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IT Capabilities, Process-Oriented Dynamic Capabilities, and Firm Financial Performance*

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Abstract

More and more publications are highlighting the value of IT in affecting business processes. Recognizing firm-level dynamic capabilities as key to improved firm performance, our work examines and empirically tests the influencing relationships among IT capabilities (IT personnel expertise, IT infrastructure flexibility, and IT management capabilities), process-oriented dynamic capabilities, and financial performance. Process-oriented dynamic capabilities are defined as a firm's ability to change (improve, adapt, or reconfigure) a business process better than the competition in terms of integrating activities, reducing cost, and capitalizing on business intelligence/learning. They encompass a broad category of changes in the firm's processes, ranging from continual adjustments and improvements to radical one-time alterations. Although the majority of changes may be incremental, a firm's capacity for timely changes also implies its readiness to execute radical alterations when the need arises. Grounded on the theoretical position, we propose a research model and gather a survey data set through a rigorous process that retains research validity. From the analysis of the survey data, we find an important route of causality, as follows: IT personnel expertise → IT management capabilities → IT infrastructure flexibility → process-oriented dynamic capabilities → financial performance. Based on this finding, we discuss the main contributions of our study in terms of the strategic role of IT in enhancing firm performance.

***Keywords**: IT Capabilities, IT Resources, Process-oriented Dynamic Capabilities, Firm Performance, Resource-based View, IT Business Value*

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1. Introduction

The relationship between IT and firm performance is a crucial research issue that symbolizes the value of information systems research (Devaraj & Kohli, 2003; Tanriverdi, 2005). Many studies have attempted to understand the role of IT in organizational performance, and more researchers are paying attention to the notion of *IT capabilities*, including their potential to transform IT resources into business value. Recognizing firm-level, *process-oriented dynamic capabilities* (PDCs) as key to improved firm performance, this study intends to enhance our knowledge about how IT is tied to business value by offering an integrated view of the relationships among IT capabilities, PDCs, and financial performance.

PDCs are defined as a firm's ability to change (e.g., improve, adapt, adjust, reconfigure, refresh, renew, etc.) a business process better than the competition. We look at firm competence in this area in terms of three key dimensions of business processes: integration/connectivity (e.g., connecting parties for communication and information sharing), cost efficiency, and capitalization of business intelligence/learning (e.g., bringing business analytics and information into the process) (Butler & Murphy, 2008; Fang & Zou, 2009). In fact, dynamic capabilities have been defined as "the ability to integrate, build, and reconfigure internal and external competencies to address rapidly changing environments" (Teece, Pisano, & Shuen, 1997, p. 517). More recently, Helfat et al. (2007, p. 1) have defined dynamic capabilities as "the capacity of an organization to purposefully create, extend or modify its resource base." They are demonstrated by a firm's ability to recognize changing opportunities in internal and external environments, configuring organizational processes and deploying resources efficiently and promptly to capitalize on them (Eisenhardt & Martin, 2000).

Changes in business processes, ranging from incremental adjustments and improvements to radical reconfigurations and alterations (Ambrosini, Bowman, & Collier, 2009), constitute an important indicator of dynamic capabilities. Whether the enhancement is radical or gradual, it has been recognized that even seemingly minor innovations (e.g., technological changes) can have dramatic impacts on a firm's abilities in terms of market competition (Salvato, 2009). In addition, a firm's ability to make changes in business processes in a dynamic fashion (though gradual) indicates its readiness to undergo other radical reconfigurations effectively when the situation demands.

Our research offers two primary contributions to the IS community. The first is to compare the outcomes of two different modeling approaches (direct vs. indirect modeling). Scholars have taken different avenues to elucidate the relationship between IT and firm performance. Some studies are based on the modeling approach, in which IT capabilities and firm performance are directly tied; others treat the relationship as indirect (Pavlou & El-Sawy, 2006; Wade & Hulland, 2004). This difference in the modeling paradigm makes it difficult to compare findings of existing studies. To facilitate comparison, our study utilizes PDCs, the ability to improve business processes to respond to changing market environments, as a differentiator between the two models.

Second, we examine the interrelationships among three primary IT capability constituents (i.e., IT personnel expertise, IT management capabilities, and IT infrastructure flexibility). A literature review indicates that the primary focus of existing studies has been to understand the contribution of IT capabilities toward creating business value. Consequently, the issue of the dynamics among different types of IT capabilities has been largely overlooked.

With previous research contributions in mind, we propose a research model that depicts how enhanced IT capabilities ultimately result in improved financial performance (Figure 1). The research model includes the following constructs: perceived financial performance, PDCs, and IT capabilities (i.e., IT infrastructure flexibility, IT personnel expertise, and IT management capability). The operating presumption is that IT capabilities influence PDCs and, subsequently, a firm's financial performance. As for the relationships among IT capabilities, we expect IT personnel expertise to influence IT infrastructure flexibility and IT management capability directly. It is also anticipated that IT management capability affects the level of IT infrastructure flexibility.

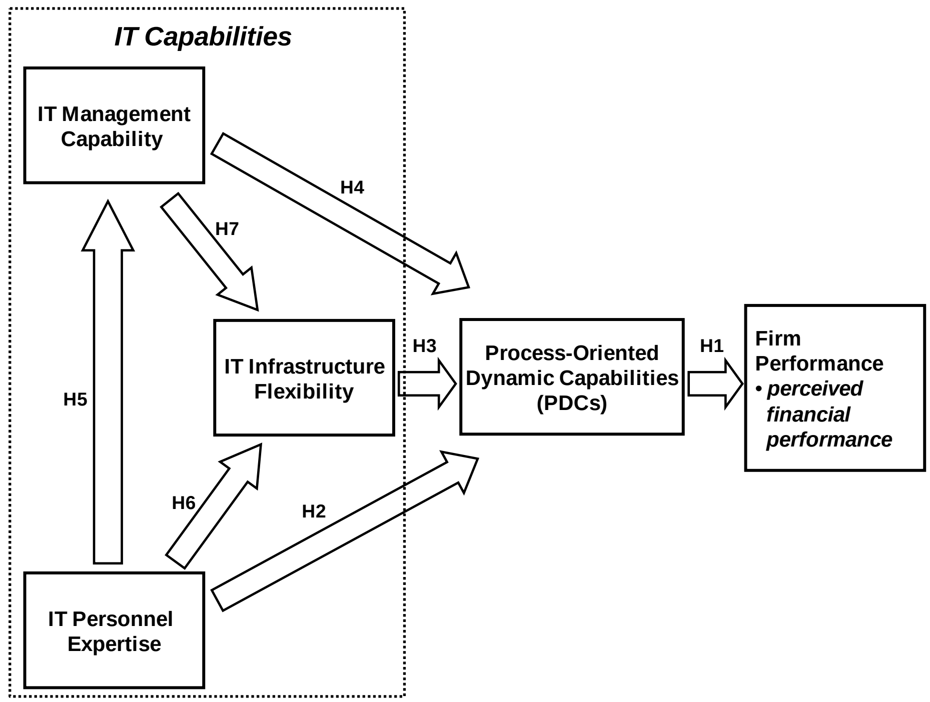


Figure 1. Research Model

In order to test the integrity of the research model, the study proceeds as follows. In section 2, we review existing literature and theories and characterized and propose relevant hypotheses. We describe details of the research method utilized for this study in Section 3. Section 4 summarizes the results of our data analysis based on structural equation modeling. Section 5 discusses the findings and contribution of this work from two different perspectives. Section 6 concludes by discussing the limitations of this study and possible directions for future research.

2. Literature and Hypotheses

2.1. IT and Firm Performance

Early studies of IT business value examined the impact of IT investment on organizational performance, primarily at the firm level (Melville, Kraemer, & Gurbaxani, 2004). Many of them relied on the production function approach (or black box approach), in which a mathematical specification is defined based on microeconomic theory, and utilized to link production inputs (e.g., labor, IT, other capital) and outputs (e.g., quality and quantity) directly (e.g., Brynjolfsson & Hitt, 1996). However, this research paradigm was grounded on the simplistic idea that IT provides the tools necessary to transform inputs to outputs effectively (Orlikowski & Iacono, 2001). Early empirical studies that relied on the black box approach lack consistency in explaining the association between IT investment and organizational performance; they set off the controversy of the IT productivity paradox (Brynjolfsson, 1993).

To tackle the productivity paradox problem, arguments have been made that research on IT business value should investigate the effects of IT on business processes (Ray, Barney, & Muhanna, 2005). Proponents point out that it is the process (e.g., a better way of doing things) rather than the product where IT makes a true impact (McAfee & Brynjolfsson, 2008). Naturally, relying on the black box approach means a loss of statistical power in determining the meaningful relationship between IT investment and organizational performance because of the large distance (i.e., temporal gap) between them (Barua Kriebel, & Mukhopadhyay, 1995). Studies grounded on the process model have shown more consistent and explanatory results (Ravichandran & Lertwongsatien, 2005).

Recently, researchers have depended primarily on the resource-based view (RBV) as the main theoretical framework to understand the relationship between IT and its business value. The RBV argues that competitive advantage emerges from unique combinations of resources that are economically valuable, scarce, and difficult to imitate (Barney, 1991; Grant, 1991). These resources are heterogeneously distributed across firms, and their innate traits--such as path dependency, embeddedness, and causal ambiguity--make them a springboard for competitive advantage (Barney, 1991). The IT capability literature recognizes that competence in mobilizing and deploying IT-based resources is a source of competitive advantage and differentiates firm performance (Bharadwaj, 2000; Piccoli & Ives, 2005; Ha & Jeong, 2010). As seen in Table 1, recent studies of IT capabilities performed on the basis of RBV take both direct (e.g., Bhatt & Grover, 2005; Powell & Dent-Micallef, 1997) and indirect (e.g., Pavlou & El-Sawy, 2006; Tippins & Sohi, 2003) views in understanding the linkage between IT capabilities and firm performance. Studies grounded on the two research paradigms generally report positive associations between IT capabilities and firm performance.

Table 1. Summary of RBV-based Studies

Related Studies	Study Type	Linkage between IT Capabilities and Firm Performance	Statistical Significance of Links
Mata, Fuerst, and Barney (1995)	Conceptual	Direct	N/A
Ross Beath, and Goodhue (1996)	Conceptual	Direct	N/A
Powell and Dent-Micallef (1997)	Empirical	Direct	IT human resources → firm performance (o) Business resources → firm performance (x) Technology resources → firm performance (x)
Bharadwaj, Sambamurthy, and Zmud (1998)	Conceptual	Direct	N/A
Bharadwaj (2000)	Empirical	Direct	IT capability → firm performance (o)
Santhanam and Hartono (2003)	Empirical	Direct	IT capability → firm performance (o)
Tippins and Sohi (2003)	Empirical	Indirect	IT competency → organizational learning (o) → firm performance (o)
Sambamurthy, Bharadwaj, and Grover (2003)	Conceptual	Indirect	N/A
Melville et al. (2004)	Conceptual	Indirect	N/A
Ravichandran and Lertwongsatien (2005)	Empirical	Indirect	IT capabilities → IT support for core competencies) (o) → firm performance (o)
Bhatt and Grover (2005)	Empirical	Direct	IT infrastructure quality → competitive advantage (o) IT business expertise → competitive advantage (o) relationship infrastructure → competitive advantage (o)
Pavlou and El-Sawy (2006)	Empirical	Indirect	IT leveraging competence → process capabilities (dynamic and functional) (o) → competitive advantage (o)

Note: (o) significant link, (x) insignificant link

2.1.1. PDCs and financial performance

As stated, PDCs represent a firm's capacity to change organizational processes to achieve better integration, cost reduction, and business intelligence. Enhanced PDCs, thus, should increase the effectiveness of a firm's operational processes by allowing the acquisition and assimilation of internal and external knowledge, configuration/reconfiguration of the resource base, and deployment/redeployment of resources to be aligned with the firm's corporate vision (Liao, Kickul, & Ma, 2009). Firms with excellent PDCs are expected to remedy ineffective operational processes better, faster, and cheaper than the competition, and turn them into processes responsive to changing business environments (Butler & Murphy, 2008; Eisenhardt & Martin, 2000). Such firms can outperform competitors by reacting more effectively to changing environments through enhanced communication, coordination, and information-sharing (Tippins & Sohi, 2003). Also, PDCs can result in timely and accurate decision making (Davenport & Short, 1990; Eisenhardt & Martin, 2000; Sher & Lee, 2004). Excellent PDCs, therefore, are expected to engender better firm performance and give firms a competitive advantage (Pavlou & El-Sawy, 2006; Rothaermel & Hess, 2007; Zollo & Winter, 2002).

However, the presumption that stronger PDCs automatically result in better financial performance should be made with caution, because the benefits of process improvement may be diluted or neutralized before they affect a firm's financial performance, which is the ultimate bottom line. For example, the benefits may be shared with business partners in such forms as incentives, or they may be channeled to improve customer satisfaction through lower costs and higher product/service quality (Hitt & Brynjolfsson, 1996; Ray, Barney, & Muhanna, 2004). Accordingly, our empirical efforts examine the relationship between a firm's PDCs and its financial performance by hypothesizing that:

Hypothesis 1: *PDCs of a firm are positively associated with its financial performance.*

2.2. IT Capabilities and PDCs

The IT function is an independent organizational function, just like marketing or R&D. Most IS studies utilize a taxonomy of organizational resources, as outlined by Grant (1991) or Barney (1991), as their theoretical basis. Grant (1991) divided organizational resources into tangible, personnel-based, and intangible resources. Barney (1991) categorized organizational resources into physical capital, human capital, and organizational capital resources. These taxonomy schemes, although they differ in their terminology, are similar in that they reflect physical (e.g., equipment), human (e.g., individual skill or knowledge), and organizational (e.g., structure, rules, relationships, and culture) aspects.

Table 2 summarizes typologies of IT resources or capabilities that previous studies have introduced. One notable observation is that most IS studies utilize taxonomy schemes in which physical and human resources/capabilities are consistently mapped onto IT functions (e.g., technical IT resources and human IT resources). However, efforts to translate organizational resources/capabilities into those germane to the IT function in a systematic fashion have been generally lacking (Melville et al., 2004). Table 2 demonstrates that organizational resources investigated by existing studies can be classified more divergently than simply as physical or human resources. In addition, certain variables in studies of organizational resources/capabilities (e.g., access to capital, business resources, complementary organizational resources, and culture of IT use) are not necessarily native to the IT function. The lack of such definitional convergence in organizational IT resources/capabilities research makes it difficult to track the cumulative progress of the domain research.

The IT function encompasses tasks that are highly distinct from other business functions, and accordingly, IT personnel develop, retain, and reproduce their own organizational resources/capabilities. For example, the IT function has its own rules (e.g., prioritization of IT projects, performance measures of IT function and staff), structures (e.g., distribution of IT function to business units), policies (e.g., IT roadmap and vision, IT enterprise architecture, balancing strategic and tactical initiatives of IT), business relationships (e.g., appointment of IT relationship managers), and other things (e.g., IT compliance to regulation, IT sourcing, and rolling budget plans in sync with changing business strategies) necessary to design, deploy, and manage IT infrastructure and support business clients (Bharadwaj, 2000; McKeen & Smith, 2008).

Table 2. Typologies of IT Resources or Capabilities

Related studies	Typologies		
	Physical aspect	Human aspect	Organizational aspect
Mata et al. (1995)	• Proprietary technology	• Technical IT skills • Managerial IT skills	• Access to capital • Customer switching costs
Ross et al. (1996)	• Technical assets	• Human assets	• Relationship assets
Powell and Dent-Micallef (1997)	• Technology resources	• IT human resources	• Business resources
Bharadwaj et al. (1998)	• External IT linkages • IT infrastructure	• Business IT strategic thinking	• IT business process integration • IT management • IT/business partnerships
Bharadwaj (2000)	• Tangible resource	• Human IT resources	• Intangible IT-enabled resources
Tippins and Sohi (2003)	• IT objects	• IT knowledge	• IT operations
Melville et al. (2004)	• Technical IT resources	• Human IT resources	• Complementary organizational resources
Ravichandran and Lertwongsatien (2005)	• IT infrastructure flexibility	• IS human capital	• IS partnership quality
Bhatt and Grover (2005)	• IT infrastructure quality	• IT business experience	• Relationship infrastructure
Pavlou and El Sawy (2006)	• Acquisition of IT resources	• Leveraging of IT resources	• Deployment of IT resources
Aral and Weill (2007)	• IT assets	• IT skills • IT management quality (skills)	• Culture of IT use • Digital transactions • Internet architecture

The majority of these organizational IT resources/capabilities represents relevant issues of IT governance in terms of planning, investment decision-making, coordination, and control (Boynton & Zmud, 1987). These IT-native organizational capabilities are highly divergent among firms, and at the same time, markedly different from other traditional, more business-driven forms of organizational capabilities. In fact, one of many challenges that CIOs face is the lack of a supportive governance structure tailored to the IT function (McKeen & Smith, 2008). This leads us to believe that IT management capability--manifested by planning, investment decision, coordination, and control--is a primary indicator of a firm's organizational capabilities. Subsequently, in parallel with the taxonomy (physical, human, organizational aspects) suggested by Barney (1991), we propose that IT infrastructure flexibility, IT personnel expertise, and IT management capability constitute the primary dimensions of IT capabilities.

2.2.1. IT personnel expertise and PDCs

IT personnel expertise is defined as professional skills and knowledge of technologies, technology management, business functions, and relational (or interpersonal) areas necessary for IT staff to undertake assigned tasks effectively (Lee, Trauth, & Farwell, 1995). Technology knowledge is the understanding of an organization's IT elements, including operating systems, programming languages, database management systems, and networking; technology management knowledge is necessary for IT resource management and includes planning, deployment, and operation; business function knowledge is the understanding of internal business units and environments; and relational (or interpersonal) knowledge is the IT staff's ability to communicate and collaborate with people from business functions.

Business operations should be able to meet emerging challenges. With IT infrastructure becoming the backbone of business operations, IT staff should be familiar with managerial, relational, and business issues to be able to formulate adequate IT solutions according to changing business requirements (Rockart, Earl, & Ross, 1996; Kim, 2010). Growing such professional knowledge in an

IT workforce is a slow and gradual process (Mata, Fuerst, & Barney, 1995) that tends to be more localized and particular to each organization (Sambamurthy & Zmud, 1997), and therefore, is hard for competitors to imitate in a short time span (Bharadwaj, 2000; Mata et al., 1995).

Firms with competent IT expertise can meet competitive demands by aligning IT strategies with business strategies, developing reliable and cost-efficient systems, and anticipating IT needs for business services better than competitors do (Bhatt & Grover, 2005; Sambamurthy & Zmud, 1997; Santhanam & Hartono, 2003). Firms lacking IT expertise are unable to redesign business processes quickly when market circumstances change (Rockart et al., 1996). We, therefore, hypothesize that IT expertise grows a firm's capacity to reconstruct its business processes better than market competitors can.

Hypothesis 2: *A firm's IT personnel expertise is positively associated with its PDCs.*

2.2.2. IT infrastructure flexibility and PDCs

IT infrastructure refers to the composition of all IT assets (e.g., software, hardware, and data), systems and their components, network and telecommunication facilities, and applications (Byrd & Turner, 2000; Duncan, 1995). *IT infrastructure flexibility* enables IT staff to develop, diffuse, and support various system components quickly, to react to changing business conditions and corporate strategies such as mergers, acquisitions, strategic alliances, global partnerships, or economic pressures (Keen, 1991; Weill, Subramani, & Broadbent, 2002). It empowers the development of a common system that links business functions and enables their synergistic engagement (Bharadwaj, 2000; Rochart et al., 1996). A firm with a flexible IT infrastructure can, therefore, take better advantage of existing IT resources to exercise business strategies and support necessary structural changes (Boar, 1996). Such IT capability becomes a valuable asset for an organization in sustaining competitive advantages in the marketplace (Rochart et al., 1996).

In today's business environment, where rapid changes and uncertainties have become normal, having a flexible IT infrastructure is crucial (Rochart et al., 1996). Studies indicate that IT infrastructure flexibility can be manifested by a firm's (1) connectivity among intra- and inter-organizational system functions; (2) compatibility, which empowers the exchange of information and data regardless of system or technology components; and (3) modularity, in which system and software components can be easily added, modified, and removed in the form of modules (Duncan, 1995; Keen, 1991; Byrd & Turner, 2001). Flexibility in IT infrastructure enables strategic innovations in business processes by allowing development of necessary applications, facilitating information-sharing across business units, and making it easy to develop common systems integrating various organizational functions (Bharadwaj, 2000; Rochart et al., 1996). Accordingly, IT infrastructure flexibility is a source of strategic ability for a firm (Weill et al., 2002), a foundation on which better business processes can be built. Therefore, we hypothesize that:

Hypothesis 3: *A firm's IT infrastructure flexibility is positively associated with its PDCs.*

2.2.3. IT management capability and PDCs

IT management is a centrally controlled or heterogeneously distributed IT function across firms (Bhatt & Grover, 2005; Boynton, Zmud, & Jacobs, 1994) and is manifested by the collection of IT processes in the areas of *planning*, *investment decision-making*, *coordination*, and *control*. *IT management capability* is the IT staff's ability to manage resources in order to transform them into business value at an organization (Peppard, 2007). It is generally reflected by the level at which such processes are structured in formal and informal practices.

IT planning focuses on formal or informal procedures and protocols to attain stated goals as to how IT can support or even strengthen a firm's strategic position. IT planning structure contributes to the formation of a shared understanding of IT values and fosters collaboration among IT people to achieve common goals. Accordingly, an organization with effective IT planning can identify innovative and useful IT applications, is competent at introducing and utilizing IT, manages IT projects according to its priorities, and makes efforts to retain formalized and long-range IT strategies (Keen, 1991; Sabherwal, 1999).

IT investment decision-making is grounded on the assumed value of IT in supporting or strengthening a firm's strategic position. Firms differ in their processes of investment decision-making; these differences lead to discrepancies in terms of firm revenue, user system adoption, and subsequent organizational performance (Ryan & Harrison, 2000; Ryan & Gates, 2004; Ryan, Harrison, & Schkade, 2002). Also, having superior resource-selecting mechanisms is critical for firms to take advantage of market resources (Makadok, 2001). With the far-reaching implications of IT investment-related activities for productivity, decision quality, cost management, and other aspects of business operations and subsequent performance, investment decision-making needs to be structured through such mechanisms as enterprise funding models (McKeen & Smith, 2008).

IT coordination represents efforts to synchronize various interactive efforts among the units of IT management via various mechanisms, including the report system, direct contact, task forces, and cross-functional teams (DeSanctis & Jackson, 1994). The cross-functional team is generally known to be the most effective structural design for IT coordination. Moreover, such distinctive characteristics as the patterns and frequency of interactions affect the ultimate effectiveness of IT coordination (Fulk & Boyd, 1991). A firm with a strong IT coordination structure better accommodates client suggestions and ideas, and encourages informal and formal gatherings of IT and business people to address pending issues (Boynton et al., 1994; Karimi, Somers, & Gupta, 2001).

At organizations with a high degree of IT control, key line managers establish means to lay out IT budgets, prioritize IT functions, control IT resource-planning, and define the roles and responsibilities of IT staff (Karimi et al., 2001). Such firms can adequately assess proposals for IT projects, monitor the performance of an IT organization (or department), and handle important decision making on the development and operation of IT according to the chain of control (Boynton et al., 1994; Karimi et al., 2001). Accordingly, firms with low IT control are expected to be weak in terms of the governance structure (rules, procedures, and policies) designed to control IT-related activities.

As the successful implementation of business process innovations requires deployment of the right IT to the right business process (Melville et al., 2004), firms with competent IT management are expected to have better internal processes for agile transformation than the competition, and are, thus, more likely to be prepared for change (Weill et al., 2002).

> ***Hypothesis 4:*** *A firm's IT management capability is positively associated with its PDCs.*

2.3. Interrelationships among IT Capabilities

2.3.1. IT personnel expertise and IT management capability

Organizations with competent IT staff are better at integrating IT and business planning, making investment decisions based on anticipated business needs, engaging in effective communications with business units, and executing systematic controls to achieve determined goals (Sambamurthy & Zmud, 1997). In fact, one of the main duties of IT staff is to develop and reinforce IT management capabilities by structuring various processes into adequate formal and informal practices.

IT personnel play a role in cultivating such IT management capabilities (Feldman & Pentland, 2003; Feldman, 2000). The agency that participates in these processes must have the capability to recall the past, project into the future, and adapt to existing circumstances as necessary. If existing processes cannot realize intended outcomes or result in undesirable consequences, the agency will make changes to the processes, thus advancing IT management capabilities. The course of such changes will rely on whatever collective IT expertise the agency can mobilize. Accordingly, it is anticipated that IT personnel with knowledge (or expertise) of technologies, IT management, business functions, and interpersonal relationships will perform better in advancing IT management capabilities.

> ***Hypothesis 5:*** *A firm's IT personnel expertise is positively associated with its IT management capability.*

2.3.2. IT personnel expertise and IT infrastructure flexibility

IS researchers recognize the importance of IT professionals' contribution to the flexibility of an organization's IT infrastructure (Byrd & Turner, 2001). Competent IT staff are able to integrate base-level IT resources and components into the IT infrastructure of an organization (Broadbent, Weill, & Clair, 1999; Broadbent and Weill, 1997). IT professionals can also integrate IS components to shape the capability of an IT infrastructure shared among various organizations (Byrd & Turner, 2001). Through interviews with 21 CIOs and executives from Fortune 500 firms, Duncan (1995) found that a flexible IT infrastructure is achieved by having a capable IT workforce that can balance competence in business and IT issues. Technical expertise is crucial to effectively integrate old and new systems and successfully assimilate new systems in an organization (Duncan, 1995; Ross et al., 1996). Also, IT personnel with in-depth business knowledge can better comprehend business issues, project IT implementation needs, and align IT and business strategies. Superior IT expertise is, therefore, a prerequisite to a flexible IT infrastructure.

> ***Hypothesis 6:*** *A firm's IT personnel expertise is positively associated with its IT infrastructure flexibility.*

2.3.3. IT management capability and IT infrastructure flexibility

IT management processes go hand in hand with IT personnel expertise to create a flexible IT infrastructure (Tippins & Sohi, 2003), guiding people to deploy, coordinate, and integrate IT infrastructure components quickly and adequately. As an IT infrastructure develops over time, IT management processes of distributing and managing various resources, including hardware, software, data, and networks, are formed and perfected (Ross et al., 1996), providing guidance for IT personnel and establishing the necessary conditions for flexibility (Duncan, 1995). These processes are crucial to blending various inputs (technological components, IT personnel, etc.) into an integrated IT infrastructure (McKeen & Smith, 2008). Increasing IT management capability through extended learning-by-doing experience, therefore, is important to develop a flexible IT infrastructure that enables quick adaptation to change (Bharadwaj, 2000).

> ***Hypothesis 7:*** *A firm's IT management capability is positively associated with its IT infrastructure flexibility.*

3. Research Method

3.1. Survey Development

Table 3 summarizes the operational definitions of our study constructs. All the measures, presented on a 7-point Likert scale, were drawn from previous literature and adapted to serve the purpose of this study. To develop the survey items, we initially generated a scale item pool from the existing literature comprised of more than 130 question items. In order to reduce the number of items to a manageable size, we went through several pretests. Key informants about IT capabilities, PDCs, and financial performance can differ in their responses. Therefore, IT executives and faculty colleagues participated in the pretest of the initial items in the survey of IT capabilities, while business executives and faculty colleagues pretested on PDCs and financial performance. We performed the pretest of measures for PDCs and financial performance after establishing the IT capabilities measures.

In the case of IT capabilities, we first examined the survey items using the focus group interview. This group consisted of three faculty colleagues who were knowledgeable about our research subject as well as the measurement theory, and five senior IT managers with practical knowledge in IT infrastructure. This group of people met three times within a two-week period to examine the content validity of the research instrument. Each time they met, the participants gradually reduced the number of items through intensive discussion. This led to a revised 50-item questionnaire that we subsequently used for another round of pretests with 20 senior IT managers. For this round, each participant was asked to complete the questionnaire and, during the debriefing period, to offer any suggestions for improvement. Again, from this process, we dropped a few items and made several minor refinements of the remaining items. The final result was a research instrument with 46 items (refer to Appendix A).

We then mailed this questionnaire to another group of 20 senior IT managers for a pilot test. Follow-up interviews with these managers indicated no need for substantive changes to the questionnaire.

For the measures of PDCs and financial performance, the process of identifying survey items was identical to that for IT capabilities, and was performed with business executives and faculty colleagues. Three colleagues and five business executives participated in the focus group interview; subsequently, 10 business executives participated in both the pretest and the pilot test.

Table 3. Definitions of Study Constructs and Antecedent Variables

Constructs / Dimensions	Definition
IT personnel expertise	The level of professional skills or knowledge of IT staff
Technical	IT staff's knowledge about technical elements, including operational systems, programming languages, database management systems, and networking
Technology management	IT staff's knowledge of IT resource management necessary to support business goals
Business functional	IT staff's understanding of various business functions and business environment
Relational (interpersonal)	IT staff's ability to communicate and work with people from other business functions
IT infrastructure flexibility	The ability of a firm's IT infrastructure to enable quick development and support of various system components
Connectivity	Ability to connect internal and external IT elements
Compatibility	Ability to share various types of information and data regardless of technical basis
Modularity	Ability to add, remove, and modify system or software components
IT management capabilities	The ability of a firm to manage IT resources to deliver business value
IT planning	The level at which the planning of IT deployment and utilizations is structured according to formal and informal procedures
IT investment decision-making	The level at which investment decision-making about IT resources is structured according to formal and informal procedures
IT coordination	The level at which coordination efforts between IT staff and business clients are structured according to formal and informal procedures
IT control	The level at which IT control activities (e.g., development, management, and operation) are structured according to formal and informal procedures
Process-oriented dynamic capabilities	A firm's competence to change existing business processes better than its competitors do in terms of coordination/integration, cost reduction, and business intelligence/learning
Perceived financial performance	Overall financial performance over the past three years

3.2. Sampling and Data Collection

We collected study data through a field survey. The firms in the DART System (an electronic system for public announcement), supervised by the Financial Supervisory Service of the Korean Government, were adopted as a sampling frame. This system includes a mailing list of 1,835 firms, comprising 629 firms listed on the Korea Stock Exchange, 857 firms listed on the Korea Securities Dealers Automated Quotation (KOSDAQ), and 349 unlisted firms. From this sampling frame, we chose a random sample of 800 firms to provide potential respondents.

To choose potential respondents, we utilized the key informant methodology in which respondents were chosen based on their position, experience, and professional knowledge rather than by the traditional random sampling procedure (Segars & Grover, 1999). In survey research, such key informants, with their practical experience and organizational position, provide reliable information on group-wise or firm characteristics that is less biased by personal attitudes or behaviors. The key informants included such high-level executives as CIOs, directors, and senior managers. We identified two key informants--one from an IT department (specifically, the IT strategy and IT planning departments) and the other from a business department--from each firm as a matching response set, curtailing the risk of common method bias. They confirmed that their organizations had a formal and sizable IT function and agreed to respond to the survey. Non-IT persons answered survey questions on perceived financial performance and PDS, and IT people answered those on IT capabilities.

Four weeks after the initial mailing, we sent a follow-up survey to those individuals who did not return the completed questionnaire. Overall, 375 firms responded to the IT survey and 395 firms responded to the business survey. The process of matching the two data sets yielded 251 pairs of complete responses (and, therefore, a dataset of 251 firms). We dropped five IT survey responses and three business survey responses from further consideration because they were incomplete. Thus, the final sample consists of 243 response sets (103 firms listed on the Korea Stock Exchange, 85 firms listed on the KOSDAQ, and 55 unlisted firms) with a joint response rate of 37.1 percent. To check for non-response bias, we compared the profiles of survey respondents and those on the mailing list, and of early and late respondents, in terms of organization size and industry. The results of Chi-square tests revealed no differences, confirming the absence of non-response bias.

The organizations in the sample represent diverse industry groups. Twenty-nine percent of the responding firms are in manufacturing; 23.9 percent are in the telecommunication and IT industries; 17.3 percent are in the financial services, banking, and insurance industries; 14 percent are in retail; and 15.6 percent are in transportation and utilities. Except for the unlisted firms, the average number of people employed in these firms is 4,277, and the average revenue of the firms is US$447 million. A significant number (47.7 percent) of the respondents are either CIOs or vice presidents in the IT division. The job titles of the other respondents (senior vice president, vice president of technology, assistant vice president, director of information technology) indicate that they are also senior IT executives. In addition, 50.6 percent of respondents who answered the questions on organizational performance are at the rank of senior vice president, vice president, assistant vice president, or director. All respondents indicated that they are within two levels of the highest position in their organizational hierarchy.

3.3. Construct Validity

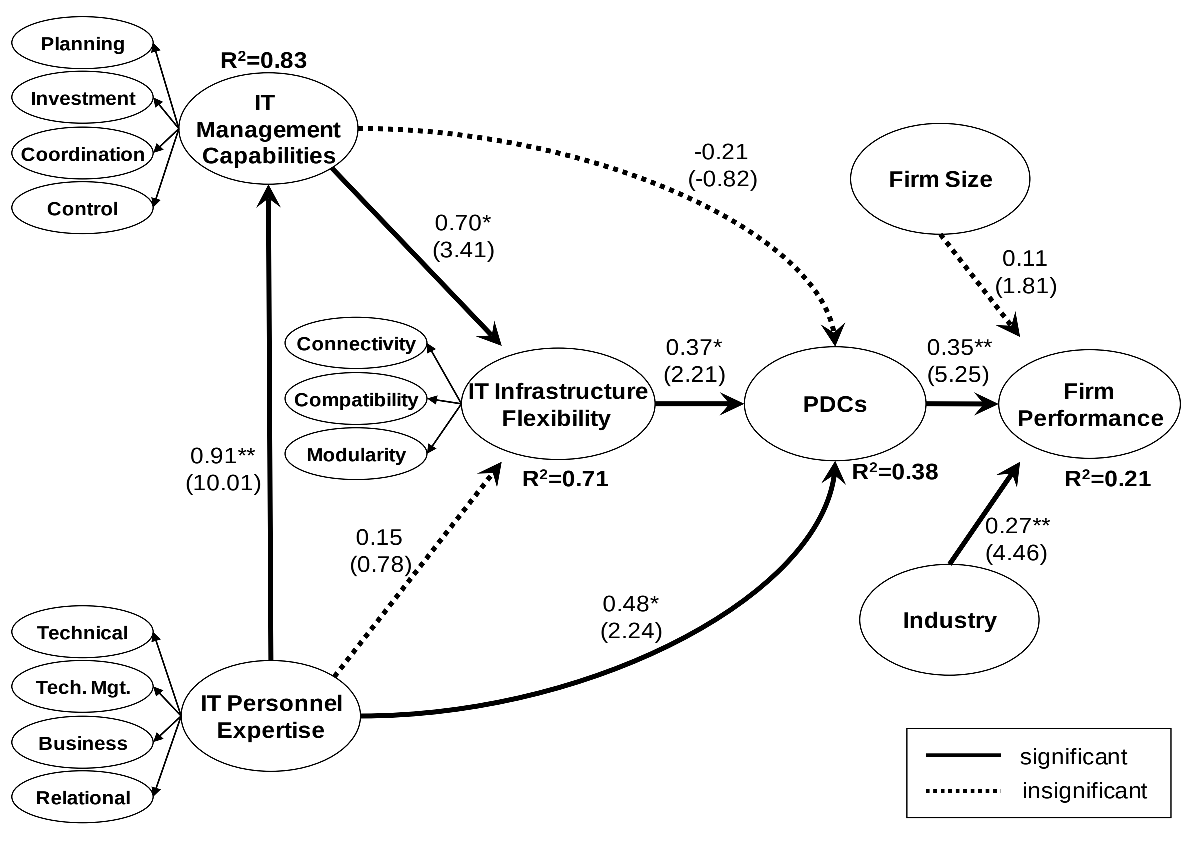
Reliability verification of the measurement models was done through confirmatory factor analysis (CFA) using LISREL. Before conducting the analysis, we checked two important assumptions underlying CFA: multivariate normality and model identification (Segars & Grover, 1999). The multivariate normality test conducted on the PRELIS function of LISREL revealed a departure of the survey data from multivariate normality. We, therefore, utilized normalized scores to fit the research model to the data set, as suggested by Jöreskog, Sörbom, Du Toit, and Du Toit (2001). After the scores had been normalized, a simple test using LISREL found no model identification problem.

In the initial examination of the measurement models, we deleted only one item (MD4) of the modularity variable due to lack of reliability. Then we conducted a series of empirical tests, as recommended by Spanos and Lioukas (2001), to examine the construct validity (e.g., uni-dimensionality, reliability, and convergent and discriminant validity) of our first-order indicators. As shown in Appendix B, the first-order indicators achieved a satisfying level of construct validity. We assessed discriminant validity among the three second-order IT capabilities with the Chi-square difference test (Venkatraman, 1989). The results demonstrated that the three second-order constructs are statistically distinct concepts at the significance level of 0.00001 (see Appendix C).

4. Analysis Results

The research model was intended to examine relationships among the studied variables. Among the variables, IT capabilities (IT personnel expertise, IT management capabilities, and IT infrastructure flexibility) are manifested by lower-order conceptual dimensions and accordingly positioned as second-order constructs in our research. In addition, perceived financial performance might be affected by such business factors as industry type and firm size; therefore, they are utilized as control variables. Industries were classified into manufacturing and non-manufacturing types, and firm size was divided into five categories (100, 300, 500, 1000, and 3000) in terms of the number of employees.

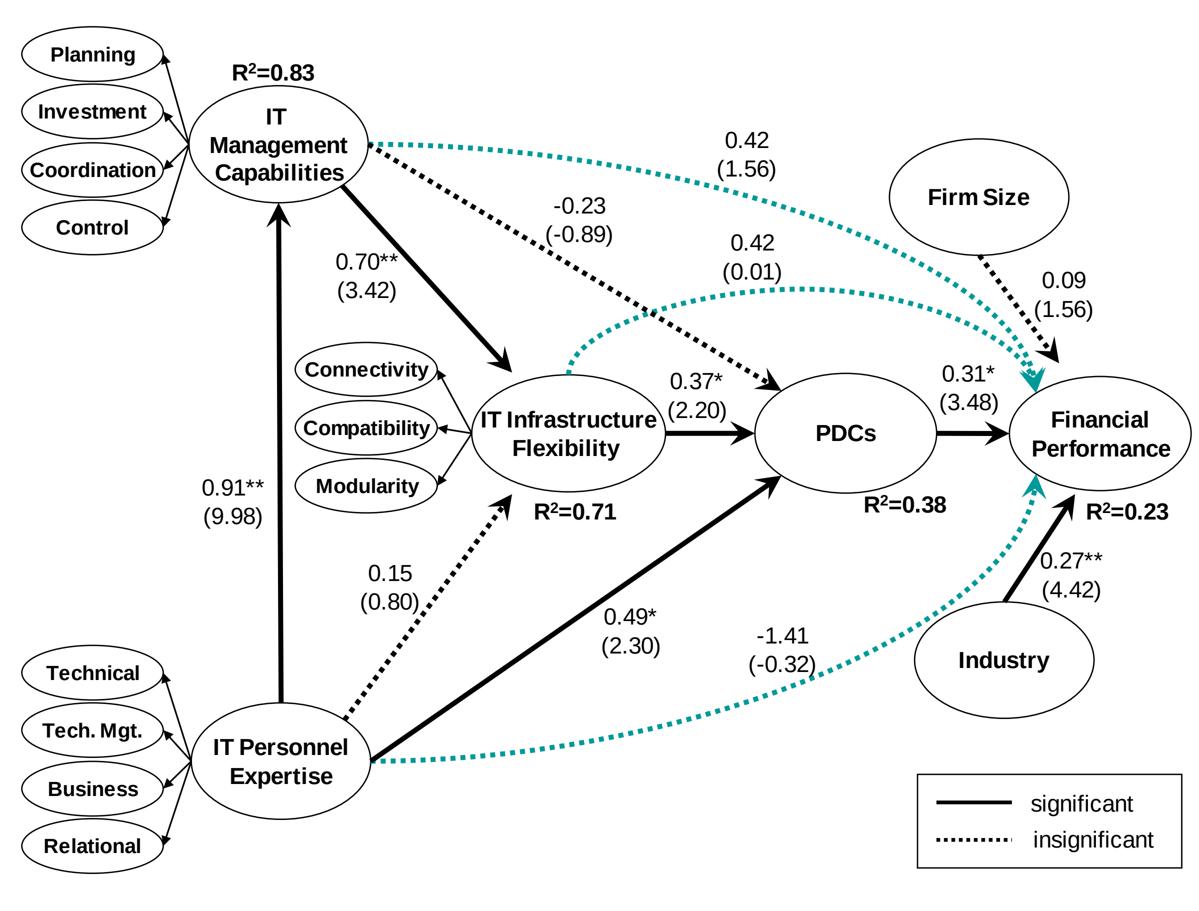
Figure 2 summarizes the estimation of path coefficients and subsequent results of hypothesis testing. Path coefficients indicate that IT personnel expertise strongly affects IT management capabilities (β= 0.91, t = 10.01, $p < 0.01$), but its influence on IT infrastructure flexibility is not substantiated. However, we observe a significant influence of IT management capabilities in enhancing IT infrastructure flexibility (β= 0.70, t = 3.41, $p < 0.05$). Both IT personnel expertise (β= 0.48, t = 2.24, $p < 0.05$) and IT infrastructure flexibility (β= 0.37, t = 2.21, $p < 0.05$) exhibit considerable influence on growing PDCs. We do not see a direct effect of IT management capabilities on PDCs. Finally, the level of PDCs is positively associated with perceived financial performance (β= 0.35, t = 5.25, $p < 0.01$).



Note: *P < 0.05, **P < 0.01

Figure 2. Analysis Results

Figure 3 shows a version of the model in which we add direct paths from the three different types of IT capabilities to firm performance to Figure 2 to test whether IT capabilities have both direct and indirect influences on firm performance. We observe no statistically significant relationship for the direct paths. This confirms the integrity of the proposed model in Figure 2, in which PDCs fully mediate the contribution of IT capabilities to firm performance.



Note: *P < 0.05, **P < 0.01

Figure 3. Additional Analysis

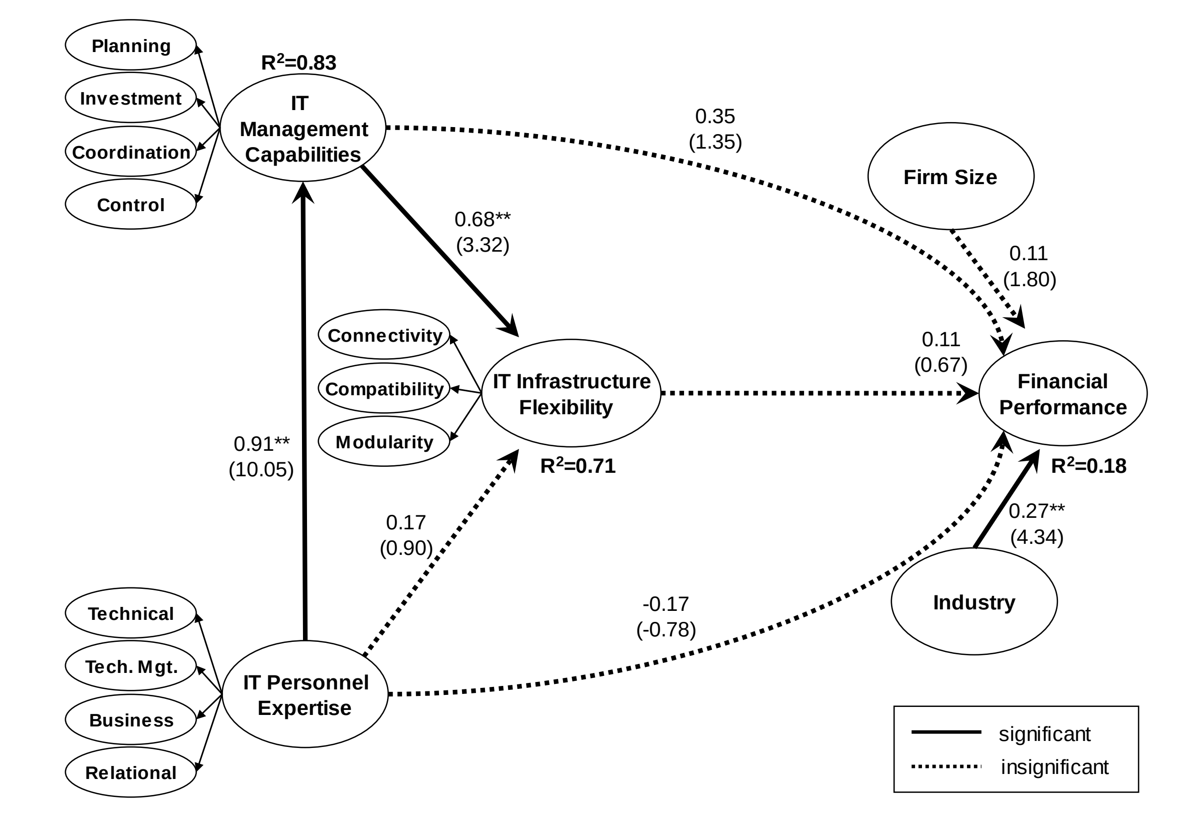
5. Discussion

We frame the discussion of data analysis in this section in terms of two main research contributions: (1) uncovering the indirect role of IT capabilities on a firm's financial performance through the augmentation of PDCs, and (2) understanding the internal dynamics among IT capabilities.

5.1. IT Capabilities and Firm Performance

We examined the process in which IT capabilities positively affect a firm's financial performance through increased proficiency in changing its business processes better than its competitors do. In this process chain, the augmented process capability (PDC) in terms of connecting business parties, reducing process cost, and capitalizing business intelligence and analytics acted as a full mediator between IT capabilities and financial performance. In Figure 2, 38 percent of variations in PDCs were explained by the variables of IT capabilities. Also, the industry and PDC variables were responsible for a considerable portion (21 percent) of firm financial performance, highlighting the critical importance of dynamic process management capabilities in enhancing firm-level performance (e.g., Pavlou & El Sawy, 2006). It was shown that firms in non-manufacturing industries performed better financially than those in manufacturing industries.

To facilitate observation of the possible direct relationship between the IT capability constructs and perceived financial performance, we estimated the parsimonious model in Figure 4. Unlike the model in Figure 2, IT capabilities had no direct influence on perceived financial performance. The discrepancy between the two models in Figures 2 and 4 seems to imply two points. First, although there may be significant causality between variables of IT capabilities and firm performance, it is difficult to expect consistency in empirical findings when the modeling is grounded on the black box approach. Second, the true business value of IT can be considerably underestimated using direct modeling. The empirical findings underscore the importance of process-driven modeling, in which the true value of IT to firm performance is understood in terms of its contribution to a firm's ability to adapt to changing business environments.



Note: *P < 0.05, **P < 0.01

Figure 4. Additional Analysis

There are other findings as well. First, IT infrastructure flexibility had a direct influence on PDCs, supporting the argument that it plays a critical role in a firm's ability to adapt resiliently to changes in business environments (e.g., Sambamurthy et al., 2003; Weill et al., 2002; Duncan, 1995). Flexible IT infrastructure empowers a firm to innovate its own business processes continuously and faster than the competition; this capacity enhances the firm's ability to react quickly to challenges arising from competition and uncertainties (Weill et al., 2002). Although some studies point to the potential of IT to offer competitive parity, our finding implies that IT infrastructure flexibility can provide rich soil in which to grow sustainable competitive advantage (McKeen & Smith, 2008).

The study results support the idea that there is a functional relationship between a firm's IT personnel expertise and PDCs. This finding is consistent with the argument that IT personnel expertise constitutes a fundamental source of competence in business competition (e.g., Bhatt & Grover, 2005). This seems to explain why many firms fail to harvest the anticipated long-term benefits of outsourcing; they may even suffer from its negative consequences, although some firms have shown very strong performance, in terms of both efficiency and growth, with high levels of outsourcing (Aral & Weill, 2007).

Today, a company must be better than the competition at discerning looming threats and opportunities, framing the correct strategies to neutralize threats or take advantage of opportunities, and executing the strategies in a sustained manner. Although outsourcing offers opportunities to curtail costs associated with the IT function (e.g., manpower and equipment), the practice may not be the best solution in terms of fostering management capabilities and organizational processes in a dynamic fashion. Outsourcing is frequently an indicator of minimal IT function and limited IT competence. Often it makes timely planning and execution of IT strategies and associated technical solutions to support business services more difficult. A firm may be able to achieve competitive parity with IT outsourcing, but it may not be the best way to set itself apart from the competition.

The results of our analysis indicate that by improving the flexibility of IT infrastructure, a firm's IT management capabilities indirectly contribute to the formation of competence in managing business processes. Extant literature demonstrates that there are organizational processes or capabilities (e.g., IT management capabilities) unique to the IT function, just like those of other business functions (McKeen & Smith, 2008; Peppard, 2007). Nonetheless, the implications of organizational capabilities germane to the IT function have not been systematically explored in an integrative manner. With the addition of IT management capabilities as the counterpart of business function-oriented organizational capabilities, more elaborate explanations can be made about the mechanism by which IT produces business value. Our study demonstrates the direct influences of both IT personnel expertise and IT infrastructure flexibility on a firm's capacity to facilitate better information sharing/communication, making operational processes more cost-effective, and drawing on business intelligence and analytical strength to respond to looming challenges.

5.2. Internal Dynamics among IT Capabilities

Interrelationships among different aspects of IT capabilities have not received warranted attention from the IS research community. However, we believe that understanding how IT boosts business performance requires comprehension of the relationship among various dimensions of IT capabilities. For example, our study indicates that the influence of IT personnel expertise on IT infrastructure flexibility is indirect, occurring through enhanced IT management capabilities. In our study, 83 percent of variations in IT management capabilities were explained by IT personnel expertise, and 71 percent of variations in IT infrastructure flexibility were explained mostly by IT management capabilities. Thus, there is a powerful chain of influence among the IT capability types, ultimately leading to a firm's improved financial performance. Although IT staff competence has been identified as a direct antecedent of superior IT infrastructure capabilities in several IS studies (e.g., Lee et al., 1995; Ross et al., 1996), our research indicates that IT management capabilities act as a reliable mediator between IT expertise and IT infrastructure flexibility. Given that IT management capabilities are largely manifested in the form of IT governance, our findings imply that adequate IT governance is a precursor to flexibility in IT infrastructure.

This result suggests the potential of IT management capabilities to bridge the gap identified in earlier studies between IT resources and firm-level performance. Existing literature on IT capabilities supports this idea. According to Amit and Schoemaker (1993), capabilities are an organization's capacity to deploy resources, primarily knowledge or skills, using organizational processes, to affect a desired end. It, therefore, follows that IT management capabilities represent the IT function's capacity to dispense various resources, including IT people's knowledge and skills, according to IT management processes to shape IT infrastructure. In other words, IT management capabilities guide the effective deployment of IT resources to produce intended outcomes (Feldman & Pentland, 2003; Dosi, Nelson, & Winter, 2000).

The absence of a direct association between IT management capabilities and PDCs implies that the primary responsibility of IT management is to ensure the ability of a firm's IT infrastructure to support fluctuating business demands effectively. This suggests that a firm can fail to capitalize on the potential of its IT expertise to produce business value if excellent IT management capabilities are not in place. Thus, competent IT staff is a necessary, but not a sufficient, condition to build a flexible IT infrastructure that supports competitive business processes. Although more study is necessary on the relationships among variables of IT capabilities, this study enables us to propose that they are important forbearers of a firm's success in making changes to business processes. This study reaffirms that IT and its proper execution do matter (Aral & Weill, 2007; McAfee & Brynjolfsson, 2008).

5.3. Implications for Practitioners

The study findings have several practical implications for IS and business practitioners. Above all, although IT investment may lead to new products or services (e.g., cloud computing by Amazon), its general value should be understood from the perspective of its ability to strengthen a firm's capability to transform its business processes (McAfee & Brynjolfsson, 2008; McKeen & Smith, 2008). Our study implies that research attempts to tie IT investment to firm-level performance directly carry much uncertainty. Further examination of the IT contribution to the effectiveness of business processes will offer deeper insights into why firms end up with divergent outcomes from the same IT investments.

Second, to react effectively to changes in market circumstances, firms should place more emphasis on reinforcing competence in key IT functions. Firms that are highly dependent on outsourcing may have to focus on growing and sustaining their internal competence to manage outsourcing so that they can execute flexible strategic planning and implementation, responding adequately to environmental uncertainties and hyper competition.

Third, IS and business practitioners should recognize that IT investment should be directed not only to IT personnel expertise and IT infrastructure flexibility, but also to IT management capabilities. Our study reveals that a flexible IT infrastructure that keeps pace with business needs is hard to attain when adequate IT management capabilities, manifested in IT governance, are not in place, regardless of the availability of IT expertise.

6. Limitations and Future Research

This study has several limitations, which can be seen as opportunities for further research. Although several empirical studies have been undertaken to shed light on the mechanisms by which IT capabilities create business value, many more studies are warranted, considering the critical importance of this subject to the IS community (Aral & Weill, 2007). These studies will require the utilization of both firm- and process-level data (Pavlou & El Sawy, 2006). Although gathering such a dataset can be a challenging process, its analysis will provide valuable knowledge regarding how IT affects a firm's financial and non-financial performance.

This study adopted PDCs as the variable that mediates the effect of IT capabilities on perceived financial performance. We anticipate that there are more variables, such as customer and partnership agility (Sambamurthy et al., 2003), that also moderate the influence of IT capabilities on firm-level performance. The identification and integration of these significant variables into the research model will further the understanding of the mechanisms by which IT capabilities foster business value.

Previously, we discussed why outsourcing of the IT function as a measure to control IT cost can work against a firm's long-term strategic and financial interests. Future studies can expand our work to compare outsourcing-dependent firms and self-sufficient companies to highlight differences in IT capabilities, in the mechanism by which IT produces business value, and the ultimate effect on firm performance.

Although the dimensions of the IT management capability construct in our study are reflective of those (e.g., planning, coordination, and control) from traditional management theory (Van der Zee & de Jong, 1999), they may not be comprehensive. In other words, there may be other management aspects native to the IT function, such as change management in IT conversion. Future research can identify these additional dimensions, incorporate them into a comprehensive multidimensional framework of IT management, and study its role in engendering business value.

PDCs, as incorporated in this study, represent those at the firm level, not at the level of the IT function. Future research can determine those native to the IT function (e.g., ability to change the IT function's operational processes) and examine their implications on firm performance. For instance, the absorptive (or learning) ability of IT personnel may be a good indicator of PDCs associated with the IT function. Studies that examine the relationship between the IT function's PDCs and IT capabilities, and between the IT function's PDCs and organization-wide PDCs, may offer a greater comprehension of how IT grows business value.

Last, the research model was validated based on cross-sectional data. Considering that IT capabilities are formed gradually over the years, the survey research is limited in its capacity to reflect accurately the prolonged formation of IT capabilities and their contribution to organizational performance. More rigorous research, therefore, can be conducted on longitudinal data obtained from an approach such as qualitative ethnographic methodology.

7. Conclusion

This study examines the relationship among IT capabilities, the ability to reshape business processes, and the economic success of a firm. In addition, it investigates the causal relationships among IT capabilities including IT personnel expertise, IT management capabilities, and IT infrastructure flexibility. Overall, the analysis indicates that IT capabilities contribute indirectly to the perceived financial performance of a firm by augmenting its PDCs, deemed critical in keeping operational processes effective (or reshaping them). Although several studies highlight the importance of human resources (i.e., IT expertise) and IT infrastructure, our work brings to light the role of IT management capabilities in bridging the gap between the two, and ultimately strengthening a firm’s financial achievement. Despite the stated limitations in research method, the findings of our empirical study emphasize the essential role that various IT capabilities play in enhancing a firm’s ultimate performance, and point to the directions that organizational strategists can take to boost a firm’s ability to improve its business processes to beat the competition.

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Appendix

Appendix A. Survey Measures

Table A-1. Measures

IT Planning		Sources
PL1	We continuously examine the innovative opportunities for the strategic use of IT.	Karimi et al. (2001) Segars and Grover (1999) Boynton et al. (1994)
PL2	We enforce adequate plans for the introduction and utilization of IT.	Karimi et al. (2001)
PL3	We perform IT planning processes in systematic and formalized ways.	Sabherwal (1999) Segars and Grover (1999)
PL4	We frequently adjust IT plans to better adapt to changing conditions.	
IT Investment Decision-making		
IV1	When we make IT investment decisions, we think about and estimate the effect they will have on the quality and productivity of the employees' work.	Sabherwal (1999) Ryan et al. (2002)
IV2	When we make IT investment decisions, we consider and project about how much these options will help end users make quicker decisions.	
IV3	When we make IT investment decisions, we consider and estimate whether they will consolidate or eliminate jobs.	
IV4	When we make IT investment decisions, we think about and estimate the amount and cost of training that end users will need.	
IV5	When we make IT investment decisions, we consider and estimate the time managers will need to spend overseeing the change.	
IT Coordination		
CO1	In our organization, IS and line people meet frequently to discuss important issues both formally and informally.	Boynton et al. (1994) Karimi et al. (2001)
CO2	In our organization, IS people and line people from various departments frequently attend cross-functional meetings.	DeSanctis and Jackson (1994) Li, Jiang, and Klein (2003)
CO3	In our organization, IS and line people coordinate their efforts harmoniously.	Li et al. (2003)
CO4	In our organization, information is widely shared between IS and line people so that those who make decisions or perform jobs have access to all available know-how.	
IT Control		
CR1	In our organization, the responsibility and authority for IT direction and development are clear.	Karimi et al. (2001)
CR2	We are confident that IT project proposals are properly appraised.	
CR3	We constantly monitor the performance of IT function.	
CR4	Our IT department is clear about its performance criteria.	
Connectivity		
CN1	Compared to rivals within our industry, our organization has the foremost available IT systems and connections.	Duncan (1995) Byrd and Turner (2000)
CN2	All remote, branch, and mobile offices are connected to the central office.	
CN3	Our organization utilizes open systems network mechanisms to boost connectivity.	
CN4	There are very few identifiable communications bottlenecks within our organization.	
Compatibility		
CP1	Software applications can be easily transported and used across multiple platforms.	Duncan (1995) Byrd and Turner (2000)
CP2	Our user interfaces provide transparent access to all platforms and applications.	
CP3	Information is shared seamlessly across our organization, regardless of the location.	

CP4	Our organization provides multiple interfaces or entry points for external end users.	
Modularity		
MD1	Reusable software modules are widely used in new system development.	Duncan (1995) Broadbent et al. (1999) Byrd and Turner (2000)
MD2	End users utilize object-oriented tools to create their own applications.	
MD3	IT personnel utilize object-oriented technologies to minimize the development time for new applications.	
MD4	The legacy system within our organization restricts the development of new applications (reverse scale).	
Technical Knowledge		
TK1	Our IT personnel are very capable in terms of programming skills (e.g., structured programming, web-based application, CASE tools, etc).	Lee et al. (1995) Boar (1996) Broadbent et al. (1999) Byrd and Turner (2000)
TK2	Our IT personnel are very capable in terms of managing project life cycles.	
TK3	Our IT personnel are very capable in the areas of data and network management and maintenance.	
TK4	Our IT personnel are very capable in the areas of distributed processing or distributed computing.	
TK5	Our IT personnel create very capable decision support systems (e.g. expert systems, artificial intelligence, data warehousing, mining, marts, etc).	
Technology Management Knowledge		
MK1	Our IT personnel show superior understanding of technological trends.	Tippins and Sohi (2003)
MK2	Our IT personnel show superior ability to learn new technologies.	
MK3	Our IT personnel are very knowledgeable about the critical factors for the success of our organization.	Byrd and Turner (2000)
MK4	Our IT personnel are very knowledgeable about the role of IT as a means, not an end.	Tippins and Sohi (2003)
Business Knowledge		
BK1	Our IT personnel understand our organization's policies and plans at a very high level.	Byrd and Turner (2000) Duncan (1995)
BK2	Our IT personnel are very capable in interpreting business problems and developing appropriate technical solutions.	Byrd and Turner (2000) Tesch, Jiang, and Klein (2003)
BK3	Our IT personnel are very knowledgeable about business functions.	
BK4	Our IT personnel are very knowledgeable about the business environment.	Tesch et al. (2003)
Relational Knowledge		
RK1	Our IT personnel are very capable in terms of planning, organizing, and leading projects.	Duncan (1995) Lee et al. (1995) Boar (1996) Byrd and Turner (2000)
RK2	Our IT personnel are very capable in terms of planning and executing work in a collective environment.	Byrd and Turner (2000) Jiang, Klein, Slyke, and Cheney. (2003) Tesch et al. (2003)
RK3	Our IT personnel are very capable in terms of teaching others.	Lee et al. (1995) Byrd and Turner (2000) Tesch et al. (2003)
RK4	Our IT personnel work closely with customers and maintain productive user/client relationships.	Lee et al. (1995) Byrd and Turner (2000) Jiang et al. (2003) Tesch et al. (2003)
Process-oriented Dynamic Capabilities		
DC1	Our company is better than competitors in connecting (e.g., communication and information sharing) parties within a business process.	Tippins and Sohi (2003)

DC2	Our company is better than competitors in reducing cost and human labor within a business process.	Eisenhardt and Martin (2000) Davenport and Short (1990)
DC3	Our company is better than competitors in bringing complex analytical methods to bear on a business process.	Eisenhardt and Martin (2000) Sher and Lee (2004)
DC4	Our company is better than competitors in bringing detailed information into a business process.	
Perceived financial performance		
FP1	Over the past 3 years, our financial performance has been outstanding.	Powell and Dent-Micallef(1997)
FP2	Over the past 3 years, our financial performance has exceeded our competitors'.	
FP3	Over the past 3 years, our sales growth has been outstanding.	
FP4	Over the past 3 years, we have been more profitable than our competitors.	
FP5	Over the past 3 years, our sales growth has exceeded our competitors'.	

Appendix B. Results of Construct Validation of First-order Indicators

Uni-dimensionality: Uni-dimensionality indicates the extent to which a set of indicators gauging a specific construct (e.g., IT planning) relates exclusively to this construct and not to another (e.g., IT control). Two sets of statistics were used for the verification of uni-dimensionality: (a) significance of factor loadings, and (b) overall model fit to the data. As shown in Table B-1, all fit indices met the recommended threshold values, and all the item-to-construct loadings were statistically significant at the 0.001 level (see Table B-2), thus confirming their uni-dimensionality.

Reliability: With respect to reliability, we computed composite reliability estimates, which are analogous to the Cronbach's alpha coefficient. As shown in Table B-2, the results indicate that the measurement instrument is reliable, well above the often-cited rule of thumb value, 0.70, for reliability (Fornell and Larcker, 1981).

Convergent Validity: Convergent validity was examined by computing average variance extracted (AVE), which measures the average amount of variance that a construct captures from its indicators relative to the amount of measurement error. Chin (1998) asserts that AVE should exceed 0.5, meaning that at least 50% of the variance in the indicators should be accounted for. Table B-2 shows that the measures exhibit satisfactory convergent validity.

Discriminant Validity: Discriminant validity is implied when the square root of AVE for each construct is greater than the correlation between constructs (Fornell and Larcker, 1981). This means that the items share more common variance with their respective construct than any variance the construct shares with other constructs. Results in Table B-3 reveal that all the diagonal elements are greater than the off-diagonal elements in the corresponding rows and columns, indicating discriminant validity of our measures.

Table B-1. Fit Indices of the First-order Measurement Model

Indices	Recommendation	Outcomes
X^2	--	2050.36
DF	--	1299
Normed X^2	< 3.0	1.578
CFI	> .90	0.985
RNI	> .90	0.985
NNFI	> .90	0.984
NFI	> .90	0.964
SRMR	< .08	0.050
RMSEA	< .08	0.049

Table B-2. Measurement Properties of the First-order Factors

IT Planning					
Item	**Mean**	**S.D.**	**ML Estimate (λ)**	**t-Value**	**P-Level**
PL1	5.21	1.12	0.80	-	P < .001
PL2	5.06	1.17	0.91	16.71	P < .001
PL3	4.89	1.20	0.87	15.65	P < .001
PL4	4.88	1.25	0.79	13.72	P < .001
Refinement from initial model: No items deleted.					
Factor Reliability = 0.908, Average Variance Extracted = 0.713					
IT Investment Decision					
Item	**Mean**	**S.D.**	**ML Estimate (λ)**	**t-Value**	**P-Level**
IV1	5.25	1.05	0.80	-	P < .001
IV2	5.21	1.04	0.84	14.94	P < .001
IV3	5.02	1.10	0.78	13.61	P < .001
IV4	5.06	1.12	0.81	14.10	P < .001
IV5	4.87	1.13	0.82	14.34	P < .001
Refinement from initial model: No items deleted.					
Factor Reliability = 0.905, Average Variance Extracted = 0.656					
IT Coordination					
Item	**Mean**	**S.D.**	**ML Estimate (λ)**	**t-Value**	**P-Level**
CO1	4.65	1.30	0.80	-	P < .001
CO2	4.42	1.20	0.79	13.38	P < .001
CO3	4.76	1.27	0.88	15.16	P < .001
CO4	4.68	1.30	0.79	13.31	P < .001
Refinement from initial model: No items deleted.					
Factor Reliability = 0.888, Average Variance Extracted = 0.664					
IT Control					
Item	**Mean**	**S.D.**	**ML Estimate (λ)**	**t-Value**	**P-Level**
CR1	4.81	1.29	0.79	-	P < .001
CR2	4.87	1.22	0.83	14.23	P < .001
CR3	4.71	1.29	0.88	15.43	P < .001
CR4	4.53	1.36	0.84	14.53	P < .001
Refinement from initial model: No items deleted.					
Factor Reliability = 0.901, Average Variance Extracted = 0.695					
Connectivity					
Item	**Mean**	**S.D.**	**ML Estimate (λ)**	**t-Value**	**P-Level**
CN1	4.97	1.23	0.73	-	P < .001
CN2	5.51	1.49	0.65	9.26	P < .001
CN3	4.94	1.54	0.73	10.30	P < .001
CN4	4.96	1.31	0.72	10.20	P < .001

Refinement from initial model: No items deleted.					
Factor Reliability = 0.799, Average Variance Extracted = 0.500					
Compatibility					
Item	**Mean**	**S.D.**	**ML Estimate (λ)**	**t-Value**	**P-Level**
CP1	4.70	1.54	0.67	-	P < .001
CP2	5.07	1.50	0.71	9.32	P < .001
CP3	5.05	1.51	0.72	9.38	P < .001
CP4	5.06	1.52	0.75	9.69	P < .001
Refinement from initial model: No items deleted.					
Factor Reliability = 0.798, Average Variance Extracted = 0.569					
Modularity					
Item	**Mean**	**S.D.**	**ML Estimate (λ)**	**t-Value**	**P-Level**
MD1	4.57	1.32	0.73	-	P < .001
MD2	4.62	1.39	0.96	15.48	P < .001
MD3	4.55	1.35	0.95	15.37	P < .001
Refinement from initial model: MD4 deleted due to lack of item reliability.					
Factor Reliability = 0.918, Average Variance Extracted = 0.792					
Technical Knowledge					
Item	**Mean**	**S.D.**	**ML Estimate (λ)**	**t-Value**	**P-Level**
TK1	4.93	1.38	0.84	-	P < .001
TK2	4.97	1.34	0.82	15.58	P < .001
TK3	5.17	1.32	0.79	14.71	P < .001
TK4	5.02	1.49	0.84	16.16	P < .001
TK5	4.61	1.48	0.81	15.16	P < .001
Refinement from initial model: No items deleted.					
Factor Reliability = 0.911, Average Variance Extracted = 0.672					
Technical Management Knowledge					
Item	**Mean**	**S.D.**	**ML Estimate (λ)**	**t-Value**	**P-Level**
MK1	5.11	1.25	0.76	-	P < .001
MK2	5.60	1.14	0.81	13.27	P < .001
MK3	5.77	1.06	0.87	14.49	P < .001
MK4	5.59	1.09	0.83	13.70	P < .001
Refinement from initial model: No items deleted.					
Factor Reliability = 0.893, Average Variance Extracted = 0.676					
Business Functional Knowledge					
Item	**Mean**	**S.D.**	**ML Estimate (λ)**	**t-Value**	**P-Level**
BK1	5.14	1.10	0.86	-	P < .001
BK2	5.13	1.12	0.82	15.97	P < .001
BK3	5.14	1.08	0.85	16.75	P < .001
BK4	4.77	1.17	0.67	11.66	P < .001

Refinement from initial model: No items deleted.					
Factor Reliability = 0.879, Average Variance Extracted = 0.648					
Relational Knowledge					
Item	**Mean**	**S.D.**	**ML Estimate (λ)**	**t-Value**	**P-Level**
RK1	5.21	1.16	0.87	-	P < .001
RK2	5.24	1.10	0.90	20.11	P < .001
RK3	5.23	1.14	0.93	21.64	P < .001
RK4	5.31	1.09	0.93	21.72	P < .001
Refinement from initial model: No items deleted.					
Factor Reliability = 0.948, Average Variance Extracted = 0.821					
Perceived financial performance					
Item	**Mean**	**S.D.**	**ML Estimate (λ)**	**t-Value**	**P-Level**
FP1	4.86	1.51	0.83	-	P < .001
FP2	4.77	1.49	0.92	18.92	P < .001
FP3	4.70	1.45	0.86	16.83	
FP4	4.63	1.48	0.90	18.12	P < .001
FP5	4.64	1.490	0.92	18.57	P < .001
Refinement from initial model: No items deleted.					
Factor Reliability = 0.949, Average Variance Extracted = 0.787					
Process-oriented Dynamic Capabilities					
Item	**Mean**	**S.D.**	**ML Estimate (λ)**	**t-Value**	**P-Level**
DC1	5.44	1.23	0.78	-	P < .001
DC2	5.47	1.15	0.86	14.27	P < .001
DC3	5.19	1.19	0.82	13.41	P < .001
DC4	5.27	1.11	0.81	13.21	P < .001
Refinement from initial model: No items deleted.					
Factor Reliability = 0.889, Average Variance Extracted = 0.668					

Table B-3. Results of Discriminant Validity Test

Var.	Mean	S.D.	DC	FP	PL	CR	CO	IV	CN	MD	CP	TK	MK	BK	RK
DC	5.34	1.01	0.82												
FP	4.72	1.35	0.37	0.89											
PL	5.01	1.05	0.47	0.19	0.84										
CR	4.73	1.13	0.51	0.34	0.79	0.83									
CO	4.63	1.10	0.33	0.22	0.67	0.75	0.81								
IV	5.09	0.93	0.47	0.29	0.71	0.77	0.69	0.81							
CN	5.10	1.11	0.55	0.32	0.61	0.66	0.54	0.56	0.71						
MD	4.58	1.25	0.36	0.20	0.57	0.60	0.47	0.54	0.57	0.89					
CP	5.01	1.18	0.43	0.20	0.58	0.53	0.51	0.56	0.69	0.59	0.75				
TK	4.94	1.21	0.42	0.19	0.67	0.68	0.51	0.67	0.68	0.66	0.68	0.82			
MK	5.52	0.98	0.56	0.24	0.73	0.68	0.56	0.77	0.56	0.47	0.57	0.67	0.82		
BK	5.05	0.96	0.53	0.26	0.70	0.72	0.55	0.74	0.50	0.41	0.54	0.66	0.79	0.89	
RK	5.25	1.04	0.46	0.16	0.67	0.67	0.52	0.71	0.48	0.43	0.50	0.72	0.76	0.77	0.91

Notes: The square roots of AVEs are on the diagonal; correlations are off-diagonal.

Appendix C. Results of Discriminant Validity Test of Second-order Constructs

Discriminant validities among second-order constructs were assessed using the Chi-square difference test (Venkatraman, 1989). With the Chi-square difference test, the constraint model's fit and the unconstraint model's fit are compared. With the constraint model, the correlation between two second-order constructs (e.g., IT management capability and IT infrastructure flexibility) is constrained as 1.0, indicating that two second-order constructs are not distinct (null hypothesis). In addition, the unconstraint model represents the alternative hypothesis in which the correlation between the two second-order constructs is allowed to be estimated freely, thus presuming their conceptual distinctness. With the significant differences between the Chi-square measures of the two models, alternative hypotheses are adopted, statistically supporting discriminant validity (Venkatraman, 1989). Table C-1 reports the results of 3 pair-wise tests. All Chi-square differences are significant at the $p < 0.0001$ level, indicating strong support for discriminant validity among the three second-order constructs.

Table C-1. Results of Discriminant Validity Test among Second-order Constructs

Second-order constructs	Constraint model χ^2 (df)	Unconstraint Model χ^2 (df)	$\Delta \chi^2$	p-value
IT management capability with IT infrastructure flexibility	532.05 (343)	503.59 (342)	28.46	< 0.0001
IT infrastructure flexibility with IT personnel knowledge	848.89 (343)	798.22 (342)	50.67	< 0.0001
IT personnel knowledge with IT management capability	968.38 (519)	916.47 (518)	51.91	< 0.0001

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