Determinants of Organizational IT Infrastructure Capabilities: An Empirical Study

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Keywords: IT infrastructure, effectiveness of IS function, business environment, information intensity, IT-business alignment, perceived role of IT, business synergy

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Abstract

Investment in information technology (IT) infrastructure has in recent years become a strategic organizational choice. Yet, there exists little understanding of the organizational factors that determine IT infrastructure capabilities and investment requirements. Using a filed survey of both business and IT executives, this study tests a research model that links a set of organizational factors to IT infrastructure capabilities. Organizational factors explored in this study include both external environment variables (competitiveness, dynamism and heterogeneity) and internal environment variables (organizational size, information intensity, the perceived role of IT, IT-business alignment, and business synergy). The results suggest that, among all the organizational factors, IT-business alignment, the perceived role of IT, and business synergy were the most significant predictors of an organization's IT infrastructure capabilities. The characteristics of an organization's external environment, however, were not directly related to an organization's IT infrastructure capabilities. Implications of the results are discussed.

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Introduction

Information technology (IT) infrastructure investment and management have become strategically important to contemporary organizations (Leclaire, Cooper and Gorrio, 2000; Weill and Broadbent, 2000). Facing the constant changing business and technology environments (Massey, Wheeler and Keen, 2000), companies strive to take advantage of the IT capabilities that enable them to provide single-contact customer services and cross-selling opportunities. Implementing such integration-based strategies demand significant IT infrastructure capabilities that are not only capable of connecting diversified technologies and media but also flexible to respond to the changes in both business and technology environments.

IT infrastructure is a major business resource and a potential source for attaining sustainable competitive advantage (Keen, 1991; McKenney, 1995). IT infrastructure investments represent more than half of total IT budgets and they have increased at about 11 percent annually (Weill and Broadbent, 1998). Because IT infrastructure involves large investments and evolves overtime on an cumulative installation basis, it is difficult to change in a short period time. Given the dependency of business on IT infrastructure and the difficulty to change an installed IT infrastructure base, IT infrastructure decision made today has a profound impact on the organization's future competitiveness.

Sound IT infrastructure decisions cannot be made without a clear understanding of the organizational context in which the infrastructure is developed and used. We have observed in our close interactions with IT executives that IT infrastructure investment remains mostly as an IT operational decision. IT infrastructure does not receive adequate attention and recognition at the time of decision-making and in the planning and implementation of business strategic and structural changes. New business initiatives and IT application projects are often planned and implemented without a careful assessment of the need for infrastructure changes, and as a result, failed to achieve desired outcomes due to lack of adequate IT infrastructure support.

IT researchers have recognized the importance of understanding organizational context of IT investment and use. In a recent literature review, Barua and Mukhopadhyay (2000) conclude that one potential limitation of most of the preceding studies is that they considered IT in the abstract in terms of investment without understanding the organizational context. They contend that researchers should move their focus away from isolated investments in IT applications to the interrelated nature of IT, business, and organizational factors, including business strategies, processes and incentives.

The IT infrastructure research is in its early theory development stage (Broadbent and Weill, 1997; Weill and Broadbent, 2000). Although a few studies have examined the characteristics of IT infrastructure (Broadbent, Weill, O'Brien and Neo, 1996; Broadbent et al., 1999; Duncan, 1995; Byrd and Turner, 2000), there is little understanding of the relationships between IT infrastructure capabilities and organizational context.

The purpose of this study is to empirically examine the extent to which a set of organizational factors relate to IT infrastructure capabilities. The paper is organized as follows. In the next section, the concept of IT infrastructure is defined and the IT infrastructure literature is reviewed. The third section develops the research model and hypotheses. The following research methods section describes the study sample, the definitions, development and validation of the measurement. The testing results of the research model and hypotheses are then discussed. The paper concludes with a discussion of the implications and limitations of the study.

Background

The Concept of IT Infrastructure

There is a general agreement among researchers on the definition of IT infrastructure. McKay and Brockway (1989) define IT infrastructure as the enabling foundation of shared information technology capabilities upon which business depends. They view IT infrastructure as the shared portion of the IT architecture. Earl (1989) defines IT infrastructure as the technological foundation of computer, communications, data and basic systems. He views IT infrastructure as the technology framework that guides the organization in satisfying business and management needs. Duncan (1995) refers to IT infrastructure as the set of IT resources that make feasible both innovations and the continuous improvement of IT systems. Broadbent et al. (1996) describe IT infrastructure as the base foundation of budgeted-for IT capability (both technical and human), shared throughout the firm in the form of reliable services, and usually managed by the IS group.

Thus, IT infrastructure is generally considered to be the foundation of shared IT capabilities that enable the development of IT applications and the support of business processes. In this study, *IT infrastructure is defined as a set of IT resources and organizational capabilities that are shared across the organization and that provide the foundation on which IT applications are developed and business processes are supported.*

Components of IT Infrastructure

McKay and Brockway (1989) were among the first to define IT infrastructure components using a three-layer model. Their model was later adapted and further elaborated by Weill (1993). Figure 1 illustrates these basic elements of IT infrastructure. IT infrastructure is shown as the foundation that supports specific IT applications that in turn enable the functioning of business processes.

At the base of the infrastructure are the shared technological components that constitute the basic technological building blocks of infrastructure, including the hardware, operating software, communications, and other equipment and support required to enable business applications (Earl, 1989; Turnbull, 1991).

The middle layer of IT infrastructure consists of the human and organizational capabilities that are needed to effectively utilize, leverage and bind all the IT components into robust and functional IT services. McKay and Brockway (1989) refer to those human and organizational capabilities as "mortar." Duncan (1995) refers to them as infrastructure planning and management factors. This layer represents capabilities that combine and deploy the technological components into a shared set of capabilities or services that are fundamental to the operation of the business. The elements of this layer allow other "direct purpose" uses of technology to be feasible, and allow the successful implementation of the IT architecture.
IT human resources represent not only the technical skills but also the managerial and organizational skills of IT professionals to innovate and support critical business processes. IT planning and management practices produce the architectures, plans, standards, policies and rules that govern the development of the technological components of IT infrastructure across the organization.

The IT components are combined into shared IT services that support IT applications and business process capabilities. These shared IT services link IT components to business capabilities to create a broader base of IT functionality and value. Broadbent et al. (1996) and Weill and Broadbent (1998) define this set of shared IT services as the range of IT infrastructure.

Empirical Literature of IT Infrastructure

In the empirical literature, Peter Weill and his colleagues have done extensive field studies on the characteristics of IT infrastructure (Broadbent et al., 1996; Broadbent et al., 1999; Weill, 1993; Weill and Broadbent, 1998; 2000). They have examined two characteristics of IT infrastructure: reach and range. Reach refers to the extent to which the various IT components and business functions are connected through IT infrastructure (Keen, 1991). Range refers to the extent to which key IT services are provided by the corporate IS function as part of infrastructure services (Broadbent et al., 1996; Weill and Broadbent, 1998).

Byrd and Turner (2000) developed an instrument for measuring IT infrastructure flexibility, including both technical and human components. The technical infrastructure flexibility is measured using four factors: IT connectivity, applications functionality, IT compatibility, and data transparency. The human infrastructure flexibility consists of four factors: technology management, business knowledge, management knowledge, and technical knowledge.

The empirical literature on IT infrastructure is characterized by a lack of understanding of how organizational context influences or is influenced by IT infrastructure. Only two studies reported some explorations of the relationship between IT infrastructure and organizational environments. Using case studies, Broadbent et al. (1996) show that more extensive of IT infrastructure reach and range were found in firms with (1) rapid product change, (2) demands for synergies across business units, (3) needs for integration of information and IT in the planning process, and (4) practices of tracking the implementation of long term strategy. Duncan (1995) reported another study on the relationships among IT infrastructure, perceived roles of IT investment, outsourcing, and responsiveness of IT function. She reported that certain dimensions of IT infrastructure such as modularity, compatibility, and connectivity were determined by (1) management attitudes toward the value of IT resources and (2) the support of organizational structures.

Based on the existing IT infrastructure, and organization and strategy literatures, this study intends to fill the research gap by testing a research model that relates a set of organizational factors, both internal and external to the organization, to IT infrastructure capabilities. The following section describes the development of the research model and a set of hypotheses.

Research Model and Hypotheses

The research model and hypotheses tested in this study are illustrated in Figure 2. Both external (environmental competitiveness, heterogeneity and dynamism) and internal organizational environments (organizational size, information intensity, the perceived role of IT, IT-business alignment, and business synergy) are included in the research model.

External Environment and IT Infrastructure Capabilities

There is a rich body of literature in the areas of organization and strategy that deal with the various aspects of an organization's external environment. Of particular interest to this study is the effect of an organization's environmental uncertainty on the characteristics of the organization's IT infrastructure. Three variables that are commonly used to describe environmental uncertainty are adopted: environmental competitiveness, environmental heterogeneity and environmental dynamism (Dess and Beard, 1984; Miller and Friesen, 1983).

Environmental Competitiveness

Environmental competitiveness refers to the severity of competition in an organization's marketplace (Miller and Friesen, 1983; Sharfman and Dean, 1991). It represents the hostility or threats faced by the organization in gaining access to the markets of scarce resources or customers. Environmental competitiveness may be manifested in such forms as tough competition among competitors based on prices, product/service quality, and product/service innovations (Porter and Millar, 1985).

Increased competitive pressure in the marketplace has been a major force propelling companies to use IT strategically (Ives and Learmonth, 1984; Johnston and Carrico, 1988). At the same time, strategic IT has become a dominant factor that influences the competitive dynamics of market place (Copeland and McKenney, 1988). In many industries, particularly those with high information intensity such as banking and insurance services, IT use has become a strategic necessity and basis for implementing competitive strategies (Clemons and Row, 1991; Das and Elengo, 1995). Sabherwal (1989) reported that firms in environments with high levels of competitiveness are more likely to utilize information resources for strategic purposes compared to other firms. As environmental competitiveness increases, there is a greater need for the organization to maintain a capable and flexible IT infrastructure so that it may be able to change strategies and products and to respond quickly to competitors' innovations (Broadbent and Weill, 1993). Therefore, greater environmental competitiveness would require more extensive IT infrastructure capabilities.

Hypothesis 1: *The capabilities of an organization's IT infrastructure are positively related to the level of competitiveness of the organization's environment.*

Environmental Heterogeneity

Environmental heterogeneity refers to the diversity or complexity of the industry in terms of factors such as customer demand and buying habits, and number and variety of product lines (Dess and Beard, 1984; Miller and Friesen, 1983). Environmental heterogeneity creates the need for organizations to compete less on cost effectiveness due to many dissimilar products/services, but more on innovation and differentiation of products and services (Porter, 1985). In other words, organizations must rely on economies of scope instead of economies of scale for competitiveness in such an environment. As environmental heterogeneity increases, the number and complexity of factors that need to be considered in strategic decisions and planning increases. As a result, there is a greater need for organizational flexibility to coordinate the diversified business units and product lines.

IT is inherently an integrating technology that allows better integration and coordination of different organizational subunits and products (Malone et al., 1987). Coordinating and integrating diversified business units and product lines require a common IT platform and architecture (Weill and Broadbent, 2000). IT infrastructure provides a common basis for the development of various IT applications and the operation of diversified business systems. Therefore, as environmental heterogeneity increases, there is a greater need for organizations to maintain a strong and flexible IT infrastructure that allows information sharing across diversified product lines, services, locations, and business units (Keen, 1991). In order words, greater environmental heterogeneity would require more extensive IT infrastructure capabilities.

Hypothesis 2: *The capabilities of an organization's IT infrastructure are positively related to the level of heterogeneity of the organization's environment.*

Environmental Dynamism

Environmental dynamism refers to the rate of product/service changes in the industry as well as the unpredictability of the actions of suppliers, customers and competitors (Dess and Beard, 1984; Miller and Friesen, 1983). As product life cycle becomes increasingly shorter, there is a greater need for organizations to rely on technologies such as just-in-time (JIT) and EDI to maintain a high level of flexibility to initiate new product development and to respond to competitors' innovations quickly (Bradley, Hausman and Nolan, 1993; Stalk and Hout, 1990).

The fast changing pace of the marketplace demands organizations to innovate and change IT applications and the business processes quickly (Johnston and Carrico, 1988). However, IT applications and business processes can not be changed quickly unless the IT infrastructure upon which the IT applications are built and the business systems are operated is flexible. For example, Otis Elevator's flexible IT infrastructure enabled the company to launch their Otisline system four years faster than its competitors and helped the company gain substantial competitive advantage. On the other hand, K-Mart's existing IT infrastructure inhibited it from imitating and catching up with Wal-Mart's IT-based strategies. Greater IT infrastructure capabilities are required when firms need to respond more rapidly to changes in the marketplace (Weill, 1992). Broadbent et al. (1996) found that firms in industries where products changed quickly had more extensive IT infrastructure capabilities. Therefore, greater environmental dynamism would require more extensive IT infrastructure capabilities.

Hypothesis 3: *The capabilities of an organization's IT infrastructure are positively related to the level of dynamism of the organization's environment.*

Internal Environment and IT Infrastructure

Each organization's IT infrastructure is developed over time in an internal environment that is unique and idiosyncratic to the organization. A firm's strategic use of IT may be influenced by many organizational factors. For the purpose of this study, five factors that have been studied or suggested in the literature to be most relevant to IT infrastructure are considered. These factors are organizational size, information intensity, the role of IT, IT-business alignment, and business synergy.

Organizational Size

IS researchers have treated size as an important organizational factor that influences IT investment and practices (e.g., Dos Santos and Pfeffer, 1993; Harris and Katz, 1991b). The importance of organizational size is based on the argument that larger organizations have greater needs for IT because of requirements for economies of scale and have more resources for developing and implementing IT than smaller organizations (Markus and Soh, 1993). A key role of IT infrastructure is to support the commonality among different applications and to facilitate information sharing across the organization to obtain economies of scale (Broadbent et al., 1996). Larger organizations, which have more opportunities and demand for cross-functional integration, relationship-based services and cross-selling, are more likely to take advantage of the economies of scale inherent in IT infrastructure (Weill, 1993). Smaller organizations may be unable to match the benefits without incurring higher costs. Therefore, larger organizations would need and maintain greater IT infrastructure capabilities than smaller organizations.

Hypothesis 4: *The capabilities of an organization's IT infrastructure are positively related to the size of the organization.*

Information Intensity

An organization's information intensity is defined and captured by the information intensity of its products' value-chain and the information content contained within those products (Porter, 1985; Porter and Millar, 1985). A product's information content refers to the amount of useful information contained within that product that is actually received and understood by its users. The information intensity of a product's value chain can be understood as the amount of information processing that is required to acquire, process and then deliver the product in its final form to the users. Although various products may vary in information content, the increasing utilization of IT to manufacture and deliver products results in a corresponding increase in the information intensity of the value chain.

The demand for information processing and IT infrastructure capabilities vary among organizations due to their different levels of information intensity of the value-chain (Linder and Ives, 1988). Firms with high information intensity will have greater need for and opportunities to exploit IT (e.g., launch new IT related products, form strategic alliances through interorganizational systems) compared to other firms. Porter and Millar (1985) argue that the greater the information intensity, the greater the likelihood that the organization will depend on IT for its operations. Sabherwal (1989) and Busch, Jarvenpaa, Tractingsky and Glick (1991) reported that higher levels of information intensity were associated with more strategic and progressive use of IT. Accordingly, firms with high information intensity are more likely to have greater needs for IT integration and greater sophistication in IT use than other firms, thus a greater need for IT infrastructure capabilities. In other words, greater information intensity would require greater IT infrastructure capabilities.

Hypothesis 5: *The capabilities of an organization's IT infrastructure are positively related to the level of the organization's information intensity.*

Perceived Role of IT

Top management's perceptions of IT importance and role have been found to be significantly associated with the progressive use of IT in organizations (Busch et al., 1991; Jarvenpaa and Ives, 1991; King et al., 1989; Neo, 1989). The perceived role of IS reflects the extent of the organization's dependence on information systems (infusion) and the extent of information systems use within the organization (diffusion) (Sullivan, 1985). It also reflects both the vision of the leadership to see the strategic opportunities for IT investment and the commitment and support to overcome barriers to effective IT implementation (Johnston and Carrico, 1988; Kwon and Zmud, 1987; Premkumar and King; 1992).

Top management's perceptions of the role of IT influence the importance and resources allocated to IT infrastructure and the extent of IT infrastructure capabilities present in the firm (Broadbent and Weill, 1993). Organizations differ in their emphasis on the role of IT and in their level of sophistication of IT use, thus requiring different IT infrastructures (McFarlan et al., 1983; Venkatraman, 1991; Weill, 1993). Organizations that use IT for strategic purposes would need greater IT infrastructure capabilities. Such organizations allocate more resources to IT infrastructure in order to enhance their ability to support strategic initiatives and to improve organizational performance (Duncan, 1995b). It follows that the more the role of IT is viewed as strategic, the more likely firms will need and implement greater IT infrastructure capabilities.

Hypothesis 6: *The capabilities of an organization's IT infrastructure are positively related to the strategic role of IT in the organization.*

IT-Business Alignment

The alignment between IT and business refers to the fit IS strategies and plans have with business strategies and goals (King, 1978, 1988; King and Teo, 1997). Alignment implies not only communicating the goals and objectives of the firm at a single point in time, but also an active interaction between business and IS planning on a continuing basis so that changes in one of them are reflected in the other (Lederer and Mendelow, 1986; Teo and King, 1995). By identifying critical applications for development and ensuring that adequate resources are allocated to IT infrastructure and critical applications, the alignment between IT and business helps to ensure that the IS function supports organizational goals and activities at every level. The importance of aligning IT and business to achieve IS and organizational effectiveness has been demonstrated in a number of empirical studies. For instance, Das, Zahra and Warkentin (1991) cited an A.T. Kearney study which found that organizations with integrated business and IT plans generally outperformed those with no or separated IT and business plans. Chan and Huff (1993) and Chan, Huff, Barclay and Copeland (1997) reported that IS strategic alignment was consistently related to various dimensions of IS effectiveness and business performance. Teo and King (1996) found that the greater the alignment between IT and business planning, the fewer IS planning problems and the greater IS contributions to organizational performance.

The alignment between IT and business is a critical factor that determines the role and capabilities of IT infrastructure (Henderson and Venkatraman, 1993). Based on the extent of IT-business alignment, Venkatraman (1991) proposes that firms may use IT infrastructure in one of three ways: independent, reactive or interdependent. Weill (1993) suggests three similar ways that firms employ IT infrastructure: utility, dependent or enabling. In an independent or utility perspective, IT infrastructure is viewed as a utility service and an administrative expense. Because IT infrastructure is developed outside the strategic context, management's goal is to minimize the expenses associated with the IT infrastructure for a desired level of utility service. Planning for IT infrastructure is unrelated to business planning. A reactive or dependent view of

IT infrastructure implies that the infrastructure investments are primarily in response to specific business strategies or are derived from business plans. Thus, planning for IT infrastructure is undertaken after current business strategies have been articulated. An interdependent or enabling view implies that IT infrastructure investments relate primarily to long-term requirements for flexibility in order to achieve the organization's business strategic intent. IT infrastructure is viewed as a strategic source for competitive advantage and IT infrastructure expenditures are viewed as business investments. An interdependent or enabling IT infrastructure is often created by expanding a reactive or dependent IT infrastructure beyond the current requirements of the business, and thus provides future options for implementing business strategies.

The different views imply different levels of up-front infrastructure investments, with different approaches to cost justification and different expected benefit profiles. In organizations where IT infrastructure is viewed as interdependent, greater infrastructure emphasis and investments should lead to greater capabilities and organizational returns. Broadbent et al. (1996) found that organizations with greater integration of information and IT needs as part of the organization's overall planning processes have a greater extent of IT infrastructure capabilities.

Key to our understanding of IT infrastructure characteristics is the issue of responsiveness. Infrastructure is flexible when the IS function is able to respond rapidly and effectively to emergent IT and business needs or opportunities (Duncan, 1995a). A fit between IT and business strategies is critical to effectively leverage IS opportunities and to build flexible IT infrastructure (Broadbent et al., 1996). With such an alignment, managers can identify business and IT maxims that help them determine the IT infrastructure capabilities necessary to achieve their business goals (Broadbent and Weill, 1997). Therefore, the greater the alignment between IT and business strategy, the more likely the capabilities profile of the IT infrastructure will meet the organization's long term needs.

***Hypothesis** 7: The capabilities of an organization's IT infrastructure are positively related to the extent of IT-business alignment.*

Business Synergy

Increasing market competition and customer demands are forcing organizations to synergize products and services provided by various business units and to integrate vertically with both their suppliers and customers. These relationship-based services and cross selling demand information sharing and common transaction processing across business units.

IT infrastructure is intertwined with organizational structure and strategy. A high level of business synergy with a large extent of information sharing and cross-selling activities will likely require a greater level of IT infrastructure capabilities. These business needs demand an IT infrastructure that ensures platform compatibility, data transparency, and network connectivity among the various business units (Duncan, 1995b). This proposition was supported by Broadbent et al. (1996) who found that firms emphasizing the cooperation between business units to achieve strategic intent had more extensive IT infrastructure capabilities in terms of both the number of services provided and the reach and range of shared IT services. They concluded that the identification and achievement of business unit synergies seemed to be a primary driver for the development of IT infrastructure capability. With higher demand for synergy, greater IT infrastructure capabilities are needed to seamlessly integrate dispersed business units, to enable the units to consolidate and share information, to communicate business problems, and to make coordinated business decisions. Therefore, greater need for business synergy would require greater IT infrastructure capabilities.

Hypothesis 8: *The capabilities of an organization's IT infrastructure are positively related to the need for synergy among the organization's business units.*

IT Infrastructure Capabilities and the Effectiveness of the IS Function

IT infrastructure capabilities are a major factor that determines the effectiveness and the appropriate role of the IS function within the organization. Since organizations that use IT for strategic purposes allocate more resources to IT infrastructure and expect greater gains from IT capabilities to improve the performance of the organization, their expectations for the effectiveness of the IS function might be higher compared to organizations spending less on IT infrastructure.

IT infrastructure influences the effectiveness of the overall IS function by defining the "freedom of IT." Since the capability to develop new or change old IT applications is based on the existing hardware and software platforms, network configurations, distributed databases and system architecture, the extent of IT infrastructure capabilities either facilitate or inhibit both innovation and continuous improvement of IT applications and systems (Duncan, 1995b). Thus the unique characteristics of an organization's IT infrastructure make the cost and efficiency of developing and implementing IT applications different for different organizations.

In organizations with an inflexible or obsolete IT infrastructure, it may be necessary to upgrade or redesign their IT infrastructure before any IT innovations become feasible, resulting in significantly higher costs and a longer development cycle. Therefore, it may be expected that the greater the IT infrastructure capabilities, the more effective and efficient the overall IS function is in meeting the organization's needs for the development and implementation of IT applications.

Hypothesis 10: *The capabilities of an organization's IT infrastructure positively affect the effectiveness of the IS function.*

Research Methods

The data used test the research model and hypotheses were collected using a survey method. A sample of 980 firms in a variety of industries was randomly selected from two sources: (1) the *Corporate Yellow book* and (2) an on-line commercial database provided by Hoovers, Inc. (http://www.hoovers.com). The CEO of each selected organization was sent a package containing a cover letter to the CEO and two unsealed envelopes. One envelope was addressed to a senior IS executive and the other was addressed to a senior business planning executive. Each envelope contained a cover letter, the appropriate questionnaire and a postage-paid business return envelope. The cover letter to the CEO explained the purpose and importance of the study, and requested the CEO to forward the enclosed envelopes to the appropriate executives.

Figure 3 depicts the correspondence between the variable measures and the responding executives. The business executive responded to questions measuring the organizational factors and the effectiveness of the IS function, whereas the IS executive responded to questions measuring the IT infrastructure capabilities. The use of multiple respondents to capture independent and dependent variables separately would enhance the quality of the research by minimizing the effects of common source biases.

The total response rates for the business and IS questionnaires were 28.66% and 29.81%, respectively. These response rates are considered to be reasonably good given that the respondents were senior executives. Of all usable responses, 236 pairs were matched, representing a "matched pair" response rate of 24.69%.

A careful screening of the returned surveys revealed that all the responses were complete and useful. No unusual patterns or careless responses were identified, indicating that the questionnaire's design was appropriate and the respondents were serious and careful in completing the questionnaires. In addition, appropriate comparisons were made with externally generated data on industry, sales, and employees to test for non-response bias. Comparisons of early respondents to late respondents were also conducted. No response biases were detected.

All of the 274 responses from the business executives were used to assess the validity and reliability of the measures contained in the business executive questionnaire. Similarly, all of the 285 responses from the IS executives were used for the validation of the measures contained in the IS executive questionnaire. However, only the 236 matched pairs of responses were used for testing the research model and the hypotheses.

Sample Characteristics

The characteristics of the firms in the sample were show in Table 1. In general, the respondents were business executives at high levels of their organizations. Specifically, 41.6% of the respondents were at least at the level of senior or executive vice president, 74.9% at least at the level of vice president and 88.3% at least at the level of director. The high level and the business orientation of the respondents indicate that the respondents were likely to be knowledgeable about their firm's overall business operations and were able to evaluate the effectiveness of IT from a business executive perspective.

Similarly, the IS executive respondents were the highest ranked IS executive in their firms. 38.9% of the respondents were CIOs, 26.2% were vice presidents of IS/IT, and 28.5% were managers of IS/IT. Overall, 93.6% of the respondents were at least at the level of director of IS/IT. The high level of the IS executives suggest that the respondents were likely to be knowledgeable about their firm's overall IS operations and were able to provide a comprehensive assessment of their IT infrastructure.

The summary suggests that the sample provides an appropriate representation of a wide range of industries. The results are therefore unlikely to biased by the industry representation of the sample. The average size of the firms included in the study was $3,742 million. These average and their distributions suggest that the firms are medium to large in size.

Definitions, Development and Validation of Measures

To ensure the validity and reliability of the measurement, all constructs in the research model were measured using multiple items. In addition, whenever possible, measures that were tested and used in previous research were adopted or adapted for this study. For those variables for which no validated measures exist, new measures were created based on the literature and/or derived from field interviews with IS and business managers. The scores of the items for a construct were combined to created an overall scale for that construct. Before testing the research model and hypotheses, the validity and reliability of the measures for the various constructs were assessed. Such an assessment is necessary to warrant further data analysis and to ensure that the results of the model and hypotheses testing are meaningful.

Validity is the degree to which an instrument measures the construct it is intended to measure (Kerlinger, 1973). Reliability refers to the stability of the instruments and the consistency of the measures (Kerlinger, 1973; Nunnally, 1978). In this study, construct validity was tested to establish the validity of the measurement. The main concern of this study was the internal consistency of the instruments. Therefore, Cronbach's Alpha statistic was used as indicators of reliability for the measures.

In this study, the initial items for measuring the various constructs were derived from an extensive literature review and some field interviews with both IS and business managers. These initial items were refined through a series of pre-testing procedures using eight doctoral students, 35 part-time MBA students, four graduate school faculty members, and four business and IS managers. Results of the Q-sort procedure and feedback from the evaluations of the expert panels were used to finalize the measures and the questionnaire format.

Construct validity refers to the extent to which a measurement instrument actually appraises the theoretical constructs it purports to assess (Carmines and Zeller, 1979). Two related concepts, convergent validity and discriminant validity, are commonly used to establish the construct validity. Convergent validity refers to the extent to which multiple methods or scales measuring the same concept are in agreement (Nunnally, 1978). A measure that correlates highly with other measures designed to measure the same construct provides evidence for convergent validity. Discriminant validity refers to the extent to which a measure is different from measures not measuring the same construct.

The procedures used for validating the instruments include: (1) All items measuring each construct were subjected to a factor analysis. Principal component analysis with oblique rotation was used to obtain an easily interpretable factor solution. Common factors were extracted based on eigenvalues greater than one. Items with loadings of less than 0.4 on the relevant factor or with loadings greater than 0.5 on more than one factor were dropped from subsequent analyses. (2) The corrected item-total correlation of each item with the overall scale was calculated and used as a criterion for convergent validity. (3) Cronbach's Alpha was used as an indicator of reliability for each construct. An item was dropped if deleting the item significantly increased the reliability of the scale. Various criteria and cut-off scores of Cronbach's Alpha have been suggested as acceptable levels of reliability. For example, Nunnally (1978) suggests an alpha value of 0.7 or greater as an indicator of acceptable reliability. On the other hand, the choice of the cut-off score depends on the type of research and the kinds of decisions being made on the basis of the research results (Pedhazur and Schmelkin, 1991). It has been suggested that for exploratory research, an alpha value of 0.6 or higher be accepted as reasonable (Nunnallly, 1978). In some cases, an alpha value of 0.5 or higher was considered sufficient (e.g., Magal, Carr and Watson, 1988; Srinivasan, 1985). (4) To ensure that the results of path analyses were not affected by multicollinearity problems, the measures for the independent variables were subjected to discriminant validity test using factor analysis.

Environmental Competitiveness

Environmental competitiveness refers to the threats and pressure the markets impose on an organization. Adapted from Miller and Friesen (1982), Miller and Droge (1986), Miller (1988), and Sabherwal (1989), four items were used to measure environmental competitiveness. These terms capture the levels of competition in the marketplace based on price, product quality and product innovations.

A factor analysis of the four items revealed that one item (item 4) did not load on to the same factor. This item had a low corrected item-total correlation, indicating that the item shared little commonality with the other three items. In addition, the results of the reliability analysis suggested that deleting item 4 would significantly increase the Cronbach's Alpha of the overall scale. Therefore, item 4 was dropped from subsequent data analyses. As shown in Table 2, the remaining three items loaded on to a single factor, indicating that the measures formed an uni-dimensional construct. This single factor explained 54.7% of the variances of the items. However, the reliability of the scale was low (Cronbach's Alpha = .58).

Environmental Heterogeneity

Environmental heterogeneity is defined as the complexity that encompasses variations among the firm's markets that require diversity in production and marketing orientation. Adapted from Miller and Friesen (1982), Miller and Droge (1986), and Miller (1988), two items were used to capture heterogeneity. One item measured the level of diversity in customer demands and buying habits, and the other assessed the degree of diversity in product lines.

As shown in Table 3, the items are loaded on to a single factor. The correlation between the two items was significant at $P<.0001$, confirming the unidimensionality of the construct. Similar to the scale measuring environmental competitiveness, a noticeable weakness of this scale was the low reliability (Cronbach's Alpha=.57).

Environmental Dynamism

Environmental dynamism refers to the rate of change in an organization's markets. Adapted from Kimberly and Evanisko (1981), Miller and Friesen (1982), Miller and Droge (1986), and Miller (1988), three items were used to measure dynamism. These items assessed the rate of product obsolescence, the rate of change in production technology and processes, and the rate of organizational business strategy change in response to market changes.

As illustrated in Table 4, these three items loaded on to a single factor, explaining 57.5% of the variances. All three items demonstrated high corrected item-total correlations. The results indicate that the environmental dynamism was a uni-dimensional construct.

Organizational Size

Organizational size was measured by the annual sales of the organization.

Information Intensity

Information intensity is defined as the extent to which an organization's products/services and production processes involve intense information processing (Johnston and Vitale, 1988;

Malone et al., 1987; Porter and Millar, 1985). Information intensity may be measured based on the extent to which the production process involves information processing, and the frequency that the information used in the production process is updated (Busch et al., 1991; Porter and Miller, 1985). Based on this literature, three items were used to measure information intensity of the value chain.

As presented in Table 5, these three items loaded on to a single factor, explaining 69% of the variances. In addition, all items had high corrected item-total correlations. The results indicate that the variable information intensity is a uni-dimensional construct.

The Role of IT

The role of IT is defined in terms of types of IT investment and roles of IT as perceived by top management. Adapted from Johnston and Carrico (1988),Venkatraman (1991), Weill (1993), Chan et al. (1997) and Broadbent and Weill (1997), four items with were used to measure the role of IT. These measures capture the importance of IT in the organization's administrative operations and core business transaction processes, in achieving the organization's strategic goals, and whether IT spending is viewed as a cost center that needs to be minimized.

A factor analysis of the four items suggested that one item (item 4) did not load on to the same factor as the other items. A further analysis of the corrected item-total correlations revealed that this item had a low correlation with the overall score (<.2). A reliability analysis of the measures suggested that deleting item 4 would significantly improve the reliability of the overall scale. Item 4 was therefore dropped from subsequent data analyses. As shown in Table 6, the remaining three items loaded on to a single factor explaining 64.1% of the variances. In addtion, all items had high corrected item-total correlations, further indicating the unidimensionality of the construct and the convergent validity of the measures.

IT-Business Alignment

IT-business alignment is defined as the extent to which IT strategies and planning processes are linked to business goals and planning processes. Synnott (1987) conceptualized the extent of alignment between IT and business into five categories: no planning, stand-alone planning, reactive planning, linked planning, and integrated planning. Jang (1989) proposed four forms of alignment: pre-planning, separate planning, linked planning, and integrated planning. Teo and King (1996) presented four types of alignment: separate planning with administrative integration, one-way linked planning with sequential integration, two-way linked planning with reciprocal integration, and integrated planning with full integration. Chan (1992) measured IT-business alignment by mapping the realized IT and business strategies along Venkatraman's (1989) strategic orientation measures. Seven items were adapted from the literature to measure IT-business alignment.

As shown in Table 7, the seven items used to measure IT-business alignment loaded on to a single factor, explaining 61.1% of the variances. All items correlated highly with the corrected total score. The results indicate that IT-business alignment is an uni-dimensional construct.

Business Synergy

Business Synergy is defined as the degree of interdependence among the various business units and functions. Broadbent and Weill (1997) suggested that business synergy may be measured by the extent of product similarity among business units and the extent of expertise that can be leveraged across the firm. Increased similarity and interdependence among the various product lines across business units demand more extensive coordination and information sharing. To achieve economies of scale, it may be necessary to provide all the information needed to service customers from one service point. Another indictor of business synergy may be the extent of cooperation and coordination among business units and functions that are required for developing new products (Ein-Dor and Segev, 1982). Based on this literature, seven items were used to measure business synergy.

A factor analysis of the seven items revealed that two items (items 6 and 7) loaded on to a second factor. Both items had low corrected item-total correlations (.16 and .18). The Cronbach's Alpha of the overall scale would be significantly enhanced if items 6 and 7 were deleted. Therefore, these items were dropped from subsequent data analyses. Table 8 presents the results of the factor analysis, corrected item-total correlations, and the overall Cronbach's Alpha of the remaining five items. The results show that all five items loaded on to the same factor, indicating that the items measuring business synergy can be considered to be uni-dimensional. In addition, all items correlated highly with the corrected total score, or the criterion, further confirming the convergent validity of the measures.

IT Infrastructure Capabilities

There were no validated instruments for measuring the IT infrastructure capabilities. Duncan (1995b) and Broadbent et al. (1996) provide useful references for developing the measures. Five constructs were defined and operationalized for measuring the characteristics of IT infrastructure: reach of IT infrastructure, range of shared IT infrastructure services, IS standards and procedures, flexibility of IT infrastructure, and IS management competence.

Reach of IT Infrastructure. Reach of IT infrastructure refers to the extent to which the various IT components or business functions are connected through IT infrastructure (Keen, 1991). Duncan (1995b) operationalized reach in terms of connectivity and sharability of IT infrastructure components (e.g., computer platforms, networks, data, and applications). In addition, Broadbent and Weill (1997) suggested that connectivity with customers and suppliers may also need to be considered in measuring the reach of IT infrastructure. Based on the literature, three items were used to assess the connectivity and sharability of IT infrastructure components. Two items were used to measure the percentage of all transactions with customers and suppliers that are electronically transmitted. These items were measured using an 11-point interval scales ranging from 0–100 percentage. To help the respondents anchor their responses, both numbers and dashes between numbers were used, each dash represented approximately 10 percentage.

As shown in Table 9, two factors were extracted from the five items. The first factor may be interpreted as network connectivity whereas the second factor may be labeled as electronic connections with customers and suppliers. This factor structure was expected since network connectivity emphasizes technological reach while electronic connections with the suppliers and customers emphasize business reach. The two factors were significantly correlated ($r=.65$, $P<.0001$). The overall scale had a Cronbach's Alpha of .65. Thus all items were used to create an overall score of the reach of IT infrastructure.

Flexibility of IT Infrastructure. The flexibility of IT infrastructure was assessed in terms of compatibility, adaptability and expandability of the technological components of IT infrastructure. Fifteen items were used to measure the flexibility of platforms, networks, data and applications. The results of the analyses are shown in Table 10. As expected, these items measure three factors. These factors may be labeled as network flexibility, application/data flexibility, and platform flexibility. Although three factors emerged from the factor analysis, they were correlated significantly with each other. All items correlated highly with the corrected total score. The results suggest that the items share sufficient commonality. In addition, the overall scale had a high reliability (Cronbach's Alpha=.91). Therefore, all items were used to compute an overall score of IT infrastructure flexibility.

Range of shared IT Infrastructure Services. Range of shared IT infrastructure services refers to the extent of organization-wide IT services provided by the corporate IS function. A list of 21 IT infrastructure services was adapted from Broadbent et al. (1996). A three-point Likert-type scale was used for capturing whether each of the 21 IT activities is primarily the responsibility of the corporate IS function (centralized), the user units (decentralized), or external vendors (outsourced). The responses were based on whether each of the 21 activities was the primary responsibility of the centralized IS function, the user units, or was outsourced to external vendors. A cumulative count of the number of IT infrastructure services provided by the central organization is as the indicator of the range of shared IT infrastructure services.

IS Standards and Procedures. Adapted from Duncan (1995b), seven items were used to measure IS standards and procedures. Seven items were used to measure IS standards and procedures. As shown in Table 11, the 7 items loaded on to a single factor, explaining 62.4% of the variances. All items had high corrected item-total correlations. The results indicate that the items measuring IS standards and procedures form an uni-dimensional construct.

IS Management Competence. IS management competence was measured in terms of the IS staff's technical skills, managerial skills, and the flexibility of the IS function in response to changing user needs. Seven items were used to measure IS management competence. As shown in Table 12, the 7 items loaded on to a single factor, explaining 63.2% of the variances. All items had high corrected item-total correlations. The results indicate that the items measuring IS management competence constitute an uni-dimensional construct.

Effectiveness of the IS Function

Effectiveness of the IS Function is defined and measured in terms of the quality of services and application projects provided by the IS function. Adapted from Srinivasan (1985), Pitt, Watson and Kavan (1985), Scudder and Kucic (1991), and Van Dyke, Kappelman and Prybutok (1997), four items were used to capture the effectiveness of the IS function. These items assess the extent to which (1) the IT applications developed by the IS function meet users' needs, (2) the IS function delivers IT applications on time, (3) the IS function delivers IT applications within budget, and (4) the IS function provides reliable systems operations.

The results in Table 13 suggest that the four items loaded on to a single factor, explaining 63.8% of the variances. All items correlated highly with the corrected total score. Therefore, the effectiveness of the IS function can be considered as uni-dimensional.

Discriminant Validity of the Measures for Organizational Factors

To ensure that multicollinearity does not constitute a significant problem for path analyses, all items measuring the independent variables were subjected to a factor analysis. The results of the factor analysis are presented in Table 14. As expected, seven factors emerged from the analysis, which corresponded to the seven organizational variables. With the exception of two items (ITALIGN7 and ENVCOMPET2) that loaded on to an additional factor, all items measuring each construct loaded cleanly to the corresponding factor. The results indicate that the measures for the contingency variables provide sufficient discriminant validity, which in turn suggests that multicollinearity among the independent variables is not likely to be a significant problem for performing path analyses.

Results

The research model and hypotheses were tested using path analyses. To ensure that the assumptions of path analyses were met and that the models being tested were not misspecified, scatter plots of the residuals were examined. The results of the residual scatter plots indicated that the patterns of the residuals were random and contained few outliers, thus path analyses were deemed to be appropriate.

The analyses involved two steps. In the first step, the direct effects or the path coefficients of the exogenous variables on the endogenous variables were estimated using hierarchical regression analyses. In the second step, the indirect and total effects of an exogenous variable on an endogenous variable were computed based on the direct effects estimated in the first step.

Two nested regression models were formulated to estimate the direct effects or path coefficients of the exogenous variables on the endogenous variables in the research model. In the first model, capabilities of IT infrastructure (ITCAPAB) was included in the regression as the dependent variable and the eight organizational contingency variables as independent variables:

Model 1: ITCAPAB=$\beta_0 + \beta_1$ ENVCOMPET + β_2 ENVHETER + β_3 ENVDYNAM
+ β_4 SIZE + β_5 INFINT + β_6 SYNERGY + β_7 ITROLE + β_8 ITALIGN

The standardized coefficients (βs) were used as estimates of the direct effects or path coefficients of the organizational contingency variables on ITCAPAB. T-tests of the standardized coefficients (βs) were used to evaluate the significance of the direct effects or path coefficients. The adjusted R^2 was used as an indicator of the statistical power of the regression model. Since Hypotheses 1 to 8 propose direct and positive effects of the organizational variables on ITCAPAB, the results of Model 1 were used to test these hypotheses.

In the second model, the effectiveness of the IS function (ISEFF) was included in the regression as the dependent variable, ITCAPAB and the eight organizational contingency variables were included in the model as independent variables. Thus, Model 2 was a nested model of Model 1:

Model 2: ISEFF=$\beta_0 + \beta_1$ ENVCOMPET + β_2 ENVHETER + β_3 ENVDYNAM
+ β_4 SIZE + β_5 INFINT + β_6 SYNERGY + β_7 ITROLE + β_8 ITALIGN + β_9 ITCAPAB

Similar to Model 1, the standardized coefficients (βs) and their corresponding t-values were used to determine the estimates and strengths of the direct effects or path coefficients of the organizational contingency variables and ITCAPAB on ISEFF. The results of Model 2 were used to test Hypothesis 9 that proposes a direct and positive effect of ITCAPAB on ISEFF.

The testing results of Model 1 and 2 are presented in Table 15 and Figure 4.

External Environment Variables and ITCAPAB

Hypotheses 1 to 3 propose that the capabilities of an organization's IT infrastructure are positively affected by the competitiveness, heterogeneity and dynamism of the organization's external environment. None of the standardized coefficients (βs) of the three external environment variables was significant, indicating that these variables were not significant predictors of IT infrastructure capabilities. Therefore, Hypotheses 1 to 3 are not supported.

Internal Environment Variables and ITCAPAB

Hypotheses 4 to 8 predict that the capabilities of an organization's IT infrastructure are positively affected by the organization's size, information intensity of the value chain, business synergy, the role of IT, and IT-business alignment. The standardized coefficient (β) of organizational size was not significant. Hence, Hypotheses 4 is not supported. Information intensity had a significant but negative effect on IT infrastructure capabilities. Therefore, Hypothesis 5 is not supported. Three internal environment variables, business synergy, the role of IT, and IT-business alignment, had positive and significant standardized coefficients (βs), indicating that they were significant predictors of IT infrastructure capabilities. Therefore, there is sufficient evidence to support Hypotheses 6, 7 and 8. The overall results suggest that IT infrastructure capabilities are influenced more by the organization's internal environment than by its external environment.

The values of the standardized coefficients (βs) indicate that IT-business alignment is the strongest predictor of IT infrastructure capabilities. This result is consistent with Broadbent et al. (1996) who found that extensive IT infrastructure capabilities were strongly associated with high levels of integration of information and IT in the organization's overall planning processes. The integration between IT and business goals and planning has long been recognized as a key factor determining the strategic use and success of IT (King, 1978, 1988; Henderson and Venkatraman, 1994). The findings of this study provide more specific empirical evidence for the importance of IT-business alignment in determining IT infrastructure capabilities.

Business synergy was found to be a moderate predictor of IT infrastructure capabilities. This result conforms with Broadbent et al. (1996) who found that firms with greater emphasis on identifying synergies between business units had more extensive IT infrastructure capabilities. The need for integration and cooperation between business units presents the opportunity and potential for strategic use of IT (Chan et al., 1997). The above results provide further evidence that a necessary condition for extensive IT infrastructure capabilities is the organizational need for business synergy.

The results indicate that the role of IT was also a moderate predictor of IT infrastructure capabilities. This finding provides empirical support for Duncan's (1995b) proposition that the role of IT is a key factor that determines IT governance structure and infrastructure flexibility. IT infrastructure involves substantial long-term investments. In addition, the implementation of new IT infrastructure often accompanies changes in business processes and structure. Therefore, the role of IT as perceived by top management is particularly important in securing organization-wide support.

The results suggest that information intensity had a significant but negative effect on IT infrastructure capabilities. This finding is not consistent with the general beliefs that high information intensity would be associated with greater IT infrastructure capabilities. A plausible explanation is that, IT infrastructure differs from IT applications. Higher information intensity may cause more frequent changes in IT infrastructure and thus lead to a less stable infrastructure. Further investigation is needed to clarify this result.

Although organizational size has been suggested to be an important factor determining organizations' use and success of IT (Ein-Dor and Segev, 1978; Lind et al., 1989), it was not found to be a significant predictor of IT infrastructure capabilities. This finding is consistent with the findings of Harris and Katz (1991b) in a study of IT investment intensity in life insurance firms. A plausible explanation for this result is that, as the costs of IT increasingly decrease and the infusion and diffusion of IT in organizations dramatically increase, how IT is managed may be a more important predictor of IT infrastructure capabilities than firm size.

ISEFF as the Dependent Variable

In Model 2, shown in the second set of columns in Table 15, organizational variables (both the external and internal environments) plus ITCAPAB were treated as independent variables and the effectiveness of the IS function (ISEFF) was treated as the dependent variable. The direct, indirect and total effects of the independent variables on ISEFF are reported in the table.

Hypothesis 10 proposes that IT infrastructure capabilities have a direct and positive effect on ISEFF. The results of Model 2 suggest that IT infrastructure capabilities had a significant direct effect ($\beta = .32$, $p < .0001$) on ISEFF. The overall regression model explained about 16.5% of the variance in ISEFF. The direction of this relationship was positive as hypothesized. Therefore, there is sufficient evidence to support Hypothesis 10. Although the importance of IT infrastructure in supporting the operation of the IS function and the development of IT applications has been widely recognized (Broadbent et al., 1996; Duncan, 1995b; Keen, 1991; McKay and Brocway, 1989; Weill, 1993), no empirical results had been produced to support this notion. The result of this study provides important empirical evidence that IT infrastructure is a critical factor that influences the effectiveness of the IS function.

In addition, the results suggest that information intensity of the value chain had a significant but negative effect on ISEFF ($\beta = -.16, p<.05$). A plausible explanation for this result may be that although a greater level of information intensity is positively associated with greater needs for information processing (Porter and Millar, 1985), it does not necessarily relate to the effectiveness of the IS function. In fact, in firms with greater information processing needs, the IS function is more likely to experience frequent requests and backlogs for systems changes and maintenance. At the same time, greater information processing needs may also lead the users to increase their expectations with regard to the efficiency and quality of the services and projects provided by the IS function. As a result, a greater level of information intensity may affect negatively the effectiveness of the IS function.

The results also indicate that, IT-business alignment and business synergy had significant and positive effects on ISEFF. The result reinforce the widely recognized importance of IT-business alignment in achieving effective IS functional performance. It also confirm that higher business synergy needs provide a necessary context for utilizing IT capabilities.

Explorations of the Determinants of the IT Infrastructure Dimensions

Five dimensions were used to define and measure IT infrastructure capabilities (ITCAPAB): reach of IT infrastructure (ITREACH), IS standards and procedures (ITSTAND), range of shared IT infrastructure services (ITRANGE), flexibility of IT infrastructure technological components (ITFLEX), and IS management competence (ITMGT). To gain further insights about the patterns and differences in terms of the determinants of the five dimensions of ITCAPAB, five regression models were formulated and analyzed. In each regression model, one of the five ITCAPAB dimensions was treated as the dependent variable while all the organizational variables (both the external and internal environments) were included in the model as independent variables.

In order to compare the results and detect specific patterns of relationships across the five ITCAPAB dimensions, the results of the five regression analyses are summarized and presented in Table 16. Each column reports the estimates of the standardized beta coefficients (βs) and the percentage of variances in the dependent variable that was explained by the regression model.

Consistent with the results presented in Table 15, none of the external environment variables had a significant effect on any ITCAPAB dimension. The robustness of this finding, regardless of whether ITCAPAB is measured at the aggregate or component level, provides further evidence that environmental uncertainty, measured in this study by environmental competitiveness, heterogeneity and dynamism, did not directly influence ITCAPAB.

The standardized coefficients (βs) of organizational size were not significant in any of the five regression models. These results provide further confirmation for the findings reported in Table 15 that organizational size is not a strong predictor of ITCAPAB.

As shown in Table 15, four variables, information intensity, business synergy, the role of IT and IT-business alignment, were found to be significant predictors of ITCAPAB. However, as can been seen from Table 16, these variables demonstrated quite different effects on the different dimensions of ITCAPAB. Each regression equation is discussed below.

ITREACH as the Dependent Variable

ITREACH was directly influenced by business synergy, the role of IT, and IT-business alignment. This result is expected since ITREACH was defined and measured in terms of the extent to which all business units are networked, the extent to which various computer platforms are connected, and the extent to which transactions with customers and suppliers are electronically transmitted. In organizations with greater needs for business synergy, a stronger emphasis on the strategic role of IT, and a higher level of IT-business alignment, it is more likely that the organization will require and implement greater connectivity across business units and computer platforms, and more extensive electronic transactions with customers and suppliers (Duncan, 1995b; Keen, 1991).

ITSTAND as the Dependent Variable

ITALIGN was the only significant positive predictor of ITSTAND, with a path coefficient of .38 at $p<.001$. ITSTAND consists of rules, standards and procedures that constitute the technological blueprint and architecture for the firm. It also represents a high-level map of the information requirements of the organization (Niederman et al., 1991) and a detailed plan that combines business directions, technology, processes and human resources into a cohesive whole (Duncan, 1995b). Accordingly, ITSTAND provides a common language and tool for governing IT practices and for communicating between IS and the users. Therefore, as the need for IT-business alignment increases, there will be a greater need for ITSTAND to guide and ensure the process through which IT and business are integrated (Earl, 1989).

ITRANGE as the Dependent Variable

The range of the shared IT infrastructure services refers to the extent to which shared IT services are provided by the centralized IS function (Keen, 1991). ITRANGE was measured in this study by whether each of the 21 common IT infrastructure services was provided by the centralized IS function, was decentralized and provided by the user units, or was outsourced to an outside vendor. As shown in Table 16, business synergy had a significant and positive direct effect ($\beta = .28, p<.05$), whereas information intensity of the value chain had a significant but negative direct effect ($\beta = -.16, p<.05$).

The positive effect of business synergy on ITRANGE suggests that as the organization's needs for business synergy increases, it is likely that a greater extent of shared IT infrastructure services will be provided by the centralized IS function. This result is consistent with the general expectation in the research literature that in organizations where various users units are in greater controls of their IT resources, there would be a greater need for centralization of IT infrastructure services in order to ensure synergy among the diversified business units (Zmud et al., 1986).

Information intensity of the value chain had a significant but negative effect on ITRANGE. This result is contradictory to the general belief that a greater level of information intensity requires more extensive IT infrastructure services be provided by the centralized IT function (Broadbent et al., 1996). A plausible explanation may be that a greater level of information intensity results in more diversified and sophisticated IT use, which may demand the IS function to focus on the most important and common aspects of IT infrastructure services while decentralizing or outsourcing those less important or less common services.

ITFLEX as the Dependent Variable

The role of IT and IT-business alignment were significant and positive predictors of ITFLEX. IT infrastructure flexibility may reduce the time to market for new products (Weill, 1992). ITFLEX determines the ability of the IS function to respond quickly and cost-effectively to systems demands, which evolve with changes in business practices and business strategies

(Clemons and Row, 1991). Therefore, organizations with a more strategic role of IT and greater IT-business alignment are more likely to implement an IT infrastructure with greater flexibility so that the IT infrastructure does not need to be changed when changes in business strategies or processes occur.

Duncan (1995b) contends that the more the business executives view IT as a strategic weapon for the business, the greater flexibility the IS function would have. The above finding supports her argument. It also empirically validates the proposition by Broadbent et al. (1996). They proposed that firms with a greater emphasis on the strategic role of IT and on IT-business alignment would have different patterns of IT infrastructure capabilities from those with less emphasis on the strategic role of IT and on IT-business alignment.

ITMGT as the Dependent Variable

Three variables, information intensity of the value chain, the role of IT, and IT-business alignment, were significant and positive predictors of ITMGT. IT-business alignment (ITALIGN) was the most significant predictor of ITMGT, with a standardized coefficient of .55 ($p<.001$). This result is consistent with the general expectation of the IS literature that IT professionals' knowledge and understanding of the organization's business plan and activities, as well as their good relationships with the users are critical for the alignment between IT and business and for supporting the organization's needs (Chan et al., 1997; Henderson and Venkatraman, 1994). This IT management competence is also fundamental for dealing with the dynamics and sophistication of IT use caused by the high levels of information intensity and business integration. It seems plausible that the competence and performance of the IS function may influence the perceptions of the top management with regard to the strategic role of IT.

Discussion

The results suggest that IT infrastructure capabilities are influenced more by the organization's internal environment than by its external environment. A possible explanation is that IT infrastructure may be more directly driven by the organization's business needs and IT practices than by its external environment. The external environment may affect IT infrastructure characteristics only indirectly through its impact on the organization's strategic orientation and business process changes. From a contingency theory perspective, the results suggest that the micro-congruence between IT and the organization's internal environment may be more important in predicting IT infrastructure characteristics than the macro-congruence between IT and the organization's external environment. This finding is consistent with the results of previous IS studies examining the effects of contingency variables on an organization's strategic use of IT. For example, Teo (1994) found that environmental characteristics, measured by dynamism, heterogeneity and hostility did not have any significant effects on the extent of integration between IT and business; whereas all the organizational internal environmental variables had significant impacts. Busch et al. (1991) reported similar results, suggesting that organizational internal characteristics play a greater role in predicting the organization's strategic use of IT than the characteristics of its external environment.

In addition, IT-business alignment and the role of IT were found to be significant and positive predictors of IT infrastructure capabilities. This result is consistent with the findings of previous research on the relationship between IT-business alignment and the strategic use of IT (Chan et al., 1997; Johnston and Carrico, 1988; Teo and King, 1996). Since these internal factors are more controllable by the organization than the external environment, these results suggest that managers may be able to change their IT infrastructure patterns and capabilities by effectively planning and controlling IT-business alignment and by educating the top management about the role of IT.

The finding that IT-business alignment is a significant and positive predictor of IT infrastructure capabilities has important practical implications. IT infrastructure influences significantly the effectiveness of the IS function and the effectiveness of the business processes. Managers must recognize that misalignment between IT and business plans may result in IT effects on the value chain that are inconsistent with the organization's strategy, which in turn may lead to decreased organizational performance. This important role of IT infrastructure in supporting business processes makes IT-alignment not only an IS issue but also an organization-wide issue that directly affects business processes and organizational performance.

Limitations

Limitations of this study should be taken into consideration when interpreting the results. First, the measures used to capture the characteristics of the organization's external environment were weak. Several other studies using similar measures for environmental uncertainty have also reported low reliability (e.g., Teo, 1994), indicating that alternative measures may be needed to improve the quality of these measures. These measurement weaknesses might have confounded the results of no significant effects of external environment on IT infrastructure capabilities. Future research using more valid and reliable measures for these constructs is needed to verify that the non-significant effects of external environment on IT infrastructure capabilities were indeed true and were not caused by weak measurement. Second, firms in the sample used in the study were mostly large in size. Therefore, the results of the study should be generalized only to that population. Additional research is needed to test the generalizability of this study's results to small to medium size organizations.

Future Research Directions

There are a number of directions and avenues that future research may take to extend this study, in addition to overcoming the limitations of the study as discussed in the preceding section. This study produced several interesting results that were not consistent with general expectations expressed in the existing literature. These contradictions call for further studies to provide alternative explanations and new insights. It was found that the characteristics of the external environment had no significant effects on the characteristics of IT infrastructure. However, Johnston and Carrico (1988) reported that industry environmental factors influence the direction and pace of strategic deployment of IT. Broadbent et al. (1996) proposed and reported in a case study that the condition of the firm's industry affects the patterns of the firm's IT infrastructure capabilities. In addition to the measurement problems mentioned above, further research is needed to investigate alternative explanations for this observation.

Information intensity of the value chain was found to have a significant but negative effect on the IT infrastructure capabilities. These results are contradictory to the general belief that greater information intensity would demand greater IT infrastructure services and would present greater opportunities for the strategic use of IT (Porter and Millar, 1985; Weill, 1992). A possible future research direction is to select firms in controlled industries with distinctively different information intensities to examine whether the firms demonstrate different patterns of IT infrastructure capabilities.

Conclusion

Research on IT infrastructure capabilities and value cannot make significant progress without understanding the organizational context in which IT infrastructure is developed and used. This study is a first attempt to use a large-scale data to examine organizational determinants and impacts of IT infrastructure. The results insinuate that IT infrastructure capabilities are positively related to the perceived role of IT, the level of IT-business alignment, and business synergy, but are negatively related to the level of an organization's information intensity. The study can be used as the basis for future research in developing theories that explain the organizational determinants of IT infrastructure capabilities requirements.

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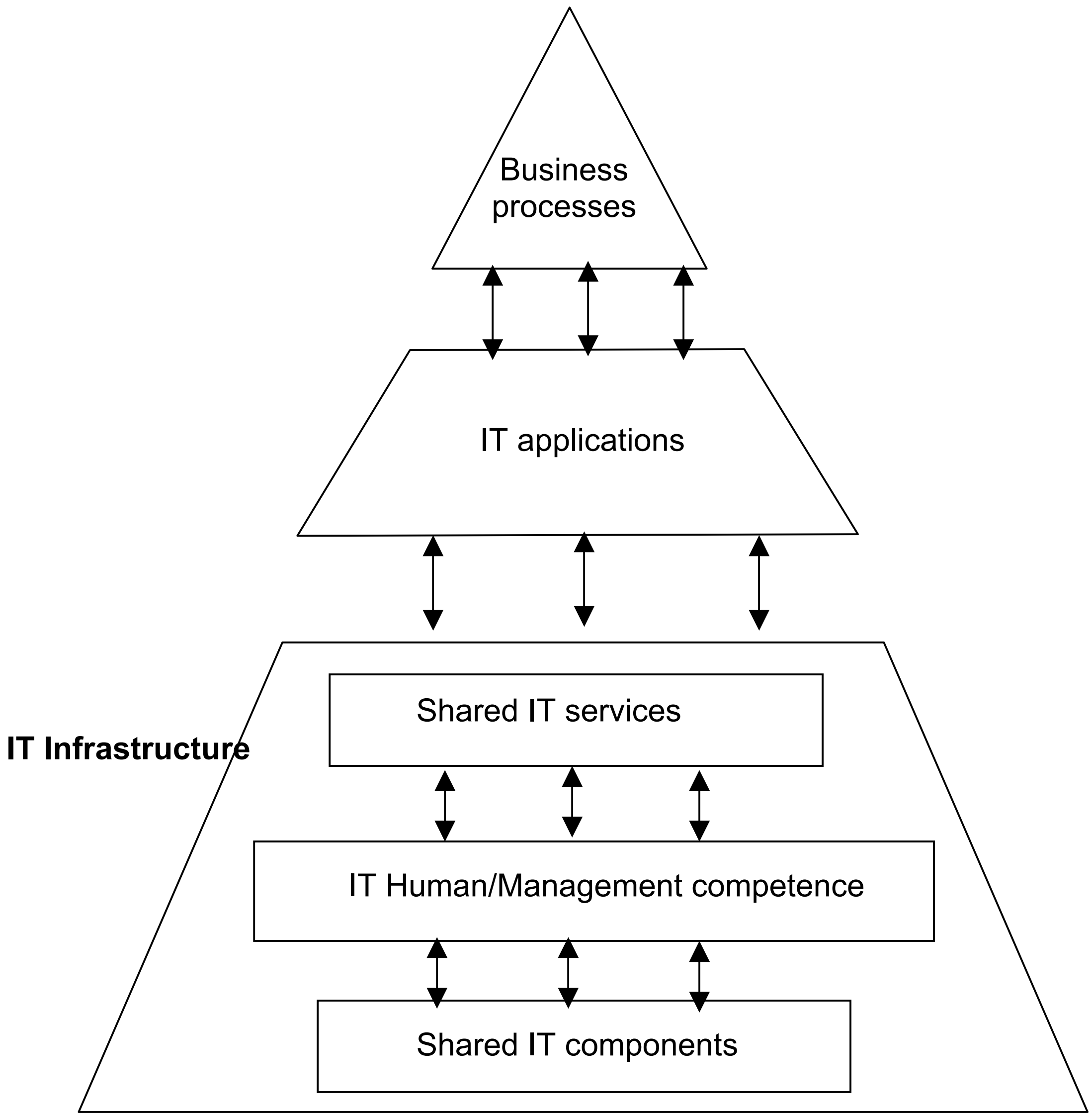

Figure 1. Key Components of IT Infrastructure
(Adapted from McKay and Broackway, 1989)

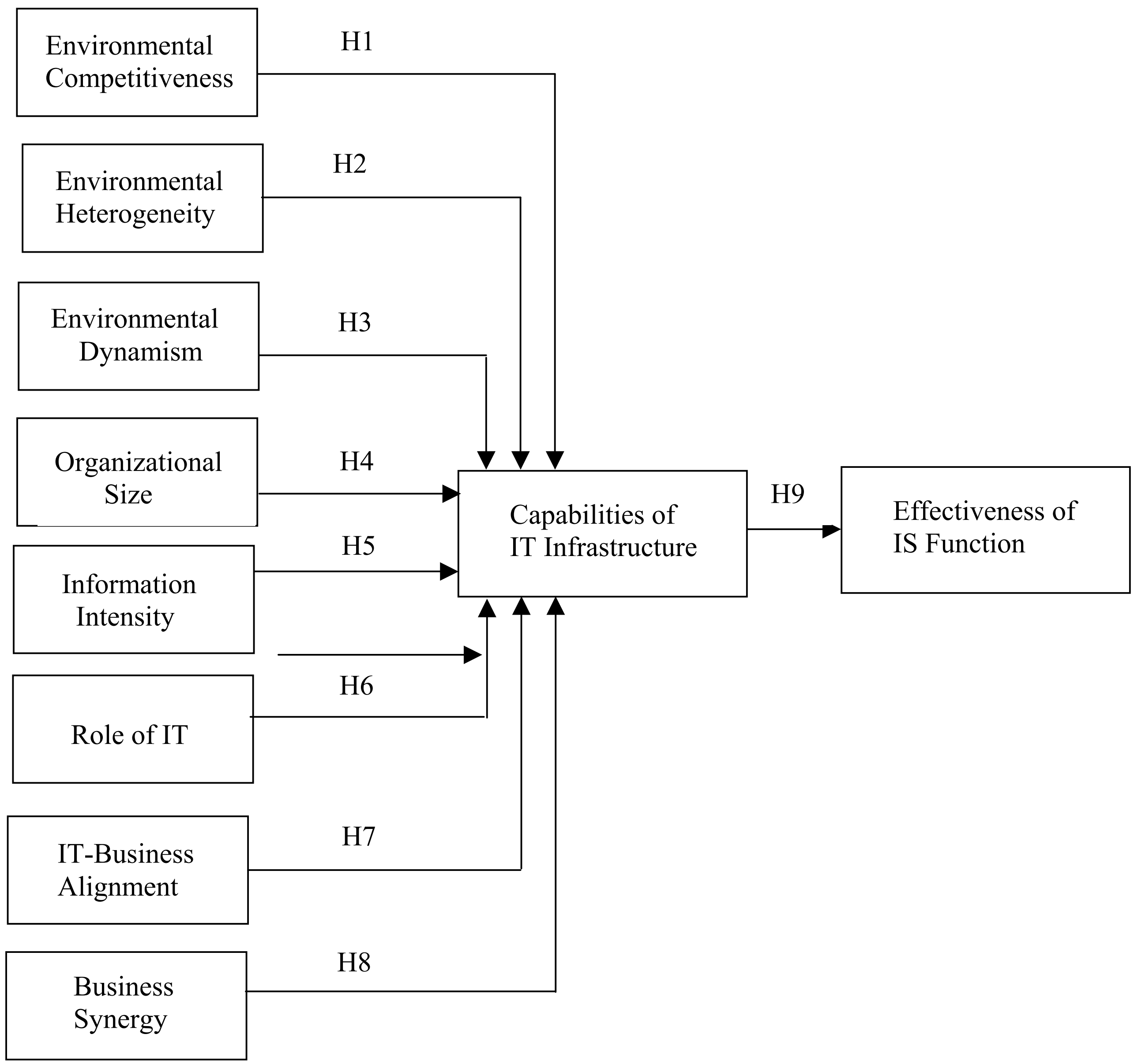

Figure 2. Research Model and Hypotheses

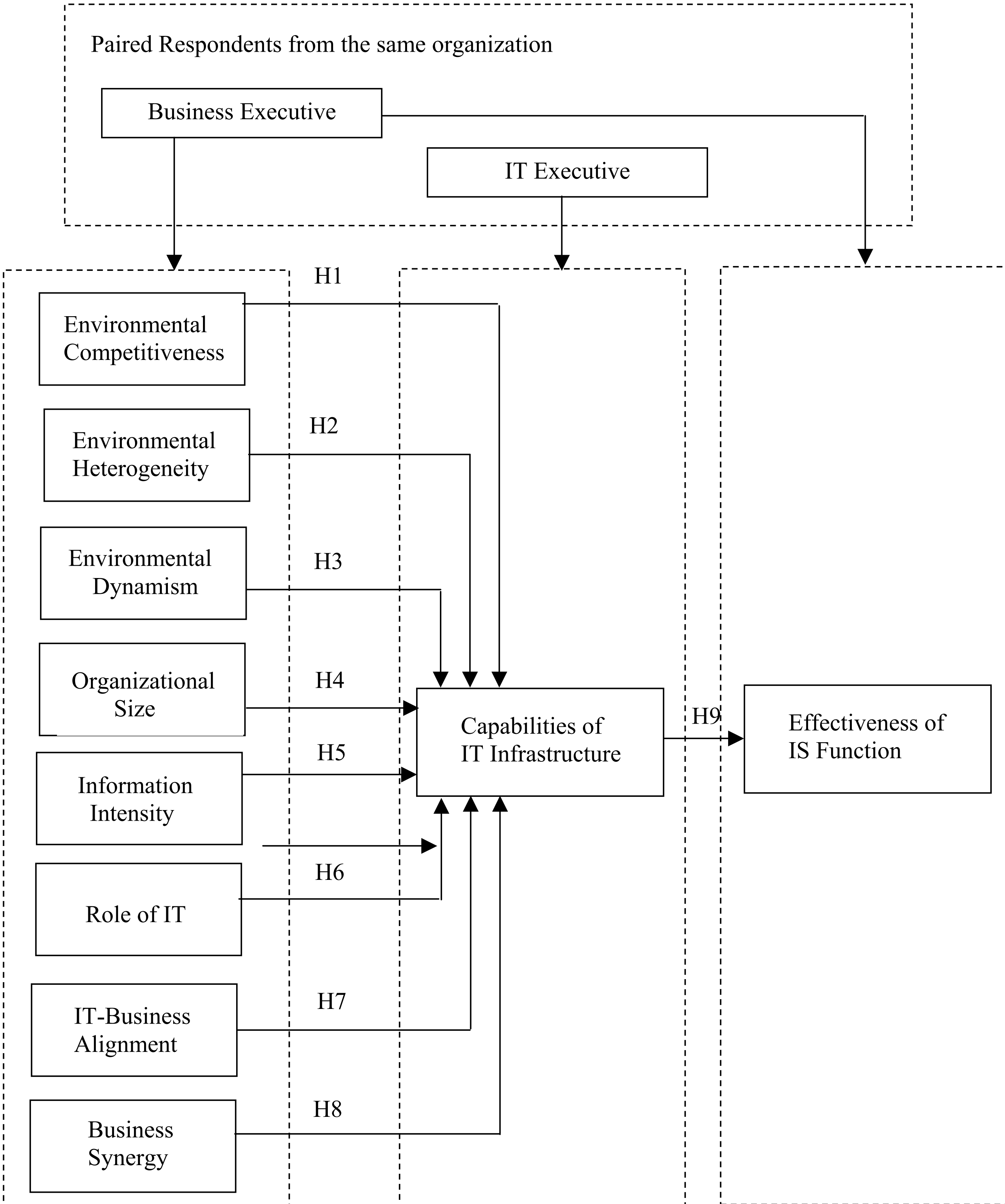

Figure 3. Measures of Variables Responded by Matched Pair Executives in Each Organization

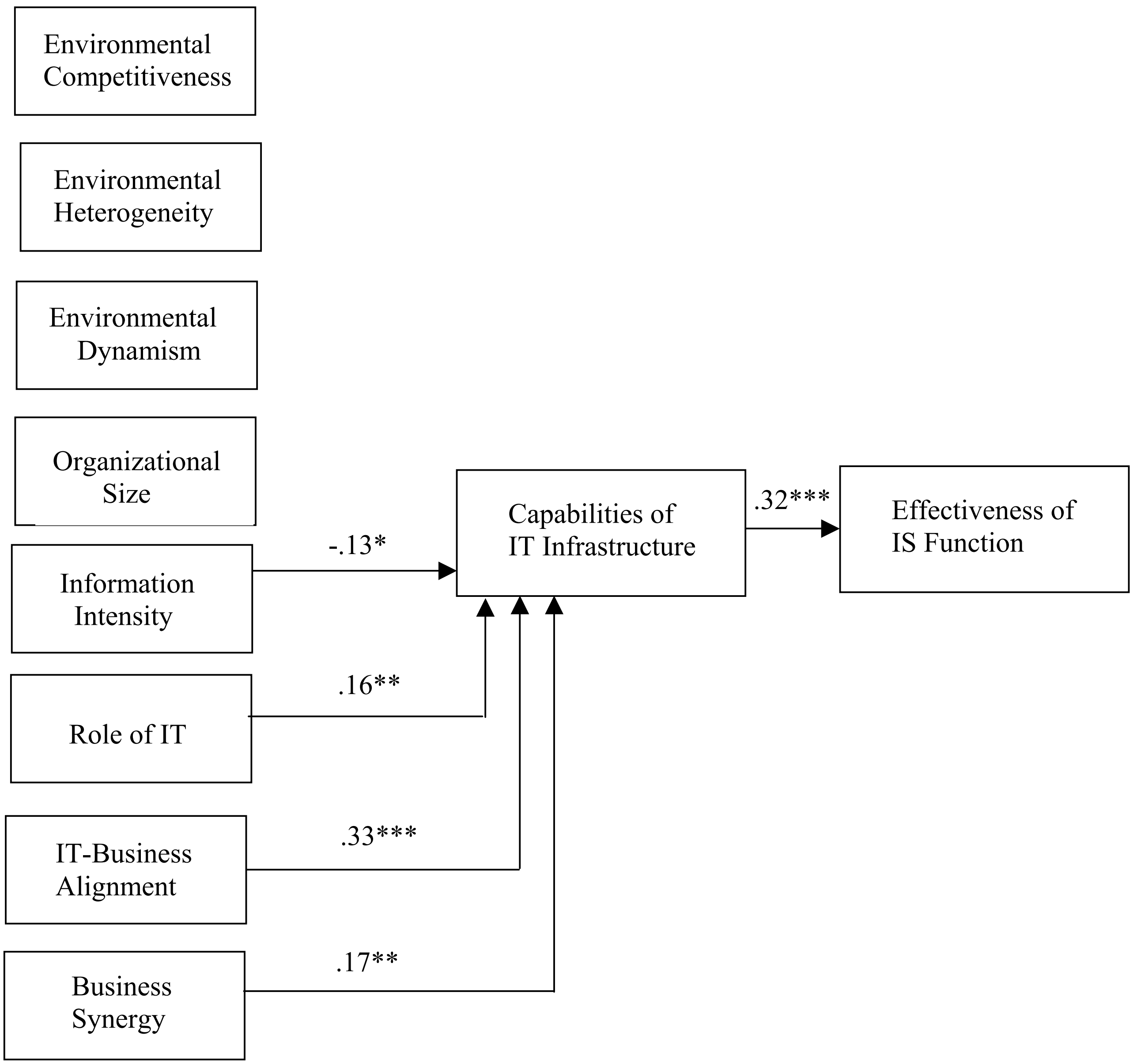

Figure 4. Results of Model Testing

Table 1. Characteristics of the Study Sample

I. Title/level of business respondents (n=274)	
President & CEO	10.9%
Senior VP & CFO	30.7%
Corporate VP	33.3%
Senior Director-corporate	13.5%
Manager	11.3%
Missing	0.3%
I. Title/level of respondents (n=285)	
Senior VP & CIO	38.9%
VP - IS/IT	26.2%
Direct/manager - IS/IT	28.5%
Other	6.4%
II. Size of company by sales (n=274)	
Less than 500	13.9%
500 – 999 million	20.1%
1000 – 1999 million	26.3%
2000 – 2999 million	7.3%
3000 – 4999 million	11.9%
5000 – 9999 million	11.7%
Over 10000 million	8.8%
III. Industry (n=274)	
Agriculture	2.2%
Banking/Finance/ Insurance	14.6%
Communications	5.1%
Computers/Software	5.5%
Manufacturing	27.4%
Medicine/Health	6.9%
Oil/Petroleum/ Utilities	7.7%
Restaurant/Hotel	4.7%
Transportation	6.9%
Wholesale/Retail/Distribution	10. 9%
Industrial Services	4.7%
Other	3.3%

Table 2. Factor Analysis – Environmental Competitiveness (ENVCOMPET)

	Factor1 Loading	Corrected Item-Total Correlation
1. There is tough competition based on product/service quality	.870	.55
2. There is tough competition based on product/service innovations	.768	.38
3. There is tough price competition in our industry	.542	.24
Eigenvalue 1.64		
Variance Explained 54.7%		
Overall Cronbach's Alpha .58		

Table 3. Factor Analysis – Environmental Heterogeneity (ENVHETER)

	Corrected Factor1 Loading	Item-Total Correlation
1. Customers are quite diverse in their demands/buying habits	.837	.40
2. In our industry, there is considerable diversity in product lines	.837	.40
Eigenvalue 1.40		
Variance Explained 70.0%		
Overall Cronbach's Alpha .57		

Table 4. Factor Analysis – Environmental Dynamism (ENVDYNAM)

	Factor1 Loading	Corrected Item-Total Correlation
1. Products/services in our industry become obsolete quickly	.787	.47
2. Product/process technologies in our industry change quickly	.786	.47
3. We must frequently change our business strategy to keep pace with the market and competitors	.698	.38
Eigenvalue 1.72		
Variance Explained 57.5%		
Overall Cronbach's Alpha .63		

Table 5. Factor Analysis – Information Intensity (INFINT)

	Factor1 Loading	Corrected Item-Total Correlation
1. Information is used to a great extent in our production/service operations	.886	.70
2. Information used in our production/service operations is frequently updated	.843	.61
3. Information is an essential part of our products/services	.758	.51
Eigenvalue	2.07	
Variance Explained	69.0%	
Overall Cronbach's Alpha	.77	

Table 6. Factor Analysis – The Role of IT (ITROLE)

	Factor1 Loading	Corrected Item-Total Correlation
1. IT is an integral part of our core business transaction processes	.825	.58
2. We can not achieve our strategic goals without IT	.813	.56
3. Operations of our administrative functions depend on IT	.764	.49
Eigenvalue	1.92	
Variance Explained	64.1%	
Overall Cronbach's Alpha	.72	

Table 7. Factor Analysis – IT-Business Alignment (ITALIGN)

	Factor1 Loading	Corrected Item-Total Correlation
1. Top management provides continuous support for the IS function	.848	.77
2. Top management is committed to IT investment	.819	.73
3. IS executives are always involved in business planning	.815	.74
4. The IS plan and business plan are well-aligned and coordinated	.792	.71
5. Business executives are actively involved in IS planning	.743	.65
6. IS planning adequately takes into account organizational goals/strategies	.734	.64
7. We believe that IT has significant strategic potential	.712	.61
Eigenvalue	4.27	
Variance Explained	61.1%	
Overall Cronbach's Alpha	.89	

Table 8. Factor Analysis – Business Synergy (SYNERGY)

	Factor1 Loading	Corrected Item-Total Correlation
1. Our business requires extensive interactions among business units/functions	.801	.62
2. Cooperation among business units/functions is required to develop new products/services	.790	.61
3. To achieve economies of scale, we need to share business processes among business units/functions	.712	.52
4. Information is constantly exchanged among business units/functions	.648	.46
5. The products/services provided by different business units are similar	.635	.45
Eigenvalue 2.60		
Variance Explained 51.9%		
Overall Cronbach's Alpha .76		

Table 9. Factor Analysis – Reach of IT Infrastructure (ITREACH) [a,b]

	Factor1 Loading	Factor2 Loading	Corrected Item-total Correlation
Approximately what percentage of			
1. all PCs in your organization are networked?	.768		.33
2. all business units/functions are connected through networks?	.798		.36
3. the computer platforms used by various units/functions are connected?	.810		.40
4. all transactions with your customers are electronically transmitted?		.879	.25
5. all transactions with your suppliers are electronically transmitted?		.867	.35
Eigenvalue	1.93	1.49	
Variance Explained	38.6%	29.8%	
Total Variance Explained 68.4%			
Overall Cronbach's Alpha .65			

Note: a. Factor loadings less than .40 are not shown.
b. Factor1 – Network connections;
Factor2 – Electronic connections to customers/suppliers.

Table 10. Factor Analysis – Flexibility of IT Infrastructure (ITFLEX) [a,b]

	Factor1 Loading	Factor2 Loading	Factor3 Loading	Corrected Item-Total Correlation
ITFLEX1	.939			.69
ITFLEX2	.896			.74
ITFLEX3	.889			.71
ITFLEX4	.870			.70
ITFLEX 5	.859			.75
ITFLEX6	.780			.65
ITFLEX 7	.523			.58
ITFLEX 8	.781			.51
ITFLEX9	.769			.58
ITFLEX10		.763		.29
ITFLEX11		.743		.61
ITFLEX12		.553		.38
ITFLEX13			.889	.60
ITFLEX 14			.818	.60
ITFLEX15			.758	.67
Eigenvalue	6.88	2.12	1.17	
Variance Explained	45.8%	14.1%	7.8%	
Total Variance Explained	68.3%			
Overall Cronbach's Alpha	.91			

Note: a. Factor loadings less than .40 are not shown.
b. Factor1 – Network flexibility; Factor2 – Application/data flexibility; Factor3 – Computer platforms flexibility.

Table 11. Factor Analysis – IS Standards and Procedures (ITSTAND)

	Factor1 Loading	Corrected Item-Total Correlation
1. data sharability across applications	.869	.80
2. compatibility of computer platforms across user units	.805	.72
3. data consistency and integrity across systems	.855	.78
4. application module reusability	.767	.65
5. user interface commonality across applications	.816	.73
6. network connectivity across user units	.727	.64
7. data security and privacy	.672	.57
Eigenvalue	4.36	
Variance Explained	62.4%	
Overall Cronbach's Alpha	.90	

Table 12. Factor Analysis – IS Management Competence (ITMGT)

	Factor1 Loading	Corrected Item-Total Correlation
1. The IS staff has good relationships with the user units	.856	.78
2. The IS function is flexible in meeting changing user needs	.827	.74
3. The IS staff is knowledgeable about our business activities	.806	.72
4. The IS function is responsive to user service requests	.790	.71
5. The services provided by the IS function are often *unreliable*	.786	.70
6. We have a high regard for the technical expertise of the IS staff	.770	.67
7. The IS function is able to identify and plan for future technology challenges	.724	.62
Eigenvalue	4.42	
Variance Explained	63.2%	
Overall Cronbach's Alpha	.90	

Table 13. Factor Analysis – Effectiveness of the IS Function (ISEFF)

	Factor1 Loading	Corrected Item-Total Correlation
1. The IS function delivers application systems on time	.886	.69
2. The IS function completes application systems within budget	.841	.63
3. The applications developed by the IS function meet users' needs	.830	.66
4. There is a low percentage of information systems downtime	.609	.41
Eigenvalue	2.55	
Variance Explained	63.8%	
Overall Cronbach's Alpha	.81	

Table 14. Factor Analysis of All Independent Variables [a]

	Factor1	Factor2	Factor3	Factor4	Factor5	Factor6	Factor7
IT-Business Alignment							
ITALIGN4	.837						
ITALIGN1	.794						
ITALIGN3	.777						
ITALIGN6	.759						
ITALIGN2	.756						
ITALIGN5	.722						
ITALIGN7	.572			.459			
Synergy							
SYNERGY2		.724					
SYNERGY1		.723					
SYNERGY5		.700					
SYNERGY3		.669					
SYNERGY4		.509					
Information Intensity							
INFINT1			.783				
INFINT2			.760				
INFINT3			.625				
Role of IT							
ITROLE2				.762			
ITROLE3				.661			
ITROLE1				.656			
Environment Dynamism							
ENVDYNAM1					.801		
ENVDYNAM2					.700		
ENVDYNAM3					.606		
Environment Heterogeneity							
ENVHETER2						.731	
ENVHETER 1						.680	
Environment Competitiveness							
ENVCOMPET3							.791
ENVCOMPET1							.707
ENVCOMPET2						.456	.502
Eigenvalue	6.59	2.72	1.99	1.51	1.43	1.28	1.17
Variance Explained	25.4%	10.4%	7.7%	5.8%	5.5%	4.9%	4.5%

Note: a – Factor loadings less than .40 are not shown.

Table 15. Effects of Predictors on Dependent Variables

	ITCAPAB	ISEFF		
Predictors	Direct Effect	Direct Effect	Indirect Effect	Total Effect
ENVCOMPET	.01	.07	.01	.08
ENVHETER	.01	.11	.01	.12
ENVDYNAM	.02	-.10	.01	-.09
INFINT	-.13*	-.12	-.04	-.16*
SYNERGY	.17**	.15*	.05	.20**
ITROLE	.16**	.05	.05	.10
ITALIGN	.33***	.12*	.11	.23**
SIZE	-.03	.07	-.01	.06
ITCAPAB		.32***		
ISEFF				
BUSPROC				

Note: * - P<.05, ** - P<.01, *** - P<.001

Table 16. Predictors of IT Infrastructure Dimensions

Predictors	ITREACH	ITSTAND	ITRANGE	ITFLEX	ITMGT
ENVCOMPET	.07	.01	.02	.03	.03
ENVHETER	-.06	-.01	-.15	-.02	-.05
ENVDYNAM	-.05	.03	.06	.03	-.08
INFINT	-.04	-.14*	-.16*	-.12	.15*
SYNERGY	.17*	.01	.28*	.01	.09
ITROLE	.15*	.06	.05	.22**	.17*
ITALIGN	.19*	.38***	.07	.23**	.55***
SIZE	.08	-.09	.03	-.04	-.02

Note: * - P<.05, ** - P<.01, *** - P<.001