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Gaining Agility through IT Personnel Capabilities: The Mediating Role of IT Infrastructure Capabilities

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Research Article

Gaining Agility through IT Personnel Capabilities: The Mediating Role of IT Infrastructure Capabilities *

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Abstract:

This study develops a research model of how the technical, behavioral, and business capabilities of IT personnel are associated with IT infrastructure capabilities, and how the latter are associated with IT-dependent organizational agility, which is conceptualized as comprising IT-dependent system, information, and strategic agility. Analysis of cross-sectional data collected from 293 IT managers generally corroborates the hypothesized relationships, showing that the technical and behavioral capabilities of IT personnel have a positive effect on infrastructure capabilities. The analysis also provides evidence that the effect of infrastructure capabilities on IT-dependent strategic agility is direct, as well as mediated by IT-dependent system and information agility. The validity of the findings is strengthened by demonstrating that the hypothesized research model fits the data better than two alternative theoretically-anchored models describing different relationships between the same constructs. This study advances understanding of the interrelationships between two major subsets of IT capabilities, and their relationships with the agility afforded by IT.

Keywords: IT personnel capabilities, IT infrastructure capabilities, IT-dependent organizational agility, IT-dependent strategic agility

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1. Introduction

Research has suggested that firms can realize both operational and strategic benefits from firm-wide information technology (IT) use (Massetti and Zmud, 1996; Subramani, 2004). Studies have also suggested that firm-wide IT capabilities are related to positive strategic outcomes for firms (Bharadwaj, 2000; Ross et al., 1996; Sambamurthy et al., 2003). Accordingly, the strategic importance of building a highly capable IT infrastructure – the base foundation of IT capability shared across the firm – has been identified as a crucial management issue (Kayworth et al., 2001). This view has been supported by studies of the key issues in information systems (IS) management (Brancheau et al., 1996) and the level of IT infrastructure investments (Broadbent and Weill, 1997). The strategic value of IT infrastructure has generally been associated with its ability to allow a firm to adapt successfully to changes in the external environment (Broadbent et al., 1999; Byrd and Turner, 2001b; Weill et al., 2002). Duncan (1995) noted that while one firm's infrastructure may enable strategic innovations in business processes, the characteristics of its competitors' infrastructures may inhibit them from imitating the innovations rapidly. This is why IT infrastructure capabilities have been considered a potential source of strategic agility (Weill et al., 2002). The present study empirically explores the relationship between IT infrastructure capabilities and strategic agility. By defining IT-dependent organizational agility as a multidimensional construct, comprising IT-dependent system agility, information agility, and strategic agility, this study examines the degree to which the strategic impact is mediated by impacts on systems and information. This extends existing evidence on the strategic consequences of IT infrastructure capabilities and the mechanisms that underlie them.

The question, however, that remains to be addressed is what are the firm-related factors that lead to the development of these complex IT infrastructure capabilities? One such potential factor is the capabilities of the firm's IT personnel. Prior studies have shown that more effective interaction between IT personnel and users promotes IT innovativeness (Kettinger and Lee, 2002; Lind and Zmud, 1991; Swanson, 1994), and that new IT knowledge is created at the confluence of business expertise and technical mastery (Nambisan et al., 1999). For IT personnel to be able to appropriately engage users in the development of new IT capabilities, they should possess a blend of technical, behavioral, and business knowledge and skills (Bassellier and Benbasat, 2004; Ross et al., 1996; Todd et al., 1995; Trauth et al., 1993). IT personnel capabilities are strategically valuable, because efforts to redesign business processes to meet competitive demands may be seriously debilitated by the lack of appropriate IT skills (Rockart et al., 1996; Ross et al., 1996). Thus, this study fills the gap in the literature concerning the antecedents of IT infrastructure in firms by focusing on IT personnel capabilities as a key influence on IT infrastructure capabilities.

This study develops a research model that depicts IT infrastructure capabilities as mediating the relationship between IT personnel capabilities and IT-dependent organizational agility. We test the model using cross-sectional data collected from IT managers. The data is also used to demonstrate that the hypothesized research model is superior to two alternative models of the relationships between IT personnel capabilities, IT infrastructure capabilities, and IT-dependent organizational agility. This study investigates constructs and relationships that Bharadwaj (2000) highlighted in her suggested avenues for future research:

The notion of IT as an organizational capability itself needs more attention and a model for examining and classifying the IT capability of firms based on the quality of their IT resources and skills must be developed. Such a model can then be related to measures of firm performance and the specific IT resources and skills most strongly associated with superior performance can be identified (p. 188).

The paper proceeds as follows. Section 2 draws on existing literature to develop the research model. Section 3 describes the methodology used to operationalize the theoretical constructs and collect empirical data. Section 4 establishes the reliability and validity of the research instrument, empirically tests the proposed research model, and compares this model with two alternative models depicting different relationships. Finally, Section 5 discusses the implications of the findings and suggests directions for future research.

2. Theoretical Background and Research Model

This section draws on the IS literature to develop a research model that associates the three key capabilities of IT personnel (technical, behavioral, and business) with IT infrastructure capabilities. The model also describes how IT infrastructure capabilities are associated with IT-dependent strategic agility through IT-dependent system agility and information agility. These constructs are defined in Table 1, and the research model developed in this study is presented in Figure 1. We next discuss the theoretical underpinnings of the constructs and their hypothesized relationships.

2.1. IT Infrastructure Capabilities

Studies have noted the inadequate conceptualizations of IT infrastructure (Kayworth et al., 2001) and the lack of a clear meaning of its domain (Born, 2002). This conceptual difficulty most likely stems from the different research approaches taken toward IT infrastructure. One stream of research has employed a definition that regards IT infrastructure as an arrangement (architecture) of shared technical components: platforms (hardware and operating systems), networks and telecommunications, data, and core applications (Bharadwaj, 2000; Byrd, 2001; Duncan, 1995; Rockart et al., 1996). Another stream of research has viewed IT infrastructure as a collection of

Table 1. Construct Definitions

Construct	Definition	Examples	References
Technical Capability	The technical ability of IT personnel based on their specific expertise in technical areas	Database management skills, competencies in emerging technologies	Bharadwaj (2000) Byrd and Turner (2001a) Lee et al. (1995) Nelson (1991) Ross et al. (1996)
Behavioral Capability	The interpersonal and management ability of IT personnel to interact with and manage others	Effective interpersonal communication, working in collaborative environments, planning and leading projects	Bassellier and Benbasat (2004) Bharadwaj (2000) Byrd and Turner (2001a) Lee et al. (1995) Tesch et al. (2003)
Business Capability	The ability of IT personnel to understand the overall business environment and the specific organizational context	Organization-specific knowledge, ability to learn about business functions	Bassellier and Benbasat (2004) Byrd and Turner (2001a) Lee et al. (1995) Rockart et al. (1996) Ross et al. (1996) Tesch et al. (2003)
Infrastructure Capabilities	The ability of the IT unit to provide extensive firm-wide IT infrastructure services that support the organization's business processes	Extensive communication services, data management services, IT management services	Broadbent et al. (1996) Kayworth et al. (2001) Weill et al. (2002)
IT-Dependent System Agility	The ability to accommodate change in information systems without incurring significant penalty in time or cost	Reducing system modification or enhancement costs, developing applications faster	Allen and Boynton (1991) Conboy and Fitzgerald (2004) Gebauer and Schober (2006) Mirani and Lederer (1998)
IT-Dependent Information Agility	The ability to easily accommodate change in the way organizational users access and use information resources	Faster retrieval of information, increasing the flexibility of information requests	Bajgoric (2000) Chang and King (2005) Mirani and Lederer (1998)
IT-Dependent Strategic Agility	The ability to respond efficiently and effectively to emerging market opportunities by taking advantage of existing IT capabilities	Responding more quickly to market changes, gaining competitive advantage	Borjesson and Mathiassen (2005) Sambamurthy et al. (2003) Weill et al. (2002)

shared IT services (Born, 2002; Kayworth et al., 2001; McKay and Brockway, 1989; Weill, 1993). What both approaches share is the definition of IT infrastructure as IT that is being shared across an organization. However, while the former approach focuses on the static technical resources that comprise the IT infrastructure, the latter approach focuses on the IT capabilities that are being deployed to support business processes. This latter approach defines IT infrastructure as the base foundation of budgeted-for IT capability, shared throughout the firm in the form of reliable services, and managed by the IT group (Broadbent et al., 1996). It considers IT infrastructure capabilities to be reflected in the range and number of IT infrastructure services (Broadbent et al., 1996; Broadbent and Weill, 1997; Broadbent et al., 1999). Therefore, the infrastructure capabilities of a firm may be considered superior to those of others when its IT unit offers a wider range of infrastructure services. Weill et al. (2002) integrated data from four studies on the infrastructure needs of leading enterprises and identified 10 capability clusters of infrastructure services: channel management, security and risk management, communication, data management, application infrastructure, IT facilities management, IT management, IT architecture and standards, IT education, and IT research and development. Weill et al. (2002) suggested that strategic benefits result from more services in each cluster of infrastructure capabilities and broader implementations of each service.

This study draws on this approach to define IT infrastructure capabilities as the ability of the IT unit to provide extensive firm-wide IT infrastructure services that support the organization's business processes. The IT unit is able to accomplish this when it offers a wide range of infrastructure services in each capability cluster. Infrastructure services represent any IT capability available to the whole enterprise and not just to a single functional area or business unit (Kayworth et al., 2001). In this sense, the present study uses a simplistic definition of IT infrastructure capabilities, because it does not consider the IT capabilities of business units or functional areas as part of IT infrastructure unless those are shared throughout the organization. However, as infrastructure services are gravitating toward being provided firm wide (Weill and Vitale, 2002), the importance and contribution of IT services that are provided locally or at the business unit level gradually decrease.

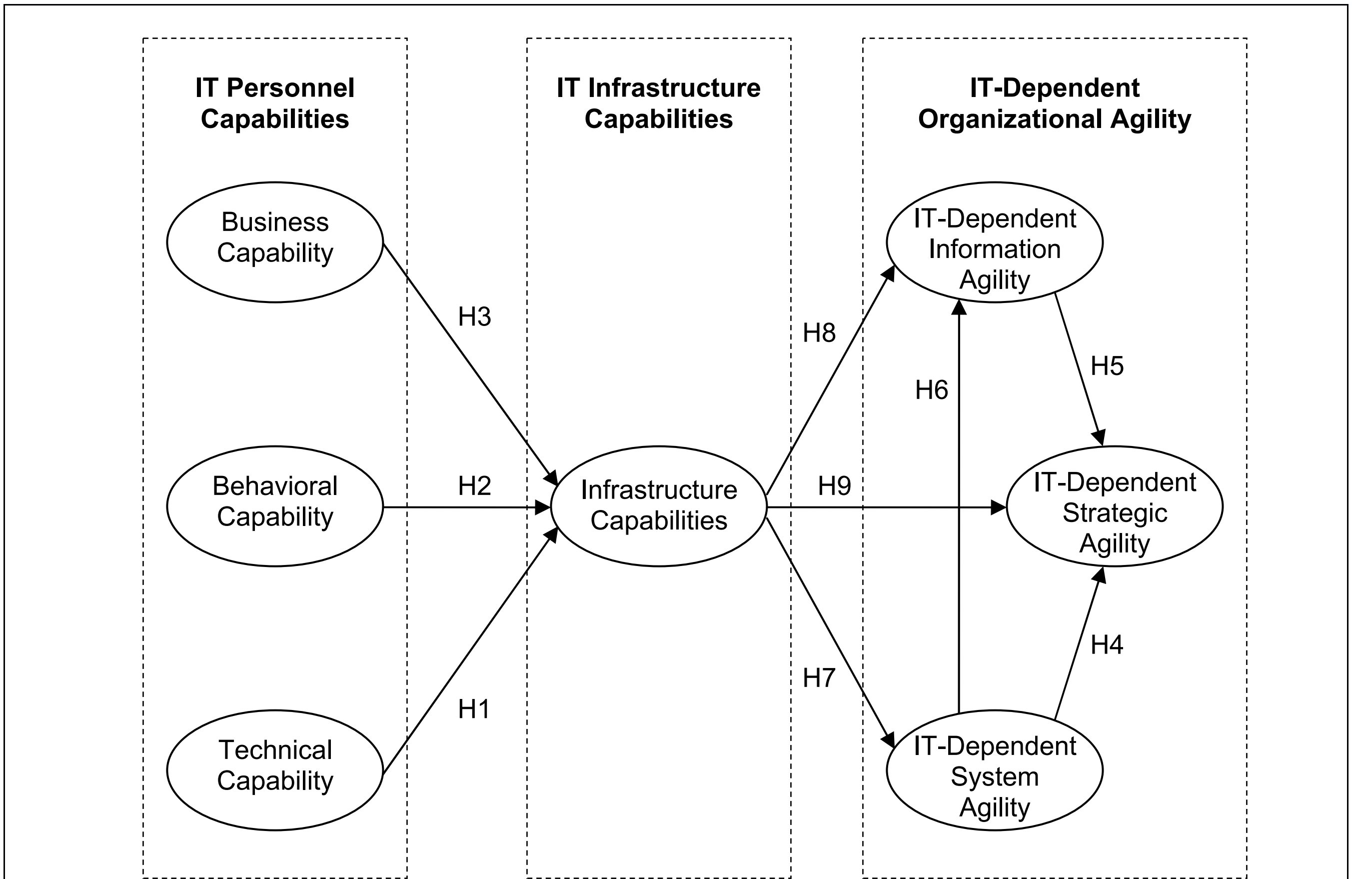


Figure 1. Research Model

2.2. IT Personnel Capabilities

Despite the economic downturn of recent years and its negative effects on the IT job market, the task of attracting, developing, and retaining IT professionals is still ranked as a top management concern by IT executives (Luftman et al., 2006). Research has been consistent in reporting that IT professionals require technical, behavioral, and business knowledge and skills in order to serve their organizations effectively (Bassellier and Benbasat, 2004; Rockart et al., 1996; Ross et al., 1996; Todd et al., 1995; Trauth et al., 1993). The behavioral domain encompasses interpersonal and management knowledge and skills, which relate to the boundary-spanning role IT professionals must assume in organizations (Byrd and Turner, 2001a; Lee et al., 1995). During the 1970s, research recognized the greater importance of technical skills over managerial and business skills for programmers and systems analysts. This finding was mainly attributed to the support role of IT in organizations (Byrd et al., 2004). In the 1980s, as the strategic potential of IT became increasingly emphasized (Porter and Millar, 1985), researchers found that behavioral and business skills were at least as important as technical skills for IT professionals (Benbasat et al., 1980; Cheney and Lyons, 1980; Green, 1989; Leitheiser, 1992; Nelson, 1991). The accepted approach in recent years has been that IT personnel should have a combination of technical, behavioral, and business skills (Bassellier and Benbasat, 2004; Byrd et al., 2004).

The experience and expertise of IT personnel may constrain the quality of other resources (Duncan, 1995). Broad definitions of IT infrastructure suggest that IT personnel capabilities and IT infrastructure capabilities are causally interrelated. McKay and Brockway (1989) described IT infrastructure as comprised of two layers: a layer of IT components (technical base) underlying a layer of shared IT services. In their view, human IT capabilities serve as the "mortar" that binds the physical IT components into robust and functional IT services. This multidimensional representation implies a cause-and-effect relationship between IT personnel capabilities and IT infrastructure capabilities. Therefore, the present study hypothesizes that IT infrastructure capabilities, reflected in the extent of infrastructure services, depend on the capabilities of IT personnel. IT personnel can be conceptualized as a transformation mechanism that converts static inputs of physical components into dynamic outputs of IT services, where the capabilities of IT personnel represent the knowledge and skill base for the conversion process. Therefore, when IT personnel possess broad technical, behavioral, and business capabilities, the IT unit can capitalize on these capabilities to offer users superior IT infrastructure capabilities.

The development of infrastructure capabilities requires IT personnel to possess a technical capability. This capability refers to specific expertise in technical areas (Lee et al., 1995). In spite of the tremendous changes that have occurred in the IT field during the last decades, and in spite of the widespread assertion that business skills are of increasing importance to IT professionals, empirical evidence reflects an increasing need for technical knowledge (Todd et al., 1995). Given the rapid rate of technological change, IT personnel require more varied and in-depth technical skills (Byrd and Turner, 2000; Lee et al., 1995; Ross et al., 1996). A technical capability is crucial for the provision of infrastructure services, because it allows IT personnel to effectively identify, integrate, and utilize technical components in the process of developing and maintaining these services. Technical knowledge and skills are essential for effectively integrating new systems with old ones, for delivering data across locations and applications, for optimizing IT investments, and for recognizing opportunities to apply new technologies as they become available (Duncan, 1995; Ross et al., 1996). This reasoning leads to the following hypothesis:

H1: The technical capability of IT personnel positively affects infrastructure capabilities.

However, a technical capability is necessary but insufficient. Because of the boundary-spanning role of IT in contemporary organizations and the shared nature of IT infrastructure, infrastructure capabilities also depend on IT personnel having a behavioral capability. This capability encompasses interpersonal and management knowledge and skills, such as effective interpersonal communication, working in collaborative environments, and planning, organizing, and leading projects (Lee et al., 1995). Senior managers believe that human factors and managerial knowledge, skills, and abilities are important for all IT professionals, particularly for project managers (Cheney et al., 1990). Bassellier and Benbasat (2004) recently noted that "the profile of the IT professional is changing from one in which technical skills are paramount to one in which the ability to form business relationships is as important" (p. 674). What's more, the dramatically increasing horizontal nature of business processes and information systems requires IT professionals to demonstrate better interpersonal and management skills (Green, 1989; Lee et al., 1995; Ross et al., 1996). Such a behavioral capability can allow them to perform more successfully in collective settings, and to establish better partnerships with their business clients (Bashein and Markus, 1997; Bassellier and Benbasat, 2004). Research has shown that the ability to introduce IT innovations depends on the quality of the interaction between IT personnel and users (Lind and Zmud, 1991; Swanson, 1994). The ability to provide extensive infrastructure services should, therefore, be largely influenced by the ability of IT personnel to communicate effectively with their business clients and to plan, organize, and lead technological projects in collaborative environments.

H2: The behavioral capability of IT personnel positively affects infrastructure capabilities.

Finally, the strategic expectations of IT infrastructure are difficult to meet when IT personnel do not possess a solid business capability. This capability involves knowledge of the various functions within the business and the ability to understand the overall business environment (Lee et al., 1995). The importance of IT professionals' business knowledge has been acknowledged by both recruiters and graduates (Noll and Wilkins, 2002). Deep business knowledge enables IT personnel to understand their firm's strategy and business needs, to anticipate and plan for implementation needs, and generally to align IT and business strategies (Duncan, 1995; Henderson and Venkatraman, 1993; Nelson, 1991). Duncan (1995) argued that knowing the probability of various requirements and understanding their business meaning might be useful skills for those who plan and manage IT infrastructure. IT-business shared domain knowledge, largely dependent on the business capability of IT personnel, can improve the performance of the IT unit through the social mechanisms of common language and mutual understanding (Nelson and Cooprider, 1996; Reich and Benbasat, 2000). While the technical expertise and behavioral skills of IT personnel may suffice for the deployment of infrastructure services, business knowledge is necessary for these services to be deployed in a manner that meets strategic business objectives.

H3: The business capability of IT personnel positively affects infrastructure capabilities.

2. 3. IT-Dependent Organizational Agility

For over 60 years, since economists first explored the impact of oscillations in the business cycle on firms, research has investigated different aspects of organizational agility and organizations' ability to deal with changing and uncertain environments (Evans, 1991). In an organizational context, agility refers to an organization's ability to effectively control outside environments (Byrd, 2001; De Leeuw and Volberda, 1996) through its capability to do something other than originally intended (Eardley et al., 1997; Evans, 1991; Golden and Powell, 2000). Neumann (1994) defined organizational agility as a measure of an organization's ability to change and adapt to its new environment. Such definitions accentuate the strategic dimension of organizational agility and downplay the significance of operational and informational dimensions. While the literature stresses the reliance of organizational agility on IT capabilities, it often shies away from incorporating concepts related to the agility of technologies, systems, or information in definitions or frameworks of organizational agility. However, there are numerous examples of broader approaches. Huang and Nof (1999) distinguished between two perspectives – business agility and operational agility. Sambamurthy et al. (2003) referred to agility as the ability to detect and seize competitive market opportunities by assembling requisite assets, knowledge, and relationships with speed and surprise. This conceptualization is noteworthy for two main reasons: it considers operational agility to be a dimension of organizational agility, and it highlights the temporal aspect of agility. According to Conboy and Fitzgerald (2004), the main difference between the concepts of agility and flexibility is that agility emphasises the dimension of speed. We define IT-dependent organizational agility as the ability to respond *operationally* and *strategically* to changes in the external environment through IT. The response has to be quick and effective for the organization to be considered agile. We posit that IT can be used to enhance strategic agility only to the extent that existing information systems and information use practices are also agile. This suggests that (1) IT-dependent organizational agility is a second-order construct, comprising IT-dependent system agility, information agility, and strategic agility as first-order constructs, and (2) IT-dependent system agility and information agility should have a positive effect on IT-dependent strategic agility. Next, we define these first-order constructs and hypothesize on their interrelationships.

In the face of frequent market discontinuities and an increasing rate of change, IT-dependent strategic agility relates in this study to the ability to respond efficiently and effectively to emerging market opportunities by taking advantage of existing IT capabilities. The efficiency of a strategic response is primarily defined in terms of time. Its effectiveness can be defined in terms of alignment to organizational goals and competitiveness enhancement. IT-dependent system agility refers to the ability to accommodate change in information systems through activities of system development, implementation, modification, and maintenance. An organization's information systems are considered agile when its IT capabilities allow the development or modification of systems without incurring significant penalties in time or cost. IT-dependent information agility relates to the ability to accommodate change in the way organizational users access and use information resources. It relies on existing IT capabilities to increase the efficiency of using internal and external information.

This study hypothesizes that the three dimensions of IT-dependent organizational agility are interrelated, so that IT-dependent system agility and information agility positively affect IT-dependent strategic agility. While the literature does not offer direct support for the relationship between these agility dimensions, existing frameworks of organizational impacts suggest that they are indeed interrelated. For instance, Mirani and Lederer (1998) categorized the organizational benefits of IS projects as transactional, informational, and strategic. Lederer et al. (2001) suggested in a subsequent study that strategic benefits depend on transactional and informational benefits. Researchers of agility have argued that the two complementary elements required to practice agility are response ability and knowledge management (Borjesson and Mathiassen, 2005; Dove, 2001). In the context of the agility afforded by IT, these elements can reflect the transactional and informational dimensions of agility. When change takes place in the external environment, the capacity to adapt information systems to changing requirements (IT-dependent system agility) and to adjust the utilization of information resources in accordance with new information needs (IT-dependent information agility) is needed for using IT to react quickly and effectively (IT-dependent strategic agility). An organization would probably not be able to use IT to respond successfully to emerging opportunities or threats if changes to its systems and information use practices are costly and complicated.

H4: IT-dependent system agility positively affects IT-dependent strategic agility.

H5: IT-dependent information agility positively affects IT-dependent strategic agility.

Information is commonly perceived as the product of information systems. DeLone and McLean (1992) noted that "rather than measure the quality of the system performance, other IS researchers have preferred to focus on the quality of the information system output, namely, the quality of the information that the system produces, primarily in the form of reports" (p. 64). This perception suggests that the quality of an information system may constrain the quality of the information produced by it. If a system does not record real-time data, for instance, this is directly reflected in the timeliness of the information it produces. We follow this reasoning to suggest that IT-dependent system agility may constrain IT-dependent information agility. The inability to introduce changes to existing systems quickly and cost-effectively may impose a technological constraint on the ability of users to change the way they access and utilize information when conditions require them to do so. For example, users may want to mine cross-functional, real-time data for the purpose of improving customer service. The ability to accommodate such a change in information use practices depends on the ability to integrate real-time data warehousing technology into the existing infrastructure. If system modifications cannot be introduced easily, it is unlikely that new information capabilities will be available in a timely manner.

H6: IT-dependent system agility positively affects IT-dependent information agility.

Once the interrelations among the dimensions of IT-dependent organizational agility are described, we can proceed to develop hypotheses about the relationships between IT infrastructure capabilities and these dimensions. We view infrastructure capabilities as reflected in the extent of infrastructure services: an organization has a high level of infrastructure capabilities when it offers extensive infrastructure services in each capability cluster (e.g., data management, application infrastructure, IT research and development). Having extensive infrastructure services puts the organization in a superior position when the need to modify existing information systems arises, because it reduces the likelihood of having to develop new services. If the time- and resource-consuming task of developing new services can be avoided, because the required services already exist as part of the organization's infrastructure, system modifications are significantly less challenging. To illustrate this point, assume that an organization wants to Web-enable its inventory management applications so that its suppliers can gain access to inventory data relevant to their activities. This technological effort is more likely to be quick and effective when the organization has extensive channel management, communication, data management, application infrastructure, IT architecture and standards, and IT research and development services, compared to when it has to develop many infrastructure services to support the change.

H7: Infrastructure capabilities positively affect IT-dependent system agility.

Infrastructure capabilities include services that allow users to locate, access, and utilize information. Channel management services provide users with integrated access to information about customers and business partners (e.g., Web sites, point of sale, and call centers). Communication services encompass network services, Intranet/Extranet capabilities, and groupware services. Data management services include data warehousing, knowledge management, storage area networks, and data management consultancy. Application infrastructure services provide the underlying integration and functionality required for data access and manipulation. These and other services are designed to address the information needs of the organization. Extensive infrastructure services provide better response to emerging information needs because of the likelihood that the new needs could be met by already existing services. When an organization has a limited set of infrastructure services, chances are that each time new information requirements are identified, new infrastructure services must be developed to meet those requirements. Therefore, we suggest that extensive infrastructure services in each capability cluster increase the efficiency of information access and use across different information needs.

H8: Infrastructure capabilities positively affect IT-dependent information agility.

Finally, we also hypothesize that infrastructure capabilities directly affect IT-dependent strategic agility. Research has frequently found that IT infrastructure has a critical role in organizations facing strategic change. Duncan (1995) described how differences in infrastructure characteristics might underlie firms' ability to introduce strategic innovations more rapidly than the competition. Broadbent et al. (1999) showed that infrastructure capabilities had an impact on the successful implementation of business process redesign. Weill et al. (2002) found a significant correlation between infrastructure capability and strategic agility, defined by the set of business initiatives an enterprise can readily implement. Sambamurthy et al. (2003) considered IT competence, of which the quality of IT infrastructure is a key element, a critical antecedent for firms to generate more competitive actions and greater action repertoire complexity. The success of strategic innovations and new business initiatives often depends on having the necessary infrastructure capabilities. A firm may carry out a broader set of actions when it has a more complex resource base (Ferrier et al., 1999). Whether a firm seeks to become a global player, to redesign its procurement processes, or to establish a new electronic channel to its customers, it would find it difficult to do so without the appropriate communication, application infrastructure, and IT architecture and standards services, in addition to other infrastructure services. In such situations, a firm with more extensive infrastructure services has a superior competitive position, as its competitors would more likely have to engage in the development of new infrastructure services.

H9: Infrastructure capabilities positively affect IT-dependent strategic agility.

3. Research Methodology

We employed a field study approach to test the hypothesized research model. We developed a Web-based survey instrument, and then used it to collect data from IT managers across a range of industries in Israel. In recent years, Web browser-based administration of surveys has gained popularity in academic research. Data integrity concerns (e.g., nonsampled and multiple responding) have rapidly diminished, as procedures to overcome methodological difficulties have been developed and positive experiences have been reported. Research comparing browser-based results with other modalities painted a positive picture (Stanton and Rogelberg, 2001). Shaw (2002) reported that such modality comparisons of results were statistically insignificant in IT infrastructure research. Similar conclusions were drawn concerning the integrity of Web-delivered experiments (McGraw et al., 2000), which represent a more rigorous research methodology compared to field surveys. In the present study, following a pretest and multiple pilot tests of the instrumentation, we administered the main survey in a way that minimized data integrity concerns. We discuss instrument development and sampling issues next.

3.1. Instrument Development

We developed the survey instrument to capture the attitudes of IT managers toward IT personnel capabilities, IT infrastructure capabilities, and IT-dependent organizational agility in their organizations. This was our preferred population based on the assumption that nonprofessional assessments of professional competencies are less accurate than self-assessments, and thus our belief that IT professionals should evaluate their own competencies (Bassellier and Benbasat, 2004). Efforts to develop measures of IT infrastructure (e.g., Byrd and Turner, 2000; Lewis and Byrd, 2003) or organizational impacts of IT (e.g., Mirani and Lederer, 1998; Sethi and King, 1994) adopted a similar approach. Based on the notion that valid assessments of IT-dependent organizational impacts warrant a managerial perspective, we targeted IT professionals holding managerial positions.

The measures of IT infrastructure capabilities were developed in this study based on Weill et al. (2002). Following the approach that the level of infrastructure capability depends on the extent of infrastructure services (Broadbent et al., 1996; Broadbent et al., 1999), we constructed 10 measures to assess the range of infrastructure services in each of the 10 capability clusters identified by Weill et al. (2002). Measures of the technical, behavioral, and business capabilities of IT personnel were based on Byrd and Turner (2001a), who operationalized the knowledge and skill domains outlined by Lee et al. (1995). Measures of IT-dependent system, information, and strategic agility were based on Mirani and Lederer (1998), who developed an instrument to assess the transactional, informational, and strategic benefits of IS projects. To reflect this study's definition of IT-dependent organizational agility and its focus on shared IT capabilities as a source of agility, these measures assessed the agility attributed directly to IT shared across the organization. The questionnaire items are presented in Appendix A. All items used a seven-point scale, anchored at the ends by either "strongly agree" and "strongly disagree" or "very large extent" and "not at all", following the original instrumentation. The questionnaire also collected data on the characteristics of the respondent and the evaluated organization.

3.2. Pretest and Pilot Tests

We pretested the initial instrument in nine separate interviews with IT managers and academics. Each interviewee was briefed on the purpose of the study and was asked to evaluate the questionnaire items for comprehensibility, relevance, and completeness. Following the interviews, we modified some questionnaire items.

We pilot tested the modified instrument in three separate Web-based surveys, using three different convenient samples of IT managers. This stage had two purposes. The first was to analyze the feasibility of a Web-based survey in light of potential technical difficulties (e.g., mail server filtering) and methodological concerns (e.g., anonymity issues). Altogether, 37 IT managers participated in the three pilot tests. The tests accentuated the importance of reassuring respondents that the research was academic. The second purpose of the pilot tests was to provide an initial assessment of the scales' measurement properties. Cronbach's α coefficients ranged from 0.80 to 0.96, representing acceptable scale reliabilities.

3.3. Data Collection

We administered the questionnaire instrument via the Web in a large-scale, cross-sectional survey. Data were collected by distributing e-mail messages to the target population of IT managers in Israel, through a leading community provider that manages an active database of IT professionals nationwide. For our purposes, this database was queried for IT managers at all management levels, producing a list of about 8,000 potential respondents. The e-mails sent to potential respondents included a link to the questionnaire and a link to a "verification" page, which provided means of communication with the research team. We distributed the e-mails only once, with no reminder notices. The application used to collect data minimized data integrity concerns by sending a personal link to each respondent. The link only identified the respondent against the database, while retaining her or his anonymity.

Table 2. Sample Characteristics

Characteristic (Valid N)	Frequency	Percent
Job title (290)		
CIO / Manager of the IT unit	46	15.9%
Senior IT management	76	26.2%
Junior IT management	70	24.1%
Other management (e.g. CEOs, CTOs)	98	33.8%
Time with the company (290)		
Two months to a year	17	5.9%
One to five years	112	38.6%
More than five years	161	55.5%
Number of employees (288)		
< 50	30	10.4%
51 – 250	60	20.8%
251 – 500	38	13.2%
501 – 1000	39	13.5%
> 1000	121	42.0%
Industry (281)		
Banking/finance	20	7.1%
Business services	13	4.6%
Communications	47	16.7%
Defense	14	5.0%
Distribution/retail	13	4.7%
Education	9	3.2%
Government/municipalities	18	6.4%
Health services	14	5.0%
Insurance	8	2.8%
Logistics	3	1.1%
Manufacturing	17	6.0%
Real estate	2	0.7%
Technological development	38	13.5%
Transportation	7	2.5%
Utilities	5	1.8%
Other	53	18.9%

A total of 361 questionnaires were returned, which constituted roughly 4.5 percent of the sent e-mails. Empirical evidence shows that Web surveys typically generate lower response rates (Ballard and Prine, 2002; Crawford et al., 2001; Kaplowitz et al., 2004), with significantly lower response rates in business sectors relative to academic sectors and the general Web (Ilieva et al., 2002). Privacy concerns, related both to receiving the message and to providing the data, are more salient in e-mail surveys, and can substantially lower response rates in online research (Cho and LaRose, 1999). Moreover, it is difficult to ascertain the number of respondents actually contacted in Web surveys because of technical problems that interfere with the delivery of online recruiting messages (Stanton and Rogelberg, 2001) such as invalid e-mail addresses and filtering software. These technical problems significantly reduce the number of actual recipients. The 361 respondents in this study constituted 27.5 percent of the "active" recipients (i.e., recipients who clicked on the questionnaire page link).

We evaluated non-response bias by comparing the functional role distribution of respondents and non-respondents. The original database of IT professionals recorded specific functional roles, thus enabling such a comparison. Preliminary descriptive statistics indicated that one functional role category, which included "other" (less typical) functional roles, showed lower response rates. A χ^2 test of the distribution of the remaining four functional role categories, comparing respondents and non-respondents, produced a χ^2 value of 3.80 with three degrees of freedom, which was statistically insignificant ($p=0.28$). Thus, the possibility of a dominant non-response bias was rejected. T-tests comparing respondents with "other" or unspecified functional roles with the rest of the respondents in the initial dataset found statistically insignificant mean differences for all questionnaire items. Consequently, we maintained the responses of all functional role categories for further analysis. Non-response bias may also be evaluated by comparing early and late responses (Armstrong and Overton, 1977). T-tests comparing early responses (lower quartile of response time) with late responses (upper quartile of response time) found no statistically significant mean differences. This strengthened our conclusion about the lack of non-response bias.

Of the 361 returned questionnaires, 68 questionnaires were dropped for reasons of non-management positions (34 responses), relatively small-sized organizations (22 responses), unfamiliarity with the organization (3 responses), and partially completed questionnaires (16 responses). Several questionnaires were dropped because of more than one criterion. The final dataset used for testing the hypothesized research model consisted of 293 responses. Table 2 outlines the characteristics of the final sample.

4. Data Analysis and Results

We tested the measurement model (psychometric qualities of the scales) and structural model (directions and strengths of the prespecified relationships) using covariance-based structural equation modeling (SEM) techniques (EQS 6.1 software). Covariance-based SEM enabled the assessment of the plausibility of the hypothesized research model with its complete set of paths, through goodness-of-fit tests (Gefen et al., 2000). It also enabled the comparison of the hypothesized research model with alternative structural models. We analyzed the sample data by following a two-step approach, where the measurement model was separately estimated and respecified prior to the estimation of the full structural model that simultaneously modeled measurement and structural relations (Anderson and Gerbing, 1988; Gerbing and Anderson, 1988).

4.1. Assessment of the Measurement Model

The procedure for the estimation and respecification of the measurement model followed the standard SEM methodology (Anderson and Gerbing, 1988; Gefen et al., 2003). We revised the measurement model by dropping items (one at a time) that shared a high degree of residual variance with other items, based on reported standardized residuals. Given the broad scope of the measurement model, a confirmatory factor analysis showed satisfactory model fit. The adjusted χ^2 (ratio of χ^2 to degrees of freedom) was 2.41 (χ^2_{356}=858.75), below the recommended 3. Almost all fit indices – the normed fit index (NFI) at 0.891, non-normed fit index (NNFI) at 0.931, comparative fit index (CFI) at 0.939, adjusted goodness-of-fit index (AGFI) at 0.809, standardized root mean square residual (RMR) at 0.051, and root mean square error of approximation (RMSEA) at 0.070 – were within or slightly outside the accepted levels for confirmatory factor analysis.[1] Only the goodness-of-fit index (GFI) at 0.844 was somewhat below the recommended level. However, SEM models "seldom show excellent fit values in all the indices" (Gefen et al., 2003, p. 69). For instance, Byrd and Turner's (2000) original instrument for measuring IT personnel knowledge and skills showed a GFI of 0.79. Table 3 presents the questionnaire items, their descriptive statistics, and the standardized item loadings for the initial and modified confirmatory factor analyses.

We further assessed the measurement model for construct reliability and validity. All composite construct reliabilities were considerably above the recommended 0.70 threshold, indicating that the specified items sufficiently represented their respective constructs (Segars, 1997). To ascertain convergent validity, the average variance extracted (AVE) should be above 0.50, indicating that the variance captured by the construct is larger than the variance due to measurement error (Fornell and Larcker, 1981), and item loadings should be above 0.70 (Gefen et al., 2000). The confirmatory factor analysis showed that AVE values and item loadings exceeded these levels, establishing the convergent validity of the constructs.

Finally, discriminant validity could be assessed by demonstrating that the shared variances between constructs were lower than the AVE of the individual constructs (Fornell and Larcker, 1981). Table 4 presents the composite construct reliabilities, as well as the inter-correlations among constructs and the square roots of AVE values (on the diagonal). The table provides evidence to support the discriminant validity of the constructs. We further assessed discriminant validity using pairwise comparisons of a constrained model and an unconstrained model for each pair of constructs. The former set the correlation between the two constructs to 1.0 and the latter freed the correlation between them. A significantly lower χ^2 value for the unconstrained model indicated that the constructs were not perfectly correlated and provided evidence of discriminant validity (Anderson and Gerbing 1988, Segars 1997). The results of these analyses are presented in Appendix B. In all possible pairwise comparisons of the constructs in this study, the χ2 difference was highly significant ($p<0.001$), providing additional evidence of discriminant validity.

4.2. Assessment of the Structural Model

We assessed the structural model using the hypothesized relationships in the research model to model the paths between the constructs. The adjusted χ^2 of the structural model was 2.55 (χ^2_{365}=930.72), the NFI was 0.882, the NNFI was 0.923, the CFI was 0.931, the GFI was 0.833, the AGFI was 0.801, the standardized RMR was 0.082, and the RMSEA was 0.073. The discrepancies between the fit indices of the structural model and the measurement model were relatively small, indicating that the research model had captured the major relationships between the constructs.

[1] The recommended threshold for NFI, NNFI, CFI, and GFI is 0.90, for AGFI 0.80, and for RMR 0.05 (Chin and Todd, 1995; Gefen et al., 2000; Segars and Grover, 1993). The literature suggests 0.06 or 0.08 as the recommended cutoff for RMSEA (Gefen et al., 2003).

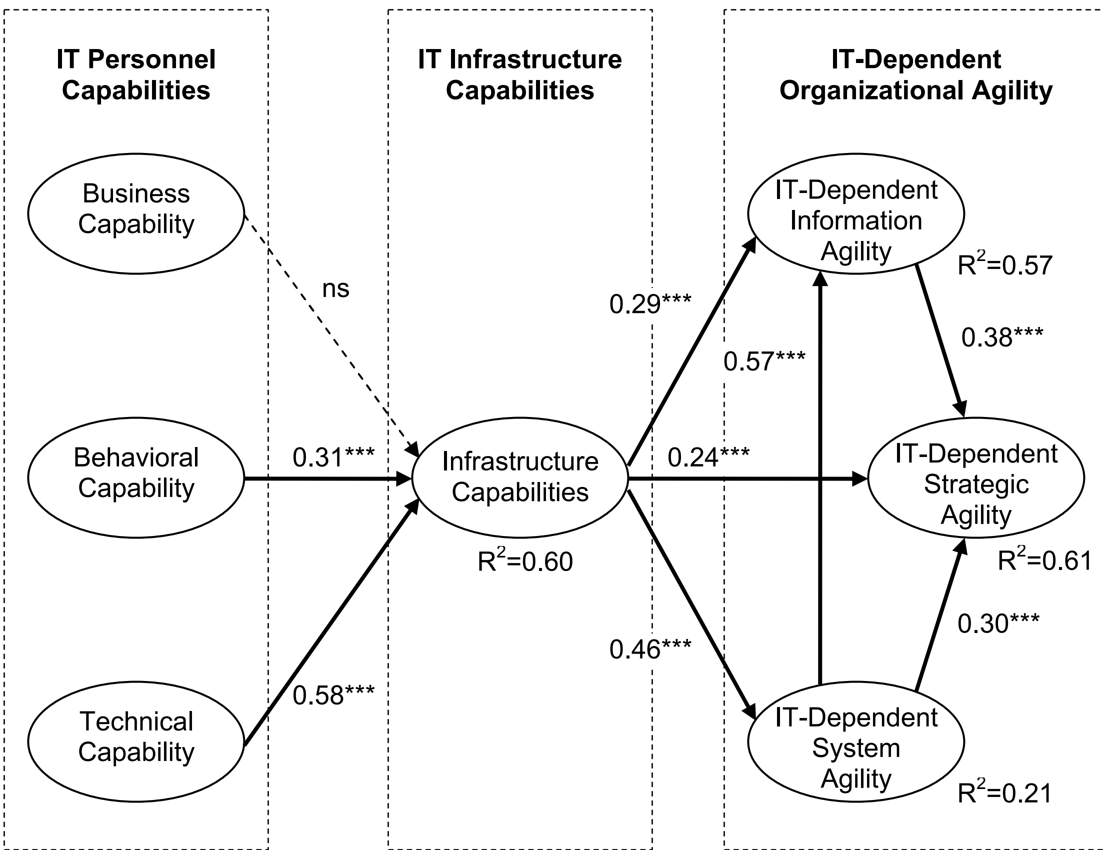
Table 3. Descriptive Statistics and Standardized Loadings of Items

Item	Wording	Mean	Std. Dev.	Loading (Initial Model)	Loading (Modified Model)
	Technical Capability				
TC1	The IT personnel are skilled in multiple structured programming, CASE methods, or tools	4.24	1.71	0.77	Dropped
TC2	The IT personnel are skilled in distributed processing or distributed computing	4.18	1.81	0.78	0.71
TC3	The IT personnel are skilled in network management and maintenance	5.83	1.46	0.50	Dropped
TC4	The IT personnel are skilled in developing Web-based applications	4.94	1.74	0.76	0.78
TC5	The IT personnel are skilled in data warehousing, mining, or marts	4.58	1.87	0.74	0.79
	Behavioral Capability				
BC1	The IT personnel are self-directed and proactive	5.29	1.53	0.82	0.80
BC2	The IT personnel have the ability to plan, organize, and lead projects	5.64	1.49	0.90	0.95
BC3	The IT personnel have the ability to plan and execute work in a collective environment	5.56	1.49	0.91	0.92
BC4	The IT personnel work well in cross-functional teams addressing business problems	5.02	1.64	0.83	Dropped
BC5	The IT personnel are cross-trained to support other IT services outside their primary knowledge domain	4.99	1.68	0.78	Dropped
	Business Capability				
BU1	The IT personnel are knowledgeable about the key success factors that must go right if the company is to succeed	5.20	1.70	0.77	Dropped
BU2	The IT personnel are encouraged to learn new information technologies	5.17	1.60	0.62	Dropped
BU3	The IT personnel closely follow the trends in current information technologies	5.49	1.35	0.62	Dropped
BU4	The strategies of the IT unit and the company's strategies are well aligned	4.80	1.74	0.80	Dropped
BU5	The IT personnel understand the company's policies and plans	5.11	1.63	0.83	0.77
BU6	The IT personnel are able to interpret business problems and develop appropriate technical solutions	5.15	1.69	0.89	0.93
BU7	The IT personnel are knowledgeable about business functions	4.94	1.77	0.85	0.92
	Infrastructure Capabilities				
IC1	The IT unit provides a wide range of channel management services *(electronic channel to the customer or partner to support multiple applications, such as point of sale, Web sites, call centers, mobile computing)*	4.88	1.86	0.75	0.76
IC2	The IT unit provides a wide range of security and risk management services *(security policies, disaster planning, firewalls)*	5.45	1.64	0.72	0.75
IC3	The IT unit provides a wide range of communication services *(network services, broadband services, Intranet capabilities, Extranet capabilities, groupware)*	5.80	1.39	0.74	0.78
IC4	The IT unit provides a wide range of data management services (key data independent of applications, centralized data warehouse, data management consultancy, storage area networks, knowledge management)	5.15	1.68	0.75	0.77
IC5	The IT unit provides a wide range of application infrastructure services (centralized management of applications, middleware, mobile and wireless applications, ASP, workflow applications, payment transaction processing)	5.00	1.79	0.77	0.78

Table 3. Descriptive Statistics and Standardized Loadings of Items (Continued)					
Item	Wording	Mean	Std. Dev.	Loading (Initial Model)	Loading (Modified Model)
IC6	The IT unit provides a wide range of IT facilities management services (large scale processing/mainframe, server farms, common systems development environment)	5.32	1.74	0.75	0.77
IC7	The IT unit provides a wide range of IT management services (IS planning, investment and monitoring, IS project management, negotiations with suppliers and outsourcers, service level agreements)	5.29	1.78	0.79	0.76
IC8	The IT unit provides a wide range of IT architecture and standards services (specify and enforce architectures and standards for: technologies, communications, data, applications, and work)	4.94	1.76	0.81	0.78
IC9	The IT unit provides a wide range of IT education services (training in the use of IT, management education for generating value from IT use)	4.53	1.78	0.69	Dropped
IC10	The IT unit provides a wide range of IT research and development (R&D) services (identify and test new technologies for business purposes, evaluate proposals for new IS applications)	4.41	1.88	0.72	Dropped
	IT-Dependent System Agility				
SA1	IT shared across the company saves money by reducing system modification or enhancement costs	4.79	1.83	0.84	0.84
SA2	IT shared across the company allows other applications to be developed faster	4.74	1.79	0.94	0.94
SA3	IT shared across the company allows previously infeasible applications to be implemented	4.87	1.73	0.87	0.87
SA4	IT shared across the company provides the ability to perform maintenance faster	5.11	1.63	0.80	0.80
	IT-Dependent Information Agility				
IA1	IT shared across the company enables faster retrieval or delivery of information or reports	5.70	1.46	0.87	0.88
IA2	IT shared across the company enables easier access to information	5.81	1.41	0.90	0.90
IA3	IT shared across the company presents information in a more concise manner or better format	5.35	1.53	0.86	0.86
IA4	IT shared across the company increases the flexibility of information requests	5.25	1.58	0.83	0.83
	IT-Dependent Strategic Agility				
ST1	IT shared across the company enhances competitiveness or creates strategic advantage	5.29	1.64	0.88	0.90
ST2	IT shared across the company enables the company to catch up with competitors	5.31	1.65	0.90	0.92
ST3	IT shared across the company aligns well with stated organizational goals	5.24	1.44	0.84	0.82
ST4	IT shared across the company helps establish useful linkages with other organizations	4.81	1.67	0.73	Dropped
ST5	IT shared across the company enables the company to respond more quickly to change	5.08	1.58	0.82	0.80

Table 4. Standardized Correlation Matrix								
Construct	Composite Construct Reliability	TC	BC	BU	IC	SA	IA	ST
Technical Capability (TC)	0.80	0.76						
Behavioral Capability (BC)	0.92	0.43	0.89					
Business Capability (BU)	0.91	0.50	0.77	0.88				
Infrastructure Capabilities (IC)	0.92	0.71	0.55	0.52	0.77			
IT-Dependent System Agility (SA)	0.92	0.54	0.38	0.41	0.43	0.86		
IT-Dependent Information Agility (IA)	0.92	0.45	0.50	0.46	0.53	0.71	0.87	
IT-Dependent Strategic Agility (ST)	0.92	0.46	0.54	0.60	0.56	0.68	0.72	0.86

Diagonal elements are the square roots of AVE



*** $p<0.001$, ns – nonsignificant ($p>0.05$)

Model fit indices: $\chi^2_{365}=930.72$, adjusted $\chi^2=2.55$, NFI=0.882, NNFI=0.923, CFI=0.931, GFI=0.833, AGFI=0.801, standardized RMR=0.082, RMSEA=0.073

Figure 2. Standardized Solution of the Structural Model

Figure 2 depicts the structural model with the standardized path coefficients, squared multiple correlations, and model fit indices. The standardized path coefficients in the structural model supported all hypotheses but one. Technical capability and behavioral capability significantly affected infrastructure capabilities, supporting H1 and H2. IT personnel capabilities accounted for 60 percent of the variance in infrastructure capabilities. Infrastructure capabilities significantly affected the three dimensions of IT-dependent organizational agility, supporting H7, H8, and H9. The interrelationships among agility dimensions were also supported. IT-dependent system agility significantly affected IT-dependent information agility, and both significantly affected IT-dependent strategic agility, supporting H4, H5, and H6. The structural model explained 21 percent of the variance in IT-dependent system agility, 57 percent in IT-dependent information agility, and 61 percent in IT-dependent strategic agility. The analysis did not support H3 – business capability did not have a significant effect on infrastructure capabilities.

Using a single instrument to measure all the constructs in a study typically raises concerns of common method bias. Therefore, we used a rigorous test to reject the possibility that common method bias was responsible for the significant relationships between the constructs. Podsakoff et al. (2003) suggest adding a common methods variance factor to the structural model and allowing all items to load on this factor, as well as on their theoretical constructs. By doing so, the variance of the responses to a specific item is partitioned into three components: trait, method, and random error. Comparing the significance of the structural parameters both with and without the common methods factor represents a test of common method bias. Accordingly, we retested the structural model with an eighth common methods factor, on which all items loaded. We received the same results – all hypotheses were supported except H3 – ruling out the possibility of common method bias.

4.3. Assessment of Alternative Models

The theoretical reasoning underlying the hypothesized research model viewed IT personnel capabilities as the transformation mechanism responsible for the development of IT infrastructure capabilities, which enable or constrain the organizational agility afforded by IT. The hypotheses therefore described a chain of effects from the technical, behavioral, and business capabilities of IT personnel; through infrastructure capabilities; to IT-dependent system, information, and strategic agility. The assessment of the structural model supported the hypothesized relationships.

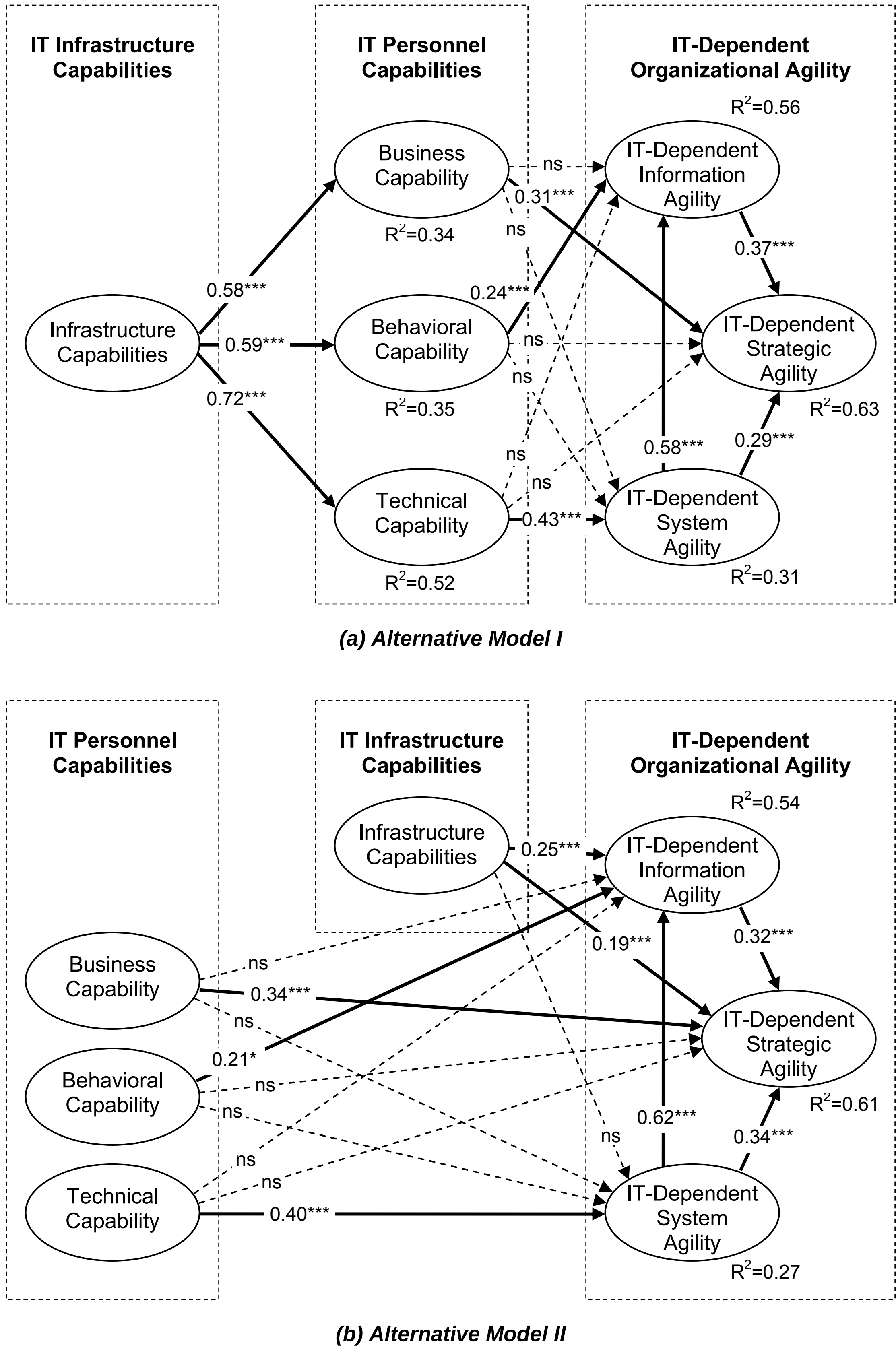
However, two alternative theoretically-anchored models may describe different relationships between IT personnel capabilities, IT infrastructure capabilities, and IT-dependent organizational agility. The first alternative model reverses the relationships between the two sets of capabilities. Accordingly, IT infrastructure capabilities positively affect IT personnel capabilities, which then positively affect IT-dependent organizational agility. This model is based on the theoretical notion that extensive infrastructure services may increase the need to develop complementing human capabilities. Research has demonstrated that organizations at more advanced stages of technological maturity require more complex behavioral and organizational skills (Benbasat et al., 1980; Choe, 1996). It may be argued that IT management first decides on the appropriate level of infrastructure capabilities that best supports existing and emerging business needs, and then develops the IT personnel capabilities needed for infrastructure management. This model includes 15 paths: three from infrastructure capabilities to technical, behavioral, and business capabilities; nine from them to IT-dependent system, information, and strategic agility; and the original three paths among agility dimensions. Panel (a) of Figure 3 graphically depicts this alternative model and its results (standardized path coefficients and squared multiple correlations). The second alternative model views the two sets of capabilities as direct antecedents of IT-dependent organizational agility, omitting the causal relationships between them. This model is based on conceptualizations of IT personnel and IT infrastructure as key building blocks of the organizational IT capability (Bharadwaj, 2000; Henderson and Venkatraman, 1993; Ross et al., 1996). Those conceptualizations have typically not described any hierarchy between IT capability elements. This model also includes 15 paths: 12 from technical, behavioral, business, and infrastructure capabilities to IT-dependent system, information, and strategic agility, and the original three paths among agility dimensions. Like the hypothesized research model, this model includes three correlations among IT personnel capabilities. This alternative model and its results are depicted in panel (b) of Figure 3.

To test whether the hypothesized research model fits the data better than the two alternative models, we compared the model fit indices of the three structural models. Such a comparison is relatively straightforward, since all three structural models are based on the same measurement model (i.e., the same constructs and indicators). The results, presented in Table 5, show the superiority of the research model according to all fit indices. The research model uses fewer relationships to obtain a lower χ^2 value. This means that it provides a better fit to the data while being more parsimonious.

5. Discussion

This study investigates the role of IT infrastructure capabilities in mediating the effects of IT personnel capabilities on the organizational agility afforded by IT. The findings show that the technical and behavioral capabilities of IT personnel have positive effects on infrastructure capabilities, which positively affect IT-dependent system, information, and strategic agility. The findings also confirm the positive effect of IT-dependent system agility on IT-dependent information agility, and of both on IT-dependent strategic agility. Research has acknowledged the strategic value of IT personnel knowledge and skills (Bharadwaj, 2000; Melville et al., 2004; Ross et al., 1996). However, additional research is warranted before a thorough understanding is gained of the mechanisms underlying the relationship between IT personnel capabilities and IT business value. This study offers one such rationalization, supported by empirical evidence. It describes the extent of infrastructure services and the ability to accommodate change in information systems and in information use as the mechanisms responsible for the strategic value of IT personnel capabilities. While other mechanisms undoubtedly exist, this study stresses the contribution of infrastructure capabilities in gaining agility from human IT resources.

Contrary to our hypothesis, the business capability of IT personnel does not have a significant effect on infrastructure capabilities. A plausible explanation for this result is that the effect of behavioral capability on infrastructure capabilities mitigates the effect of business capability. Both behavioral and business capabilities are necessary to provide extensive infrastructure capabilities. Given the important role users play in the development and deployment of IT capabilities, the behavioral capability of IT personnel is valuable because it allows them to establish better partnerships with business clients based on their effective interpersonal communication skills. The business capability of IT personnel is valuable because it allows them to provide IT capabilities that best serve business objectives based on their understanding of the business environment. Our results suggest that IT personnel do not necessarily need deep business knowledge to



* $p<0.05$
*** $p<0.001$
ns – nonsignificant ($p>0.05$)

Figure 3. Alternative Models

Table 5. Fit Indices Comparison			
Model Fit Index	Research Model	Alternative Model I	Alternative Model II
χ^2 (df)	930.72 (365)	1011.01 (362)	1036.23 (359)
Adjusted χ^2	2.55	2.79	2.89
NFI	0.882	0.870	0.867
NNFI	0.923	0.908	0.903
CFI	0.931	0.918	0.914
GFI	0.833	0.820	0.825
AGFI	0.801	0.784	0.787
Standardized RMR	0.082	0.083	0.194
RMSEA	0.073	0.078	0.080

develop infrastructure capabilities, when they possess a strong behavioral capability. Once IT personnel are able to establish effective partnerships with business clients, based on their behavioral capability, the necessary business knowledge may come from the business side. To examine this explanation, we conducted a *post hoc* analysis of the structural model without the construct of behavioral capability, its indicators, and the path from it to infrastructure capabilities. The analysis resulted in a significant effect of business capability on infrastructure capabilities ($\gamma=0.25$, $p<0.001$), while maintaining all the other significant effects. The decrease in the variance of infrastructure capabilities explained by IT personnel capabilities was small (from 0.60 to 0.57).

An important, frequently overlooked challenge of using SEM techniques is demonstrating that the hypothesized research model fits the data better than any alternative theoretically-sound model. This can strengthen the validity of a study's findings by showing their superiority relative to the results from alternative models. This study develops a theoretical model of the relationships between IT personnel capabilities, IT infrastructure capabilities, and IT-dependent organizational agility. The model is supported by the structural analysis of the collected data. However, the study goes a step forward and shows the empirical strength of this model relative to alternative theoretical models, describing other relationships between the same constructs. These alternative models depict direct relationships between IT personnel capabilities and IT-dependent organizational agility. The results in Figure 3 show that most of these direct relationships are statistically insignificant. Interestingly, the results indicate that each IT personnel capability is associated with a different agility dimension: technical capability with IT-dependent system agility, behavioral capability with IT-dependent information agility, and business capability with IT-dependent strategic agility. The implications of this capability-agility symmetry for research and practice may be important, and therefore it should be the focus of future research. While the direction of the relationship between IT personnel capabilities and IT infrastructure capabilities has to be established further in research using different data sources, the overall findings of this study suggest that IT personnel capabilities shape IT infrastructure capabilities, and not the other way around.

5.1. Limitations

This study has several limitations that should be considered in interpreting the results. First, as noted in the early stages of model development, this study takes a simplistic view of IT infrastructure capabilities, because it does not consider the IT capabilities of business units or functional areas as part of IT infrastructure unless those are shared throughout the organization. Based on this view, the relationships between the IT unit and the business units are not directly included in the research model. We argue that the behavioral and business capabilities of IT personnel may serve as a proxy for IT-business unit relationships. These non-technical capabilities reflect the ability of IT personnel to build effective relationships with the business units and to strengthen the involvement of business unit executives in making and implementing strategic IT decisions. Furthermore, the research model lacks consideration of the extent to which external providers are involved in IT provision. Incorporating constructs that reflect the relationship among the IT unit and the business units and the level of external IT provision seems a promising direction for future research

Second, the measurement of constructs at one point in time means that the dynamics of longitudinal processes cannot be analyzed to produce knowledge of how shared IT capabilities and their relationships evolve over time. IT personnel capabilities are sometimes developed to facilitate the *future* development of IT infrastructure capabilities, which may allow a better response to *future* changes in the external environment. Therefore, shared IT capabilities generate benefits that can be fully appreciated only over time. Future research should address the time dimension in studying the strategic value of shared IT capabilities, preferably by using qualitative methodologies.

Third, a research population of technology providers may have a different perspective from that of technology users. Beyond the extreme difficulty of collecting matched-pair data in a large-scale survey, our approach relies on the assumption that professionals are better positioned to assess professional capabilities (Bassellier and Benbasat, 2004). The same applies to the evaluation of IT infrastructure capabilities, part of which is not perceptible to most organizational users. However, collecting data only from IT managers does not allow a comparison of different organizational views in the context of the research model.

Last, the respecification of the measurement model by dropping items may be another concern. While a common practice in SEM analyses (Anderson and Gerbing, 1988; Gefen et al., 2003), dropping items merely based on data may change the meaning of the constructs and cause an over fitting of the model to the data (Gefen et al. 2003). To address this concern, the process of dropping items in this study was driven by the data, but also by a careful examination of the resulting scales to ensure their content validity. In one instance, dropping items narrowed the domain of a construct. The original technical capability construct had five items, two of which – those that reflected the more basic technical skills (structured programming and network management) – were later dropped. The modified technical capability construct consequently included items that reflected more advanced technical skills (distributed processing, developing Web-based applications, data warehousing and mining). To show that this had no effect on our results, we conducted a *post hoc* analysis of the structural model with the original technical capability construct. This analysis also resulted in a significant effect of technical capability on infrastructure capabilities ($\gamma=0.57$, $p<0.001$), while maintaining all the other significant effects.

5.2. Implications and Future Research Directions

Research has highlighted the need for conceptual understanding and empirical evidence of the mechanisms underlying the strategic consequences of IT capabilities. Bharadwaj (2000) concluded that the full chain of variables connecting IT capability to firm performance had been unclear. Byrd et al. (2004) stated that empirical evidence on the relationships between the knowledge and skills of IT personnel and organizational success variables had been lacking. Bassellier and Benbasat (2004) reached a similar conclusion concerning the ability of IT professionals' business competence to enable competitive positioning. The present study contributes by developing and testing a research model that establishes the role of IT personnel capabilities and IT infrastructure capabilities in shaping the agility afforded by IT. Future research can extend this conceptual platform to examine additional organizational impacts (e.g., interorganizational collaboration) of shared IT capabilities.

Given the scope of this study, IT infrastructure capabilities are modeled using a single construct. Such an approach overlooks the interrelationships that may exist among the various clusters of infrastructure capabilities, as well as the relationships between specific clusters and IT personnel capabilities or organizational agility. Future research should employ a multidimensional approach to IT infrastructure capabilities in order to promote understanding of their interrelationships, antecedents, and impacts. This would allow managers to better prioritize their IT infrastructure investments based on strategic needs.

The findings accentuate the role of IT personnel capabilities in extending IT infrastructure capabilities. Beyond the technical capability of IT personnel, their behavioral capability, which reflects their ability to plan, execute, and manage work in cross-functional settings, positively influences the extent of infrastructure services. Our findings suggest that the business capability of IT personnel has a similar influence, which is mitigated by the influence of the behavioral capability. The practical implication is that personnel development efforts focused on strengthening the technical capability of IT professionals may have limited contribution at the organizational level, unless comparable efforts are undertaken to enhance their behavioral and business capabilities as well.

Finally, the findings show that extensive infrastructure services are associated with strategic benefits. A practical implication of this finding is that firms should encourage and invest in initiatives to widen and improve the array of shared IT services provided by the IT unit. Such efforts should not be restricted to particular capability clusters, and may be perceived as an investment in strategic agility, derived from superior IT utilization. Extensive infrastructure capabilities may serve a firm in confronting not only the strategic needs of today, but also the strategic opportunities and threats of tomorrow.

6. Conclusions

Following recent controversies about the mechanisms that underlie the strategic contribution of IT, this study formulates and tests the relationships between IT personnel capabilities, IT infrastructure capabilities, and IT-dependent organizational agility. The resulting research model offers an elaborate explanation of how the capabilities of IT personnel are associated with IT-dependent strategic agility through their effects on IT infrastructure capabilities. Recent technological trends in organizations moving toward centralized IT governance and implementing enterprise-wide information technologies and systems stress the importance and potential contribution of cross-organizational IT capabilities. Given the competitive nature of contemporary business environments, researchers and practitioners should not remain indifferent to the large investments in shared IT capabilities and to their ability to trigger, facilitate, or seriously inhibit strategic initiatives. IT personnel capabilities and IT infrastructure capabilities represent major subsets of an organization's IT capability. Research has established the critical role of both in using IT resources effectively and efficiently. This study describes the causal relationship between them and their influence on the agility afforded by IT. Future research should adopt such an approach in further identifying the mechanisms underlying the strategic consequences of shared IT capabilities.

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Appendix A: Questionnaire Items

A seven-point scale was used for all items.

Technical Capability

TC1 The IT personnel are skilled in multiple structured programming, CASE methods, or tools
TC2 The IT personnel are skilled in distributed processing or distributed computing
TC3 The IT personnel are skilled in network management and maintenance
TC4 The IT personnel are skilled in developing Web-based applications
TC5 The IT personnel are skilled in data warehousing, mining, or marts

Behavioral Capability

BC1 The IT personnel are self-directed and proactive
BC2 The IT personnel have the ability to plan, organize, and lead projects
BC3 The IT personnel have the ability to plan and execute work in a collective environment
BC4 The IT personnel work well in cross-functional teams addressing business problems
BC5 The IT personnel are cross-trained to support other IT services outside their primary knowledge domain

Business Capability

BU1 The IT personnel are knowledgeable about the key success factors that must go right if the company is to succeed
BU2 The IT personnel are encouraged to learn new information technologies
BU3 The IT personnel closely follow the trends in current information technologies
BU4 The strategies of the IT unit and the company's strategies are well aligned
BU5 The IT personnel understand the company's policies and plans
BU6 The IT personnel are able to interpret business problems and develop appropriate technical solutions
BU7 The IT personnel are knowledgeable about business functions

Infrastructure Capabilities

IC1 The IT unit provides a wide range of channel management services *(electronic channel to the customer or partner to support multiple applications, such as point of sale, Web sites, call centers, mobile computing)*
IC2 The IT unit provides a wide range of security and risk management services *(security policies, disaster planning, firewalls)*
IC3 The IT unit provides a wide range of communication services *(network services, broadband services, Intranet capabilities, Extranet capabilities, groupware)*
IC4 The IT unit provides a wide range of data management services *(key data independent of applications, centralized data warehouse, data management consultancy, storage area networks, knowledge management)*
IC5 The IT unit provides a wide range of application infrastructure services *(centralized management of applications, middleware, mobile and wireless applications, ASP, workflow applications, payment transaction processing)*
IC6 The IT unit provides a wide range of IT facilities management services *(large scale processing/mainframe, server farms, common systems development environment)*
IC7 The IT unit provides a wide range of IT management services *(IS planning, investment and monitoring, IS project management, negotiations with suppliers and outsourcers, service level agreements)*
IC8 The IT unit provides a wide range of IT architecture and standards services *(specify and enforce architectures and standards for: technologies, communications, data, applications, and work)*
IC9 The IT unit provides a wide range of IT education services *(training in the use of IT, management education for generating value from IT use)*
IC10 The IT unit provides a wide range of IT research and development (R&D) services *(identify and test new technologies for business purposes, evaluate proposals for new IS applications)*

IT-Dependent System Agility

SA1 IT shared across the company saves money by reducing system modification or enhancement costs
SA2 IT shared across the company allows other applications to be developed faster
SA3 IT shared across the company allows previously infeasible applications to be implemented

SA4	IT shared across the company provides the ability to perform maintenance faster

IT-Dependent Information Agility

IA1	IT shared across the company enables faster retrieval or delivery of information or reports
IA2	IT shared across the company enables easier access to information
IA3	IT shared across the company presents information in a more concise manner or better format
IA4	IT shared across the company increases the flexibility of information requests

IT-Dependent Strategic Agility

ST1	IT shared across the company enhances competitiveness or creates strategic advantage
ST2	IT shared across the company enables the company to catch up with competitors
ST3	IT shared across the company aligns well with stated organizational goals
ST4	IT shared across the company helps establish useful linkages with other organizations
ST5	IT shared across the company enables the company to respond more quickly to change

Appendix B: Pairwise Analyses of Discriminant Validity

Model	Constrained χ^2 (df)	Unconstrained χ^2 (df)	Difference in χ^2 1df
Technical Capability with Behavioral Capability	194.87 (9)	17.40 (8)	177.47***
Technical Capability with Business Capability	167.51 (9)	18.50 (8)	149.01***
Technical Capability with Infrastructure Capabilities	266.06 (44)	164.49 (43)	101.57***
Technical Capability with IT-Dependent System Agility	183.92 (14)	27.84 (13)	156.08***
Technical Capability with IT-Dependent Information Agility	268.71 (14)	86.40 (13)	182.31***
Technical Capability with IT-Dependent Strategic Agility	212.85 (14)	35.62 (13)	177.23***
Behavioral Capability with Business Capability	254.97 (9)	38.70 (8)	216.27***
Behavioral Capability with Infrastructure Capabilities	634.67 (44)	170.34 (43)	464.33***
Behavioral Capability with IT-Dependent System Agility	595.97 (14)	17.64 (13)	578.33***
Behavioral Capability with IT-Dependent Information Agility	598.49 (14)	83.87 (13)	514.62***
Behavioral Capability with IT-Dependent Strategic Agility	526.53 (14)	39.48 (13)	487.05***
Business Capability with Infrastructure Capabilities	591.83 (44)	163.78 (43)	428.05***
Business Capability with IT-Dependent System Agility	510.43 (14)	27.99 (13)	482.44***
Business Capability with IT-Dependent Information Agility	554.63 (14)	117.88 (13)	436.75***
Business Capability with IT-Dependent Strategic Agility	407.71 (14)	35.90 (13)	371.81***
Infrastructure Capabilities with IT-Dependent System Agility	772.06 (54)	154.63 (53)	617.43***
Infrastructure Capabilities with IT-Dependent Information Agility	821.13 (54)	233.21 (53)	587.92***
Infrastructure Capabilities with IT-Dependent Strategic Agility	677.06 (54)	166.30 (53)	510.76***
IT-Dependent System Agility with IT-Dependent Information Agility	442.55 (20)	112.14 (19)	330.41***
IT-Dependent System Agility with IT-Dependent Strategic Agility	429.55 (20)	67.82 (19)	361.73***
IT-Dependent Information Agility with IT-Dependent Strategic Agility	452.49 (20)	160.89 (19)	291.60***

*** $p<0.001$

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