

# **Information Technology and Process Performance: An Empirical Investigation of the Interaction Between *IT* and *Non-IT* Resources**

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# **Information Technology and Process Performance: An Empirical Investigation of the Interactions Between *IT* and Non-*IT* Resources**

## **ABSTRACT**

Drawing on the resource-based view, we propose a configurational perspective of how IT assets and capabilities affect firm performance. Our premise is that IT assets and IT managerial capabilities are components in organizational design, and as such, their impact can only be understood by taking into consideration the interactions between those IT assets and capabilities and other non-IT components. We develop and test a model that assesses the impact of explicit and tacit IT resources by examining their interactions with two non-IT resources (open communication and business work practices). Our analysis of data collected from a sample of firms in the third party logistics (3PL) industry supports the proposed configurational perspective, showing that IT resources can either enhance (complement) or suppress (by substituting for) the effects of non-IT resources on process performance. More specifically, we find evidence of complementarities between shared business-IT knowledge and business work practice, and between the scope of IT applications and an open communication culture in affecting the performance of the customer-service process. For decision-making, our results reinforce the need to account for all dimensions of possible interaction between IT and non-IT resources when evaluating IT investments.

*Keywords:* IT Business Value; Firm Performance, Organizational Design;  
Resource-Based View, Resource Interaction; Complementarity;  
Third Party Logistics; Supply Chain Management.

## INTRODUCTION

The rapid evolution and adoption of information technology (IT) has catalyzed significant interest among IS scholars and decision-makers as to whether, and if so, how, the anticipated economic benefits of investments in IT are being realized. Although studies (e.g., Brynjolfsson & Hitt, 1996; Menon, Lee, & Eldenberg, 2000) do show that IT spending is associated with increased firm output, early empirical studies examining the relationship between IT investments and firm financial performance report mixed findings. These range from insignificant or negative association (Weill, 1992; Ahituv & Giladi, 1993; Markus & Soh, 1993; Dos Santos, Peffers, & Mauer, 1993; Hitt & Brynjolfsson, 1996), to bi-modal distribution of impacts (Cron & Sobol, 1983; Harris & Katz, 1991), to a positive association between IT investments and firms' Tobin's q values (Brynjolfsson & Yang, 1997; Bharadwaj, Bharadwaj, & Konsynski, 1999). (Melville, Kraemer, & Gurbaxani, 2004, provide a comprehensive review.) Such mixed empirical findings provide equivocal guidance for IT investment decision-making, and are an invitation for better theorizing. Scholars have responded in a number of ways.

One stream of research has focused on building "process-oriented" models of value creation. The supportive argument is that enterprise-level impacts of IT investments can be measured only through their intermediate, process-level contributions, since it is at this level where the first-order effects of IT are often realized (Barua, Kriebel, & Mukhopadhyay, 1995; Mukhopadhyay, Rajiv, & Srinivasan, 1997; Ray, Barney, & Muhanna, 2004). A second stream of research takes a contingency approach by considering other variables that may mediate the payoff from IT (Weill, 1992; Markus & Soh, 1993; Tallon, Kraemer, & Gurbaxani, 2000; Tippins & Sohi, 2003; Ravichandran & Lertwongsatien, 2005) as well as organizational resources and investments complementary to IT (Barua & Whinston, 1998; Brynjolfsson & Hitt,

1998; Powell & Dent-Micallef, 1997; Breshnahan, Brynjolfsson, & Hitt, 2002). More recently, drawing on the resource-based view (RBV) of the firm (Wernerfelt, 1984; Barney, 1986, 1991), scholars have argued that performance differential from IT rests on differences in firm-specific IT capabilities (Mata, Barney, & Fuerst, 1995; Bharadwaj, 2000; Wade & Hulland, 2004; Ray, Muhanna & Barney, 2005). They suggest that the payoff from explicit IT resources (e.g., raw IT spending and generic off-the-shelf hardware and software systems readily available in factor markets) is contingent on the level of valuable, rare, and costly-to-imitate IT capabilities such as shared knowledge. Shared Knowledge is defined as the level of common knowledge and mutual understanding between IT managers and business (line) managers regarding how IT can be used to improve process performance (Ray et al., 2005).

Drawing on the strategy and the organizational design literature, we advance a configurational perspective to the question of IT impact. Our perspective is consistent with all three streams discussed above, and reflects a holistic systems approach. Our basic premise is that IT assets and IT managerial capabilities are components in organizational design, and as such, their impact can only be understood by taking into consideration the *internal system interactions* between and among those IT assets and capabilities and other non-IT components. Consistent with RBV's conceptualization of the firm as a bundle of resources, we argue that the relationship between the resource bundle and performance can be either *additive* or *interactive*. Additive relationships occur when the effects of two resources are independently summed because they lead to the same goal, possibly compensating for each other. *Interactive* relationships occur when the effect of one resource depends on the levels of other resources. Moreover, the interactive relationships between resources can be *synergistic* such as when one resource magnifies the impact of another, multiplying the common effect, or *suppressive*, when

one resource diminishes the potential impact of another. Two resources interact as complements (substitutes) if the marginal benefit of each resource increases (decreases) in the level of the other resource (Poppo & Zenger, 2002; Siggelkow, 2002). The net effect of an IT resource therefore depends on the nature and strength of the interactions it has with other resources in the bundle that makes up the firm.

This general proposition is developed into a set of specific hypotheses, focusing on two-way interactions between two IT resources—one explicit (Generic IT Applications) and the other tacit (Shared Knowledge)—and two non-IT resources (Open Communication and Business Work Practices). Our analysis of data collected from a sample of firms in the third party logistics (3PL) industry provides support for the proposed configurational perspective, showing that IT resources can have both complementary and suppressive effects. More specifically, we find evidence of complementarity between shared knowledge and business work practices (e.g., investments in business-process redesign) and between the scope of sophistication of generic IT applications and open communication. At the same time, we find significant suppressive interaction between shared knowledge and open communication, in explaining variations in the performance of the customer-service process.

For decision-makers, our results confirm the need to account for interaction, whether complementarities or substitutions, between IT and non-IT resources. In particular, firms should consider that shared business-IT knowledge can increase returns from investments in business work practices, and that returns from investments in the scope of IT applications can be enhanced with an open communication culture. However, suppressive interaction suggests that when IT resources primarily support coordination in logistics, an open communication culture may dampen the potential impact of shared knowledge.

Our study makes three important contributions. First, we empirically investigate complementarities between IT resources, especially tacit IT resources, and non-IT resources at the process level. Prior work has been conducted, for the most part, at the firm level, focusing exclusively on the complementarities between explicit IT resources (IT spending or generic systems) and organizational factors. For example, Breshnahan et al. (2002) suggest that firm-level productivity increases when the level of IT spending on computers is accompanied by work reorganization investments. Similarly, Brynjolfsson and Hitt (1998) examine the complementarities between IT spending and “work practices”, and conclude, “organizational practices are important determinants of IT demand and productivity.” In research on the retail industry, Powell and Dent-Micallef (1997) concluded that IT alone does not explain variation in measures of firm performance, but that the advantages gained by some firms can be explained by their ability to combine explicit *technology* (IT) resources with complementary human and business resources. Similarly, Zhu (2004) found evidence of complementarity between e-commerce capability (measured through content analysis of each company’s website) and IT infrastructure, and at the industry level, Mittal and Nault (2008) found indirect effects of IT investment on the productivity of labor and non-IT capital. At the process level, Ray et al. (2005) investigate the differential effects of various types of IT resources and the moderating role of shared knowledge, but did not consider complementarities between IT and non-IT resources.

Secondly, our proposed configurational perspective represents a first step towards a systemic theory of IT impact. It goes beyond the traditional contingency perspective, offering an integrative model in which IT resources, both tacit and explicit, are but components of a bundle of resources that form a complex and interactive system. We argue and empirically demonstrate

that complementarity is but one potential outcome of how IT resources could interact with non-IT resources in the bundle; those resources can interact as *substitutes* as well. Our analysis results in a richer model that can serve as a blueprint for future research concerning the performance implications of IT. For decision-makers, our findings demonstrate that the performance impact of IT resources is shaped and influenced by their interactions with other non-IT resources. Although the RBV places greater emphasis on complementarity, our study suggests that recognition of the possibility of suppressive interaction is of equal strategic significance. Failure to recognize complementary interactions could lead to unnecessary overemphasis on certain categories of investment, whereas failure to take into consideration substitutive interactions could lead to a failure to address redundancies that may dampen the anticipated net impact of some investments. Thus, managers should build such considerations into their strategic decision-making process.

Finally, by testing this perspective in the context of supply-chain management (SCM), we contribute to the SCM literature on the role of IT. Logistics is a central component of supply-chains and the intricate level of coordination facilitated through IT, both at the intra-firm level (in cross-functional processes) and inter-firm level (between buyer and seller), is a critical success factor (Vickery, Droge, Stank, Goldsby, & Markland 2004; Rivard, Raymond, & Verreault, 2006; Danese, 2006; Klein, Rai, & Straub, 2007). Collaborative buyer-customer relationships and integrated partnerships have been gaining in popularity in recent years and have captured researchers' attention as companies search for new strategies in dealing with the unprecedented challenges of the New Economy (Day, 2000; Klein, et al., 2007). In the face of hyper-competition, many are redefining buyer-seller relationships, seeking to integrate essential processes and increase collaboration as a deterrent against market-share erosion. These processes

often require synchronization of activities across multiple parties in intricate business arrangements such as supply-chain partnerships and alliances, and virtual organizations (Vickery et al, 2004).

Third party logistics (3PL) providers represent an important category of supply-chain relationships in which IT plays a critical role in support of complex outsourcing arrangements. Our findings hold direct implications for attaining the “media richness” (Vickery et al, 2004) necessary for efficient process coordination across time and space, by highlighting the need to proactively mitigate potentially confounding effects of process components’ interaction.

Clearly, customer-centrism is an important theme of modern B2B supply-chain arrangements (Day, 2000). In this regard, our analysis also empirically assesses the validity of a basic SCM principle by positing that customer service process performance mediates the relationship between IT resources, including both its direct and (indirect) interaction effect, and firm (financial) performance.

The rest of the paper is organized as follows. Next we discuss how the RBV of the firm provides an overarching theoretical basis for the proposed configurational perspective of IT impact, and we develop a set of hypotheses regarding the two-way interactions between IT and non-IT resources. Then we present the method used to test the hypotheses. We then describe the data, the data collection process and present our results, followed by a discussion of theoretical and practical implications of our findings. Finally, we summarize our conclusions and limitations, and suggest possible directions for future research.

## **THEORY AND HYPOTHESES**

### **Theoretical Framework**

Our theoretical framework adopts the business process as the unit of analysis and draws on resource-based theory to examine which IT resources and capabilities used in the process can generate distinctive advantages. The RBV, which has emerged as a potential integrating paradigm for strategy research, seeks to explain sources of competitive advantage, sustained or otherwise (Wernerfelt, 1984; Barney 1986, 1991; Amit & Schoemaker, 1993). Under RBV, a firm is conceptualized as a bundle of resources with each firm's particular configuration of resources making it unique among competitors (Barney, 1991). In the RBV literature, the term "resource" carries a much broader interpretation than the economic concept of a factor of production. A variety of labels (such as: inputs, assets, capabilities, competencies) have been used to describe the firm's resource endowments. Following Grant (1991), Amit and Schoemaker (1993), and Makadok (2001), we use the label 'resource' in the general sense to indistinctly infer all these concepts. Resources, in turn, can be seen as comprising three distinct sub-groups, namely, tangible assets, intangible assets and capabilities. Thus for our purposes, the term 'capability' is defined as a special type of resource, and it encompasses the firm's capacity to coordinate and deploy resources to affect a desired end (Amit and Schoemaker, 1993).

Although competitive advantage, sustained or otherwise, is often thought of as a firm-level notion, several researchers have identified business processes as the more relevant basic unit, arguing that business processes are the way that firms exploit their resources to implement their strategies (Porter, 1991; Stalk, Evans, & Shulman, 1992; Ray et al., 2004). Our approach is consistent with the broader work on process and process-level advantages as well as the process perspective to the question of IT business value.

Differences in performance are often explained in resource-based logic in terms of the

types of resources that different firms control. According to this logic, resources that are valuable but common can only be a source of competitive parity; resources that are valuable and rare can be a source of temporary competitive advantage; and resources that are valuable, rare, and costly to imitate can be a source of sustained competitive advantage (Barney, 1991). A resource can be rendered imperfectly imitable in the presence of isolating mechanisms, such as path dependence, causal ambiguity, social complexity and team-embodied skills (Rumelt, 1984; Barney, 1991).

Focusing on IT, RBV suggests that IT can influence the ability of processes within a firm to generate competitive advantages in at least three ways. First, if a firm possesses valuable, rare, and costly to imitate IT resources, the application of those resources to information/coordination intensive processes in a firm can generate process-level competitive advantages, even if there are no other sources of competitive advantage involved in these processes. In this case, IT resources, per se, are likely to explain variation in performance. Second, even if a firm's IT resources are not a source of distinctive advantage, if these resources are used to realize the full competitive potential of non-IT resources that are valuable, rare, and costly to imitate, then IT can enable a firm to gain competitive advantages. For this reason, any effort to study the competitive implications of IT should also include non-IT determinants of competitive advantage, especially those resources whose use is facilitated or enhanced by IT resources. This is consistent with Amit and Schoemaker's (1993) notion of complementary relationships affecting the value of a resource, and that the effects of IT depend on its "complementary" or synergistic relationship with other non-IT resources (Powell & Dent-Micallef, 1997; Barua & Whinston, 1998; Breshnahan et al., 2002; Zhu, 2004). Finally, a firm that has valuable, rare, and costly to imitate IT resources may be able to apply these resources to

realize the full competitive potential of resources that are also valuable, rare, and costly to imitate. In this context, IT resources can have both a direct and indirect effect on the ability of a firm to gain distinctive advantages.

Our proposed configurational perspective goes beyond the recognition of potential *positive* interaction between IT and non-IT resources. Specifically, following Black and Boal (1994), we believe that in order to fully understand IT's performance implications, it is necessary to open the "black box" of the organization and consider the system configuration (bundle of resources) in which IT resources are embedded and the nature of relationships between the resources that make up the resource bundle. Black and Boal (1994) note that inter-resource relationships could take one of three forms: compensatory, enhancing, or suppressing/destroying. A *compensatory* relationship exists when a change in the level of one resource is offset by a change in the level of another resource. An *enhancing* relationship exists when one resource magnifies the impact of another resource. A *suppressing* relationship exists when one resource diminishes the impact of another. Enhancing relationships do not require the mutual dependency implied in the notion of Complementarity and may be unidirectional or asymmetric. Focusing on suppressing relationship, we argue that resource-based logic also suggests, albeit indirectly, that the value of IT resources (even those that are valuable, rare and difficult to imitate) may be *diminished* in the presence of some other non-IT resource that functions as a substitute. Conversely, the value of a non-IT resource may be diminished by the presence of an IT-resource that acts as a replacement in accomplishing the same objective. Thus, while an IT resource may have a direct positive effect, the net effect of that resource depends on the type and strength of its interactions with other resources in the bundle that make up the firm.

## Hypotheses

To test our proposed configurational perspective, we focus on two types of IT resources and their two-way interaction with two non-IT resources. We first discuss their potential direct effects and then examine potential two-way interaction effects.

An examination of the literature has led to the identification of two categories of IT resources that may influence process performance. The first category of resources is represented by generic IT applications (Mata et al., 1995; Powell & Dent-Micallef, 1997; Ray et al., 2005). Generic IT applications refer to the set of well-known hardware and software computing technologies in an industry that are available from factor markets and understood to have a positive impact on the performance of specific processes. As such, these resources are valuable as they may improve performance of specific processes. However, they are neither rare nor difficult to imitate, and as such they are not likely to be directly associated with above average process performance. For example, Powell and Dent-Micallef (1997) in their study of the retail industry found that generic IT like point-of-sale terminals and EDI with suppliers did not have a significant impact on performance. We therefore do not expect to be able to reject the following *null* hypothesis:

*H1a: Generic IT applications used to support a process do not explain variance in process performance.*

The second category of IT resource is represented by shared knowledge (Boynton, Zmud, & Jacobs, 1994; Ray et al., 2005), an *IT managerial capability* that influences how the first category (generic IT resources) are deployed and used in support of a process. As Ray et al. (2005) notes, there is considerable evidence to suggest that shared knowledge—*the level of common knowledge and understanding between the IT and the line managers regarding how IT can be used to improve process performance* - is a critical factor in successful utilization of IT in

the pursuit of business objectives (Rockart, 1988; Henderson, 1990; Mata et al., 1995; Ross, Beath, & Goodhue, 1996). Shared knowledge has been linked to increased levels of IT use (Boynton et al., 1994), increased operational and service performance of the IS group (Nelson & Coopriider, 1996), increased IT assimilation in value-chain activities and business strategies (Armstrong & Sambamurthy, 1999), and improved process performance (Ray et al., 2005). Accordingly, we posit the following direct effect:

*H1b: The level of shared knowledge is positively associated with process performance.*

Existing literature also identifies two general categories of non-IT resources that are likely to influence performance: *human resources* and *business work practices* (Powell & Dent-Micallef, 1997).

The prevailing culture of an organization can offer a competitive advantage through its “causal ambiguity,” which renders it difficult to recreate (Reed & DeFillippi, 1990). We focus on the impact of one dimension of human resources: openness of communication. An environment of open communication is highly conducive to ‘learning,’ a high-value trait (Fiol & Lyles, 1985) critically important for enhancing performance. Learning requires experimentation, unlearning of past methods and encouraging multiple perspectives and debate. Such activities must be nurtured proactively and are squarely the responsibilities of executive management. Successful companies foster a desire for knowledge among employees and ensure its continual creation, distribution and application (Hauschild, Licht, & Stein, 2001). Open communication can foster closer ongoing collaboration among the various functional interests of an organization, sparking more innovative approaches to finding solutions and developing strategies, an increasingly important element of world-class 21<sup>st</sup> century companies (Rockart & Short, 1989). The trust and interpersonal relationship required for open communication can take years to

evolve, thus an open communication culture is often a path-dependent and socially complex resource. To the extent that this dimension of corporate culture is valuable and heterogeneously distributed across firms, it can be a key differentiator of process performance as it is not subject to low-cost imitation. These observations lead to the following hypothesis:

*H1c: The degree of open communication is positively associated with process performance.*

The second non-IT resource we consider is business work practices, which refer to a set of practices such as team-orientation, bench-marking, and business-process redesign (Powell & Dent-Micallef, 1997). Like generic IT applications, business work practices may be valuable in the sense that they increase the *absolute* level of performance of a process. Investing in such a resource, however, does not necessarily improve the *relative* performance of this process across competing firms. Whether valuable resources explain variance in the performance of a process across competing firms depends on how rare and costly to imitate these resources are.

Accordingly, while valuable, such practices are neither particularly rare nor difficult to imitate and, as such, by themselves, they are not likely to be direct sources of distinctive advantage.

Thus, we do not expect to be able to reject the following *null* hypothesis:

*H1d: Business work practices, per se, do not explain variance in process performance.*

Consistent with our theoretical framework, when combined with IT managerial capability (shared knowledge), a valuable and rare IT resource, business work practices can lead to the creation of superior firm-specific processes. Thus, we hypothesize a *positive interaction* effect between business work practices and shared knowledge.

*H2a: Shared knowledge and business work practices function as complements (i.e., positively interact) in explaining process performance.*

However, combining business work practices with a common IT resource (generic IT applications) readily available in the factor market is not likely to yield distinctive advantage. Thus, we do not expect to be able to reject the *null* hypothesis of *no interaction* effects between generic IT applications and business work practices.

*H2b: Business work practices combined with generic IT applications do not create advantages that explain variance in process performance.*

On the other hand, as noted earlier, even if a firm's IT resources, such as generic IT, are not, per se, a source of distinctive advantage, if these resources are used to realize the full competitive potential of non-IT resources that are valuable, rare, and costly to imitate, such IT resources can enable a firm to gain competitive advantages. Accordingly, we expect that generic IT applications are capable of helping the firm to realize the full-potential of an open communication culture, itself a source of distinctive advantage. We therefore posit a complementary (positive) interaction between those two resources.

*H2c: Generic IT applications and open communication function as complements (i.e., positively interact) in explaining process performance.*

Both open communication and shared knowledge are strategic resources that share a common goal, namely, enhancing the organization's coordination capacity, which in turn impacts process performance. As such, these two resources are likely to serve as substitutes. In general, two resources serve as substitutes when more of one makes more of the other less valuable (Poppo & Zenger, 2002; Siggelkow, 2002). In this particular case, to the extent that the two resources lead to the accomplishment of the same goal, an open communication culture diminishes the need for, and hence, the payoff of shared knowledge. Conversely, the payoff (in terms of enhanced coordination and hence improved overall process performance) of open

communication may be diminished in organizations with superior shared knowledge, since those organizations already have a capability to conceive, implement and deploy IT applications to achieve the desired level of coordination. Accordingly, we posit a negative (suppressive) interaction effects between these two resources.

*H2d: Shared knowledge and open communication function as substitutes (i.e., negatively interact) in explaining process performance.*

### **The Link between Process Performance and Firm Performance**

Since a firm may excel in some of its business processes, be only average in others, and be below average in still others, overall performance depends on, among other things, the net effect of these business processes on a firm's position in the market place (Ray et al., 2004). However, to the extent that a given process is strategic for a given industry, it is likely that performance of that process is the most salient determinant of firm performance. We focus on the customer service process in the 3PL industry (more on that in the next section), and researchers have highlighted the centrality and strategic importance of customer service (Cooper, Lambert, & Pagh, 1997; Lambert, Stock, & Ellram, 1998; Naude, Holland, & Sudbury, 2000; Sterling & Lambert, 1998). Prior research suggests that establishing and maintaining close relationships with one's most valued customers is fundamental to the economic well-being of the firm and a leading indicator of future financial performance (Rinehart, et al., 1989; Fornell et al., 1996). Retention of valued customers is cost-efficient, but also provides a disproportionate boost to overall profits (Reichheld & Sasser, 1990; Reichheld et al., 2000; Copacino, 2001). Satisfied customers could even help to attract new customers (Innis & La Londe, 1994). Research also suggests that customer satisfaction is an essential precursor to any effective long-term marketing strategy and that customer retention is key to long-term profitability (Szymanski & Henard, 2001). Reflecting the centrality of customer service process in the 3PL industry, we hypothesize

the following:

*H3: Customer service process performance is positively associated with financial performance.*

The resulting research model is depicted in Figure 1.

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Insert Figure 1 about here  
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## **RESEARCH METHODOLOGY**

In this section, we present our research plan for testing the above hypotheses. Our empirical analysis is based on the performance of the customer service process in the 3PL industry. We adopt the industry definition of customer service as “a selection of value-adding activities encompassing buyer, seller and possibly a third party, before, during or after a transaction” (Londe, Cooper, & Noordeweir, 1988). These activities can be either short-term, involving only one transaction, or a longer-term relationship governed by a contractual agreement.

This particular business process was chosen for several reasons. First, the logistics industry, because of its information intensity, has historically been amongst the largest investors in IT. Second, in the highly competitive 3PL industry, customer service is widely seen as being strategically important (Sterling & Lambert, 1998). Third, IT is a critical tool for providing customer service personnel with the information they need to deliver quality service (Leigh & Marshall, 2001; Liang & Tanniru, 2007). Fourth, in this industry there is a high level of variance in the reported ability of firms to satisfy their customers, suggesting that some firms may experience competitive advantages (or disadvantages) in executing this business process. This makes it possible to test the model at the level of an important business process.

3PL providers contractually manage the logistics functions of clients, providing support that extends well beyond traditional trucking and warehousing services (Coyle, Bardi, & Langley, 2003). These are companies that have successfully positioned themselves as business-process outsourcers, capable of handling the back-end processes of a client after an order has been received. As an industry based on supply-chain outsourcing, 3PL providers' existence depends on *reliability* and *responsiveness*. The competitive advantages of 3PL alliances include a reduction in inventory normally used as a buffer against economic shock and improved customer service through shared operational transparency, joint planning and coordination. Reduced inventory frees up financial resources for pursuing other strategic goals; improved order-fulfillment can shorten cash-to-cash cycles, thereby reducing accounts receivables and improving liquidity. These benefits largely depend on the strategic deployment of IT. Some practitioners even argue that among the critical factors shaping the logistics field supply-chains arrangements are secondary in importance to IT (Thomas & Griffin, 1996; Bradley, 1996). While 3PL firms perform services on behalf of their clients, the ultimate concern of both parties is the net value delivered to the end consumer.

### **Measures**

A survey instrument was designed to elicit information about all the variables. Wherever possible, existing, previously validated scales were used (Appendix I).

***Generic IT Applications (T)***: The 3PL respondents in this study provide a variety of support services, which is characteristic of this industry, so that the range of IT applications offered clients as sub-specialties of the firm is an important strategic consideration. To determine which technologies to include in the construct *IT Applications*, we used Armstrong & Associates Third-party Logistics Directory – “Who’s Who in Logistics.” This annual publication provides a

detailed profile of the major players of the industry, including the range of IT applications they have deployed. Eighteen IT applications were identified as critical according to this directory, and were used to measure the IT applications resources of each firm. We used a Likert scale to measure the extent to which each of the eighteen IT applications had been implemented at the time of the survey.

Recognizing that the “menu” of 3PL services provided was strategically significant, we explored several methods for converting the survey responses to a scale that measures both the range of services as well as the level of implementation for each group of IT applications. After lengthy consultation with other academic researchers and detailed explorations of each alternative, we segmented the responses into categories based on an identifiable grouping of the eighteen IT applications. Five such categories were identified as listed below with their individual IT applications. The item scores for each group of applications were summed and *standardized* and used as the measure of the firm’s IT applications for each category. These five category measures were represented in our model as indicators of the latent construct *IT Applications*. Each category comprises 3-5 individual applications (see Appendix I):

1. *Warehousing and Transportation (WhT – items T1, 2, 7)*: This category is comprised of warehousing management systems, transportation management systems, and integrated warehousing and transportation management systems software. These software suites provide the ability to automate and manage warehousing space as well as the material flow into and out of the facility. Warehousing and transportation are widely viewed as mutually providing inherent opportunities for economies of scale in logistics, hence the logic for combining both categories of services.

2. *Customer interaction (CI – items T3, 8, 13)*: This category comprises IT resources that

can facilitate more intricate levels of interaction between participants in a supply-chain setting. These include customer relationship management, demand and supply forecasting, and Internet-based customer access (via web portals).

3. *Network and Process Modeling (NPM –items T4, 11, 14)*: This category comprises network modeling related resources - transportation optimization, network modeling and Enterprise Resource Planning interface.

4. *Data Exchange (DE –items T5, 6, 10, 15)*: These IT applications facilitate data exchange and paperwork reduction, a growing concern among logistics firms - freight billing, automated broker interface, paperless logging and electronic data interchange (EDI).

5. *Visibility and Tracking (VT – items T9, 12, 16, 17, 18)*: These IT applications enhance transparency and visibility in inventory movement and related financial transactions. Worldwide tracking and tracing, global visibility, bar-coding, radio frequency and satellite vehicle communication fall into this category.

***Shared Knowledge (S)***: The construct, *Shared Knowledge*, was measured using the scale developed by Ray, et al (2005). Three items were used to measure “IT Manager’s Knowledge” and a corresponding 3 items used to measure the “line-Managerial IT Knowledge” side of the dyad.

***Open Communications (O) and Business Work Practices (B)***: The items used to measure the independent constructs *Open Communications* and *Business Work Practices* were drawn from the instrument previously developed and utilized by Powell and Dent-Micallef (1997).

***Customer-service Process Performance (CSP)*** - our intermediate dependent variable, is an adaptation of the original dual performance constructs – relational and operational performance – used by Stank et al. (1999) to measure customer perceptions of logistics service providers’

performance in the fast foods industry. Their constructs were reportedly developed from service elements and priorities previously identified by Roth and van der Velde (1991) and the SERVQUAL scale (Parasuraman, Zeithamel & Berry, 1985), and had been utilized for similarly-focused research both in service and manufacturing before being adapted to the logistics industry. The indicators retained are the results of a *post hoc* factor analysis and capture the two most elementary dimensions of customer service: *reliability*, which is basic customer service, centered on order-cycle time, on-time delivery and inventory availability, and *responsiveness* to customer issues and requests (Maltz & Maltz, 1998). Although reliability has been shown to vary with industry, responsiveness is often viewed as strategically significant, particularly in a global market, where it is often more important to provide localized customization than to provide efficient levels of homogeneous service (Harrigan & Dalmia, 1991; Fornell, et al., 1996).

***Financial Performance (FP)***: The second dependent construct, *FP*, was measured using a (composite) scale adapted from Powell & Dent-Micallef (1997). Such subjective measures are widely used in organization research (Dess, 1987; Powell, 1992). They reflect the assumption that senior executives are capable of assessing the relative performance of their firm compared to key competitors. Furthermore, many of the firms in this industry are privately owned making it virtually impossible to acquire financial data from a third source.

### **Questionnaire Testing**

The quality of self-reports is largely a manifestation of the quality of the survey instrument (Liang, 1988; Spector, 1994; Howard, 1994). In addition to using previously validated scales, both a pre-test and a pilot test were conducted to validate the instrument and identify any weakness in the survey questionnaire. For the pre-test, a group of faculty members initially

examined the survey instrument. They were asked to suggest additions, modifications, and/or deletions to the questionnaire, and to comment on the length and clarity of each item. Their suggestions were incorporated into the final questionnaire. The instrument was then pilot-tested using a small group of 3PL executives and consultants. The pilot-test results confirmed the revised questionnaire.

Another safeguard used was to pose questions regarding the main dependent construct, *CSP*, before those related to the independent constructs, in order to minimize the possibility of common method variance. Various diagnostic tests (discussed later in Section 4) supported assumptions regarding data integrity and consistency.

## **DATA COLLECTION AND ANALYSIS**

### **Sample Selection and Questionnaire Administration**

Initially, 350 surveys were mailed to a database of contacts obtained from a SCM research center contact database, allowing the options of either mailing or faxing the response (self-addressed, prepaid enveloped was enclosed). Respondents were expressly assured that their responses would be kept confidential. In an effort to increase the response rate and lower potential non-response bias, a modified version of Dillman's (1991) methodology was followed. Along with careful design and pilot testing of the instrument, these included careful wording of the cover letter, addressing respondents by name when possible, and immediately following-up on undelivered questionnaires by calling companies to verify addresses or names. Three weeks later, a follow-up letter was sent which did not include an actual copy of the survey, but instead directed the respondent to a website which provided the option of either completing the survey online, or downloading a copy from a PDF file that could either be mailed or faxed in, once

completed. Many of the respondents were also contacted by telephone and e-mail, requesting their assistance through participation. Three weeks later a second follow-up letter, duplicating the first, was mailed. The overall response rate was roughly 12.3% (44 responses), so it was decided to extend the original database of contacts.

An additional 150 respondents were identified from 3PL directories available on the Internet, including LogLink, Business.com and Leonard's Guide Online. Based on the information provided on their websites, we selected only those companies that reportedly generated in excess of \$1M annual revenue and that identified themselves as 3PL providers. These companies were then contacted, replicating the procedure used for the initial survey. The response rate was roughly the same – 13.3% (20 responses) - yielding a total of 64 responses, or an overall response rate of 12.8%. Of these, 22 (35%) were received online, 8 (13%) were received via fax, and 34 (53%) by regular mail. The respondents vary in terms of size, which is a characteristic of the industry. Fifty-seven percent (57%) of the respondents were companies with less than 100 employees; 30% had employees numbering between 100 and 1,000, and 13% had employees numbering over 1,000 employees. Overall, 53 (87%) of the total responses were companies with less than 500 employees which fit the U.S. Congress' numerical definition of a small business. The remaining 13% captured many of the recognized leaders in the industry. Generally, we targeted high-level officers of the firms, requesting in our cover letter that they assign someone who they felt would be most knowledgeable in responding to the survey. A breakdown of the respondents by position and title is provided in Table 1.

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Insert Table 1 Here  
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Based on the statistic DFITS, one outlier was identified and subsequently dropped from

the initial sample. Two other observations were dropped, one because of incompleteness and the other because two responses were received from the same company. In this latter case, the corporate office's response was favored over the regional office. These corrective measures resulted in a usable sample of 61 responses. Small businesses surveys are notorious for their low response rates (Dennis jr., 2003) as are surveys involving senior executives. Moreover, the anthrax scare and geo-political conflict in the wake of the "9-11" tragedy, undoubtedly exacerbated this problem at the time the data was collected in 2003 (Birnkranz & Callahan, 2002). Nevertheless, the response rate is comparable to other studies involving surveys of senior executives, and as will be discussed in the next section was deemed adequate for the purpose of statistical analysis. (Sivo, Saunders, Qing, & Jiang (2006) report response rates ranging from 7% to 93.3% for articles published in ISR, and 5.7% to 100% for articles published in MISQ between 1998 and 2002.)

### **Representativeness of the Sample**

Non-response bias is always a concern in survey research (Fowler, 1993). Wave analysis was employed to investigate whether a self-selection bias exists such that units/firms with certain characteristics were more likely to respond to the survey. Wave analysis gauges non-response bias by comparing initial respondents against those who responded after follow-up activities, and is based on the observation that in mail surveys, non-respondents tend to be more similar to late respondents than to early respondents (Fowler, 1993). Comparisons of means and correlations for respondents to the first mailing and respondents to the second mailing reveal that the two groups do not differ significantly in either the level of the variables or in the relationships between the variables. These results suggest that non-response bias is not a problem in the data.

## **Data Analysis**

Data analysis was performed using Partial Least Squares (PLS), a structural equation modeling technique that uses a component-based approach to estimation. The advantages of PLS relative to both first generation multivariate methods like multiple regression and covariance-based structural modeling approaches (exemplified by software such as LISREL) are well documented in the literature (Wold, 1985; Falk & Miller, 1992; Barclay, Higgins, & Thomson, 1995; Chin, 1998; Chin & Newsted, 1999). Like other structural modeling techniques, PLS provides for the simultaneous assessment of the reliability and validity of the measures of theoretical latent constructs (the measurement model) and the estimation of the relationships among those constructs (the structural model) (Wold, 1985; Chin & Newsted, 1999). By contrast, when using first generation multivariate methods (e.g., multiple regression, factor analysis), measurement and structural model assessments are performed in two separate steps, with scale items being aggregated (e.g., summed or averaged) into single scores for the latent variables at the end of the first step. This two-step process, in which item aggregation is performed outside of the theoretical context in which the aggregated score is subsequently used, masks measurement error and can lead to suboptimal estimates relative to structural modeling approaches like PLS (Chin, Marcolin, & Newsted 2003). During the last decade, PLS has gained favor among management researchers, especially in the IS area, in large part because, unlike covariance-based approaches, PLS places minimal demands on measurement scales, sample size, and distributional assumptions (Fornell & Bookstein, 1982; Wold, 1985; Falk & Miller, 1992; Chin 1998; Chin & Newsted, 1999).

Brown and Chin (2004) list three reasons for choosing to use PLS in their study, all of which strongly apply in the context of our study: “First, this study was primarily intended for

causal-predictive analysis, a condition for PLS suggested by Chin and Newsted (1999) and Joreskog and Wold (1982). Second, PLS requires fewer statistical specifications and constraints on the data than the covariance-based strategy of LISREL (e.g., assumptions of normality). Finally, “PLS is robust for small to moderate sample sizes” (Cassel, Hackl, & Westlund, 2000) (p. 538). Additionally, one of the constructs in our model (Generic IT Applications) is formative and cannot be adequately modeled using covariance-based approaches due to the assumptions they impose; PLS, being component-based, flexibly accommodates both formative and reflective indicators (Chin, 1998). Except for the generic IT applications, modeled formatively, the indicators of the latent constructs were modeled reflectively, according to the recommended guidelines (Jarvis, Scott, & Philip, 2003; Chin et al., 2003).

Although there is universal agreement among researchers that the larger the sample the more stable the parameter estimates, there is no agreement as to what constitutes an adequate sample size. Regarding PLS, the technique we use in our study, Chin et al. (2003) note the following:

“As a consequence of using an iterative algorithm consisting of a series of ordinary least squares analyses, identification is not a problem for recursive (i.e., one way path) models nor does it presume any distributional form for measured variables. Furthermore, sample size can be smaller, with a standard rule of thumb suggesting that it be equal to the larger of the following: (1) ten times the number of indicators for the scale with the largest number of formative (i.e., causal) indicators (note that scales for constructs designated with reflective indicators as specified in this study can be ignored), or (2) ten times the largest number of structural paths directed at a particular construct in the structural model. A weak rule of thumb, similar to the heuristic for multiple regression (Tabachnik and Fidell, 1989, p. 129), would be to use a

multiplier of five instead of ten for the preceding formulae. An extreme example is given by Wold (1989) who analyzed 27 variables using two latent constructs with a data set consisting of ten cases. For more details, see Chin and Newsted (1999).” [Appendix A, p. 5]

As noted later in the paper, we used PLS to estimate two models: a main-effects model and a full model with interaction terms. Our sample size of 61 cases is more than adequate for the main-effects model, comfortably satisfying even the more stringent “10 times” suggested guideline noted above: there is only one formative construct (T) with five indicators and the largest number of paths directed at an endogenous construct is five ( $5 * 10 = 50 < 64$ ). The largest number of structural paths directed at a construct in the full model is nine. Based on the above guidelines, the sample size requirement would be between 45 ( $9*5$ ) and 90 ( $9*10$ ). Our sample size of 61 falls within this range. Importantly, as will become evident in the results section, our sample size was adequate to detect significance of all interactions posited to have an effect, and as such, statistical power should not be a concern in this study despite the modest sample size.

We conducted our analyses in two stages. First, we tested the measurement model to ensure that the constructs had sufficient psychometric validity, then addressed the structural model in which the hypotheses were tested.

### **Assessment of Measurement Model**

The reliability and validity of the constructs can be demonstrated through measures of internal reliability, convergent, and discriminant validities. Evidence of internal reliability of the examined constructs was obtained by estimating composite reliability. A composite reliability of 0.70 or greater is acceptable for social science research (Chin, 1998). Table 2 provides

descriptive statistics about the latent variables including reliability scores, all of which are above 0.70. Convergent validity is confirmed by verifying that the correlations between the indicators and the latent variable that they represent are greater than the correlation between the items and any other latent variable (Gefen & Straub, 2005). Further evidence of discriminant and convergent validity is obtained by examining the diagonal elements (which represent the square root of average variance extracted - AVE) of the correlation matrix shown in Table 3. The square root of the average variance explained by each latent variable is greater than the correlations between that latent variable and other latent variables in the model, demonstrating discriminant validity (Chin, 1998). Collectively, the evidence suggests that the constructs demonstrate adequate measurement properties.

Harman's single-factor test was used to test for common method bias (Podsakoff & Organ, 1986; Jarvis, Scott, & Philip, 2003). According to this approach, significant common method variance is evident if a single factor emerges as the results of a principal component analysis, or one factor overwhelmingly accounts for the majority of covariance among the variables in an unrotated factor analysis. The results showed seven factors with eigenvalues greater than one, with the first accounting for 35% of the total variance.

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### **Assessment of the Structural Model**

Analysis of the structural model for the purpose of hypothesis testing includes estimating the path coefficients, which indicate the strengths of the relationships between the dependent and

independent variables, and the  $R^2$  value, which indicates the amount of variance explained by the independent variables. As is customary, a bootstrap re-sampling procedure (300 resamples) was used to test the significance of the path coefficients (Chin, 1998).

We assessed our structural model using two stages of analysis: first, to test hypotheses 1a-d concerning main effects, we estimated a model with CSP as the dependent variable and only first-order terms (the four latent variables) as the independent variables. Size, measured in terms of the log of the number of employees, was also included as a control. The results are shown in the first row of Table 4. The model with only the main effects included explained 43.9% of the variance in CSP, with two out of the four main effects being significant. Consistent with our expectation, neither IT applications (H1a) nor business work practices (H1d) explained variation in CSP. The (path) coefficient for shared knowledge, however, is positive and significant ( $p$ -value  $< 0.05$ ). Thus, hypothesis 1b is supported by the data. Similarly, the coefficient on open communication is positive, albeit weakly significant. Thus, hypothesis 1c is weakly supported by the data.

In the second stage, we tested our hypotheses on the interaction between IT and non-IT resources (H2a-d) using the full model, by introducing four interaction terms into the PLS model as per the guidelines suggested by Chin et al. (2003), one for each hypothesis. Each interaction latent variable (term) was measured using as indicators the cross product of the (standardized) measurement items for the individual (first-order) constructs. The results are shown in the second row of Table 4. The inclusion of the interaction terms explained an additional 31.4% of the variance in CSP, for a total of 75.3% of explained variance. An  $F$ -test confirmed that this increase in explained variance is highly significant (Cohen, 1988; Chin et al, 2003). This further

highlights the need, consistent with our configurational perspective, to take into consideration interaction effects in empirical tests of IT impact.

As hypothesized, three out of the four interaction terms are significant. The coefficient on the interaction term involving shared knowledge and business work practices was positive and significant, suggesting a complementary (enhancing) relationship. Hypothesis H2a is, therefore, strongly supported by the data. On the other hand, the interaction of IT applications and business work practices was insignificant, consistent with our expectation (H2b). The coefficient on the interaction term involving IT applications and open communication was positive and weakly significant. Hypothesis H2c therefore receives only moderate support. Further, consistent with H2d, the coefficient on the interaction term involving shared knowledge and open communication is negative and significant, suggesting a suppressing relationship. In other words, the value-adding potential of shared knowledge is diminished in organizations with higher levels of open communication. Hypothesis H2d is supported, therefore, by the data. Finally, the path coefficient between CSP and financial performance is positive and highly significant in both the main-effects model and the full model.

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Insert Figure 2 here  
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Insert Table 4 here  
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## **DISCUSSION**

Our results provide strong support for our proposed configurational perspective of IT impact. Consistent with RBV expectations, our main-effects analysis shows that tacit, socially complex resources such as shared business-IT knowledge and open communications explain variation in

process performance while explicit resources such as generic IT applications and common business work practices do not, on average, explain variation in process performance across firms.

Our findings, however, demonstrate that both explicit and tacit IT resources (i.e., both infrastructure and managerial IT capabilities) are likely to be more value-adding in some firms than others, and that both their impacts can only be fully understood by taking into consideration their interaction with non-IT resources in the bundle of resources that make up the firm. More specifically, we find evidence of a positive interaction effects between shared knowledge (a tacit managerial IT capability) and business work practices, and between generic IT applications (an explicit IT resource) and open communication. This provides support for our contention that (a) the impact of tacit, socially complex IT resources (such as shared knowledge) can be further enhanced when coupled with appropriate non-IT resources, even explicit ones, since it is through such superior IT resources that explicit non-IT resources can be made firm-specific; and (b) even if a firm's explicit IT resources are not, in and of themselves, a source of distinctive advantage, when used to realize the full coordinative potential of tacit non-IT resources such as an open communication culture, these explicit IT resources can enable a firm to gain competitive advantages. This suggests that in the 3PL industry where firms depend heavily on IT, managers should be aware that IT applications do not automatically merge with processes (Rai, Patnayakuni, & Seth, 2006). Instead, lower-order technology capabilities must be focused and leveraged to enable higher-order process integration capabilities. Thus, extra care is needed to integrate IT applications with business process to ensure positive payoffs.

Our analysis also highlights the important role of shared knowledge as a key differentiator. Capable managers who are knowledgeable about both IT and its potential for

leveraging various aspects of the business model are critically important. In addition to its positive direct impacts on CSP, shared knowledge has substantial indirect impact through its influence on non-IT resources, interacting with business work practices, in particular, to improve the availability of information for coordinating and enhancing CSP. Thus, shared knowledge and business work practices are complements.

By contrast, we find significant suppressive interaction between shared knowledge and open communication in explaining variations in CSP. This suggests that higher levels of communication openness among employees can effectively dampen the net impact of improved coordination that would otherwise be attained through an increase in shared knowledge. While IT resources, both explicit and tacit, are essential to supporting more intense forms of communication and information-sharing, more traditional linkages such as face-to-face dialogue and employee-employee contact remain the staple core of learning models of control and are believed to be more capable of withstanding the complexity, turbulence and fluidity of today's business environment (Simon, 1995).

The implications are similar to the long-held premise that proliferation of computers would reduce the need for mid-level managers (Crowston & Malone, 1988; Bertschek & Kaiser, 2004). Argyres (1999), in his case study of the B-2 "Stealth" Bomber project noted that IT can substitute for many functions of an organization's bureaucracy and that effective coordination across teams as facilitated by IT can limit the need for hierarchical authority. These results deliver the important caveat that developing IT applications to assist in coordination require an appreciation for the underlying characteristics of each IT application and how it interacts with the business environment in which it is being utilized. Managers should be mindful of the fact that the complementarities so heavily emphasized in RBV have to be proactively engineered,

reducing possibilities for redundancies and conflicts as new resources are introduced into the firm (Rathan, Mahajan & Whinston, 1995).

Finally, our analysis shows that CSP mediates the impact of IT on firm performance. This lends additional support to the notion that IT impact should be examined at the process level, where its first-order effects are often realized. The significant correlation between our process-level variable (CSP) and firm-level measures of (financial) performance also provides support for the view that long-term viability and success of the firm can be enhanced by its ability to nurture close relationships with its customers, specifically in the 3PL industry where customer service is regarded as strategically important.

## CONCLUSIONS

The findings of this study suggest that the relationship between IT assets/capabilities and firm performance is more complex than scholars have previously theorized. More specifically, our analysis supports our proposed configurational perspective in which IT assets and IT managerial capabilities are viewed as components in organizational design, and the argument that their impact can only be understood by taking into consideration the *internal system interactions* between and among those IT assets and capabilities and other non-IT components that make up the firm's bundle of resources. Our analysis further shows that the interactive relationships between resources can be *synergistic* (when one resource magnifies the impact of another, multiplying the common effect) or *suppressive* (when one resource diminishes the impact of another).

Our analysis of the proposed configurational perspective contributes to the literature investigating the performance implications of IT in a number of ways. First, it offers an

explanation for the seemingly conflicting findings in the extant literature regarding IT impact. Second, from a theoretical point of view, we have argued for a more systemic theory of IT impact, one that goes beyond the contingency perspective, offering an integrative model in which IT resources (both tacit and explicit) are but components of a bundle of resources that form a complex and interactive system. The result is a richer model that can serve as a blueprint for future research concerning the performance implications of IT. Finally, our study adds to the growing body of work that expands and empirically tests the RBV in the context of IT, further demonstrating its utility as a theoretical lens.

For decision-makers, our findings reinforce the need to take a more holistic view of IT impact. Firms should consider their unique bundle of non-IT resources before making the case for and adopting the latest IT. An improved understanding of how those resources interact may help firms determine which aspects of the organization stand to benefit the most from investments in IT and act proactively to reduce conflicts and redundancies. For example, in contextual settings where the primary aim is to enhance process coordination, managers should recognize that the value-adding potential of superior IT managerial capability is likely to be smaller in firms already endowed with an open communication culture. Furthermore, IT interaction dramatizes, in a way, the significance of the of supply-chain theoretical perspective, which propagates that the firm should be viewed *not* as a collection of functional “silos” but as a series of cross-functional processes, oriented laterally – as opposed to vertically – across its organizational fabric. Furthermore, doing so facilitates the introduction of an important group of stakeholders that exists beyond the firm’s traditional boundaries, but is, nevertheless, central to any discussion regarding firm performance – namely, the customer. The supply-chain paradigm continues to grow in popularity and practice, as businesses seek new responses to the challenges

of globalization and the resultant hypercompetitive business environment. IT remains the cornerstone of these inter-organizational systems facilitating closer ties being forged with customers. In this light, our lateral process-level approach to examining how IT can contribute to firm performance is timely and as demonstrated by our findings, an important dimension to consider when measuring returns from IT investments.

Like all empirical research, our study is not without limitations. First, while a larger sample size would provide us with greater confidence regarding the generalizability of our findings, the diagnostics used throughout the analysis did not reveal any cause for concern regarding overall data quality or the representativeness of our sample, and our findings are all consistent theoretical expectations despite the modest sample size. Second, while our analysis show that the impact of IT resources is contingent on the level of other non-IT resources in the firm endowment, our data set and cross-sectional research design do not allow us to address the question of causality; we are able only to establish associations. A longitudinal study would be needed to directly address the question of causality and sustainability. Finally, we have focused exclusively on examining two-way interactions between IT and non-IT resources. Our configurational perspective suggests that the interactions may be even more complex. Further, from a methodological perspective, we have argued that efforts to study the competitive implications of IT should also include non-IT determinants of competitive advantage. As such, another fruitful avenue for future research is to examine, in different process and industry contexts, the complex (higher-order) interactions, not just between, but also among IT and non-IT resources.

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## APPENDIX A: MEASUREMENT SCALES ITEMS

For all items Likert Scale ranges from 1 (strongly Disagree) to 7 (Strongly Agree)

### SECTION 1: PERFORMANCE

#### **Customer-Service Process Performance (CSP)** – Adopted from Stank et al, 1999

- CSP1 Our customers are pleased with our record of delivering on time *as promised*.
- CSP2 Our customers are pleased with our record of delivering on time *as requested*.
- CSP3 Our customers are pleased with our record of completing tasks or projects as contracted.
- CSP4 Our customers always receive our deliveries in good condition.
- CSP5 We efficiently resolved errors, disputes and complaints from our customers.
- CSP6 Our customers think our office personnel are responsive.

#### **Financial Performance (FP)** – Adopted from Powell and Dent-Micallef, 1997

- FP1 Over the last 3 years, our financial performance has been outstanding compared to our leading competitors.
- FP2 Over the last 3 years, our financial performance has exceeded our leading competitors’.
- FP3 Over the last 3 years, our sales growth has been outstanding compared to our competitors.
- FP4 Over the last 3 years, we have been more profitable than our leading competitors.
- FP5 Over the last 3 years, our sales growth has exceeded our leading competitors’.

### SECTION 2: RESOURCES

#### **Human Resources-Open Communications (O)** - Adapted from Powell and Dent-Micallef, 1997

- HR-O1 Our workers are open and trusting with each other.
- HR-O2 Written and oral communications are open in our organization.
- HR-O3 Our people communicate widely, not just within their own departments.
- HR-O4 Communication is open between our branch offices and our corporate home office.
- HR-O5 In general our people readily accept change.

#### **Business Work Practices (B)** - Adapted from Powell and Dent-Micallef, 1997

- B1 Our companies actively researches new ways of accomplishing projects
- B2 Redesigning key processes is an important part of our business plan
- B3 Over the past year we have used cross-departmental teams to address key problems.
- B4 We actively research the best IT practices of other 3PL providers.
- B5 We frequently and systematically measure customer satisfaction.

#### **Shared Knowledge (S)** – Adapted from Ray et al, 2004

- S1 Our IT managers understand our key business resources.
- S2 Our IT managers understand our business strategy.
- S3 There is common understanding between our IT managers and line managers regarding how IT can be used to improve process performance.
- S4 Our line managers generally recognize the potential of IT to increase our efficiency.
- S5 Our line managers generally recognize the potential of IT to improve service quality.
- S6 There is a common understanding between IS managers and line managers regarding how IT can be used to improve process efficiency and effectiveness.

## **IT Applications (T)**

Listed in this segment are some commonly used software and IT equipment in the 3PL industry. For each, indicate the extent to which they have been implemented in your firm, where '1' = not yet begun, '0' = no immediate plans to implement and '7' = fully implemented and in use. For those questions that do not apply, please indicate by responding N/A (for "Not applicable").

### *Warehousing & Transportation (WhT)*

- T1 Wh. Mgnt. Systems (WMS)
- T2 Transp. Mgnt. Systems (TMS)
- T7 Integrated TMS & WMS

### *Customer Interaction (CI)*

- T3 Customer Relationship Mgmt. (CRM)
- T8 Demand and Supply Forecasting
- T13 Internet Customer Access

### *Network and Process Modeling (NPM)*

- T4 Network Modeling
- T11 Transportation Optimization
- T14 Enterprise Res. Plng. (ERP) Interface

### *Data Exchange (DE)*

- T5 Freight Billing
- T6 Automatic Brokerage Interface
- T10 Paperless Logging
- T15 EDI

### *Visibility and Tracking (VT)*

- T9 Worldwide Freight Tracking & Tracing
- T12 Global Visibility
- T16 Bar-Coding
- T17 Radio Frequency
- T18 Satellite Vehicle Communication

Table 1: Breakdown of 3PL Survey Respondents by Title

Title	Count
Chief Executive Officer (CEO)	4
Chief Financial Officer (CFO)	2
Chief Operations Officer (COO)	1
Director	3
General Manager	3
Manager	6
Executive Vice President	6
President	19
Vice President	19

Table 2: Descriptive Statistics and Composite Reliabilities

Construct	Type	No. of Items	Mean	Std Dev	Composite Reliability
1. T	Formative	5	57.02	22.44	0.75
2. O	Reflective	5	26.64	5.13	0.92
3. B	Reflective	5	25.13	6.03	0.87
4. S	Reflective	6	32.72	6.82	0.91
5. CSP	Reflective	6	36.28	4.48	0.90
6. FP	Reflective	5	22.49	6.37	0.94

Table 3: Correlations of Latent Constructs and AVEs (Values on diagonals are the square root of average variance explained by the construct).

	T	O	B	S	CSP	FP
AVE*	0.359	0.692	0.567	0.633	0.608	0.758
T	<b>0.599</b>					
O	0.099	<b>0.832</b>				
B	0.350	0.559	<b>0.753</b>			
S	0.147	0.585	0.666	<b>0.796</b>		
CSP	-0.101	0.569	0.441	0.553	<b>0.780</b>	
FP	0.344	0.164	0.378	0.191	0.234	<b>0.871</b>

Table 4: Results of PLS Analysis

Model Description	PLS Path Coefficients								CRP→FP	R <sup>2</sup>	
	IT Resources		Non-IT Resources		Interactions						
	T	S	O	B	TO	TB	SO	SB		CRP	FP
Main-effects	-0.170 (0.178)	0.314** (0.181)	0.329* (0.213)	0.086 (0.141)					0.267*** (0.108)	0.439***	0.168***
Full Model (Fig. 2)	-0.231* (0.157)	0.290** (0.133)	0.088 (0.157)	0.177 (0.191)	0.234* (0.149)	-0.069 (0.165)	-0.763** (0.390)	0.444** (0.244)	0.265*** (0.103)	0.753***	0.167***

Cell Content: Path Coefficient  
(Standard Error of Path Coefficient)

Significance Level: \* *P*-value < 0.1  
 \*\* *P*-value < 0.05  
 \*\*\* *P*-value < 0.01

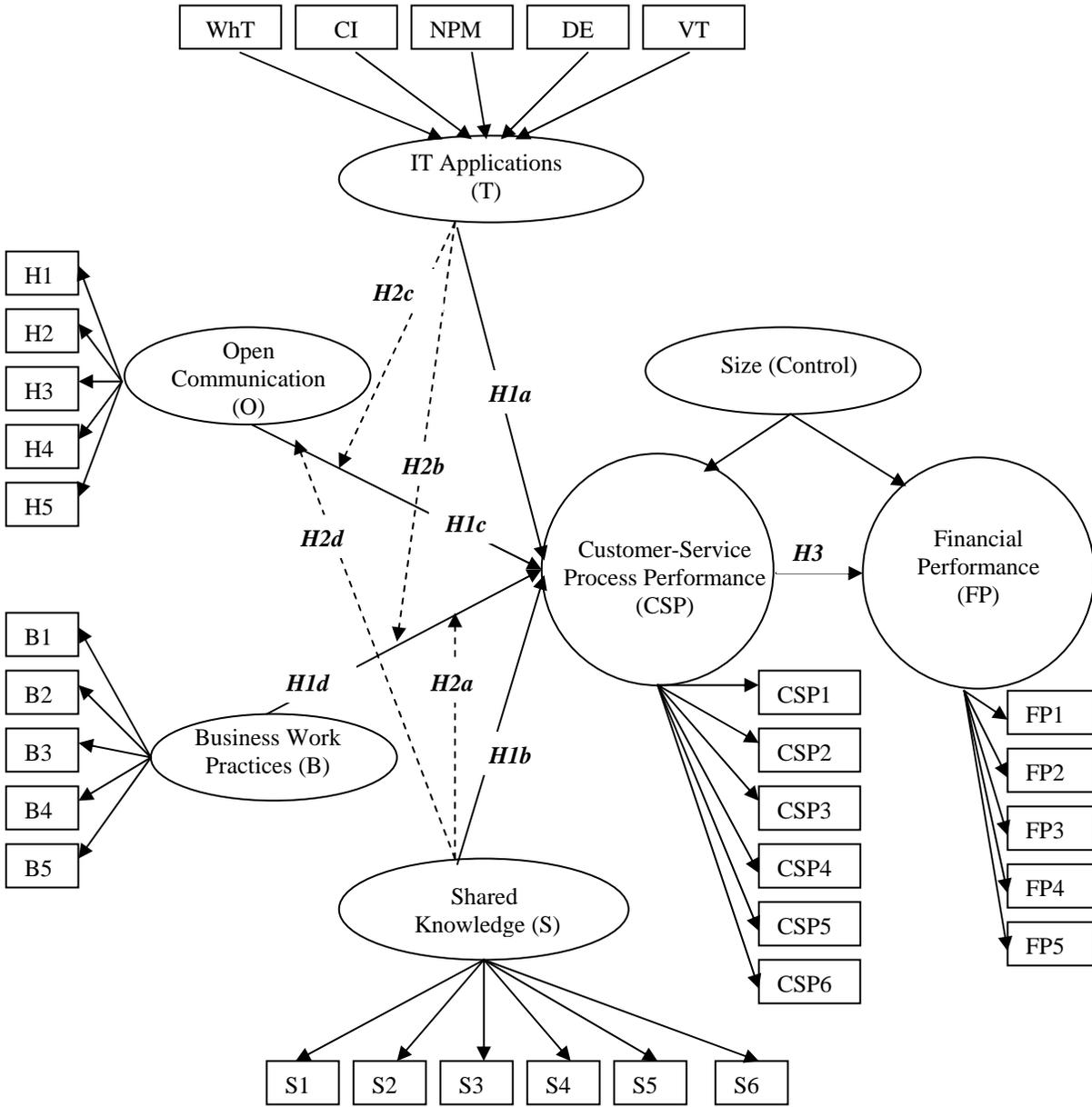


Figure 1: Customer-Service Process Performance model

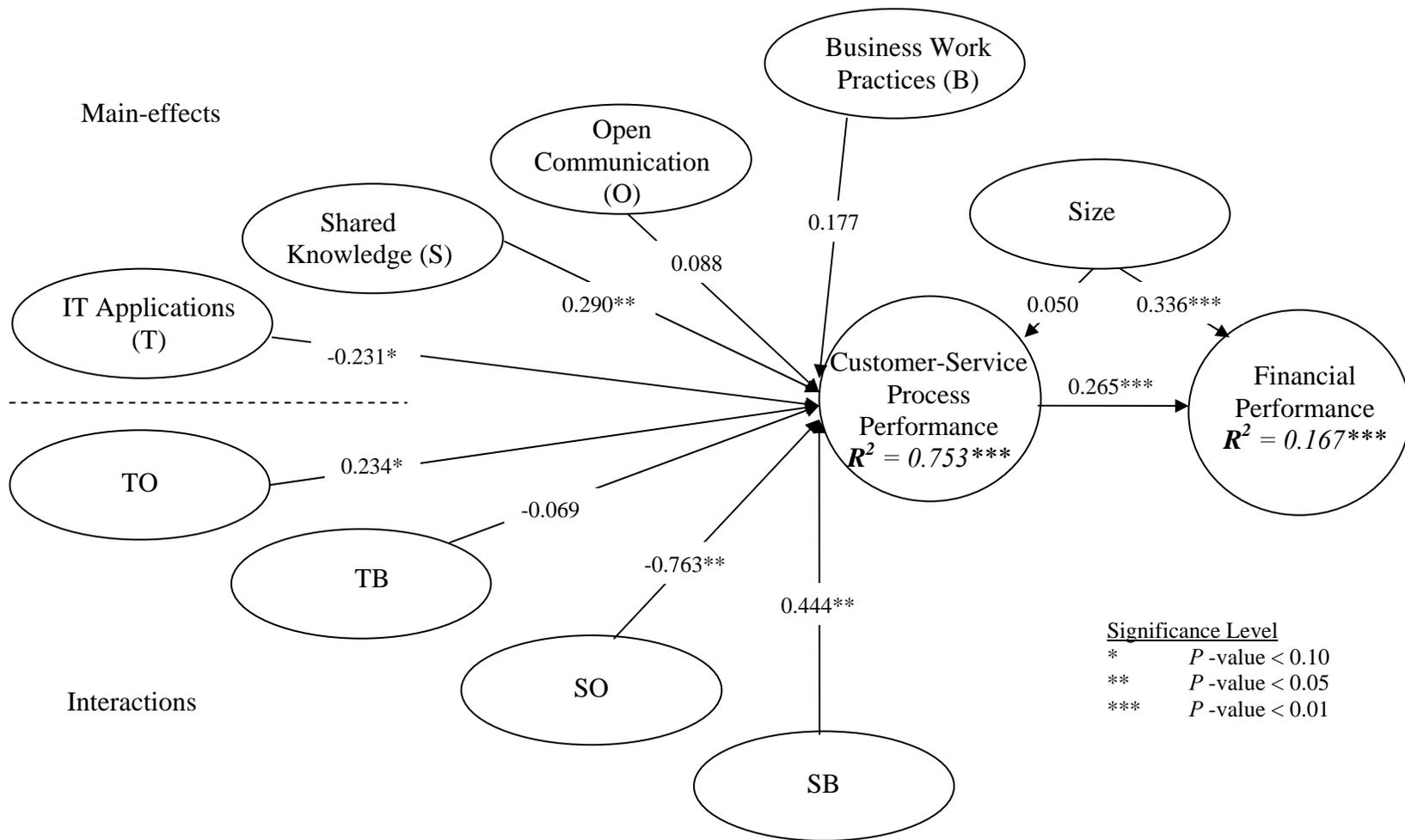


Figure 2: Path Coefficients and Significance Level for Customer-Service Process Performance Model.