance impacts of information technologies (Devaraj & Kohli, 2003). Consistent with Devaraj & Kohli (2003), this assimilation will enable the development of superior digitized business and clinical processes and improve hospital performance. Therefore, our first two hypotheses are as follows:

> ***H1a:*** *Greater longevity of IT application architectures in the business domain will be positively associated with hospital performance.*
>
> ***H1b:*** *Greater longevity of IT application architectures in the clinical domain will be positively associated with hospital performance.*

3.1. Synergies between ITAAS and ITAAL: An Exploration-Exploitation Perspective

In addition to the direct positive effects of longevity, we argue that IT applications architecture spread (ITAAS) and longevity (ITAAL) will have a synergistic effect on performance. The exploration and exploitation perspective on organizational learning (March, 1991) provides the conceptual foundation to examine the synergies manifested within ITAAS and ITAAL. We contend that IT applications architecture spread (ITAAS) may be analogous to the exploration of a broader array of IT applications across the hospital's work processes. A higher spread of technologies suggests that the hospital has engaged in efforts to explore more venues for digitizing its work processes. March (1991) states, "Exploration includes things captured by terms such as search, variation, risk taking, experimentation, play, flexibility, discovery, innovation." Voss, Sirdeshmukh, & Voss (2008) define product exploration as "an organizational emphasis on introducing radical innovations that extend existing product competencies." In contrast, longevity (ITAAL) reflects a greater exploitation focus. ITAAL captures the length of time for which information technologies have been tested, tried, and implemented in an organization. March (1991) suggests, "Exploitation includes such things as refinement, choice, production, efficiency, selection, implementation, and execution."

Organization theorists argue that the benefits from exploration (such as induction of new IT in a work process) are uncertain, unless such exploration is subsequently followed by an extended period of exploitation (assimilation and adaptation of technology). Similarly, although ITAAS helps hospitals to enhance the range of digital options available, ITAAL helps them to develop the deep expertise and experience in leveraging the performance benefits of each option. To illustrate the synergistic effects of IT applications architecture spread and longevity, consider the case of a hospital that has integrated its physician order entry system with emergency room records, pharmacy medication orders, laboratory information, and nursing documentation. As the hospital expands spread through adoption of IT solutions for many of these important clinical processes, doctors could have real-time access to data that facilitate treatment decisions (Rogoski, 2006). However, if some of the key IT solutions have not been assimilated and the hospital does not have extensive experience with their use, then the effectiveness of digitization could be impaired. Poor communication among care providers could lead to costly medical errors, such as administering the incorrect medication or an inappropriate dose (Rogoski, 2006). Efficient performance would require not just the procurement or existence of a large number of clinical technologies (a wider ITAAS for clinical domain), but also the ability of the hospital to develop extensive experience with these technologies (Zima, 2002). As a result, we argue that ITAAS and ITAAL complement each other in enhancing performance.

H2a: *Synergies between ITAAS and ITAAL within the business domain will be positively associated with hospital performance.*

H2b: *Synergies between ITAAS and ITAAL within the clinical domain will be positively associated with hospital performance.*

4. Data and Methods

We collected data for hypothesis testing from two sources: HIMSS Analytics (formerly The Dorenfest Integrated Healthcare Delivery System+ (IHDS+) database) and the Healthcare Quality and Analysis Division of the California Office of Statewide Health Planning and Development (OSHPD). HIMSS collects data on information technology usage via a survey of hospitals and maintains the data for 27,000 care delivery organizations (CDOs), including 3,989 hospitals in the U.S (Angst & Agarwal, 2009; Housman, Hitt, Elo, & Beard, 2006). Using the HIMSS data, we classified 21 technologies as business technologies and 29 technologies as clinical (see table A1 in appendix). These technologies represent the comprehensive set of IT applications in hospitals, as reported by HIMSS. To avoid any bias that may arise from using the same database for measuring the dependent and independent variables, we obtained data on hospital performance from OSHPD. Our final merged sample consists of 285 observations for the year 2004.

4.1. Dependent Variable

The dependent variable in this study is hospital performance. Health care researchers acknowledge that the measurement of hospital performance is complex and fraught with difficulties because of the large variety of stakeholders and the multiple, often contradictory, goals of the stakeholders. For example, a hospital is required to provide care regardless of the patient's ability to pay. At the same time, the hospital is expected to remain financially viable (McCracken, McIlwain, & Fotter, 2001). Hence, revenues, costs, and margins are important in hospitals. Not surprisingly, IS researchers have used both cost-based (Menon et al., 2000; Menon & Lee, 2000), and revenue-based (Devaraj & Kohli, 2003) measures to assess IT impacts. Further, a large body of prior research has used net income margin – a summary measure including both costs and revenues – to assess hospital performance (Coyne, 1986; Flood, Shortell, & Scott, 1997; Griffith, Alexander, & Jelinek, 2002a; Griffith, Knutzen, & Alexander, 2002b; Shortell et al., 1995).

We propose that net income is a comprehensive measure of hospital performance for several reasons. First, it reflects the effects of improvements in cost efficiency and revenues due to superior decisions about prices and product mix, as well as the cost and revenue effects of higher quality enabled by IT. Second, it is a broadly accepted measure in the financial and managerial community. For example, researchers in accounting and economics often use it as a benchmark measure of performance (see Skinner, 1999). Finally, the measurement of net income is standardized and permits cross sectional comparisons across hospitals. Therefore, our study uses net income, scaled by patient days, to measure hospital performance.[3]

4.2. Independent Variables

Our operationalization of ITAAS and ITAAL utilizes the approach of Katila and Ahuja (2002), who studied patent citation in the global robotics industry. They measured search scope (akin to exploration) as the proportion of previously unused citations in a firm's focal year list of citations. Exploitation effects are measured using search depth, i.e., the average number of times a firm uses citations in its patent applications. Similarly, Rothaermel and Deeds (2004) used count measures to assess the impacts of alliances between firms on new product development in the biotechnology industry. In our study, we used the HIMSS categorization to define information technologies as belonging to either the business or clinical domain.

We define ITAAS as the number of technological solutions adopted and used by each hospital, whereas ITAAL is the average years of experience (up to year 2004) with each of these solutions.

Computation of ITAAS: If $k_{ib\theta h} \epsilon \{0,1\}$ indicates whether the information technology i was adopted by the business process b in the work domain θ in the hospital h, then ITAAS is measured as:

$$ITAAS_{\theta h} = \sum_{b=1}^{M} k_{ib\theta h},$$

where M represents the number of business processes available for the work domain θ.

Computation of ITAAL: ITAAL with the adopted information technologies is computed as:

$$ITAAL_{\theta h} = \frac{1}{M}\sum_{i=1}^{M}\left[\frac{\sum_{i=1}^{N} Y_{ib\theta h} K_{ib\theta h}}{\sum_{i=1}^{N} K_{ib\theta h}}\right]$$

In the above equation, $Y_{ib\theta h}$ represents experience, or the number of years that a hospital h has used the information technology i in the work process b of its domain θ. $ITAAL_{\theta h}$ measures the overall average experience with all information technologies in the work domain θ.[4]

Computation of Synergies ($SynSL_\theta$): Synergies between ITAAS and ITAAL are measured as the product (interaction) of $ITAAS_\theta$ and $ITAAL_\theta$. According to recent conceptualizations, the joint synergies ($SynSL_\theta$) may be represented as $\frac{\partial^2 NI}{\partial ITAAS_\theta \partial ITAAL_\theta}$ (Milgrom & Roberts, 1990, 1995; Siggelkow, 2002; Tanriverdi & Lee, 2008). In addition, we perform an in-depth assessment of synergies between ITAAS and ITAAL by developing three unique ratios – Overall Application Architecture Growth to Spread (AAGS), Overall Application Architecture Growth to Longevity (AAGL), and Application Architecture Growth across Domains (AAGD). AAGS and AAGL are the ratio of the synergistic impacts (second order cross partial derivative) to the direct effects (the first order derivative) of performance with respect to spread and longevity of IT application architecture, respectively. The two ratios are evaluated in two domains of health care (business and clinical). Thus, for example, the business domain application architecture growth to spread ratio (AAGS) evaluates the strength of synergistic impact with respect to spread of the business IT application architecture portfolio. A value

[3] Alternatively, to test the robustness of our results to the choice of dependent variable, we also test our hypothesis with Return on Assets as the dependent variable. The results are found to be qualitatively similar.

[4] This form of average experience gives equal weight to each type of business function (N) (e.g., HR, or Financial management) in a work domain. Hence, it is robust to the larger numbers that might be needed for a function (even though their impact on performance may not be proportional). Also, the formulation controls for any missing data that might distort the results across hospitals. Further, we tested the robustness of results against any missing data by dropping these missing observations, and the results are qualitatively unchanged.

greater than one for the AAGS or AAGL implies that the synergistic impact of the IT application architecture has a stronger influence on performance than the direct impact of spread or longevity in the business domain.[5]

AAGS and AAGL offer valuable managerial information to assess the impacts of IT application architecture. For example, if $\frac{\partial^2 NI}{\partial ITAAS_\theta \partial ITAAL_\theta} > 0$, $AAGS_\theta > 1$, and $AAGL_\theta > 1$, $\theta \, \varepsilon \, (b, c)$, the spread and longevity have complementing synergies in the domain θ. Therefore, greater performance effects may be expected in hospitals that have both higher spread and longevity (both) of IT application architectures, since the incremental returns to direct effects (of ITAAS and ITAAL) may be limited and less than their synergistic influences.

In addition to the above two ratios, we compute a third ratio, Application Architecture Growth across Domain (AAGD), which is the ratio of synergies across the two domains θ_i and θ_j, $i \neq j$. AAGD assesses the relative impact of synergies in the business domain compared to their impacts in the clinical domain, i.e., $AAGD_{bc} = \frac{\partial^2 NI}{\partial ITAAS_b \partial ITAAL_b} \Big/ \frac{\partial^2 NI}{\partial ITAAS_c \partial ITAAL_c}$. A value greater than one for |AAGD| implies that the synergies between spread and longevity have greater impact in the business domain than corresponding synergies in the clinical domain. Further, a positive AAGD implies that synergies in both the business and clinical domains operate in the same direction. On the other hand, a negative AAGD indicates that while one of the work domains is marked with complementing synergies, the other is marked with substitutive synergies. These ratios will enable us to develop richer insights about the effects of spread and assimilations across the two domains.

4.3. Control Variables

We control for other factors that may impact hospital performance, such as size, specialty type, and ownership. We use the number of staffed beds to control for the size (BEDSTF). The type of care (TYPE_CARE) offered by the hospital (general or specialty) is controlled using a dummy variable. We also control for learning effects by including the age of the facility as a control (AGEOFFAC). Further, to control for the influence of human resources availability, we include the total number of full time equivalent employees at the hospital (HOSPFTE). Ownership can influence a hospital's objective function, performance, and investments in technology. Therefore, we control for each hospital's ownership type by including two dummy variables corresponding to government, nonprofit (NPDUMMY), and for-profit (INVDUMMY) hospitals. In addition, because the patient mix may have an impact on services provided, we control for patient mix by including the proportion of patients from Medicare (MCRTPATR) and Medicaid (MCLTPATR) (Devaraj & Kohli, 2003). Important differences in performance as well as technology might arise due to cross sectional differences in the severity of illness of the patients admitted at different hospitals. Hence, we control for the case mix (CMI), which is a measure of the average severity of illness of patients treated in a hospital. We also control for asset intensity by including the ratio of total assets to patients (ASSTCTRL). In addition, we control for urban versus rural hospital (RURAL), and for whether the hospital is a member of a multihospital system (SYSTEM). Finally, because the regulatory and competitive environment faced by hospitals differs across states, our sample consists of hospitals only from the state of California.

4.4. Descriptive Statistics

A majority of the hospitals (81 percent) are general hospitals, with the remaining 19 percent representing children's, psychiatric, or other specialty hospitals. Sixty-one percent of the hospitals are nonprofit, and the remaining are either owned by investors, city/county, government, or hospital districts (see Table 3). The average size of the hospital is approximately 198 staffed beds. Our sample is representative of the hospitals in the country, with the exception that the sample hospitals are larger and more likely to include general hospitals (the average staffed beds of the entire population of

[5] Mathematically, this is represented as $AAGS_b = \left|\frac{\partial^2 NI}{\partial ITAAS_b \partial ITAAL_b}\right| \Big/ \left|\frac{\partial NI}{\partial ITAAS_b}\right| \geq 1$; or $AAGL_b = \left|\frac{\partial^2 NI}{\partial ITAAS_b \partial ITAAL_b}\right| \Big/ \left|\frac{\partial NI}{\partial ITAAL}\right| \geq 1$

hospitals is 179, 60 percent are nonprofit, 67 percent are general hospitals). This arises because smaller hospitals (<25 beds) and specialty hospitals are less likely to report to the OSHPD and HIMSS. Further, the percentages of Medicare and Medicaid discharge in hospitals in our sample – 34 percent and 19 percent, respectively – are representative of these percentages nationwide (35.2 percent and 19 percent, respectively). Nearly 80 percent of the hospitals in our sample have more than one year of average experience, 60 percent have more than four years of average experience, and around 35 percent of the hospitals have more than eight years of average experience with a business information system. For the business information systems, more than half of the hospitals have less than eight years of average digitization experience with a business technology.

Table 3. Descriptive Statistics for Selected Variables (N=285)

Variable	Description	Mean	Std. Dev.
NI	Net Income Per Patient Day	$721.80	4028.9
CMI	Case Mix Index of the hospital	1.11	0.30
BEDSTF	Number of staffed beds	198.64	139.63
AGEOFFAC	Age of Facility	26.68	31.97
HOSPFTE	Number of FTEs in the hospital	1055.82	1041.03
ASSTCTRL	Total Assets Per Patient Day	2981.40	2457.97
MCRTPATR	Ratio of number of medicare discharges to total discharges	0.34	0.16
MCLTPATR	Ratio of number of medicaid discharges to total discharges	0.19	0.14
TYPE_CARE	Whether the hospital is a children's, psychiatric, or specialty (as opposed to being a general hospital)	0.19	0.65
NPDUMMY	Whether the hospital is a nonprofit hospital	0.61	0.49
INVDUMMY	Whether the hospital is an investor/for-profit hospital	0.26	0.44
RURAL	Whether the hospital is located in a rural area	0.12	0.33
SYSTEM	Whether the hospital belongs to a multi-hospital system	0.52	0.50
IT Application Architecture Spread within business domain (ITAASb)	Spread of information technology applications in business domain	8.21	1.96
IT Application Architecture Spread within clinical domain (ITAASc)	Spread of information technology applications in clinical domain	8.005	2.64
IT Application Architecture Longevity within Business domain (ITAALb)	Longevity (in years) of business domain information technology applications	10.90	8.12
IT Application Architecture Longevity within Clinical domain (ITAALc)	Longevity (in years) of clinical domain information technology applications	7.20	4.60

4.5. Empirical Model

We estimated the following regression model using ordinary least squares (OLS), and with net income per patient as the dependent variable. Figure 3 provides a summary of the hypotheses tested.

$$NI_h = b_{0h} + b_{sb}\, ITAAS_b + b_{lb}\, ITAAL_b + b_{sc}\, ITAAS_c + b_{lc}\, ITAAL_c + b_b\, SynSL_b + b_c\, SynSL_c + b_{7h}\, Z_h + \varepsilon_h \rightarrow (\mathbf{1})$$

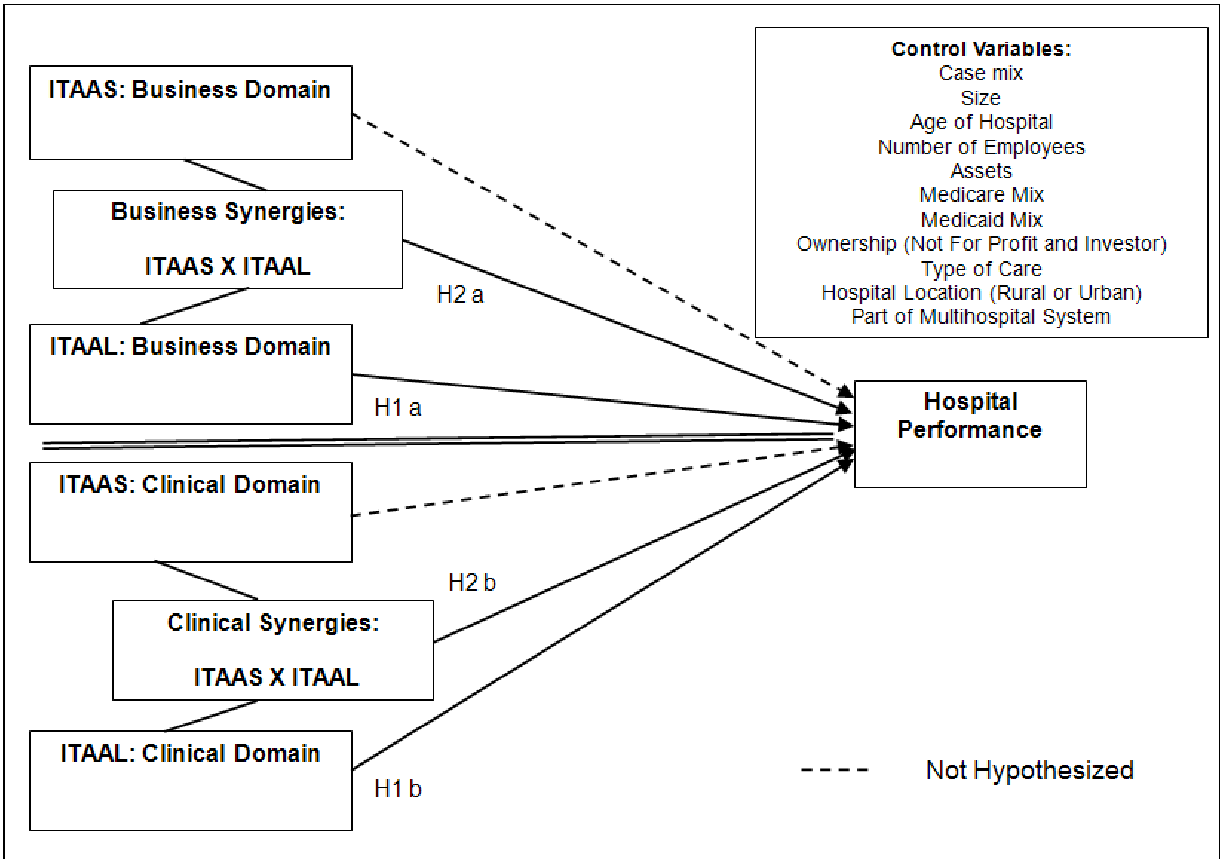

Figure 3. Empirical Model

5. Results

Table 4 provides the results of the estimations. Model 1 analyzes the effects of the control variables, whereas Model 2 contains the results with the control and predictor variables. The results for Model 2 indicate a positive and significant coefficient on $ITAAL_b$, which represents the financial returns from ITAAL within the business domain $(\beta = 0.81, p < 0.05)$. This result is consistent with H1a and indicates that in the business domain, the longevity of IT applications architecture ($ITAAL_b$) is associated with higher financial performance. H1b predicts that the longevity of the IT applications architecture within the clinical domain ($ITAAL_c$) will be associated with superior hospital performance. However, contrary to the prediction in H1b, longevity within clinical IT is negatively associated with performance $(\beta = -0.57, p < 0.05)$. Thus, H1b is not supported. The negative coefficient on SynSLB $(\beta = -0.72, p < 0.10)$ indicates that ITAAS and ITAAL are substitutive in the business domain (Table 4). Taken together, these results suggest that, in the business domain, the longevity of the IT applications architecture is sufficient by itself for improving performance. However, within the clinical domain, the coefficient on SynSLC is positive and significant, and it is indicative of the presence of positive synergies between IT application architecture spread (ITAAS) and longevity (ITAAL) $(\beta = 0.61, p < 0.05)$, as predicted by H2b. Collectively, the patterns of IT applications architecture explain around 13.24 percent more variance relative to the variance explained by the control variables.

To obtain additional insights, we examined the combined impacts of ITAAS and ITAAL and estimated two additional models. In the first model, both $ITAAS_b$ and $ITAAS_c$ were constrained, whereas in the second model, $ITAAL_b$ and $ITAAL_c$ were constrained to zero (i.e., proposed to have null effects). The results indicate that there were no significant impacts on the variance explained by constraining

ITAAS, but there were significant impacts of constraining ITAAL across the two domains.[6] These analyses provide further evidence that longevity, and not spread, is the key factor influencing the performance impacts of IT application architectures.

We tested the robustness of our results through various sensitivity tests. The results are robust against the violation of normality, heteroskedasticity (Breusch-Pagan test), specification errors (Linktest), and endogeniety (2 SLS test) (Greene, 2000). Next, we used two tests to examine if multi-collinearity may have influenced the results. First, we mean centered our variables and found that the results are unchanged. Second, to test the robustness of the results in presence of interactions, which might induce high collinearity, we ran an orthogonal regression using the ORTHOREG procedure of SAS. We found the results from this analysis to be similar to the main results. Thus, while collinearity could be present due to interactions, it does not bias the estimation of our coefficients or their significance testing. We also examined the robustness of our results to the inclusion of a dummy variable for a teaching hospital. There was no qualitative change in the results after the inclusion of this variable. Finally, we found adequate power in our tests for the hypothesized and tested relationships.

We also performed a comparative assessment of the relative impacts of IT assimilation and use of IT applications within and across the business and clinical domains by evaluating three ratios: AAGS, AAGL, and AAGD. Table 5 provides a detailed interpretation of these ratios. An examination of AAGL indicates that the longevity of an IT application architecture (ITAAL) has a stronger impact than synergies between ITAAS and ITAAL in the business domain ($AAGL_b < 1$). However, synergies have a higher impact in the clinical domain ($AAGL_c > 1$). Synergies have an approximately 8 percent greater impact as compared to the impact of longevity of IT application architecture in the clinical domain. Also, the value of $AAGD_{bc}$ (~ -1.18) indicates that synergies between ITAAS and ITAAL in the clinical domain are opposite in direction to the synergies in the business domain. While ITAAS may be substituted with ITAAL in the business domain, greater performance impacts are realized when both are present concurrently in the clinical domain.

6. Conclusion and Discussion

In this research, we examined the performance impacts of the adoption and use of IT applications in hospitals. Specifically, we assessed the performance impacts of two dimensions of IT application architectures, ITAAS and ITAAL, within a hospital. While ITAAS measures the range of information technologies used to perform hospital activities, ITAAL represents the longevity of a hospital's IT application architecture. Besides examining the independent impacts of ITAAS and ITAAL, we also examined the relationships between them by assessing synergies between the two. We tested impacts across two domains – business and clinical – within a hospital (Menon et al., 2009). Our empirical analysis uses data from 285 California hospitals. The results indicate variations in the performance impacts of IT application architecture spread (ITAAS) and longevity (ITAAL) across the two domains of healthcare work processes.

[6] We conducted an F test to examine the change in variance explained across the constrained and unconstrained models.

Table 4. Regression Results

Variables	Model with Control Effects Only (Model 1)		Full Mode (Model 2)	
	Standardized Coefficient	t-statistic	Standardized Coefficient	t-statistic
(Constant)	0.01**	-2.28**	0.01	-1.48
CMI	0.267***	3.641	0.268***	3.641
BED_STF	-0.184*	-1.727	-0.181*	-1.698
AGEOFFAC	0.037	0.561	0.033	0.503
HOSPFTE	0.209*	1.789	0.210*	1.804
ASSTCTRL	0.078	1.269	0.071	1.153
MCRTPatR	0.121	1.519	0.143*	1.770
MCLTPatR	0.154**	2.450	0.151**	2.355
TYPE_CARE	0.165***	2.837	0.186***	3.134
NPDUMMY	-0.407***	-4.459	-0.384**	-4.160
INVDUMMY	-0.366***	-3.777	-0.316*	-3.150
RURAL	-0.103	-1.646	-0.096	-1.525
SYSTEM	0.057	0.982	0.059	1.005
ITAASb (ITAAS for business domain)			0.110	0.808
ITAASc (ITAAS for clinical domain)			-0.178	-1.133
ITAALb (ITAAL for business domain)			0.809**	2.236
ITAALc (ITAAL for clinical domain)			-0.572**	-2.217
SynSLB (Synergies between ITAAS and ITAAL in Business domain)			-0.724*	-1.867
SynSLC (Synergies between ITAAS and ITAAL in Clinical domain)			0.614**	2.090
R Sq	0.219		0.248	
Adj R Sq	0.180		0.198	
F-Statistic	6.35***		4.79***	

Note: Dependent variable is net income per patient day. *, **, *** Coefficients significant at p<0.10, p<0.05, and p<0.01 level, respectively. The government hospital is the base case.

Table 5. Results of Complementary Estimations

Estimated Statistic	Measure	Value	Result	Inference
$AAGS_b$	$\left\lvert\frac{\partial^2 NI}{\partial ITAAS_b \partial ITAAL_b}\right\rvert \Big/ \left\lvert\frac{\partial NI}{\partial ITAAS_b}\right\rvert$	Un Defined	Inconclusive	Relative impacts of spread and longevity synergies for the business domain cannot be compared in this study.
$AAGL_b$	$\left\lvert\frac{\partial^2 NI}{\partial ITAAS_b \partial ITAAL_b}\right\rvert \Big/ \left\lvert\frac{\partial NI}{\partial ITAAL_b}\right\rvert$	0	<1	For business domain longevity of a hospital's IT application architecture has stronger impact on performance than the synergistic impacts.[7]
$AAGS_c$	$\left\lvert\frac{\partial^2 NI}{\partial ITAAS_c \partial ITAAL_c}\right\rvert \Big/ \left\lvert\frac{\partial NI}{\partial ITAAS_c}\right\rvert$	∞	>1	Synergies between spread and longevity are complementary and are stronger than the direct impacts of IT application architecture spread.
$AAGL_c$	$\left\lvert\frac{\partial^2 NI}{\partial ITAAS_c \partial ITAAL_c}\right\rvert \Big/ \left\lvert\frac{\partial NI}{\partial ITAAL_c}\right\rvert$	1.07	>1	Impacts of complementary synergies in clinical domain are stronger than the impacts of longevity of a hospital's IT application architecture.
$AAGD_{bc}$	$\frac{\partial^2 NI}{\partial ITAAS_b \partial ITAAL_b} \Big/ \frac{\partial^2 NI}{\partial ITAAS_c \partial ITAAL_c}$	-1.18	<0	The synergies in the business domain are in an opposing direction as compared to the synergies in clinical domain.
$\lvert AAGD_{bc}\rvert$	$\left\lvert\frac{\partial^2 NI}{\partial ITAAS_b \partial ITAAL_b} \Big/ \frac{\partial^2 NI}{\partial ITAAS_c \partial ITAAL_c}\right\rvert$	1.18	>1	Substitutive synergies in business domain are stronger than the complementary synergies between spread and longevity in clinical domain

Our study is best characterized as a test of middle range theory to examine the performance impacts of IT assimilation and use. Fichman (2000, p. 4) contends that such middle range theories are the preferred way to make advances in the domain of innovation diffusion (Rogers 2003). Our theoretical and empirical insights suggest that the impacts of assimilation and use of IT applications in a hospital vary across two work domains: business and clinical. A hospital's ability to leverage IT for superior performance is dependent on the work domain – business or clinical – of IT applications. In the case of business domain IT applications, performance benefits occur when hospitals identify specific information technologies and develop deep experience with these technologies. As a hospital's IT application architecture evolves over time (high ITAAL), i.e., a hospital develops deep experience with specific technologies and becomes more adept at exploiting and assimilating those technologies, there is an improvement in financial performance (Barua & Mukhopadhyay, 2000; Fichman & Kemerer, 1997). The mere adoption of many technology solutions in the business domain (high ITAAS) will not have a significant impact on performance. Further, a business domain application architecture with both spread and longevity is not advantageous, and in fact, it may have a weakly negative effect (substitutive synergies between ITAAS and ITAAL in the business domain). While it is beyond the scope of this research to examine the reasons for such substitutive effects, we think that this may be due to overlapping functionalities across IT applications that lead to redundancies in functionalities across the IT application architecture. Increased complexity due to a broad range of technologies that have redundant functionalities may result in mismatch in data, processes, and work routines and lead to adverse impacts on performance. However, more research is needed to test the source of these substitutive effects. Overall, our results suggest that hospitals benefit when they focus their attention on specific business IT solutions and develop deep experience with them (Figure 1c).

[7] Even considering the weakly significant substitutive impacts, $AAGL_b$ is less than one.

Similarly, the mere adoption of many IT solutions (high ITAAS) may not be a sufficient antecedent of performance in the clinical domain. Surprisingly, our study indicates that the depth of assimilation (high ITAAL) is also not sufficient on its own to influence performance (and this over-exploitation may even have adverse effects).[8] Superior performance impacts are realized only by the joint spread and longevity of the clinical IT applications. In other words, there are significant synergistic effects of ITAAS and ITAAL in the clinical domain (also see Table 5). Overall, our results reveal the performance benefits that accrue when hospitals adopt and develop deep experience with an extensive set of clinical IT applications (Figure 1d).

Table 6. Summary of Results

Relation	Hypothesis	Result
Impact of IT application architecture longevity (ITAAL) within business domain on Hospital Performance	H1a	Positive
Impact of IT application architecture longevity (ITAAL) in clinical domain on Hospital Performance	H1b	Negative
Impact of IT application architecture Spread (ITAAS) and longevity (ITAAL) synergies in business domain on Hospital Performance	H2a	Weakly Substitutive
Impact of IT application architecture Spread (ITAAS) and longevity (ITAAL) synergies in clinical domain on Hospital Performance	H2b	Complementary

Although our study is in the context of health care, the results have important implications for IT assimilation outside of the healthcare context as well. The two proposed dimensions of IT assimilation, ITAAS and ITAAL, are objective and generic. They can be used to assess the assimilation of IT applications across other contexts, such as supply chain or accounting. Overall, our research adds to the repertoire of knowledge in the IT assimilation and IT value literatures by developing a mid range theory within hospitals, but it has wide applicability across other contexts. Before highlighting other contributions of the study, we discuss some of the limitations of our research.

6.1. Limitations

A potential limitation of this study is that ITAAS and ITAAL may not comprehensively capture diffusion within a hospital's IT architecture. Indeed, management and use of IT architectures encompass varied aspects, such as development of critical IT capabilities, relational architecture, and integration architectures (Ross, 2003; Ross et al., 2006; Ross & Westerman, 2004; Sambamurthy & Zmud, 2000). While these dynamics are important, our research is limited to examination of diffusion from the IT adoption and use perspective in the hospitals. ITAAS and ITAAL respectively measure the adoption of new IT and extent of organizational use of existing IT. A more thorough analysis of architectural design would call for a focus on interoperability as well. However, this study does not capture the integration of process and data, and hence, is not able to offer a comprehensive assessment of how architecture evolution and design influence firm performance. Overall, in our secondary data analysis, we can only obtain limited assessment of diffusion dynamics.

This study employs ITAAS and ITAAL to offer one view of exploration and exploitation within IT application architecture. Exploration and exploitation dynamics may span various other facets of enterprise IT architectures including data, processes, and technology (Ross et al., 2006). However, our focus in this study is limited to IT applications, and the other dimensions of enterprise IT architectures are beyond the scope of this study. Further, the literature on exploration and exploitation posits them as multi-dimensional constructs. As a result, researchers have employed diverse

[8] These results are consistent with those of Menon et al. (2009), who use data from Washington hospitals and find that higher expenditure on clinical IT (similar to ITAAS in this study) by itself has neither an immediate nor a lagged positive impact on hospital performance.

methodologies, including case studies, surveys, and archival data analysis to obtain better insights related to the definition, measurement, modeling, and interaction of exploration and exploitation (Gupta, Smith, & Shalley, 2006) and related dynamics (Katila & Ahuja, 2002; Rothaermel & Deeds, 2004; He & Wong, 2004; Holmqvist, 2004; Winter & Szulanski, 2001; Ghemawat & Ricart i Costa, 1993). In this study, we employ the archival method and attempt to develop objective measures of ITAAS and ITAAL. However, our measures may not offer a complete description of exploration and exploitation processes.

A comprehensive examination of exploration and exploitation calls for incorporating additional issues that may require varied theoretical lenses from the domains of organizational theory (He & Wong, 2004; Holmqvist, 2004), strategy (Winter & Szulanski, 2001), and managerial economics (Ghemawat & Ricart i Costa, 1993). For example, future research could explore the influence of a hospital's structure, processes, strategies, and culture on the performance impacts of IT. A more in-depth examination of such issues through alternate methods, such as survey-based or case study methods, will help enrich our understanding regarding these issues. Further, since there is relatively limited new adoption of IT each year, our analysis uses cross sectional data. Longitudinal data analysis may provide a more comprehensive assessment of exploration and exploitation dynamics. Our use of secondary data offers objectivity in measurement, arguably at the expense of richness that is a characteristic of archival research. Additionally, our analyses are restricted to financial performance impacts, and we do not study healthcare and quality outcomes, which can be a fruitful area for future research. Finally, our analysis of ITAAS and ITAAL is restricted within the business and clinical domains, and we hope will form the basis for future research that may test the diffusion dynamics and cross domain interactions.

6.2. Contributions

Our research makes important contributions to the business value and the IT assimilation and use literatures. Prior research has used an investment perspective. Our study extends this line of enquiry by examining the impacts of IT assimilation within the hospitals' architecture of IT applications. Specifically, two dimensions – ITAAS, ITAAL – are proposed to have varying financial impacts across the hospitals' business and clinical domains. Our research moves the examination of IT impacts in health care beyond the investment focus to a more in-depth focus on assimilation and use. While an investment focus gives a broad and holistic picture of overall investments, the assimilation and use perspective offers a more nuanced examination of how IT applications impact financial performance across the two domains in distinct ways.

Our research also makes important contributions to the literature that seeks to assess the synergies in IT impacts (see Table 7 for representative studies assessing synergies). Specifically, we provide a richer examination of synergistic relations through the development and assessment of three ratios – AAGS, AAGL, and AAGD. These ratios may serve as tools to compare the performance impacts of various adoption and use patterns within a hospital's IT application architectures. Also, our systematic assessment of these effects may help establish a framework that will guide a more thorough empirical assessment of such interactive synergies in future research.

Finally, the results have important implications for policy. Our results highlight that policy makers and researchers should not consider the extent of digitization through information technologies as a de-facto antecedent to greater performance. Differences in the impacts of ITAAS and ITAAL across business and clinical work processes indicate that it is important to recognize that IT digitization does not play out in the same manner across the two domains. Greater performance should be expected in hospitals if they explore and adopt a broad range of IT applications for their clinical domain and develop deep experience with each one of these solutions. However, in the business domain, hospitals should focus on a few key IT solutions and develop deep experience with them. Though our research brings out differences in dynamics across business and clinical domains, we hope that future research will further examine characteristics, such as complexity or sophistication of processes, to assess the diffusion dynamics in hospitals.

Table 7. Summary of Reseach Examining Synergies

Study	Synergies examined	Context of Study
Milgrom and Roberts (1995)	Fit between the firm's strategy structure and managerial processes. Develops the notion of Edgeworth complements and formalizes supermodularity using lattice theory.	The shift of firms' manufacturing systems from mass production to modern lean or flexible manufacturing.
Parthasarthy and Sethi (1992)	Superior firm performance results when the firm's strategy and choice of organizational structure are congruent with the competencies and constraints of the technological choices.	Study of advanced manufacturing technologies such as CAD, CAM, automatic storage and retrieval systems and CIM.
Parthasarthy and Sethi (1993)	Empirical test of the differences in fit of the firm's manufacturing systems with its structure and strategy.	Flexible automation systems and different strategy types (quality leadership, flexibility leadership, or low cost), structure (mechanistic or organic), shop floor personnel skills (specialized or diversified), design manufacturing workflows (sequential or parallel), and project teams and workgroups (rarely used versus often used).
Ray, Muhanna and Barney (2005)	Complementarities between shared knowledge and technical IT skills, generic information technologies, and level of IT investments differentiate the performance of firms' customer service processes.	Survey data collected from matched sample analysis of respondents from 72 firms in health and insurance industry with over 100 employees.
Tarriverdi (2006)	Studies the relatedness and synergies between multiple units in a firm. Use of common IT infrastructure technologies and IT management practices (relatedness) leads to sub-additive cost synergies while complementarities between the two lead to super-additive value synergies.	Analysis of data from 356 multi-business fortune 1,000 firms.
Bharadwaj, Bharadwaj and Bendoly (2007)	Complementarities between IS capabilities and a firm's manufacturing, marketing, and supply chain processes as antecedents to a firm's manufacturing performance.	Primary and secondary data collected from 169 manufacturing firms.

In summary, this study extends the healthcare IT literature by conceptualizing two novel dimensions of IT assimilation and use – ITAAS and ITAAL – and assessing their impacts on hospital performance. We develop these measures using recent developments in the field of new product development, and hence, our research enriches the IS literature by bringing in a new perspective to examine IT impacts. Further, while synergistic interactions are often proposed as essential for realizing the performance impacts of IT systems (Barua & Mukhopadhyay, 2000; Sambamurthy et al., 2003), our empirical findings indicate that the significance of these impacts is contingent upon the work process domain. Overall, the research offers a new look at the financial performance impacts of IT within health care. We hope that our study will help invigorate more research on the impacts of assimilation and use within health care and other contexts.

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Appendix

Appendix A

Table A-1. Clinical and Business Health Information Technologies Included in the Analyses

Business Domain	**Clinical Domain**
Business Office	**Clinical**
Credit/Collections	Cardiology Information Systems
Electronic Claims	Cardiology PACS
Patient Billing	Clinical Data Repository
Patient Registration	Clinical Documentation
Patient Scheduling	Computerized Patient Record
Decision Support	CPOE
Case Mix Analysis	Clinical Decision Support
Cost Accounting	Electronic Med Admin Record (EMAR)
Executive Information Systems	Emergency Department
Flexible Budgeting	HIS System
Outcomes and Quality Management	Intensive Care (Critical Care)
Financial Management	Laboratory Information Systems
Accounts Payable	Nurse Staffing
Enterprise Resource Planning	Obstetrical Systems
	Order Communication/Results
General Ledger	Pharmacy Dispensing
Materials Management	Pharmacy Info Sys
Human Resource	Point of Care (Med/Surg Bedside Term)
Benefits Administration	Radiology Info Systems
Payroll	Radiology PACS
Personnel Administration	Surgery
Time & Attendance	**Medical Reporting**
Managed Care	Abstracting
Eligibility	Chart Deficiency
Managed Care Contract Management	Chart Tracking/Locator
Premium Billing	Dictation
	Encoder
	Master Patient Index
	Med Recording Imaging
	Transcription

Table A-2. Correlations Amongst Variables

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
NTINPRPT	1																
CMI	.262**	1															
BED_STF	0.08	.172**	1														
AGEOFFAC	.188**	0.041	.259**	1													
HOSPFTE	.187**	.249**	.837**	.324**	1												
ASSTCTRL	.139*	.151*	.125*	.170**	.326**	1											
MCARTRRAT	0.016	.454**	-.235**	-.217**	-.303**	-.201**	1										
MCALTRRAT	0.093	-.300**	0.115	.181**	.124*	-0.028	-.397**	1									
TYPE_CARE	.196**	-0.067	-0.042	.166**	-0.039	-.122*	-0.113	.248**	1								
NPDUMMY	-.122*	0.008	.128*	0.02	.155**	.158**	0.026	-.217**	-.912**	1							
INVDUMMY	-0.048	0.09	-.217**	-.314**	-.283**	-.154**	.126*	0.08	.407**	-.746**	1						
RURAL	-0.093	-.144*	-.323**	-0.089	-.244**	-0.007	.226**	0.043	0.011	0.045	-.117*	1					
SYSTEM	-0.051	-0.039	-0.002	-.320**	-0.027	-0.04	-0.014	0.024	-.211**	.124*	0.066	0.029	1				
ITAASb	-0.047	-0.026	0.095	-0.078	0.091	0.032	-.151*	-0.015	-0.016	-0.005	0.039	-0.006	-0.042	1			
ITAASc	-0.013	-0.05	.243**	0.047	.214**	0.104	-.173**	-0.035	-0.037	0.072	-0.1	-0.077	-0.051	.734**	1		
ITAALb	0.103	-.154**	-0.039	.129*	-0.011	-0.002	-0.111	.140*	-0.084	.222**	-.358**	.140*	-0.064	0.024	0.049	1	
ITAALc	0.053	-0.093	0.001	0.078	0.021	0.001	-0.047	.121*	-.124*	.252**	-.359**	.135*	-0.02	-.117*	0.001	.786**	1

* Correlation significant at p<0.05 (2-tailed test)

** Correlation significant at p< 0.01(2-tailed test)

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