LEVERAGING IT FOR BUSINESS INNOVATION: DOES THE ROLE OF THE CIO MATTER?

Completed Research Paper

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Abstract

The evolving role of Information Technology (IT) in business innovation places increasing emphasis on the role of the Chief Information Officer (CIO). Yet, the role of the CIO in business innovation is understudied in the extant literature. Drawing on organizational theory of boundary spanning leadership, we posit that the CIO's cross-functional role pertaining to entities and functions outside the IT organization help explain the firm's propensity for IT-enabled business innovation.

Our large-sample empirical analysis of U.S. firms largely supports our theoretical propositions. We empirically find that IT-enabled business innovation is more likely when the CIO reports to the Chief Executive Officer, has more interactions with the firm's customers and is more involved in new product development. This study contributes to our understanding of the role of the CIO in IT-enabled business innovation and provides implications for practice.

Keywords: Chief Information Officer, Information Systems Leadership, Business Innovation, IT-enabled Business Innovation

Introduction

Information Technology (IT) has digitized business processes and operations of firms with substantial improvements in productivity and operational efficiency (Brynjolfsson and Hitt 1996). IT advances have also enhanced new product development (Pavlou and El Sawy 2006) and process design capabilities, helping firms increase value propositions of products and services to customers. For example, IT plays a pivotal role at Ducati Motors, aiding their design of new motorcycles (Gino and McAfee 2006). IT-enabled tools are a critical part of Amazon's ability to personalize customer experiences and boost sales. These developments in IT have been reflected in the Information Systems (IS) literature via empirical studies and theoretical models on the role of IT in organizations. Research has also addressed how IT has evolved from a mere efficiency tool to enabling business innovation and providing strategic value (Gordon and Tarafdar 2007; Joshi et al. 2010; Kleis et al. forthcoming; Pavlou and El Sawy 2006; Sambamurthy et al. 2003).

The evolving business capabilities enabled by IT reinforce emphasis on IS[1] leadership, the Chief Information Officer (CIO) (Chatterjee et al. 2001). Traditionally, CIOs were technology-focused with responsibilities primarily limited to managing IT operations (Applegate and Elam 1992; Chun and Mooney 2009). This was largely due to silo IT organizations (departments) and mere efficiency-based supportive role of IT in large firms (Chen et al. 2010). However, the modern CIO role is evolving. As IT emerges as an enabler of business innovation, CIOs are increasingly becoming business leaders who provide guidance in the strategic utilization of IT (Banker et al. 2011; Chen et al. 2010; Chun and Mooney 2009; Enns et al. 2001; Peppard et al. 2011). Firms and Chief Executive Officers (CEOs) now rely on IT and expect CIOs to leverage IT to help drive business innovation (Chen et al. 2010). It is essential that CIOs become a partner and play an integral role in innovation since CIOs can be instrumental in shaping the conditions that facilitate innovation by leveraging IT.[2]

Despite the importance of the CIO, there is relatively limited academic research to enhance our collective understanding of the CIO role in organizational performance. This is also highlighted by past research (Karahanna and Watson 2006; Preston et al. 2008). With IT increasingly enabling strategic capabilities, firms do not rely on IT to just lower costs, but also to drive revenue through business innovation. It is hence important to better understand the role of CIOs in building innovative organizations (Watts and Hendersen 2006). Yet, even as IT continues to digitize business processes and digital intelligence gets increasingly embedded in products and services, there is, to the best of our knowledge, no systematic empirical evidence of whether there is a role for the CIO in the firm's IT-enabled business innovation. To help bridge this knowledge gap in the extant literature, we examine the research question: *What is the relationship between the role of the CIO and the firm's IT-enabled business innovation?*

We draw on the definition of IT-enabled business innovation by prior research (Agarwal and Sambamurthy 2002; Joshi et al. 2010; Teo et al. 2007) as 'new products, processes or services developed by a firm through the application of IT'. For example, IT competences were critical to product innovation capabilities of a large glass-manufacturing company in Ohio (Gordon and Tarafdar 2007). YCH Group, a logistics and supply chain company, used an IT-based analytics system to implement a new process of scheduling trucks (Teo et al. 2007). This definition of IT-enabled business innovation differs from definitions of 'IS innovation' used in seminal IS research (Fichman 2004; Swanson 1994; Swanson and Ramiller 2004) which refer to IS innovation as "innovation in the application of digital computer and communications technologies" (Swanson 1994, p. 1078) and "the pursuit of IT applications new to an organization" (Swanson and Ramiller 2004, p. 556). Our definition can be mapped to and builds off the outcome of what Swanson (1994) defines as 'Type III IS innovations' which are "inherent to or imbedded in a product … or … incorporated within a service" or process (Grover et al. 1997; Swanson 1994, p. 1078).

We draw from organizational theory of boundary spanning leadership (Druskat and Wheeler 2003) and conceptual underpinnings in the IS and innovation literatures to propose a theory linking the CIO role to

[1] In this paper, we use the terms "Information Systems" (IS) and "Information Technology" (IT) interchangeably.

[2] While other executives such as knowledge management executives can also play a part in innovation (McKeen and Staples 2003), our focus in this study is on the role of the CIO.

IT-enabled business innovation. We propose that the CIO's external linkages outside the IT organization (i.e., the role of the CIO as a boundary spanner between the IT organization and the rest of the firm and beyond (Watson 1990)) can have positive implications for IT to drive business innovation. We capture the CIO role including activities of the CIO that pertain to his/her involvement and interactions with entities and functions outside the IT organization. Specifically, we examine four aspects of the CIO role: CIO's involvement in business strategy, CIO's involvement new product development, CIO's interactions with the firm's customers and CIO-CEO reporting structure.

We test our propositions on data from a large sample of U.S. firms. Our empirical study yields three principal findings. First, IT-enabled business innovation is more likely at firms with a direct CIO-CEO reporting structure. Our second and third findings are that IT-enabled business innovation is more likely when the CIO has more interaction with the firm's customers and when the CIO is more involved in new product development (R&D function). Taken together, these results suggest that the CIO role external to the IT organization can help enhance the firm's IT-enabled business innovation. The main contributions of this study are two-fold. First, it applies organizational theory of boundary-spanning leadership to the context of the CIO role in a strategic capability of IT-enabled business innovation. Second, it sheds new light on the relationship between the CIO role and IT-enabled business innovation, a dimension of value which has received limited attention in the extant IS literature.

The rest of this paper is organized as follows. In the following section, we briefly discuss the literature related to CIO, organizational performance and innovation. We then develop our theoretical framework and discuss our hypotheses, empirical setting, data, methodology and results. Subsequently, we discuss the contributions, limitations and future research directions, before concluding in the final section.

Literature Review

Prior literature pertinent to our study can be broadly categorized into three key areas. The first and second areas stem from IS research related to CIO and organizational performance. The third broad area draws from research on innovation from both strategy and IS. Next, we briefly review the three areas.

CIO and Organizational Performance Literature

Interest in the role of the CIO emanated from the differential extent of adoption of IS in organizations and varied recognition of IS as a strategic asset (Applegate and Elam 1992). Early research pointed to the increasing role of CIOs in providing strategic vision through exploitation of IT (Benjamin et al. 1985). The main responsibilities of the CIO were initially recognized to include planning and overseeing technology operations (Gupta 1991).

The CIO research stream has advanced to increase our understanding of how CIOs can be more effective.[3] Smaltz et al. (2006) found that CIO capabilities were significant predictors of CIO role effectiveness. Their analysis showed a mediating relationship between CIO-TMT (Top Management Team) engagements, CIO capability and CIO effectiveness. Relatedly, Enns et al. (2003) found that the types of influence behaviors used by CIOs with their peers can affect the CIO's capacity to gain commitment for strategic information systems. Li et al. (2006) found that CIOs who are open, extroverted and conscientious tend to use IT more effectively. Grover et al. (1993) found that the more centralized the IS resource, the more outward-looking is the role of the CIO, as captured by its interpersonal, informational and decisional aspects.

IS research has also examined how CIOs can impact IT's contribution to firm performance. This research stream emphasizes the importance of CIO structural power, CIO characteristics and CIO-CEO relationships. For example, Preston et al. (2008) found that strategic authority of the CIO influences the value that organizations get from IT. Johnson and Lederer (2005) found that CIO-CEO agreement on IT's role predicts IT's contribution to financial performance. On a related note, Banker et al. (2011) find that CIO-CEO reporting structure is beneficial for firm financial performance for differentiators, rather than

[3] The CIO literature is vast and we limit our review to representative studies of the CIO role and those linking the CIO to organizational performance. Refer Preston et al. (2008) for a list of studies linking aspects of the CIO to performance of the IT organization.

cost leaders. The CIO human capital and structural power also impact IT's contribution to strategic growth and operational efficiency via CIO leadership capabilities (Chen et al. 2010). CIO role effectiveness has been found to affect the firm's ability to apply IT to support, shape, and enable value-chain activities (Wu et al. 2008). Sobol and Klein (2009) found that the technical background of CIOs was positively correlated with return on investment, net income and market share. Announcements of CIO positions can also have a positive effect on market perception of firms (Chatterjee et al. 2001). Yet, while this stream has advanced, there remains, to our best knowledge, a gap linking the CIO role to innovation.

Business Innovation Literature

Reviews of the vast management literature on business innovation (Ahuja et al. 2008) broadly characterize Research and Development (R&D) output and innovation output as production functions with several input determinants including organizational structure, incentives and other business, firm, industry and institutional factors. It is evident from these reviews that IS capability or the managerial capabilities of the IT function has been scantly studied as one of the drivers of business innovation. In the IS literature, the effect of IT on innovation has been captured more recently in some studies. Aggregate IT investments can complement firm's investments in R&D enabling greater innovation productivity (Han and Ravichandran 2006; Kleis et al. forthcoming). IT can also facilitate innovation through improved knowledge management capabilities (Joshi et al. 2010), co-ordination and collaboration (Gordon and Tarafdar 2007; Teo et al. 2007) and a greater ability to manage the process of new product development (Pavlou and El Sawy 2006).

Literature Synthesis

Despite the importance of innovation as a strategic asset and much research on the CIO, there has been, to our best knowledge, no empirical study of the relationship between the CIO role and IT-enabled business innovation. Our study extends the CIO literature in this direction by taking an external perspective of the CIO role (outside the IT organization), consistent with the theory of organizational boundary spanning leadership. In doing so, we also build on prior research perspectives regarding the "role of IS managers in terms of the communication and information flows between the IS organization and outside environments" (Grover et al. 1993, p. 112).

Theory and Hypotheses Development

The CIO as a Boundary Spanner

In the organizational literature, 'boundary spanners' are defined as "persons who operate at the periphery or boundary of an organization, performing organizational relevant tasks, relating the organization with elements outside it"; the conceptual arguments of boundary spanning are also "applicable to inter-unit exchanges within an organization", such as the IT unit (organization) in our study (Leifer and Delbecq 1978, p. 41). Organizational theorists posit that leaders who are boundary spanners can be "strategic link[s] between the team and the organization, that can supply the team with resources and support" (Druskat and Wheeler 2003, p. 435). The boundary spanning activity of leaders has been found to be important for the performance of teams (Elkins and Keller 2003).

The importance of boundary-spanning IS capabilities is also recognized in the IS literature. For example, IT professionals serve as agents brokering both business and IT knowledge across work units of the organization (Pawlowski and Robey 2004). Similarly, Levina and Vaast (2005) and Levina and Vaast (2006) show how IT can support boundary spanning by becoming "boundary objects-in-use" (Levina and Vaast 2005, p. 335).

Since IT is now pervasive in every aspect of business, the CIO plays a boundary spanning role serving as a link between IT and the rest of the firm and beyond (Watson 1990). CIOs are "liaisons" between the IT organization and the external environment and "act as an advocate for the IS function educating the organization on the strategic role of IT" (Carter et al. 2011, pp. 20-21). Consistent with organizational

theory, it is reasonable to expect that the boundary spanning role of the CIO can be beneficial for the performance of the IT organization. Viewing the CIO role from a boundary spanning perspective is especially relevant in light of the evolving role of IT in business.

Drawing from the aforementioned theoretical foundations and from prior literature, Figure 1 presents our theoretical framework for IT-enabled business innovation. It also draws on the fundamental notion that "outside sources of knowledge are critical to the innovation process, whatever the organizational level at which the innovating unit is defined" (Cohen and Levinthal 1990, p. 128). Consistent with the view that "the environment of the IS organization consists of the host organization's environment and everything within the organization that lies beyond the borders of the IS department" (Lederer and Mendelow 1990, p. 206), the framework consists of the IS organization and its external interfaces with the business, R&D function and customers. The framework depicts IT-enabled business innovation as facilitated by interfaces of the IS organization with external entities (Teo et al. 2007).[4] First, the IS organization can transmit innovative business ideas to the business via the flow of information and ideas and development of IT systems. In a digital world, ideas originating from the business[5] are facilitated and implemented through IT. Second, IT-enabled business innovation can be facilitated through the interaction between IT and R&D functions.[6] For instance, Avaya's IT organization works closely with R&D teams to facilitate innovation (Forrester 2005). Prior research has argued that IT investments complement R&D investments (Han and Ravichandran 2006; Kleis et al. forthcoming). Third, IT-enabled business innovation can be enhanced through involvement of customers. This ties in to the open innovation and co-creation paradigms (Chesbrough 2003; Prahalad and Ramaswamy 2004) wherein firms and customers create innovations in partnership. For example, YCH partners with select clients, leveraging their expertise to generate new IT-enabled services (Teo et al. 2007). Prior management literature recognizes that customers can be sources of innovation (von Hippel 1988).

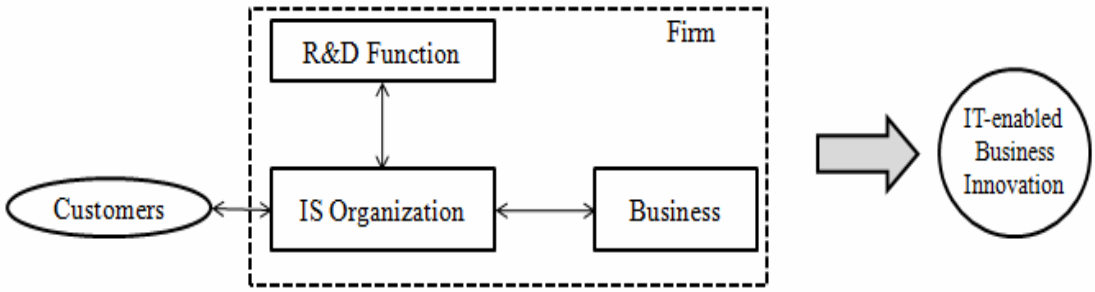

Figure 1. Theoretical Framework of IT-enabled Business Innovation

This framework helps contextualize the phenomenon we examine (IT-enabled business innovation) with the lens of the IS organization and the CIO (boundary-spanning) role, focusing primarily on aspects of the CIO role directed outside the IS organization. In the backdrop of this theory, we discuss our hypotheses focusing on the cross-functional role of the CIO in strategy, R&D and customer interaction processes.

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[4] This framework is by no means comprehensive. It captures the entities we focus on in this study. There are several other external entities (e.g., suppliers, competitors, universities, other firms) potentially important for innovation, but which are outside the scope of our study.

[5] 'IS organization' refers to "that body of individuals providing information technology (IT) resources and services to the business" (Peppard 2001, p. 249). Consistent with prior research, 'the business' refers to other non-IT "internal functions and end-users" (Teo et al. 2007, p. 220) external to the IS organization but within the firm (Chen et al. 2010).

[6] We consider the R&D function as distinct from 'the business', which is more about the business operations of the firm.

Hypotheses Development

Prior research has argued for synergy between IT and business to ensure strategic alignment of IT with the business (Armstrong and Sambamurthy 1999). In the context of alignment, Wade and Hulland (2004) refer to IS-business partnerships as 'spanning resources' that integrate the firm's 'inside-out and outside-in capabilities'. The first boundary-spanning aspect of the CIO role we examine is involvement of the CIO in business strategy.

The involvement of the CIO in business strategy can help IT-enabled business innovation in three ways. First, it can help business leaders understand how IT can be assimilated into the firm's innovation plans (Tarafdar and Gordon 2007). Incorporating IT into development of products, services and processes potentially increases the speed and reduces the cost of innovation (Dewett and Jones 2001). Second, through involvement in business strategy, CIOs can better understand the business, contribute ideas consistent with business strategies (Gordon and Tarafdar 2007; Smaltz et al. 1999) and "partner with the business to innovate" (Chen et al. 2010, p. 234). For example, Wal-Mart recognizes the importance of the CIO's business knowledge and has rotated personnel between the CIO and business roles (Prahalad and Krishnan 2008). An understanding of business issues can help CIOs articulate to senior management, in business terms, how IT is changing the competitive landscape and how the firm can take advantage of those changes for innovation. CIO involvement in business strategy can also help IS departments implement new information-based products and services and coordinate the development of IT and planned business changes in the firm to support the new IT-based products and services. Put differently, CIO involvement in business strategy can result in cross-knowledge exchanges between the business and IT (Tanriverdi 2005). The role of CIO as a strategic business partner can, in turn, foster IT-enabled innovation by bridging the disconnect between CIOs and business managers in the firm (McKenney et al. 1997). Finally, CIO involvement in strategy can help CIOs make better decisions to support IT projects consistent with firms' business innovation needs. Thus, in sum, we draw on organizational theory of boundary-spanning leadership to posit that CIO involvement in business strategy provides the CIO greater exposure to broader knowledge which can be usefully integrated and applied by the IT organization to drive business innovation. Hence we hypothesize,

H1: The extent of the CIO's involvement in business strategy is positively associated with the firm's propensity for IT-enabled business innovation.

The reporting structure between the CIO and CEO has received considerable research attention (Banker et al. 2011). It has been argued that firms that have a direct CIO-CEO reporting structure make more effective (Armstrong and Sambamurthy 1999) and strategic use of IT (Applegate and Elam 1992) whereas a CIO-Chief Financial Officer (CFO) reporting structure reflects the use of IT as a cost center (Banker et al. 2011). Relatedly, prior research (Chen et al. 2010, p. 245) found that CIO-CEO reporting relationship contributes to the CIO's "structural power", defined as the "CIO's level of legitimate power due to his or her formal position within the hierarchy of the organization", which enables the CIO to be a strategic partner and influence IT's contribution to strategic growth (in terms of market share, revenue and ROI).

Building on prior research, we posit a positive relationship between a direct CIO-CEO reporting structure and IT-enabled business innovation for the following reasons. First, a direct reporting structure between the CIO and the CEO promotes a shared understanding between the business and IT on how to use IT for competitive advantage and innovation (Smaltz et al. 2006). Second, a direct CIO-CEO reporting structure represents greater strategic authority of the CIO (Banker et al. 2011; Chen et al. 2010). Shared understanding and greater strategic authority of the CIO can facilitate faster development, advancement and approval of innovative IT-supported business ideas (Feeny et al. 1992). Moreover, innovation is more about implementing new ideas than about reducing cost of IT operations. In firms with a direct CIO-CEO reporting structure, there is, in general, a lesser tendency for IT to focus on minimizing cost of IT operations as compared to firms with a CIO-CFO reporting structure (Banker et al. 2011). These reasons make it more likely that CIOs who report to the CEO may have more authority to influence the CEO and garner support for inherently risky innovation-oriented IT initiatives (Enns et al. 2001; Teo et al. 2007). Hence, we posit,

H2: A direct CIO-CEO reporting structure is positively associated with the firm's propensity for IT-enabled business innovation.

Innovation in products and services can be enhanced through "insights, ideas, thoughts, and information the organization receives from its customers" (Desouza et al. 2008, p. 39). Customers can be a source of innovation for firms by participating as partners and co-producers (Chesborough 2003). By "identifying, analyzing, interacting and communicating with customers", firms can increase their access to insights and ideas of customers about new products and services (Desouza et al. 2008, p. 35).

Digitization and increasingly IT-enabled nature of innovation (Prahalad and Krishnan 2008) magnify the potential role of interaction between IT and customers to support innovation. We extend the interrogation of implications of customer communication for innovation to the IT context by examining whether the IS leadership's (CIO's) interaction with the firm's customers can predict IT-enabled business innovation. We posit such a relationship for three reasons. First, CIO interaction with customers promotes direct communication between IT and customers. This reduces the potential loss of information about customer needs that could occur when IT gets customer requirements from the business. Thus, CIO interaction with customers can improve his understanding of customers' unmet needs for business products and services and help CIOs drive IT initiatives to build solutions around those business needs.

Second, CIO interaction with customers can facilitate dialog, feedback and a shared understanding between customers and the IT organization about how IT can be used innovatively from perspective of customers (Teo et al. 2007). For example, for a well-known U.S. bank, "listening to customer demand for faster, easier access to their accounts" resulted in a new IT-enabled business process that minimized the need for customers to visit the bank for transactions which did not critically require their presence (Walsh 2007). As argued by Desouza et al. (2008), listening to customers transfers knowledge from customers to firms, thus helping firms implement innovations. As a Banking CIO exclaims in a study of CIOs conducted by IBM (IBM 2009), "the challenge is to change from a 'push' model to a 'pull' model, where the customer expresses requirements and IT answers immediately." In the same study, more than 80% of CIOs expected "to seek customers' active input and interaction". Third, interaction with customers can help CIOs seek customer involvement to differentiate products and services from competitors. This can result in new products, services and processes, and novel ways for IT to facilitate and deliver them. Thus, in line with organizational theory of boundary spanning leadership, the CIO's boundary-spanning role as a link between IT and customers can help tap into external sources (customers) of knowledge and ideas, which can aid the IT organization to drive business innovation. Hence we hypothesize,

H3: The extent of the CIO's interaction with the firm's customers is positively associated with the firm's propensity for IT-enabled business innovation.

New product development is a collaborative process where firms incorporate inputs from multiple entities such as scientists, designers and marketers (Clark and Fujimoto 1991). New product development is also an information-intensive process (Nambisan 2003) in which IT can play a crucial role by combining information and automating process and product design, thus increasing the value proposition of IT to the process of innovation (Pavlou and El Sawy 2006).

The CIO's involvement in new product development can help the CIO assess requirements for IT to support the innovation needs of the firm. Firms can reduce time-to-market of new products by developing "systems suggested by the CIO to streamline the product development process" (King 2008). For example, for a video equipment manufacturer, the CIO's partnership with product development groups is recognized as a key facilitator of enablement and speed of new product introductions (Mitra et al. 2011). Thus, participation in product and service development provides an opportunity for the CIO to make a more direct commitment to innovation and to align IT with the innovation initiatives of the firm. Such involvement can lead to greater commitment of IT to facilitating the creation and delivery of new products and services. This involvement also facilitates interactions between the CIO and R&D personnel. Such interactions between "individuals with diverse knowledge structures" can "augment the organization's capacity for making novel linkages and associations- innovating beyond what any one individual can achieve" (Cohen and Levinthal 1990, p. 133). Further, the direct boundary-spanning role of the CIO in the R&D function provides the CIO greater exposure and helps IT get direct information about the firm's innovation needs, potentially reducing chances of information loss (as discussed earlier). Hence we posit,

H4: The extent of the CIO's involvement in new product development is positively associated with the firm's propensity for IT-enabled business innovation.

Research Design and Methodology

Dataset

We obtain data for this study from *InformationWeek (IWeek)*, a leading, widely circulated IT publication in the United States. *IWeek* collected this data by surveying CIOs and senior IT managers at large U.S. firms across industries during the 2008-09 period. The respondents were encouraged to consult with other executives for most updated information. The survey contained questions related to IT practices, IT architecture and IT strategies of the firms. Similar to prior research, collection of data from CIOs and senior IT managers is important because they are in a good position as key respondents to be knowledgeable and most informed of IT practices and CIO role of their company (Grover et al. 1998; Preston et al. 2006). *IWeek* data has also been argued to be "consistent with data from other secondary sources such as International Data Group and Bureau of Economic Analysis" (Rai et al. 1997, p. 92). *IWeek* surveys are thus considered as reliable sources of data and have been used in prior research (e.g., Bharadwaj et al. 1999). We augment this data with firm-level variables from Standard and Poor's Compustat database and SEC filings, and industry-level data from the U.S. Census Bureau.

Variables

Table 1 provides the description of the variables, their sources and references to prior related literature. As shown, we include several control variables that may influence innovation.

Table 1. Variables

Concept	Variable	Description	Reference	Source
Independent and Dependent Variables				
Propensity for IT-enabled Business Innovation	*Innov*	A binary indicator for whether the firm sought to patent, trademark, or copyright any IT-driven business processes, products, or services in the past 12 months.	Consistent with the definition of firm-level IT-enabled business innovation in Joshi et al. (2010), Teo et al. (2007) and Agarwal and Sambamurthy (2002).	InformationWeek
CIO's involvement in Business Strategy	*CIOBusStratInvolv*	This indicates the extent to which the CIO is involved in business strategy decisions in the company ('Not at all involved', 'Somewhat involved', 'Very involved' and 'Highly involved').	A similar measurement approach is used in Armstrong and Sambamurthy (1999).	InformationWeek
CIO-CEO Reporting	*CIOCEOReport*	A binary indicator for whether the CIO reports to the CEO	Law and Ngai 2007	InformationWeek
CIO's interaction with customers	*CIOCustomerInteract*	This indicates the extent to which the CIO interacts with customers ('does not meet customers', 'meets annually', 'bi-annually', 'quarterly', 'Monthly/more frequently').	A similar measurement approach is used in Armstrong and Sambamurthy (1999).	InformationWeek
CIO's involvement in New Product Development	*CIONewProdInvolv*	A summative index (count) indicating the extent to which the CIO is involved in development of new products. It includes 'Involved in the conception of new products', 'Involved in articulating the processes needed to develop new products' and 'Involved in the systems and support mechanisms for producing products'.		InformationWeek
Control Variables				
IT Intensity	*ITIntensity*	Firm's IT budget as a percentage of its annual sales revenue	Bardhan et al. 2006	InformationWeek
R&D Intensity	*R&Dintensity*	Ratio of R&D expenditure to sales of the firm	Ahuja et al. 2008	Compustat, SEC filings
IT R&D Intensity	*ITR&DIntensity*	Share (percentage) of the IT budget devoted to R&D		InformationWeek
Proxy for IT innovativeness	*ITNewProjects*	Share of the IT budget devoted to new IT projects (as opposed to maintenance projects)	Cherian et al. 2009	InformationWeek
Organization Size	*Size*	Logarithm of the annual revenue of the firm for its most recent fiscal year	Ahuja et al. 2008	InformationWeek
Firm Age	*Firm Age*	Logarithm of the number of years since the firm was founded	Chen et al. 2010	Business & Company Resource Center, company websites, other sources
Prior Profitability	*ROA*	Ratio of Net income to Total Assets	Bharadwaj 2000	Compustat, SEC filings
Industry Concentration Ratio	*Industry Concentration*	Four-firm concentration ratio	Melville et al. 2007	2007 U.S. Census
High-tech/Low tech Industry	*Hightech Industry, Lowtech Industry*	Indicator of whether the firm's industry is classified as high-tech, low-tech or neither, based on the classification scheme identified and used in prior research.	Banker et al. 2011	U.S. Census Bureau
IT-Orientation of Industry	*Informate, Transform IT Orientation Industry*	Two dummies that capture the 'informate' and 'transform' IT roles in the firm's industry ('automate' is the default and is omitted).	Chatterjee et al. 2001; Enns et al. 2001; Mooney et al. 1996	U.S. Census Bureau
Industry Sector	*Indxx*	Dummy variables that represent the primary industry sector of the firm. These variables account for potential industry-specific idiosyncrasies beyond those accounted for by the high-tech/low-tech and IT orientation industry variables.	Veugellers and Cassiman 1999	U.S. Census Bureau

Estimation Approach

Since the dependent variable (*Innov*) is binary, Ordinary Least Squares (OLS) is inappropriate as it does not account for non-linearity (Greene 2003). To overcome such issues, we use the probit model.[7] We account for the possibility that CIO role may be endogenous. Failure to account for this can bias estimates (Greene 2003). To test our hypotheses accounting for potential endogenity, we follow a two-step method recommended by Shaver (1998) and Bharadwaj et al. (2007), first put forth by Heckman (1979). Following Bharadwaj et al. (2007) and consistent with Shaver(1998), we separate our sample firms into two groups: firms with scores above the mean on the sum of the four (standardized) CIO variables, coded as one, and firms below the mean on the sum of the four (standardized) CIO variables, coded as zero. Intuitively, this binary variable (which we label *StratCIOActivity*) captures the extent of strategic activity of the CIO of the firm. Then, we estimate the first-stage probit equation consisting of *StratCIOActivity* regressed on variables which, based on prior research, may predict a more strategic role of the CIO in the firm (Applegate and Elam 1992; Banker et al. 2011; Chatterjee et al. 2001; Chen et al. 2010; Enns et al. 2001; Feeny et al. 1992; Peppard et al. 2011; Smaltz et al. 1999). These include CIO level variables, firm-level variables and industry level variables. At the CIO level, variables are included indicating whether the CIO is on the board of another firm and whether the CIO is also responsible for security. The first of these suggest that the CIO plays a more strategic role outside the firm while the second relates to the CIO role within the firm.[8] At the firm level, *ITIntensity*, *R&DIntensity*, *ITR&DIntensity*, *ITNewProjects*, *Size and ROA* are included to account for the possibility that CIOs in firms with higher values on these variables may have a more strategic role. We also include variables indicating outsourcing of IT operations domestically or offshore to another country; we expect these variables to be negatively associated with a more strategic role of the CIO (Chen et al. 2010). Finally, at the industry level, concentration ratio (Watson 1990), high-tech and low-tech industry dummies, informate and transform industry dummies, and industry sector dummies are included to control for industry factors that may shape the CIO role (Peppard et al. 2011). In the two-step approach, endogenity is controlled for by calculating the Inverse Mills Ratio (IMR) using estimates from the first stage and including it in the second stage innovation equation as an additional predictor (Bharadwaj et al. 2007; Heckman 1979; Shaver 1998).[9] As noted by Shaver (1998), since the second stage dependent variable is binary, the two-step approach, while accounting for endogenity, provides an approximation to the probit. The equations are:

$$\underline{\text{CIORole Equation:}} \quad \text{Probability}\,(\textit{StratCIOActivity}=1) = \Phi\,(\beta_a + \beta_r \mathbf{W_r} + u) \qquad (1)$$

$$\underline{\text{Innovation Equation:}} \quad \text{Probability}\,(\textit{Innov}=1) = \Phi\,(\beta_0 + \beta_1 \textit{CIOBusStratInvolv} + \beta_2 \textit{CIOCEOReport} + \beta_3 \textit{CIOCustomerInteract} + \beta_4 \textit{CIONewProdInvolv} + \beta_5 \textit{InverseMillsRatio} + \beta_c \mathbf{X_c} + \varepsilon) \qquad (2)$$

where the βs are the parameters for the respective variables, $\mathbf{X_c}$ is the vector of control variables, $\mathbf{W_r}$ is the vector of variables as described in the above paragraph, Φ denotes the normal cumulative distribution function and u, ε are the error terms.

As a robustness check, we also jointly estimated the above two equations (without the IMR term) using the bivariate probit model (Greene 2003). The bivariate model estimates are similar to the two-step model estimates and the findings remain unchanged.[10]

The econometric structure in the two-step approach captures the potential endogenous nature of the CIO role and is a close representation of the theoretical possibility that firm and industry attributes may shape the CIO role. As we describe in the Results section, the two-step approach does not suggest the presence of endogenity after accounting for our observed variables. We also report the probit estimates of our main equation of interest (eq. 2).

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[7] Probit and logistic models are used when the dependent variable is binary (Greene 2003). The logistic model gives similar results.

[8] We do not make any prediction for the sign of the variable indicating CIO's responsibility for security. On one hand, it may suggest a wider role for the CIO in the firm and on the other hand, it may suggest a more technology-oriented role of the CIO.

[9] Technical details and derivations of the expressions for IMR can be found in Shaver (1998) and are not repeated here for brevity.

[10] The bivariate estimates are omitted here for brevity. They are available in a longer version of the paper.

Results

After dropping incomplete observations and outliers (Hosmer and Lemeshow 2000), the sample consists of 257 U.S. public firms across various manufacturing and service industries. About 54% of the firms are in manufacturing industries while 46% are in service industries. The descriptive statistics of the key variables are in Table 2.[11]

Table 2. Descriptive Statistics and Correlations among Key Variables

	Variables	Mean	SD	Min	Max	1	2	3	4
1	Innov	0.33	0.47	0	1	1			
2	CIOCEOReport	0.44	0.49	0	1	0.24*	1		
3	CIONewProductInvolv	1.91	1.02	0	3	0.26*	0.24*	1	
4	CIOBusStratInvolv	2.25	0.82	0	3	0.09	0.24*	0.26*	1
5	CIOCustomerInteract	2.52	1.41	0	4	0.27*	0.21*	0.28*	0.28*

N = 257. * indicates significance at $\alpha = 0.05$

The results are provided in Table 3. The first two columns of Table 3 report the two-step results, and the standard probit results are provided in the third column.

We interpret the two-step probit model first. In the first step (1st column, Table 3), the model is significant (Wald = 55.86, $p < 0.01$) and several variables are statistically significant. Specifically, CIOs are likely to have a more strategic role at firms in which the CIO is on the board of another company, is responsible for security and at firms which have greater IT intensity and size. CIOs are likely to play a less strategic role in firms which have outsourced domestically or offshored overseas their IT operations. The second stage of the model (2nd Column, Table 3) provides tests for our hypotheses and controls for endogenity by including the IMR calculated from the first-stage (Bharadwaj et al. 2007; Shaver 1998). A Chi-square test of the null that all the four CIO-related variables are jointly zero is rejected ($p<0.0001$). The IMR coefficient is statistically insignificant ($p=0.82$), suggesting a lack of bias due to endogenity (Heckman 1979; Shaver 1998).

Consistent with our hypothesis, we find that a direct CIO-CEO reporting structure is positively associated with propensity for IT-enabled business innovation ($\beta_2=0.61$, $p<0.01$). Quantitatively, other variables constant at their mean, firms in which the CIO reports to the CEO experience an increase of 0.21 in the predicted probability of (*Innov*=1). Similarly, H3 is supported ($\beta_3=0.21$, $p<0.05$), with a unit increase in *CIOCustomerInteract* associated with an increase of 0.07 in predicted probability of (*Innov*=1). We also find support for H4 ($\beta_4=0.33$, $p<0.05$), with a unit increase in *CIONewProdInvolv* associated with an increase of 0.11 in predicted probability of (*Innov*= 1). These findings are consistent with anecdotal recognition of the increasingly strategic role of CIOs and with the theoretical arguments of boundary-spanning leadership in the organizational literature applied to the CIO role (Druskat and Wheeler 2003; Leifer and Delbecq 1978). We find no support for H1 (business strategy involvement). Two explanations for this are plausible. First, the clarity to innovation opportunities that CIOs get through involvement in strategy may be mixed across the firms. Second, from a strategy perspective, firms may vary in how IT drives business innovation (Tallon et al. 2000). To the extent that IT investment in new projects reflects innovative IT use, the *ITNewProjects* variable controls for the innovative nature of the firm's IT strategy. This apart, our data do not allow us to identify a firm's business strategy.

The control variables are generally in expected directions. IT R&D intensity and firm size are positive and significant, consistent with prior research (Ahuja et al. 2008). *ITNewProjects* is positive and significant, corroborating the argument that IT for new projects helps IT-enabled innovation. Firms in industries where IT plays an 'informate' role may have more propensity for IT-enabled innovation compared to

[11] The pair-wise correlations of the remaining variables are along expected lines and omitted here for brevity. None of them are alarmingly high.

where IT plays an 'automate' role (Chatterjee et al. 2001). The directions of the controls further validate our model.

Table 3. Results

	Two-step Probit Estimates		Probit Estimates
	CIO Role Equation	Innovation Equation	Innovation Equation
	Dependent Variable = *StratCIOActivity*	Dependent Variable = *Innov*	Dependent Variable = *Innov*
CIOBusStratInvolv	n/a	-0.136 (0.148)	-0.150 (0.135)
CIOCEOReport	n/a	0.614*** (0.211)	0.592*** (0.189)
CIOCustomerInteract	n/a	0.210** (0.082)	0.204** (0.080)
CIONewProductInvolv	n/a	0.334** (0.130)	0.319*** (0.112)
R&DIntensity	1.597 (1.117)	-0.171 (1.332)	-0.176 (1.339)
ITR&DIntensity	0.033 (0.022)	0.046** (0.023)	0.047** (0.023)
ITIntensity	0.057* (0.033)	0.034 (0.026)	0.035 (0.026)
ITNewProjects	0.001 (0.006)	0.014** (0.006)	0.014** (0.006)
Organization Size	0.171** (0.080)	0.283*** (0.081)	0.284*** (0.080)
Firm Age	0.104 (0.109)	0.053 (0.116)	0.054 (0.116)
ROA	-1.113 (1.350)	0.284 (1.827)	0.281 (1.828)
Industry Concentration	0.002 (0.005)	0.005 (0.006)	0.005 (0.006)
High-tech Industry	0.125 (0.369)	0.198 (0.370)	0.196 (0.370)
Low-tech Industry	-0.164 (0.442)	-0.559 (0.491)	-0.551 (0.489)
Informate IT Orientation Industry	0.131 (0.320)	0.702* (0.364)	0.702* (0.364)
Transform IT Orientation Industry	-0.084 (0.332)	0.159 (0.405)	0.156 (0.405)
CIO Responsible for Security	0.420* (0.225)	n/a	n/a
CIO on the Board of another company	0.563** (0.222)	n/a	n/a
Offshored IT to another country	-0.408** (0.190)	n/a	n/a
Outsourced IT domestically	-0.478** (0.232)	n/a	n/a
Inverse Mills Ratio	n/a	-0.043 (0.190)	n/a
Constant	-1.935** (1.044)	-5.677*** (1.158)	-5.604*** (1.154)
Log Pseudo-likelihood	-145.935	-119.524	-119.546
Wald Chi-square	55.86	81.79	80.08
Prob > Chi-Sqr	0.004	0.0000	0.0000
McKelvey and Zavoina Pseudo R-square	0.351	0.468	0.467
Observations (N)	257	257	257

Notes: (1) Robust Standard Errors in parentheses. (2) Significant at *10%, **5% and ***1% level for Chi-Square tests. (3) In interest of space, estimates for industry sector dummies are not shown. (4) "n/a": Not applicable.

The standard probit model (3rd column, Table 3) gives similar results.

Robustness Tests

We performed several robustness tests which indicated robustness of the results. These included tests for goodness of fit, common method bias, multicollinearity, heteroskedasticity, model specification and correlation of the binary dependent variable with actual patents filed by the company in the same year. These tests indicated no significant issues. For example, Variance inflation factors indicated that multicollinearity is not an issue. A model specification test suggested no specification errors. Harman's one-factor test and marker variable test did not suggest common method bias. Further, there was positive and significant correlation between the innovation measure in this study (*Innov*) and patents filed by the firms. These tests further validated the model and added robustness to the findings.

Discussion

Findings

Table 4 provides a summary of the hypotheses and findings.

Table 4. Summary of Findings

Hypothesis		Finding
H1	The extent of the CIO's involvement in business strategy is positively associated with the firm's propensity for IT-enabled business innovation.	Not supported
H2	A direct CIO-CEO reporting structure is positively associated with the firm's propensity for IT-enabled business innovation.	Supported
H3	The extent of the CIO's interaction with the firm's customers is positively associated with the firm's propensity for IT-enabled business innovation.	Supported
H4	The extent of the CIO's involvement in new product development is positively associated with the firm's propensity for IT-enabled business innovation.	Supported

The role of IT in business innovation has been a subject of emerging interest in recent times (Gordon and Tarafdar 2007; Han and Ravichandran 2006; Joshi et al. 2010; Kleis et al. forthcoming). Our goal in this research was to examine the CIO role in the context of the firm's IT-enabled business innovation. Our findings add to knowledge of the relationship between a key IS resource, the CIO, and the firm's IT-enabled business innovation. It provides empirical evidence of how the IS leadership role external to IT predicts the propensity of the firm for IT-enabled business innovation. Our results show that when the CIO has more interaction with customers, is more involved in new product development and has a direct reporting relationship to the CEO, IT is more likely to drive business innovation in the firm. Overall, the results are consistent with our theoretical framework (Figure 1), applied to the CIO role.

Contributions to Research

The contributions of this study for research are multifold. First, the results are consistent with the organizational theory of boundary spanning leadership applied to the CIO role (Druskat and Wheeler 2003). Our findings suggest that the CIO's interface with external entities and functions can have positive implications for IT to drive business innovation. Second, our results are consistent with the open innovation paradigm (Chesbrough 2003), in which customers are a potential source of ideas. Specifically, our results suggest that interaction of CIOs with customers can have positive implications for IT-enabled innovation. Third, results suggest that IT is more likely to drive innovation at firms in which the CIO

reports to CEO. This result builds on prior research findings that such firms make more strategic use of IT (Banker et al. 2011). Business innovation is often risky and experimental in nature (Graves and Langowitz 1993). Our finding suggests that a CIO-CEO reporting structure gives CIOs more influence or power to champion the cause of innovation. Finally, our results suggest the potential of the CIO role in R&D function, shedding light, from an IS leadership perspective, on the interplay between IT and R&D.

Our study reinforces the notion that IT-enabled business capabilities are increasingly dependent on how the IT organization interfaces with the rest of the firm and external entities (Chen et al. 2010; Teo et al. 2007). The resource-based view applied to IS posits that IS resources in combination with other firm resources create strategic synergies that are valuable, rare, inimitable and non-substitutable (Melville et al. 2004). Our study examined some interfaces between a key IS resource (CIO) and other firm and external resources in context of a strategic capability of business innovation. Our study is also a step to addressing the call of Karahanna and Watson (2006, p. 171) to examine "relationships, processes, structures and mechanisms" that help IS leadership drive new value streams for their firms.

More fundamentally, this study contributes by showing the importance of IS capability, as reflected in the CIO role, for a strategic firm capability, IT-enabled business innovation. Our research can potentially add to the sparse but growing body of literature that is expanding the scope of IT value to include business innovation (Gordon and Tarafdar 2007; Han and Ravichandran 2006; Joshi et al. 2010; Kleis et al. forthcoming; Pavlou and El Sawy 2003). This study also provides another example of how IS resources can create "indirect" (business innovation) value, as called for by prior research (Kohli and Grover 2008, p. 33). As discussed earlier, extant research has mainly focused on IT investments and mechanisms by which IT drives business innovation. In this study, we advance this exploration in the direction of IS leadership, consistent with calls to "examine how CIO leadership influences other IT-enhanced organizational outcomes [besides efficiency and strategic growth]" (Chen et al. 2010, p. 261). In doing so, we also build on literature on IS leadership and strategic capabilities (Chen et al. 2010).

Contributions to Practice

It is well known that CIO role is crucial in the IT organization. Our findings suggest when CIOs 'boundary spans' with important constituents outside IT such as the business, R&D function and customers, IT is more likely to drive business innovation. Past research has suggested that CIOs need to advance business capabilities through IT-driven strategic and innovation initiatives (Karahanna and Watson 2006). Our results suggest a role for CIOs to engage with customers and be involved with R&D function. In a digitized world, IT can draw on customers as a means to further innovation. Although our hypothesis regarding business strategy involvement is unsupported, we find that CIO-CEO reporting structure predicts greater potential for IT-enabled business innovation. This suggests that the strategic orientation of the CIO (reflected by direct reporting structure to the CEO) is more likely associated with IT-enabled innovation. This finding builds on research related to CIO-CEO reporting structure and strategic capabilities (Banker et al. 2011). Further, our results suggest that CIO-CEO reporting structure is more likely to give CIOs power to garner support for IT-driven innovation initiatives (Enns et al. 2001; Teo et al. 2007).

Limitations

This study should be viewed in light of its limitations, some of which can be starting points for future research. First, the sample firms (*IWeek*) may not be representative of the population of firms in their use of IT. Despite our use of control variables to account for related differences in firms and industries, the lack of a perfectly random sampling frame hinders the generalizability of our results. Second, the cross-sectional analysis design limits inferences to association and not causality. However, similar to prior literature, our two-step model that statistically accounts for endogenity and that gives similar results as the standard probit model mitigates endogenity concerns (Bharadwaj et al. 2007; Shaver 1998). Third, though the self-reported measure of innovation is positively correlated with external patents and though self-reported and binary innovation measures have been used in research (e.g., Aragon-Correa et al. 2007; Leiponen and Helfat 2010, among others), future studies can use more refined measures. Crucially however, we aim to examine firms' business innovation *driven by IT*. The self-reported measure specifically captures IT-driven nature of business innovation. Finally, the data were collected from CIOs and senior IS managers who, despite being key respondents about IT practices and CIO role in their

organization, could also overrate the benefits that their firms derive from IT (Grover et al. 1998). Still, the positive and significant correlation between our innovation measure and patents, along with the common method tests that indicated no bias alleviate this concern.

Suggestions for Future Research

Our study points to several directions which can be potential opportunities for future research. First, future research can empirically validate the mechanisms by which we theorized role of CIO in IT-enabled innovation. Similarly, examination of moderating factors in the link from CIO role to IT-enabled business innovation can shed further light on the link between CIO role and innovation. Second, studies can examine other roles, such as role of CIO with regard to suppliers. Third, future work can examine how CIO leadership styles foster innovation. Finally, our study primarily considers the extent of CIO interactions with external entities. Examining how the *quality* of interaction helps innovation is potentially promising.

Conclusion

In an age when IT is called upon to provide strategic value, it is incumbent upon CIOs to contribute to their firms' capacity to innovate. This research first posited a theoretical framework in which IT-enabled business innovation is facilitated by interactions of the IT organization with external entities and functions, namely, the business, R&D function and customers. Drawing on organizational theory of boundary spanning leadership and using data on U.S. firms, we empirically examined the CIO role in the context of the framework and found that the likelihood of IT-enabled business innovation is higher when the CIO reports directly to the CEO, has more interaction with firm's customers and is more involved in product development. The findings contribute to understanding of the CIO role in IT-enabled business innovation and suggest that firms can enhance business innovation by leveraging IS leadership more extensively in external relationships outside the IT organization. More broadly, this study sheds light on the CIO role in a strategic capability, specifically IT-enabled business innovation. We hope that this research stimulates further exploration into the interplay between IS leadership and business innovation.

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