Resource Co–specialization, Firm Growth, and Organizational Performance: An Empirical Analysis of Organizational Restructuring and IT Implementations

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Abstract

This paper examines the effects of co–specialized information technology (IT) on the growth and performance of IT–investing firms as a driver of competitive advantages. By adopting resource–based and dynamic–capability perspectives on firm–specific IT systems, we first identify the mechanisms of resource co–specialization strategy in the process of IT implementation as organizational restructuring and adaptive customization of IT applications into the context of adopting firms. Then, we examine impacts of the resulting co–specialized IT system on organizational performance. Testable hypotheses are developed to investigate how the co–specialization mechanisms of organizational restructuring and IT customization influence firm growth — in terms of the number of employees, value–added, and revenue. We also examine how co–specialization mechanisms of organizational restructuring and IT customization influence project outcomes — in terms of project referenceability and license extension measures. These empirical tests control for other contextual factors and the endogeneity of decision variables. Using a unique panel data on 334 firms adopting Advanced Planning and Scheduling (APS) applications, we find strong empirical support for the co–specialization hypothesis that strategic choices of using IT co–specialization mechanisms are positively associated with firm growth and with superior project outcomes in the sample firms.
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ABSTRACT

This paper examines the effects of co-specialized information technology (IT) on the growth and performance of IT-investing firms as a driver of competitive advantages. By adopting resource-based and dynamic-capability perspectives on firm-specific IT systems, we first identify the mechanisms of resource co-specialization strategy in the process of IT implementation as organizational restructuring and adaptive customization of IT applications into the context of adopting firms. Then, we examine impacts of the resulting co-specialized IT system on organizational performance.

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Keywords: resource co-specialization, organizational restructuring, adaptive customization, information technology
INTRODUCTION

Strategy research suggests that co-specialized resources and combinative capabilities of firms are drivers of sustainable competitive advantage (Kogut and Zander, 1992; Lippman and Rumelt, 2003; Teece, 1986). However, the underlying mechanisms of resource co-specialization and the outcomes of such strategic choices have not been addressed in the resource-based and dynamic-capability literature. The current paper identifies specific mechanisms of resource co-specialization strategy in the context of information technology (IT) implementation, and provides empirical evidence on the impacts of co-specialized IT systems on organizational performance in terms of firm growth and project outcome measures.

The capability to manage information about markets and production enables firms to be more attuned to changes in their business environments, which can result in a competitive advantage over less informed competitors (Lajili and Mahoney, 2006). Many firms have begun to develop information management strategies that focus on IT as a strategic resource to facilitate effective collection and utilization of information (Karimi, Somers and Bhattacherjee, 2007; Ray, Muhanna and Barney, 2005; Tippins and Sohi, 2003).

While researchers in a variety of disciplines have long been interested in identifying economic and organizational factors that facilitate IT-driven competitive advantages, recent firm-level studies find that the relationship between IT and performance is complex because of diversity of IT use among businesses and its interactions with business strategies, organizational processes, and human resource practices (Autor, Levy, and Murnane, 2002; Bartel, Ichniowski, and Shaw, 2007; Dedrick, Gurbaxani, and Kraemer, 2003). For example, a series of new empirical evidence show that there is a positive relationship between IT investment and productivity growth in the United States, but there is much variation among studies concerning the nature and magnitude of IT effects, suggesting that much of aggregate productivity growth comes about through diverse and dynamic processes (Jorgenson, Ho, and Stiroh, 2005; O’Mahony and Vecchi, 2005; Stiroh, 2002). Recent research studies suggest that since firms make heterogeneous IT investment allocations in pursuit of different strategic goals there is still
much to learn about how IT impacts organizations and how best to utilize IT resources to generate the
greatest positive effects on organizational performance (Aral and Weill, 2007; Dehning, Richardson,
and Zmud, 2007; Raganathan and Brown, 2006). From a strategic management perspective, understand-
ing what firm resources and processes will allow the firms to benefit from the adoption of IT has
become a major challenge, which managers must overcome in order to achieve superior organizational
performance (Kim and Mahoney, 2006; Tippins and Sohi, 2003).

These observations raise important research questions such as “What organizational factors
distinguish firms able to take advantage of IT investments from others unable to do so?” and “How can IT-investing
firms effectively manage the process of IT implementation to create competitive advantages?” These questions have
not been well addressed in the Information Systems literature on the business value of IT or in the
Strategic Management literature concerning IT-driven competitive advantages. A few research studies
have suggested that IT investments are most likely to provide competitive advantages when they are
accompanied with complementary investments (Barua, Kriebel, and Mukhopadhyay, 1995; Powell and
Dent-Micallef, 1997). However, these research studies have not fully developed as a theory of strategic
IT management, which addresses the increasingly important issue of how to position IT systems
strategically with complementary firm-level capabilities in order to maximize benefits from investments
in seemingly standardized IT resources.

Teece (2007) emphasizes both the importance and the difficulties of managing resource co-
specialization: “Management’s ability to identify, develop, and utilize in combination specialized and co-
specialized assets built or brought is an important dynamic capability, but it is not always present in
enterprise settings” (2007: 1338), and “excellence in these ‘orchestration’ capacities undergirds an enter-
prise’s capacity to successfully innovate and capture sufficient value to deliver superior long-term
financial performance” (2007: 1320). In a similar vein, Lippman and Rumelt maintain that “the heart
of business management and strategy concerns the creation, evaluation, manipulation, administration,
and deployment of un-priced specialized resource combinations” (2003: 1085).
By drawing on theoretical developments concerning the dynamic capabilities of resource co-specialization, the current paper provides a co-specialization approach to IT-driven competitive advantages. In addition, by using a unique panel data set in the Advanced Planning and Scheduling (APS) applications industry, it presents new empirical evidence on the relationships among IT investment, co-specialization strategy, and organizational performance in terms of firm growth and project outcomes. We consider a firm-specific IT system or IT specificity as the outcome of a resource co-specialization strategy incorporating the complex combination of managerial capabilities and IT-related competencies (Tippins and Sohi, 2003; Wade and Hulland, 2004). A resource-based and dynamic-capability approach enables exploration of how IT can be combined and utilized with complementary firm-level resources to gain competitive advantage through the process of IT implementation. Such an approach also enables examination of the role that a firm-specific, co-specialized IT system can have on the link between IT investment and organizational performance.

Most of the empirical research studies examining the performance effects of IT have used financial performance or productivity measures at an aggregate level, such as financial benefits (Scannell, Vickery and Droge, 2000), efficiency gains (Hendricks and Singhal, 2003), Tobin’s q (Aral and Weill, 2007; Bharadwaj, Bharadwaj, and Konsynski, 1999), the magnitude of IT risk and the risk-adjusted returns on IT capital investment (Dewan, Shi, and Gurbaxani, 2007), or stock price changes around the announcement of IT investments (Dehning, Richardson, and Zmud, 2003). While these research studies provide insights into the overall business value of IT investment, associated analyses are accompanied by considerable measurement noise attributed to (1) the indirect path between the IT investment and these overarching performance metrics and (2) a recognition that these broad performance measures are affected by numerous factors other than the focal IT investment (Dehning, Richardson, and Zmud, 2007; Wade and Hulland, 2004). Researchers have emphasized the need to shift the analytical focus to either project-level or plant-level and to refine the operationalization of performance variables. Since the immediate effects of IT manifest themselves in process improvements, more conclusive results are expected when IT investments are related to process outcomes (Mukhopadhyay,
Rajiv, and Srinivasan, 1997; Segars, Grover, and Teng, 1998). Research studies utilizing immediate performance measures such as process efficiency and project outcomes have reported more consistent results, although only a small number of such studies have been undertaken (Karimi, Somers, and Bhattacherjee, 2007; Ravichandran and Lertworngsatien, 2005).

The current paper addresses these issues in the research literature by examining the impacts of strategic IT decisions on project-level and firm-level outcome measures. We maintain that in order to achieve superior organizational performance from IT investments, managers need to engage actively in the process of IT implementation to develop and utilize a co-specialized IT system, which is tailored to the unique organizational environment. Testable hypotheses are developed to investigate how the use of resource co-specialization mechanisms influences organizational performance while controlling for other contextual factors and the endogeneity of decision variables. In order to test the hypotheses, we first identify mechanisms of resource co-specialization strategy in the process of IT implementation as organizational restructuring and adaptive customization of IT applications into the context of adopting firms. Then we investigate variations across IT-investing firms in making strategic decisions in the two co-specialization mechanisms that are endogenous to our research model. Finally, we examine the impacts of IT co-specialization mechanisms on \textit{firm growth} in terms of the number of employees, value-added, and revenue, and \textit{project outcomes} in terms of project reference-ability and license extension. By using project-level and externally reported outcome measures, instead of broad financial performance measures, the current paper adds an important degree of relevance and verifiability concerning new evidence on the relationship between IT and organizational performance.

Using a unique panel data on 334 firms, we find strong empirical support for the \textit{co-specialization hypothesis} that organizational restructuring prior to IT deployment and adaptive customization of IT applications are positively associated with firm growth and with superior project outcomes in the sample firms. The empirical results indicate that, when IT applications are purchased in competitive factor markets, resource co-specialization strategy and combinative capabilities of the firm are critical to IT-enabled economic value creation and efficient firm growth.
The remainder of the paper is organized as follows. The next section highlights how the resource co-specialization approach provides a unifying basis for the results of prior research studies exploring the complex links between IT resource, dynamic capabilities, and organizational performance. From the literature review, we develop hypotheses concerning the impacts of co-specialization strategy on organizational performance. In the following section, we describe the data and analyses employed to empirically investigate the hypotheses. Following the examination of econometric results, the paper concludes with implications and discussion for managerial applications and for future research.

THEORY AND LITERATURE

Resources Co-specialization and Dynamic Capabilities

Resource-based theory prescribes that firm-specific resources are the main drivers of superior performance (Barney, 1986; Peteraf, 1993; Wernerfelt, 1984). In perfectly competitive factor markets, competitors can replicate undifferentiated inputs, merely by purchasing them. Thus, the resources needed to achieve sustainable competitive advantages are likely to be heterogeneously distributed across firms, which in turn account for the persistent differences in firm performance (Peteraf, 1993). Resource-based theory posits that firm-specific resources can yield economic rents and tend to survive competitive imitation because of isolating mechanisms such as causal ambiguity, time-compression diseconomies, organizational embeddedness, and path dependencies (Amit and Schoemaker, 1993; Barney, 1991; Dierickx and Cool, 1989). The idiosyncratic nature of firm-specific resources precludes tradeability and imitability in open factor markets and results in barriers to competitive imitation (Barney, 1986; Williamson, 1985). Being non-tradeable and inimitable, such firm-specific resources need to be accumulated internally (Dierickx and Cool, 1989).

Resource-based theory maintains that a bundle of resources must be (re-)deployed to achieve and sustain competitive advantage (Lippman and Rumelt; 2003). Such strategic resource bundles are accumulated by choosing appropriate time paths of flows as a result of consistently adhering to a set
of strategic investments in complementary resources over a period of time (Dierickx and Cool, 1989).
It follows that a key dimension of strategy formulation and implementation is the task of making appropriate choices about strategic investments in complementary resources and skills to accumulate firm-specific bundle of resources.\(^1\)

Despite the importance of complementary resources for understanding strategy, the corresponding management challenges often remain a black box. While the need to actively manage the creation and deployment of complementary resources is often acknowledged, the coordination and cooperation problems that must be addressed are rarely analyzed in the research literature, which restricts the normative value of resource-based theory for management practitioners (Stieglitz and Heine, 2007). In fast-moving competitive environments, sustainable competitive advantages require not only the ownership of inimitable resources, but also the development of difficult-to-imitate dynamic capabilities (Teece, Pisano, and Shuen, 1997). These dynamic capabilities include organizational processes, specific asset positions, and path dependencies, “that which is distinctive cannot be bought and sold short of buying the firm itself, or one or more of its subunits” (Teece, Pisano, and Shuen, 1997: 518). In the dynamic-capabilities approach, strategy involves selecting and developing new technologies and new business models that build competitive advantages through assembling and orchestrating inimitable dynamic capabilities (Teece, 2007). Making such strategic choices requires special managerial skills, which are not ubiquitously or equally distributed across firms, and the task of making strategic investment decisions is quite challenging because value-creating investments require fit or strategic coherence among resources inside the firm (Porter, 1996).

Both strategy and organizational theory emphasize the importance of fit between strategy, organizational structure, and business environments. For instance, Porter emphasizes strategic fit in a

\(^1\) Early resource-based research is often associated with a Ricardian resource-based view, emphasizing heterogeneity of resources that have differential productivity (Peteraf, 1993). However, as Mahoney and Pandian (1992) note, this Ricardian perspective has been complemented by the dynamic-capabilities view, emphasizing the importance of capabilities embedded in the organization and its processes. Amit and Shoemaker (1993) also suggest that resources are assets that are either owned or controlled by a firm, while capabilities refer to the firm’s ability to utilize and combine resources through organizational routines in order to accomplish its objectives.
system of tailored activities: “Strategic fit among many activities is fundamental not only to competitive advantage but also to sustainability of that advantage. It is harder for a rival to match an array of interlocked activities than it is merely to imitate a particular sales force approach, match a process technology, or replicate a set of product features” (1996: 73). These systems consist of interdependent firm-specific components resting on strategic fit or resource co-specialization. The resource-based and dynamic-capability approach emphasizes that resource co-specialization must be achieved and maintained through continuous resource alignments within the firm over time (Teece, 2007).

While the role of resource co-specialization to achieve sustainable competitive advantage has become increasingly recognized, this concept has not been operationalized into specific mechanisms in the dynamic-capabilities framework, and has limited utility to support management’s strategic investment decisions in practice. Co-specialized resources are a particular class of complementary resources where the full economic value of an asset is a function of its use in conjunction with other particular resources. With proper resource alignment within a firm, the use of co-specialized resources is value enhancing. Resource co-specialization is a special case of economies of scope where not only are complementary resources more economically valuable in joint use than in separate use, but they may have limited economic value in separate use and generate competitive advantages only in joint use (Teece, 2007). Since co-specialized resources are not fully decomposable ex post, it also creates the problem of irreversibility and requires strategic commitment to firm-specific and usage-specific resource alignments (Ghemawat and del Sol, 1998). Thus, co-specialization strategy of firm resources results in small-numbers bargaining (Teece, 2007), in which the co-specialized resources in question are idiosyncratic and cannot be readily bought and sold in factor markets. The inherent thin markets surrounding co-specialized resources means that competitors are not able to rapidly assemble the same resources by resource picking (Makadok, 2001), and hence cannot offer the same products and services.

Co-specialization may enable differentiated product offerings or unique cost savings, but creating and capturing co-specialization benefits requires combinative capabilities of the firm (Jansen, Van Den Bosh, and Volberda, 2005; Kogut and Zander, 1992) by which co-specialization is created by
identifying, developing, and utilizing a bundle of firm resources through continuous resource re-alignments. Teece (2007) maintains that special economic value can be created and potentially captured through various forms of effective combination of internally and externally generated inventions, such as the upgrading of best practices and new technologies into co-invention of new business models. Management ability to identify strategic opportunities to invest in co-specialized resources through its own development or astute purchase is fundamental to dynamic capabilities. Managers do not always succeed in resource co-specialization, sometimes because they do not sense the opportunity, and sometimes because they are unable to implement the desired integration. In particular, the outcome of resource co-specialization strategy will depend on management’s strategic decisions on when and how to invest in complementary resources to build co-specialized resources and their combinative capabilities with respect to matching and integrating relevant firm resources (Teece, 2007).

Thus, dynamic capabilities of identifying, assimilating, and benefiting from new technologies and business practices are a complex and firm-specific attribute that is likely to vary across firms. In addition, continuous adjustments of organizational processes and realignments of firm resources are required to successfully plan and implement a series of new technologies and new business practices, which need to be tailored to the operation of the firms. Managers can create economic value by creating co-specialized resources within the firm, which require their strategic decision to selectively invest in complementary resources and their combinative capabilities of integrating these resources into a firm-specific bundle of resources.

**Information Technology and Competitive Advantages**

One of the challenges to the earlier optimism concerning IT’s potential for creating competitive advantages comes from resource-based theory. From the resource-based perspective, IT resources that are valuable and inimitable can generate economic rents. Standardized individual IT assets such as computer hardware and software are unlikely to be rent-generating since such resources could be easily procured in competitive factor markets. In a resource-based analysis of IT investment and firm per-
formance, Clemons and Row (1991) advanced a commodity view of IT, maintaining that competitive imitation eventually erodes most IT-based advantages, and that above-normal returns to IT investments eventually dissipate. The strategic necessity hypothesis that IT investments *per se* do not generate sustainable performance advantages has received increasing support in recent empirical studies (Aral and Weill, 2007; Karimi, Somers and Bhattacherjee, 2007; Raganathan and Brown, 2006; Ray, Muhanna and Barney, 2005; Ravichandran and Lertwongsatien, 2005). This hypothesis consists of two elements: (1) IT provides economic value to the firm by increasing coordinating and operational efficiencies, and firms that do not adopt IT will have higher cost structures; and (2) firms cannot expect IT to generate sustainable competitive advantages because most IT products are readily available to all rivals in competitive factor markets (Mata, Fuerst, and Barney, 1995; Powell and Dent-Micalef, 1997).

According to this strategic view of IT, firms would appear to achieve IT-driven competitive advantages by embedding IT products into organizational systems in such a way as to create firm-specific resource complementarities. From the empirical investigation of the role of IT systems in the retail industry, Powell and Dent-Micalef (1997: 395) suggested that: (1) IT (as a commodity product) has become pervasive and relatively easy to acquire in competitive factor markets; (2) most retailers have not merged IT with the requisite human and business resources; and (3) IT systems do not merge themselves automatically with complementary resources, and that the more economically valuable the complementarity, the more difficult it is to achieve. Although the industry has invested sufficiently in IT products, only those firms that merged IT with complementary resources, particularly human resources, could gain IT-driven competitive advantages.

This strategic management view of firm-specific IT systems is consistent with the organizational process and resource alignment approach to the question of IT business value. For instance, Soh and Markus (1995) maintain that the business performance outcomes anticipated from IT investments depend on the nature of the firm’s IT conversion process. In a similar vein, Kettinger, Grover, Guha, and Segars (1994: 50) note that: “the information resources of a firm must be driven by business strategy and integrated into the product and process dimensions of the enterprise based on an
understanding of core competencies.” Bharadwaj, Sambamurthy and Zmud (2003) also suggest that firm performance outcomes attributed to IT investments are linked to a variety of IT-related capabilities of the firm, such as the existence of IT business partnerships, external IT linkages, business IT thinking, business process integration and IT management. More recently, based on data on IT investment allocations and organizational IT capabilities, Aral and Weill (2007) find that firms’ total IT investment is not associated with overall performance, but investments in specific IT assets explain performance variation. This study also reports that a system of organizational IT capabilities, such as IT competencies and organizational routines, strengthens the performance effects of complementary IT assets. In this regard, the resource-based theory focuses on strategic investments in IT and complementary firm resources as the most likely path to IT-driven competitive advantage. However, the task of combining IT resources with firm-level resources to create a firm-specific IT system is challenging because creating such a co-specialized IT system requires combinative capabilities and commitment of sunk cost investments in highly firm-specific resources.

In summary, research studies on IT and performance within the resource-based and dynamic-capability approach have suggested that IT resources are likely to influence firm performance when these resources and capabilities are carefully deployed to create firm-specific complementarities with other firm resources. This view of resource complementarity posits that firm resources are considered complementary to IT resources when the presence of one resource enhances the economic value of IT resources. The IT capabilities or resource alignment literature builds on the dynamic-capabilities perspective and focuses on how IT resources are utilized in the context of unique organizational processes as a result of the firm’s combinative capabilities of carefully integrating IT resources with firm resources and organizational processes. It is not merely the co-presence of IT and firm resources

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2 In the Information Systems literature, IT capabilities are viewed as embedded in IT-related organizational processes and routines that enable firms to create economic value from their IT investments. As a result, IT capabilities are heterogeneously distributed across firms and reflect firms’ unique histories, routines, and practices. In this regard, IT capabilities are a subset of dynamic capabilities that account for differences in organizational performance (Aral and Weill, 2007; Bharadwaj, 2000; Ravichandran and Lertwongsatien, 2005).
that results in competitive advantages, but dynamic capabilities and strategic choices concerning how IT resources are integrated and (re-)deployed in a complementary and mutually reinforcing manner.

While IT capabilities and resource alignment research studies reflect the idea of resource co-specialization strategy, these studies do not identify the specific mechanisms of co-specialization between IT resources and firm resources. Makadok (2001) postulates that two distinct mechanisms – i.e., resource-picking and capability-building – form the foundations of the resource-based and dynamic-capability approach regarding how economic rents can be created by firms. The resource-picking mechanism posits that firms can create economic rents by being more effective than their rivals in selecting resources. This Ricardian perspective emphasizes that heterogeneity in organizational performance is due to ownership or control of inimitable resources that have differential productivity. In contrast, the capability-building mechanism posits that firms create economic rents by being more effective than their rivals at deploying resources. While the resource-based and dynamic-capability literature has examined these two mechanisms independently, Makadok (2001) maintains that resource selection and resource deployment are not necessarily independent and may complement each other.

The central premise of the current paper is that resource co-specialization or mutual coherence between IT resources and firm resources is necessary to achieve IT-driven competitive advantages, and that strategic choices and combinative capabilities of creating a co-specialized IT system explain varying organizational performance of IT-investing firms. Given the availability of standardized IT resources in competitive factor markets, we focus on the capability-building mechanisms used in the process of IT implementation – i.e., organizational restructuring prior to IT deployment and adaptive customization of IT applications. In the following sections, we suggest that IT co-specialization strategy requires the use of these capability-building mechanisms in the process of IT implementation, and that the variation in these strategic decisions of IT-investing firms explains the differences in firm growth and IT project outcomes.
HYPOTHESIS DEVELOPMENT

Co-specialized IT system as an Enabler of Firm Growth

Driven by numerous case studies such as Wal-Mart and P&G, managers have been increasingly looking at IT as a strategic resource and as a key enabler of growth (Mitra, 2005). Although the trade literature postulates a direct positive effect of IT infrastructure on the growth of IT-investing firms, a systematic investigation of the relationship in the research literature is still lacking. As Mitra (2005) notes, the conventional view of IT as an enabler of firm growth sees IT as having a direct effect on revenue growth. The argument for a direct role of IT in revenue growth has been that a superior IT system improves customer service, aids in the acquisition and retention of customers, and enables the creation of new products and services that directly generate revenue (Ray, Muhanna, and Barney, 2005).

The rapid and continuing decline in the cost of computing and increases in the power and variety of computer systems are an exogenous and powerful change in the business environments of the firm. These changes and related changes in communication complements to computers lead to rapidly growing demand for IT. The growth in demand means that firms must regularly readjust their IT stocks. However, the progress of IT investments at the firm level is not smooth and direct because of complex relationships between IT resources and other firm resources, especially human resources (Bresnahan, Brynjolfsson, and Hitt, 2002).

IT resources could be a complement or substitute for human resources depending on how IT systems and IT-generated information are used in organizations. Computers are most effective in automating routine and well-defined tasks. Computers thus permit substitution of certain kinds of human efforts in record keeping, remembering and calculating data. Early research studies on the impacts of IT capital on firm size suggest that capital investment in IT is associated with subsequent decreases in the average size of U.S. firms in terms of the number of employees and sales because of substitution between computers and laborers (Brynjolfsson, Malone, Gurbaxani, and Kambil, 1994; Levy and Murnane, 1996). However, more recent empirical studies find that computer automation of information management process has been correspondingly limited in its scope. Computer automation of clerical
and blue-collar work typically does not directly substitute for all of a worker’s information-processing tasks, but instead for a subset of ancillary tasks, and in particular, those that do not require exception processing, visual or spatial skills, or non-algorithmic reasoning (Autor, Levy, and Murnane, 2003).

Increased capital investments in IT hardware and software and subsequent use of IT systems in organizations have not only created new IT-related tasks and jobs, but also increased the demand for skilled labor, because highly computerized information processing is often accompanied by a greater production of data. Raw data are basic inputs for analytic or abstract decision making, such as analyzing customer needs to target new product development, for example, thereby enhancing the economic value of skilled labor. This result will lead to a greater demand for skilled labor within the firm in order to maintain its information-processing capacity (Bresnahan, Brynjolfsson, and Hitt, 2002).

IT-enabled-growth, emphasized here, focuses on the firm-specific complementary relationship between IT resources and human resources to support various information-processing IT operations at the firm-level. IT co-specialization strategy involves a process of co-invention of new technologies and human resources in the unique organizational environment of the IT-investing firm. However, the rate of increase in IT resources and data availability is typically greater than the capability of firms to recruit and adjust their skilled human resources to balance their information-processing capacity, which is often referred to as information overload in the information-processing literature. Firms that successfully combine complementary IT and human resources via IT co-specialization could maintain a good balance of IT-generated data and information-processing capacity, and would further invest in human resources. Dynamic interactions between these complementary investments further increase the demand for IT. As these firms increase capital investments in co-specialized firm resources over time, they grow in terms of the number of employees, value-added, and revenue.

The Strategic Management research literature provides two conceptual building blocks useful for identifying characteristics of firms that complement IT and firm-specific resources towards firm growth: IT competencies and organizational practices. IT competencies refer to skills learned and embodied in organizations that actively manage or accomplish IT-related tasks (Tippins and Sohi,
Organizational practices or routines refer to recurring sets of activities that serve as mechanisms for storing and sharing knowledge about the most effective ways to accomplish organizational tasks (Cohen and Levinthal, 1990). IT competencies and firm-specific routines, which support each other (Aral and Weill, 2007), are necessary for the effective development and utilization of a co-specialized IT system in order to accomplish increasingly complex informational tasks of growing firms.

This resource-based and dynamic-capability theory of IT co-specialization and firm growth is also consistent with the cost-side explanation of IT in the Information Systems literature. For example, Mitra (2005) focuses on the efficiency function of an IT system as an enabler of firm growth, and finds that a superior IT system increases the productivity of other resources within a firm and enables a firm to grow more efficiently by controlling the complexity-related costs that the firm incurs as it grows in size. Our view of a co-specialized IT system does not preclude a direct effect of IT on revenue growth or a cost-side explanation of IT-enabled growth, but it emphasizes an indirect role of complementary investments in human resources, which can lead to a co-specialized IT system as a key enabler of firm growth by allowing the firm to fully capture the advantages from economies of scale and superior information-processing capacity. Specifically, we suggest that effective IT co-specialization necessitates complementary investments in both IT and human resources to maintain and enhance information-processing capacity. When these investments are combined together by a firm’s resource co-specialization mechanisms in the process of IT implementation, then the resulting co-specialized IT system will more likely support efficient growth of the firm as it allows the firm to better process and utilize valuable information it generates.

Hypothesis 1: The use of resource co-specialization mechanisms in the process of IT implementation is positively related to the growth of the firm, all other things being equal.

Co-specialized IT system as a Driver of Superior Performance

As discussed in the previous section, extant research suggests that competitive advantages of IT can be achieved if IT-investing firms effectively combine IT with other complementary resources.
Whereas complementarity exists when the economic value of one resource is enhanced by the presence of another resource, co-specialization exists if one resource has little or no economic value without another. In order to create and capture economic value from IT investments, it should be tailored to the unique organizational environment as a source of competitive advantage. Specifically, the economic value of IT is enhanced when firms also invest in skilled employees who utilize the IT system effectively in order to collect, transfer and process valuable information about their customers, markets, and other competitive factors that influence organizational performance. For example, an EDI system may enable a firm to enhance its procurement activities, while the pre-existing routines maximize EDI’s inherent information-sharing capacity. In this way, even commodity-like IT resources, such as an off-the-shelf EDI system, if carefully adapted through the implementation process, can become a rent-generating resource bundle. The resulting firm-specific IT system, which is the outcome of resource co-specialization with complementary firm resources, satisfies resource-based criteria for sustainable competitive advantage. Thus, we focus on the specific mechanisms of resource co-specialization in the process of IT implementation – i.e., organizational restructuring and adaptive customization of IT applications – and examine the role that firm-specific resource complementarities play in enhancing organizational performance which is measured by project-level outcome measures.

Prior research studies suggest that, while inventions that lead to improvements in IT are quickly available throughout the economy, the use of IT involves a process of co-invention by individual firms because IT generally changes the way that human work is measured, controlled, or reported (Baker and Hubbard, 2004). This change will create a number of additional indirect flows from IT to the demand for employees in general, mediated by organizational change. Identifying and implementing organizational co-inventions is difficult, costly and uncertain, yielding both successes and failures. In particular, the task of planning and maintaining information-processing capacity with increasing IT generated data requires combinative capabilities of IT-investing firms. The presence of adjustments costs for effective utilization of IT has been well supported by both case studies and statistical analyses (Bresnahan, 2000; Kemerer and Sosa, 1991). Therefore, the relationship between
investment in IT and investments in complementary human resources has a distinctive dynamic shape. In the long run, declines in the price of IT hardware and software cause the demand for all the complements to shift out, resulting in an increase in efficient scale of operation. In any particular short run, however, only a subset of firms will have made successful adjustments in complementary resources to improve organizational performance.

From the resource-based and dynamic-capability perspective, co-invention needs and adjustment difficulties related to complementary investments and combinative capabilities lead to variation across firms in their use of IT systems, IT-driven competitive advantages, and organizational performance. Firms that successfully adjust and combine IT and complementary human resources would further invest in both resources and thereby grow in their scale of operation. Firm growth can lead to higher economies of scale, but large firm size can be accompanied by high control and coordination costs, as the firm's internal operations become more complicated. We suggest that by enhancing a firm's information-processing capacity and information management capabilities, the firm-specific, co-specialized IT system would enable the firm to better coordinate organizational processes and control its administrative costs and therefore more fully capture cost advantages from economies of scale.

While earlier research studies emphasized a direct causal link between IT investment and labor demand, an empirically relevant distinction in the current paper is the role of co-specialization mechanisms as a central part of effective management of complementary resources within a firm. While advances in IT are an initial and important causal force, firm-specific complementarity is critical for achieving superior organizational performance, since IT use is more likely to be effective with other firm resources in the unique organizational processes. Business process provides a context within which economic value of IT is created by IT-investing firms, and is a vehicle to build IT-related organizational capabilities (Attaran, 2004; Karimi, Somers, and Bhattacherjee, 2007). We postulate that resource co-specialization in the process IT system enhances a firm’s information-processing capacity and information management in business processes, and is expected to result in superior business process efficiency and effectiveness (e.g., by reducing operating costs and cycle time, increasing
production productivity, and improving quality and customer service; and by improving decision making and planning, resource allocation, and product and service delivery, respectively).

The research literature recognizes that IT investments are inherently risky due to uncertainty concerning their economic impact, technological complexity, rapid obsolescence and implementation challenges (Dedrick, Gurbaxani, and Kraemer, 2003; Hitt, Wu, and Zhou, 2002). For example, drawing on options-pricing theories of investment under uncertainty, Dewan, Shi, and Gurbaxani (2007) maintain that, to the extent that IT investment opportunities have the characteristics of real options, the opportunity cost of exercising the call options, by making an irreversible investment, increases in IT risk and, hence, can be a significant contributor to the risk premium and the required returns associated with IT investments. The results show that IT capital investments are substantially riskier than non-IT capital investments, as measured by their relative contributions to the stock-return volatility and earnings volatility of the firm. Without understanding the nature of risk-return relationship in IT implementation, top managers may overstate the discounted present value of IT capital investments, simply consenting to the funding of IT projects.

From a business process manager’s perspective, implementation of IT requires substantial investments in time, money and internal resources, and is fraught with technical and business risk (Burgelman, Maidique, and Wheelwright, 2001). A typical bundle of IT solutions can cost over $1 million and the investment can be a significant proportion of revenue. IT implementations are also known to be unusually difficult due to the pervasiveness of the changes associated with IT products, the need for simultaneous process redesign of multiple functional areas within the firm, and the need to adapt business processes to the capabilities of the IT solutions. There is also a high degree of managerial complexity of these projects, and the significant amount of project cost is devoted to setup, installation and customization of the IT applications. IT customizability is the ability of the software functions when IT applications need to be tailored in the IT implementation process to the specific needs of individual IT projects (Nidumolu and Knotts, 1998). For example, ERP software packages often come in the form of tens of thousands of configuration tables that must be customized to suit a
firm’s business needs (Karimi, Somers, and Bhattacharjee, 2007). Thus, successful implementation of IT often requires additional supports by the IT vendors or consultants who can transfer their knowledge and fill gaps between the client and vendor in IT architecture expertise, applications knowledge and project experience (Raganathan and Brown, 2006). Such complexity places substantial strain on the client firm’s combinative capabilities and absorptive capacity. Success often hinges on effective collaboration among these teams to combine the business knowledge of internal business experts and the technical skills of outside consultants.

In addition, IT implementation often requires substantive changes in organizational processes, routines, and roles via business process re-engineering (Attaran, 2004; Karimi, Somers, and Bhattacharjee, 2007). Business process reengineering (BPR) is a management practice of process design, management and innovation, which involves revising current business processes and designing new core business processes (Grover, Jeong, Kettinger, and Teng, 1995). IT plays an important role in BPR efforts as an effective tool to implement organizational changes to make the organization more efficient and competitive. At the same time, IT can also be a barrier to BPR when radical change in organizational processes requires the re-design of current IT systems. Furthermore, resistance on the part of IT has often been a reason for failures in BPR implementation (Attaran, 2004). However, their joint contributions to organizational performance have not been fully explored in the research literature, and the dynamic relationship between BPR and IT is in need of further empirical analysis.

The current paper extends the idea of complementary resources and dynamic capabilities to the development and utilization of a co-specialized IT system within a firm. Given the scale of IT implementation projects as well as the possibility for both large successes and failures, it is reasonable to expect that IT implementation has a significant and measurable effect on organizational performance. Because IT implementation is a difficult and uncertain process, firms that are successful in implementing new IT systems may gain competitive advantage over other firms that are unwilling or unable to make similar changes. From the resource-based and dynamic-capability perspective, we suggest that sustainable IT-driven competitive advantage depends on dynamic capabilities of combining new tech-
nologies and organizational processes and creating firm-specific resource complementarities in the process of IT implementation. When IT resources are effectively integrated with firm-specific resources into a co-specialized IT system, we expect not only efficient growth of the firm but also superior IT project outcomes. More specifically, we suggest that the use of capability-building mechanisms of co-specialization strategy in IT implementation – i.e., adaptively customizing IT applications into the adopting firm’s organizational processes and simultaneously restructuring business processes to fit with the IT applications – enable the firm to achieve superior IT project outcomes and sustainable competitive advantage.

**Hypothesis 2**: The use of resource co-specialization mechanisms in the process of IT implementation is positively related to superior project outcomes, all other things being equal.

Based on the theoretical development in this section, we propose a research model as presented in Figure 1. The model suggests that the relationship between capital investment in IT and long-term financial performance can be better explained by examining variations across IT-investing firms in making strategic decisions of resource co-specialization in the process of IT implementation that is endogenous to our research model. A co-specialized IT system is conceptualized as endogenous since it is the result of the two resource co-specialization mechanisms, which are business process re-engineering (i.e., adjusting human resources and organizational processes to IT applications) and adaptive customization of IT (i.e., adjusting IT applications to organizational processes and needs).

In the next section, we first examine what factors induce IT-investing firms’ co-specialization strategy of implementing organizational restructuring and IT customization. Then, we examine the impacts of the two co-specialization mechanisms on firm growth in terms of the number of employees, value-added, and revenue, as well as their impacts on project outcomes in terms of project reference-ability and license extension.
RESEARCH METHODS

Data Sources

We examine the growth and performance effects of co-specialized IT systems and empirically test our theoretically-derived hypotheses using a unique dataset on the IT implementation projects of widely-adopted Advanced Planning and Scheduling (APS) applications. APS is a term covering a broad range of IT applications that address all segments of value chain activities within a firm and between firms, including manufacturing, distribution, planning, inventory replenishment, shop floor scheduling and transportation. These applications are often considered extensions of Enterprise Resource Planning (ERP) systems.

A large IT vendor (hereafter referred to fictitiously as ITSTAR) has provided access to their sales data for this study. ITSTAR offers a variety of IT solutions designed either for intra-firm or for inter-firm activities of the client firms. The ITSTAR’s APS applications can cost millions of dollars and sometimes takes years to be integrated with existing IT systems. When a client firm purchases a software application from ITSTAR, actual pricing is based on the firm’s revenue, number of employees, industry groups, and user types in addition to an upfront basic license fee. Additional training, consulting, maintenance and technical support fees are charged upon agreement, reflecting the characteristics of the client firm, value-chain activities, and work tasks. The ITSTAR products are modular, so that each of the functional modules (e.g., supply chain planning, demand planning, transportation planning, factory planning) can be installed separately. ITSTAR regularly audits and tracks IT implementation projects and keeps the records about which software modules are installed and repurchased by each client with license extension agreements.

The research data have been drawn primarily from the sales records of the software licensing, consulting, and additional support contracts between ITSTAR and its client firms over the period of 1990 to 2001 prior to the “dot com” crisis in the IT industries. We matched ITSTAR’s sales data to firm-level Compustat data. The Compustat database provides additional information on the sample firms such as the number of employees and sales. We also used Compustat database to construct firm-level
Panel data of the sample firms on value-added, vertical integration, R&D and capital intensity, and other control measures that are used for testing the hypotheses developed in this paper.

The sales data have been used for real management decisions at ITSTAR. However, care must be made in interpreting the empirical results of hypotheses testing. We discuss the generalizability issue of research findings in the concluding section. Another concern is about data matching. The ITSTAR database is maintained at the project level of individual client firm (i.e., sometimes business unit, division, subsidiary, or branch). Therefore, all ITSTAR data were aggregated to the available firm-level Compustat data. Due to no information on foreign or privately owned firms in Compustat database, this matching necessarily limits our analysis to 334 firms, which are publicly traded in the United States, excluding all private and foreign client firms in the ITSTAR sales data.

**Variable Definitions**

**Dependent Variables: Growth and Performance**

Hypothesis 1 examines the relationship between the use of IT co-specialization mechanisms and *firm growth* measures. To be consistent with the research literature on IT and firm size (Brynjolfsson, Malone, Gurbaxani, and Kambil, 1994), we use the following measures.

\[
L_i^t = \text{the number of employees for firm } i \text{ in year } t \\
S_i^t = \text{net sales for firm } i \text{ in year } t \\
Q_i^t = \text{total value-added for firm } i \text{ in year } t
\]

Hypothesis 2 examines the relationship between the use of IT co-specialization mechanisms and *project outcome* measures. As noted in the previous sections, we examine the impact on immediate and intermediary measures of organizational performance, instead of using broad and long-term financial performance measures. Poppo and Zenger (2002) use a measure of overall satisfaction in transactions that reflects both production and operational efficiency. Following Poppo and Zenger (2002) we use a measure of overall satisfaction with IT implementation, which is an index of the level
of reference-ability of each IT project. The reference-ability index reflects not only the level of client firm’s satisfaction with the adoption of ITSTAR applications, but also the level of ITSTAR’s performance rating based on externally reported multidimensional evaluation on the performance of each IT implementation project, which will guide future projects as a reference.

\[ \text{REFER}_i = 1 \sim 5 \text{ (negative, disappointed, positive, satisfied, promoter) for firm } i \text{ in year } t \]

As an alternative project outcome measure, we examine whether or not each client firm, as satisfied with the result with its previous implementation and use of an IT application, has actually repurchased the same IT application from ITSTAR via license extension. We look at the contracting history of each client firm in the sample to find if there exists a record of repeat purchase of the same ITSTAR application as an observable measure of overall satisfaction directly related to prior IT experience by the firm.

\[ \text{EXTEND}_{ijt} = 1 \text{ if firm } i \text{ has extended the use of an IT application } j \text{ by repeat purchasing additional license for the same IT application } j \text{ in year } t \]

**Independent Variables: Co-specialization Mechanisms**

**IT Customization.** Most of ITSTAR products are modular and packaged to be shippable, which allow them to be implemented at the client’s site with relatively little adjustment efforts. However, some firms have purchased, in addition to software license, membership or maintenance and technical supports in order to adaptively customize the IT products for their needs. IT customization often results in a significantly modified firm-specific IT system, which is tailored to the client firm’s operations. In such circumstances, a strategic decision to adaptively customize an IT application renders it more costly for the firm to switch its use or users. Because it is impossible to directly observe actual amounts of sunk costs related to the firm’s IT customization, the following two measures are used to represent the strategic decision to customize IT applications towards a co-specialized IT system.

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3 The data on reference-ability index are based on independent survey results conducted by Miller-Williams Inc. in 2001.

4 The correlation between the two measures (MEMBER and SUPPORT) is very high (0.7764, p < 0.001).
MEMBER$_{it}$ = 0 (None), 1 (Silver), 2 (Gold), 3 (Platinum membership) for firm $i$ in year $t$

SUPPORT$_{ijt}$ = 1 if firm $i$ has purchased additional maintenance and technical supports for its adaptive customization of IT application $j$ in year $t$

Organizational Restructuring. ITSTAR partners professional business consulting companies and provides several types of BPR consulting services designed to help the client firms redefine and adjust their value-chain activities and business processes prior to the deployment of IT applications. When the value-chain activities are highly complex, BPR consulting services are strongly recommended by ITSTAR in order for the client to gain the maximum value from IT investments. The initial value discovery phase of BPR can take up to four months prior to actual deployment of the IT applications, and resulting organizational restructuring is often very costly and difficult to reverse. Accordingly, we use the managerial decision to purchase the BPR consulting services as a measure of the organizational restructuring mechanism for resource co-specialization between the firm’s unique organizational processes and the IT application to be implemented.

$BPR_{it}$ = 1 if firm $i$ has used BPR consulting service prior to IT deployment in year $t$.

Control Variables

A measure of vertical integration is required to control for the influence of IT-driven vertical integration on resource co-specialization, firm size, and organizational performance. Following Balakrishnan and Wernerfelt (1986) and D’Aveni and Ravenscraft (1994), the following value-added-to-sales measure of vertical integration was calculated from Compustat database.

$VI_{it} = \frac{[Total\ value\ added - (Net\ income + Income\ taxes)]}{[Net\ sales - (Net\ income + Income\ taxes)]}$

for firm $i$ in year $t$

According to Levy (1985), firms in research-intensive industries tend to involve specialized inputs, and non-standardized inputs are often employed when new products and technologies are introduced. Chandler (1977) maintains that vertical integration became important in capital-intensive industries, where less flexible production scheduling can impose large costs due to excess capacity. Williamson (1985) also notes that the potential costs of market failure are magnified in capital-intensive
industries since a substantial portion of the firm’s large initial investment may not be re-deployable. To be consistent with the research literature, the following operational measures of transaction attributes are constructed from Compustat database to control for their effects on co-specialization strategy and organizational performance. In addition, while investigating the performance effect of co-specialization strategy in IT implementation, we control for the multi-factor productivity (MFP) of the sample firms by calculating a weighted average of the growth rates of labor and capital productivity as suggested in Lieberman and Demeester (1999).

\[ RDI_{it} = \text{the intensity of research and development expenditures of firm i in year t} \]
\[ KCS_{it} = \text{capital's share of costs for firm i in year t} \]
\[ LCS_{it} = 1 - KCS_{it} = \text{labor's cost share for firm i in year t} \]
\[ MFP_{it} = (\ln Q_t - \ln Q_{t-1}) - LCS_{it} \cdot (\ln L_{it} - \ln L_{it-1}) - KCS_{it} \cdot (\ln K_{it} - \ln K_{it-1}) \]

According to Cohen and Levinthal (1990), prior knowledge is the key determinant of a firm’s absorptive capacity and organizational performance. The current paper interprets the concept of IT-related absorptive capacity as representing the client firm’s prior knowledge on the APS applications, and controls for the duration of the contractual relationship with ITSTAR and each client firm (DURATION). While there are over 20 different IT modules available from ITSTAR, they can be broadly categorized into two subgroups depending on their primary functions – i.e., within a firm and between firms IT applications (INTRA_IT and INTER_IT). We test the hypotheses for each subgroup to control for confounding effects of different IT applications and task areas. Finally, we use either INDUSTRY (the four-digit SIC) or MANUFACT (a dummy variable of manufacturing Industries) to remove variations due to idiosyncratic characteristics across different industries.

**Estimation Methods**

An estimation problem arises because managers make strategic decisions, such as resource co-specialization or vertical integration, not randomly, but based on expectations of how their choices
affect firm growth and organizational performance in the future. As a result, empirical research models that do not account for this decision process are potentially mis-specified and the conclusions drawn from them are potentially misleading (Hamilton and Nickerson, 2003; Masten 1993; Shaver, 1998). To avoid this self-selection or endogeneity problem of biased coefficient estimates, it is necessary to use estimation methods addressing how the decision to use the two co-specialization mechanisms is induced by the observable and unobservable characteristics of the firm, transaction, and industry.

Our research design assumes that the sample firms purchasing IT applications from ITSTAR between 1990 and 1998 have made a strategic decision as to whether or not to pursue resource co-specialization based on the characteristics of their tasks and operations. The strategy of resource co-specialization is implemented by using the two discrete capability-building mechanisms – i.e., organizational restructuring and IT customization in the process of IT implementation – which can be observed by researchers. It allows us to empirically test the firm growth and organizational performance hypotheses of a co-specialized IT system by examining the impacts of these IT co-specialization mechanisms on firm growth and also their impacts on project outcomes measures in 2001.

Specifying and testing the hypothesized relationships independently may produce biased coefficient estimates. To account for such omitted variable problems in statistical analysis, we use several econometric methods including a two-stage instrumental variable (IV) regression with lag instruments, endogenous switching regression with Heckman correction, and fixed effect versus first difference regressions. In the two-stage IV regression method, for example, the IT customization (MEMBER or SUPPORT as an alternative measure) and organizational restructuring (BPR) decisions are first estimated by ordered-logit and binary-logit analyses as a function of the lag instruments including the characteristics of firm, transaction, and industry. The instrumented IT customization (PMEMBER or PSUPPORT) and organizational restructuring (PBPR) decisions are thus only a function of known characteristics.

\[
\chi^2 = 6.80 \ (p = 0.1470)
\]

The Hausman test of the endogeneity indicates that OLS is an inconsistent estimator for this equation with \(\chi^2 = 6.80 \ (p = 0.1470)\). The result warrants our estimation by instrumental variables.
MEMBER\(_{it}\) = \(\beta_0 + \beta_1\text{BPR}_i + \beta_2\text{RDI}_i + \beta_3\text{KCS}_i + \beta_4\text{VI}_i + \beta_5\text{EMPLOYEE}_i + \beta_6\text{SALES}_i + \beta_7\text{INDUSTRY}_i + \epsilon_{1it}\)

SUPPORT\(_{it}\) = \(\beta_0 + \beta_1\text{BPR}_i + \beta_2\text{RDI}_i + \beta_3\text{KCS}_i + \beta_4\text{VI}_i + \beta_5\text{EMPLOYEE}_i + \beta_6\text{SALES}_i + \beta_7\text{INDUSTRY}_i + \epsilon_{2it}\)

BPR\(_{it}\) = \(\beta_0 + \beta_1\text{MEMBER}_i + \beta_2\text{RDI}_i + \beta_3\text{KCS}_i + \beta_4\text{VI}_i + \beta_5\text{EMPLOYEE}_i + \beta_6\text{SALES}_i + \beta_7\text{INDUSTRY}_i + \epsilon_{3it}\)

BPR\(_{it}\) = \(\beta_0 + \beta_1\text{SUPPORT}_i + \beta_2\text{RDI}_i + \beta_3\text{KCS}_i + \beta_4\text{VI}_i + \beta_5\text{EMPLOYEE}_i + \beta_6\text{SALES}_i + \beta_7\text{INDUSTRY}_i + \epsilon_{4it}\)

In the second stage estimation, PMEMBER (or PSUPPORT) and PBPR are used as explanatory variables in which the growth and performance effects of resource co-specialization strategy are estimated. In the case of endogenous switching regression, the inverse Mills ratio is calculated for each strategic choice and also entered along with other independent variables for Heckman correction. Dependent variables in the second-stage estimation include the number of employees (L), net sales (S), total value-added (Q), and project outcome measures (REFER and EXTEND). First, the growth effect of organizational restructuring and IT customization is examined by testing the changes in the number of employees, net sales, and total value-added (Hypothesis 1).

\[ L_{it+1} = \beta_0 + \beta_1\text{PSUPPORT}_i + \beta_2\text{PBPR}_i + \beta_3\text{VI}_{it+1} + \beta_4\text{DURATION}_i + \beta_5\text{INDUSTRY}_i + u_{1it} \]

\[ S_{it+1} = \beta_0 + \beta_1\text{PSUPPORT}_i + \beta_2\text{PBPR}_i + \beta_3\text{VI}_{it+1} + \beta_4\text{DURATION}_i + \beta_5\text{INDUSTRY}_i + u_{2it} \]

\[ Q_{it+1} = \beta_0 + \beta_1\text{PSUPPORT}_i + \beta_2\text{PBPR}_i + \beta_3\text{VI}_{it+1} + \beta_4\text{DURATION}_i + \beta_5\text{INDUSTRY}_i + u_{3it} \]

Second, we empirically test for the performance effect of co-specialization strategy by examining the coefficients of predicted variables of organizational restructuring and IT customization in the two project outcome equations (Hypothesis 2). The two measures of IT project outcomes are project reference-ability index (REFER) and software license extension (EXTEND):

\(^6\) For the purpose of robustness check, we re-estimate the growth and performance effects of IT co-specialization by using the fixed effect and first difference regressions. Since different estimation methods do not change our conclusion, we report here only the empirical results of the two-stage IV regressions.
REFER\(^{_{it,s}}\) = \(\beta_0 + \beta_1PBPR_{i} + \beta_2PSUPPORT_{i} + \beta_3RDI_{i} + \beta_4KCS_{i} + \beta_5Q_{i} + \beta_6VI_{i} + \beta_7MFP_{i} + \beta_8DURATION_{i} + \beta_9INDUSTRY_{i} + \eta_{i_{it,s}}\)

EXTEND\(^{_{it,s}}\) = \(\beta_0 + \beta_1PBPR_{i} + \beta_2PSUPPORT_{i} + \beta_3RDI_{i} + \beta_4KCS_{i} + \beta_5Q_{i} + \beta_6VI_{i} + \beta_7MFP_{i} + \beta_8DURATION_{i} + \beta_9INDUSTRY_{i} + \eta_{2_{it,s}}\)

**ECONOMETRIC RESULTS**

**Sample Characteristics and Descriptive Statistics**

Table 1 and Table 2 provide means, standard deviations, and correlations for the main variables. The regression assumptions were examined for serial correlation, heteroscedasticity, multicollinearity, and normality of the residuals and for outliers. Due to missing data in matching process, the final sample for data analysis is 334 or smaller for sub-sample tests. The average firm in the sample is very large, with value-added of about $2B, net sales of $11B, and employment of 39,000 in 2001.

There exist substantial differences in the measures of IT use across the sample firms. Approximately 54% (179 firms) of firms in the sample have purchased inter-firm IT solutions while 93% (312 firms) of the sample have implemented intra-firm IT solutions. In addition, about 49% (164 firms) of the sample firms purchased membership or additional supports services from ITSTAR for adaptive customization of IT products in the process of IT implementation. Regarding the use of BPR consulting services prior to IT deployment, overall 29% (96 firms) of the firms have undertaken organizational restructuring. Finally, 16% (55 firms) have repurchased the same software licenses in order to extend their use of the IT applications.

**The Determinants of Co-specialization Strategy**

We first examined potential drivers of resource co-specialization strategy by regressing the decisions to use the two co-specialization mechanisms of IT customization and organizational restructuring on observable characteristics of firm, transactions, and industry. The results of the intermediate
first-stage logit analysis about the determinants of co-specialization strategy are summarized in Table 3. Seven explanatory variables are used to examine their impacts on IT customization (MEMBER and SUPPORT) and organizational restructuring (BPR), respectively. As expected, there exists a strong prior relationship between organizational restructuring and IT customization decisions. The measure of organizational restructuring, which is the use of BPR service prior to IT deployment, increases the probability of observing a high level of IT customization measured by either the purchase of membership services or additional support contracts (p < 0.001). It suggests that the sample firms, which have undertaken organizational restructuring in their business processes prior to IT deployment, are more likely to adaptively customize purchased IT applications into their unique operations and activities, leading to firm-specific and co-specialized IT systems. We further examined the relationship with two sub-samples separately (i.e., intra-firm IT and inter-firm IT adopters), and found similar results, which are not reported in the paper.

The first-stage results also show that the number of employees at the time of IT investment (PRE_L) is negatively related to IT customization decision whereas net sales of the client firm at the time of IT investment (PRE_S) are positively related. But the number of employees and net sales are found to have no statistically significant impacts on the co-specialization decision to undertake organizational restructuring prior to IT deployment. Finally, there is a positive relationship between R&D intensity (PRE_RDI) and organizational restructuring, implying that the sample firms with high R&D intensity tend to purchase BPR consulting services prior to IT deployment. Since graphing the results of the logit model provides a more nuanced understanding of the relationships (Hoetker, 2007), we also provide graphical presentations of the findings in Figure 2. Over the range of meaningful values, the plots illustrate the aforementioned relationships between IT customization, organizational restructuring, and other firm-level determinants of resource co-specialization decision.

In case of MEMBER, since there are three classes of membership contracts, we used an ordered logit (and probit as an alternative) estimation to investigate the determinants of IT customization in IT implementation.
The Impacts of Co-specialization Strategy on Firm Growth

Based on the previous empirical findings about the determinants of IT customization and organizational restructuring, we proceeded to examine the growth and performance effect of the two co-specialization mechanisms. Table 4 shows the empirical results with the two-stage IV regressions designed to address potential self-selection bias and the endogeneity of IT co-specialization decisions using the instrumented variables from the first estimation.\(^8\)

Hypothesis 1 examines the impact of a co-specialized IT system on the growth of the firm, which is measured by the number of employees (POST_L), net sales (POST_S), and total value-added (POST_Q) of the firm as a result of IT customization and organizational restructuring. First, Table 4 reveals positive and statistically significant relationships between the instrumented IT customization (PSUPPORT) and \textit{ex post} firm size measures (POST_L, POST_S, and POST_Q). These empirical results are consistent with resource-based and dynamic-capability arguments in that the use of a firm-specific IT system with complementary resources increases efficient scale of operation and supports the growth of the firm. We also find positive and statistically significant relationships between the instrumented organizational restructuring (PBPR) and the three measures of firm growth, which indicates a positive growth effect of the use of this resource co-specialization mechanism in the process of IT implementation.

Consistent with theoretical predictions, our measure of IT-related absorptive capacity of the sample firms (DURATION) shows a positive relationship with the three growth measures. The estimation result also indicates that sample firms in manufacturing industries (MANUFACT) have decreased their scale of operation. Overall, we can reject the null hypothesis that there is no growth effect of a co-specialized IT system at \(p < 0.01\), strongly supporting Hypothesis 1.

\(^8\) Two separate performance estimations for each strategy decision from the endogenous switching regressions with Heckman correction also provide empirical support for the hypotheses (Hamilton and Nickerson, 2003; Shaver, 1998). Thus, we report only the results of the single reduced form estimation of the IV regressions.
The Impacts of Co-specialization on Project Outcomes

We investigated the performance effect of a co-specialized IT system (Hypothesis 2) by examining its impact on the two project outcome measures – i.e., reference-ability index of IT projects (REFER) and repeat purchase of the same IT applications by license extension (EXTEND). Table 5 presents the empirical results with the first performance measure of REFER, and Table 6 shows the empirical results with the second measure of EXTEND while controlling for the transaction attributes (POST_RDI and POST_KCS), industry group (MANUFACT), and other firm fixed effects including vertical scope (POST_VI), operation scale (POST_Q), multi-factor productivity (POST_MFP), and IT-related absorptive capacity (DURATION).

The columns (1), (3), and (5) in Table 5 report the impacts on REFER using an ordered logit estimation for the sub-sample of intra-firm IT applications (INTRA_IT). As predicted, the coefficients of intra-firm IT customization (PSUPPORT) and organizational restructuring (PBPR) are positive and statistically significant (p < 0.01). It suggests that a firm’s use of co-specialization mechanisms in its internal value-chain activities improves its IT project outcomes when they are evaluated by overall satisfaction of the client firms and the IT vendor. As for the performance effect of a co-specialized IT system in the external transaction activities across firm boundaries (INTER_IT), the empirical results in columns (2), (4), and (6) show that the coefficient of organizational restructuring (PBPR) is positive and statistically significant (p < 0.01). The coefficient of IT customization (PSUPPORT) between firms is also positive but marginally significant in one-tail test.⁹

Among the control variables included in the estimation of the performance effect, R&D intensity of the sample firms (POST_RDI) is negatively related with this project outcome measure. Also, the sample firms in manufacturing industries (MANUFACT) achieve superior organizational performance from their IT investments in intra-firm and inter-firm IT applications while controlling for

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⁹ In the model specification and testing, we assumed an additive relationship between organizational restructuring (PBPR) and IT customization (PSUPPORT). We also tested the performance effect of the two co-specialization mechanisms in a multiplicative form (PBPR x PSUPPORT) and found the same results supporting Hypothesis 2.
for other firm fixed effects. Together, the empirical results provide support for Hypothesis 2, and suggest that a firm’s strategic decision to develop and utilize a co-specialized IT system via organizational restructuring and IT customization mechanisms improves project outcomes when measured by reference-ability index of the IT implementation project.

In Table 6, we present the estimation results on the impacts of the use of co-specialization mechanisms on another performance measure of project outcomes (EXTEND) using a logit estimation. When compared to the other performance measure of overall satisfaction (REFER), EXTEND captures actual strategic commitment made by the client firms as they repeat purchase the same IT applications in use by extending the software license with the IT vendor. More specifically, in the case of intra-firm IT applications (INTRA_IT), the coefficients of organizational restructuring and IT customization are positive and statistically significant as shown in columns (1), (3), and (5). The coefficients in the equations of inter-firm IT applications (INTER_IT) are also positive and statistically significant in (2), (4), and (6). Thus, consistent with the previous results with the project outcome measure of REFER, the empirical results with EXTEND support Hypothesis 2, and suggest that a firms’ resource co-specialization strategy improves organizational performance in terms of the IT project outcomes in its intra-firm and inter-firm activities.

To evaluate the combined effect of these results further, we plotted the predicted probabilities of REFER and EXTEND as a function of the instrumented IT customization and organizational restructuring variables while keeping the values of other control variables at their means. As shown in Figure 3(b), the probabilities of license extension increase as the probabilities of IT customization increase. The probabilities are considerably higher when IT customization is accompanied by organizational restructuring (upper line in the figure). However, as depicted in Figure 3(a), such relationships are not monotonic between the probabilities of high reference-ability index and the probabilities of organizational restructuring with IT customization decision.

To summarize, our tests for the growth and performance effects of resource co-specialization strategy in the process of IT implementation provide strong empirical support for our central hypoth-
eses that the use of IT co-specialization mechanisms – i.e., organizational restructuring prior to IT deployment and adaptive customization of IT products in IT implementation – enables IT-investing firms to grow in size efficiently and to achieve superior organizational performance.  

**DISCUSSION AND CONCLUSIONS**

The idea that IT can provide firms with a new source of competitive advantage has received considerable attention in recent years. However, there are at least three reasons to believe that previous research studies do not adequately explain the effects of IT investment on organizations. First, prior studies using the amount of IT investment as a proxy for the IT capability of IT-investing firms have found mixed empirical results. From the resource-based and dynamic-capability perspectives, we suggested that IT enhances organizational performance only when it is used to leverage pre-existing, complementary firm resources. The empirical results confirm that to assess IT capability and its impact on organizational performance one needs to look beyond IT capital and investigate strategic decisions to use the two interrelated capability-building mechanisms of IT co-specialization, i.e., organizational restructuring and adaptive customization of IT applications in the process of IT implementation.

Second, the growth and performance effects of IT can be indirect and broad financial measures of performance can be misleading. Specifically, prior research studies, which focus on a direct relationship between IT investment and financial performance, fail to take into consideration the importance of managing complementary human resources and business processes. The economic values of these resources are enhanced with the utilization of a co-specialized IT system. We found that combinative capability of integrating IT and complementary firm resources is critical to efficient growth of IT-investing firms. The current paper also highlights the importance of these firm-specific

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10 When we used multi-factor productivity and financial performance measures in the second-stage estimation, we also found positive relationships between these broad measures of organizational performance and the two co-specialization mechanisms. However, the coefficients of co-specialization mechanisms were not statistically significant. We conjecture that this empirical result is because of numerous uncontrollable noises affecting financial measures and also because of a relatively short time-frame of the study to observe broad and long-term performance effects of co-specialized IT systems.
complementarities on organizational performance to fully capture the advantages of scale economies and to enhance its information-processing capacity. In addition, by using immediate outcome measures of IT project, while controlling for potential endogeneity issues, it provides more relevant empirical evidence on the role of a co-specialized IT system as the facilitator of performance enhancement.

Third, while the use of standardized IT can improve operational efficiencies, it may not provide sustainable competitive advantages because the same IT applications could be competitively adopted by rival firms. We proposed that IT-driven competitive advantages can only be realized and sustained when a firm makes a strategic commitment to the two co-specialization mechanisms in the process of IT implementation. It requires the firm to adaptively customize standardized IT products into its unique organizational environment, and to simultaneously restructure its business processes and operations to better utilize the IT applications. The results from the unique panel data support these hypotheses and provide additional insights into how IT and firm resources can be co-specialized within a firm and between firms and become a source of sustainable competitive advantages.

This paper makes a contribution to the Strategic Management and Information Systems literatures by providing a resource-based and dynamic-capability explanation of IT systems. We find that a firm’s IT-driven growth and superior performance are a function of the firm’s strategic use of capability-building mechanisms centered on IT co-specialization. Successful IT implementation requires adjustment efforts to achieve firm-specific complementarities, and strategic coherence between new technologies and existing organizational processes. By restructuring existing business processes and adaptively customizing IT products, advanced technologies are integrated into the organization as a firm-specific IT system. This paper identifies these specific mechanisms of IT co-specialization and reports empirical supports for the hypotheses on their value enhancing functions. The empirical results suggest that the economic value of IT systems varies across firms with management’s dynamic capabilities in making organizational changes and managing IT implementation processes.

The limitations of this paper are as follows. First, the current study uses observations of IT adoption for ITSTAR products. Since ITSTAR has maintained a dominant share of the Advanced
Planning and Scheduling (APS) market during the observation period, we are confident that our data set captures a significant portion of the APS population while controlling for the variation across the sample firms in their resource-picking strategy and the variation across IT vendors in their product and support quality. However, care must be made when interpreting the empirical results in terms of generalizability of research findings because of the potential effects of multiple APS standards and IT vendors on co-specialization strategy and organizational performance. Second, this paper does not consider IT price effects, which could be an important factor in models of IT-enabled growth of the firm. We believe, however, that the sample firms in this study had equal access to IT applications in the factor market at competitive prices as we have witnessed increased competitive entries into the APS industry. Third, since our research model focuses on firm-specific complementarity among IT, human recourses, and business processes, it does not specify the relationships between IT and other strategic resources and capabilities, such as unique production technologies and non-IT absorptive capacity, or the relationships between IT and other strategic decisions such as product and business diversification. Finally, we estimate a firm’s IT co-specialization decision as a function of observed characteristics of the firm, transaction and industry. Certainly, not all firms need to pursue co-specialization strategy for every IT project since it requires management’s sunk cost commitment, which entails expensive service charges and irreversible organizational changes. The determinants of IT co-specialization found in this study may reflect the nature of highly sophisticated APS applications. As the current paper focuses on the growth and performance effects of a co-specialized IT system, it does not develop a theoretical model concerning management’s decision-making process towards IT co-specialization.

The importance of understanding how IT affects the organization becomes even more critical in light of the significant percentage of new capital investment that is being allocated as organizations continue to search for ways to manage information more efficiently. However, scholars and managers have realized that simply investing in IT capital is not enough, especially when it cannot be utilized to leverage other firm-specific resources. The current paper provides strategic implications that IT-investing firms must give more attention to managing IT implementation processes, which can result in a co-
specialized IT system. The empirical results of our study suggest that managers should understand and use IT-related capability-building mechanisms in IT implementation to develop and utilize a tailored IT system by which sustainable competitive advantages can be created from IT investments. This paper also provides various research agendas concerning IT-enabled firm growth and IT-driven sustainable competitive advantage. Regarding IT-enabled firm growth, we find that superior information-processing capacity of a firm is the outcome of complementary investments in IT and firm-specific resources to acquire and process valuable information, expanding the efficient boundary of the firm. Sustainable competitive advantage may rest on distinct absorptive capacity of IT-investing firms since it allows the firms to internalize new technologies from outside experts and to strategically co-specialize them into IT capabilities by using resource-picking and capability-building mechanisms. As opposed to the prior research literature that has focused on the flexibility of general-purpose IT, the current paper provides a strategic explanation for a firm-specific IT system. We encourage future research studies to further investigate when each of these attributes becomes more important.
Figure 1: Research Model

- IT Implementation
- Resource Co-specialization
  - organizational restructuring
  - adaptive IT customization
- Organizational Performance
  - firm growth measures
  - project outcome measures
- Control Variables
  - firm
  - industry
  - transaction attributes
- Control Variables
  - firm
  - industry
  - IT vendor relationship

- IT Utilization
- Financial Performance

$t \rightarrow t + s$
Figure 2: Plots of IT Customization, Organizational Re-structuring, and Firm Characteristics

(a) The interaction effects of Organizational Restructuring and Net Sales

(b) The interaction effects of Organizational Restructuring and Number of Employees
(c) The interaction effects of IT Customization and R&D Intensity

(d) The interaction effects of IT Customization and Vertical Integration
Figure 3: Plots of Project Outcomes, IT Customization, and Organizational Restructuring

(a) Reference-ability Index Measure of Performance Effect with IT Customization

(b) License Extension Measure of Performance Effect: with and without BPR
Table 1: Descriptive Statistics

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*p < 0.05

**p < 0.01
Table 3: Determinants of IT Customization and Organization Restructuring

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<td>(1.44)</td>
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Observations  | 137    | 137     | 137          | 137          |
LR chi2(10)    | 27.83  | 32.12   | 27.41        | 34.01        |
Prob > chi2    | 0.0002 | 0.0000  | 0.0003       | 0.0000       |
McFadden’s R2  | 0.0954 | 0.1706  | 0.1515       | 0.1880       |

Absolute value of z statistics in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%
Table 4: Growth Effects of Organizational Restructuring and IT Customization:
The Number of Employees, Net Sales, and Value-Added Measures

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<td>PBPR</td>
<td>2.019</td>
<td>1.968</td>
<td>1.901</td>
</tr>
<tr>
<td></td>
<td>(3.04)**</td>
<td>(2.94)**</td>
<td>(2.15)⁺</td>
</tr>
<tr>
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<td>1.454</td>
<td>-2.033</td>
<td>4.186</td>
</tr>
<tr>
<td></td>
<td>(0.83)</td>
<td>(1.40)</td>
<td>(1.93)⁺</td>
</tr>
<tr>
<td>DURATION</td>
<td>0.013</td>
<td>0.018</td>
<td>0.014</td>
</tr>
<tr>
<td></td>
<td>(2.44)⁺</td>
<td>(3.43)**</td>
<td>(2.05)⁺</td>
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<td>-0.760</td>
<td>-0.936</td>
<td>-0.926</td>
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<tr>
<td></td>
<td>(1.74)⁺</td>
<td>(2.12)⁺</td>
<td>(1.61)</td>
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<td>6.588</td>
<td>4.640</td>
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<tr>
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<td>(13.49)**</td>
<td>(10.71)**</td>
<td>(5.67)**</td>
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<td>130</td>
<td>107</td>
</tr>
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<td>F (6, 122)</td>
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<td>9.56</td>
<td>4.28</td>
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<td>Prob &gt; F</td>
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<td>0.0000</td>
<td>0.0014</td>
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<td>R²</td>
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<tr>
<td>Adj R²</td>
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Absolute value of t statistics in parentheses
⁺ significant at 10%; * significant at 5%; ** significant at 1%
Table 5: Performance Effects of Organizational Restructuring and IT Customization:

Reference-ability Index Measure of IT Project Outcomes

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<td>(2) INTER</td>
<td>(3) INTRA</td>
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<td>--------</td>
<td>--------</td>
<td>--------</td>
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<td>PSUPPORT</td>
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<td>1.491</td>
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</tr>
<tr>
<td></td>
<td>(3.39)**(1.21)</td>
<td></td>
<td>(1.47)</td>
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<tr>
<td>PBPR</td>
<td>5.260</td>
<td>5.260</td>
<td>6.108</td>
</tr>
<tr>
<td></td>
<td>(5.62)<strong>(3.85)</strong></td>
<td></td>
<td>(4.98)<strong>(3.73)</strong></td>
</tr>
<tr>
<td>POST_RDI</td>
<td>-0.014</td>
<td>-0.026</td>
<td>-0.058</td>
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<td>(1.00)</td>
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<td>(3.35)<strong>(2.95)</strong></td>
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<td>(1.55)</td>
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<td>0.002</td>
<td>-0.082</td>
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<td>(0.06)</td>
<td>(0.01)</td>
<td>(0.72)</td>
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<td>-1.546</td>
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<td>(0.54)</td>
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<td>0.005</td>
<td>-0.002</td>
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<td>(0.49)</td>
<td>(0.21)</td>
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<td>1.794</td>
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<td>(0.65)</td>
<td>(1.73)+</td>
<td>(2.56)<strong>(2.59)</strong></td>
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<td>66</td>
<td>97</td>
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<tr>
<td>McFadden's R²</td>
<td>0.06</td>
<td>0.05</td>
<td>0.15</td>
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Absolute value of t statistics in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%
Table 6: Performance Effects of Organizational Restructuring and IT Customization:
License Extension Measure of IT Project Outcomes

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<td>(3) INTRA</td>
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<td>PSUPPORT</td>
<td>3.061</td>
<td>2.503</td>
<td>2.071</td>
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<td></td>
<td>(2.34)*</td>
<td>(1.68)+</td>
<td>(1.50)</td>
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<td>PBPR</td>
<td>4.070</td>
<td>3.342</td>
<td>3.428</td>
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<td>(2.78)**(2.12)*</td>
<td>(2.22)*</td>
<td>(1.87)*</td>
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<td>POST_RDI</td>
<td>0.007</td>
<td>-0.012</td>
<td>-0.016</td>
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<td>(0.38)</td>
<td>(0.62)</td>
<td>(0.73)</td>
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<td>-1.237</td>
<td>-1.953</td>
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<td>(1.07)</td>
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<td>(1.31)</td>
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<td>POST_Q</td>
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<td>POST_VI</td>
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<td>(2.08)*</td>
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<td>(0.24)</td>
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<td>(0.95)</td>
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<td>-0.007</td>
<td>-0.014</td>
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<td>(0.76)</td>
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<td>MANUFACT</td>
<td>0.108</td>
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<td>1.083</td>
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<td>(0.11)</td>
<td>(0.73)</td>
<td>(1.18)</td>
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<td>(0.98)</td>
<td>(0.03)</td>
<td>(0.96)</td>
</tr>
</tbody>
</table>

Observations 97 66  97 66  97 66
McFadden's R2 0.15 0.10  0.17 0.12  0.19 0.14

Absolute value of t statistics in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%
REFERENCES


