Journal of the Association for Information Systems

Volume 5 | Issue 11 Article 18

12-24-2004

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Journal of the Association for Information Systems

RESEARCH ARTICLE

The Role of Information Technology in Risk/Return Relations of Firms*

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Abstract

Information Technology (IT) investments are the largest capital budgeting item in most U.S. firms. Thus, there is significant scholarly interest in understanding the relationship between IT investments and firm performance. However, findings to date remain mixed: while some studies find a positive relationship between IT investments and firm performance, others fail to find any significant relationships at all. One possible reason for this may be that most studies conceptualize and measure firm performance in terms of returns—but ignore risk. Although risk is also an important aspect of firm performance, and there are tradeoffs between risks and returns, most IS studies have not included risk in examining the relationship between IT investments and firm performance. Focusing only on the return implications of IT ignores risk/return tradeoffs and the possibility that IT can influence the risk/return positions of firms. In this study, we build on and extend the economic theory of complementarities to explain how and why IT influences risk/return relations of firms. We discuss how the incorporation of risk into the analysis of performance effects of IT provides new insights for theory and practice.

Keywords: Information Technology, Corporate Risk, Corporate Return, Risk/return Tradeoff, Theory of Complementarities, Complementary Activities and Investments

* Robert Zmud was the accepting senior editor for this paper. Anandhi Bharadwaj and Vern Richardson were reviewers for this paper.

Introduction

The firm-level performance impacts of information technology (IT) have been an enduring research topic in the information systems (IS) literature. Although firm performance has two major dimensions: (a) return and (b) risk (Bettis and Mahajan, 1985; Jemison, 1987), IS researchers have conceptualized and measured firm performance predominantly in terms of returns (for reviews of this literature, please see Kohli and Devaraj, 2003; Melville, Kraemer and Gurbaxani, 2004). The risk dimension of firm performance has been overlooked in the IS literature, although the risk implications of IT have been examined at lower levels of analysis such as IT projects or IT investments (e.g., Weill and Broadbent, 1998; Benaroch and Kauffman, 1999; Keil, Cule, Lyytinen and Schmidt, 1998; Lyytinen, Mathiassen Ropponen, 1998).

By focusing only on the return implications of IT, IS research has implicitly ignored the possibility of a risk/return tradeoff. Consider two very similar firms that differ only in the levels of their IT investment: one firm invests heavily in IT while the other minimizes IT investment. Suppose that the two firms achieve an equivalent level of return. If firm performance is measured only in terms of returns, one would conclude that IT investments do not make a difference in firm performance. But if risk as a dimension of firm performance is also considered in the analysis, one may find that the firm investing heavily in IT subsequently achieves a lower level of risk, leading to a different conclusion: by investing in IT, firms may be able to achieve the same level of return at a lower level of risk. Alternatively, one may find that the firm investing more in IT is able to achieve higher returns for a given level of risk. Thus, examining only the return or only the risk dimension of firm performance is an oversimplification that fails to consider possible tradeoffs between risk and return (Bettis and Mahajan, 1985).

The purpose of this study is to explain how and why IT influences the risk/return performance of firms. According to recent reviews of business value in the IT literature (Barua and Mukhopadhyay, 2000; Dedrick, Gurbaxani and Kraemer, 2003; Melville, Kraemer and Gurbaxani, 2004), IS researchers explain the performance effects of IT using two major theories: the resource-based view (RBV) of the firm (Barney, 1991) and the economic theory of complementarities (Milgrom and Roberts, 1990, 1995). Just like the IS studies that draw from them, these theories focus only on the return dimension of firm performance. Thus, understanding the risk/return implications of IT requires an extension of our fundamental theories about the business value of IT. In this study, we choose to build on and extend the economic theory of complementarities. The complementarity view of the business value of IT is gaining recognition even in the RBV-based IS research. In a recent review of RBV-based IS research, Wade and Hulland (2004) state, "Information systems exert their influence on the firm through complementary relationships with other firm assets and capabilities. While the RBV recognizes the role of resource complementarity, it is not well developed in the theory. The refinement of this element is necessary to enhance the usefulness of the RBV to IS researchers." Thus, the incorporation of risk considerations into the theory of complementarities is also likely to provide insights for refinement of the RBV-based thinking on the business value of IT.

We begin the paper by reviewing the risk literature and clarifying that, for the purposes of this paper, risk is defined as the chance of loss and magnitude of loss. Then, we review finance and strategic management literatures on the risk/return relations of firms. Following the finance literature, we assume that there is a positive relationship between risk and return. We improvise this assumption by introducing the strategic management assumption that managerial interventions such as IT initiatives can significantly impact the risk/return relations of firms. Next, we justify the need to extend theories of the business value of IT in order to understand the risk/return implications of IT. We extend the economic theory of complementarities to incorporate both the risk and return dimensions of firm performance, and use the extended theory to explain how and why IT impacts the risk/return relations of firms. We conclude the paper by discussing implications of the extended theory of complementarities for the business value of IT research and practice.

Theoretical Foundations

The concept of risk

In the management literature, recognition of risk as an important component of firm performance can be traced as far back as the writings of Knight (1921). Economists and decision theorists conceptualize risk of a decision alternative in terms of the variance of possible outcomes associated with that alternative. However, March and Shapira (1987) argue that managers have a substantially different conceptualization of risk than do economists and decision theorists. Managerial judgments of risk appear to focus more on organizational losses than organizational gains. Managers in their studies "…saw uncertainty as a factor in risk, but the magnitudes of possible bad outcomes seemed more salient to them" (Shapira, 1986). These findings are also supported by the findings of a survey of 670 financial analysts (Baird and Thomas, 1990:40). In order of frequency that financial analysts mention them, four possible definitions of risk are ranked as follows: (1) size of loss, (2) probability of loss, (3) variance of returns, and (4) lack of information. Variance of returns, the measure most widely used by researchers, was a poor third for practitioners. In this study, we adopt a definition of risk that is most relevant to practicing managers. We define risk *"as the chance and magnitude of loss*."

Corporate risk/return relationships

In order to examine the risk/return implications of IT, we must first consider two streams of literature on risk/return: financial economics and strategic management. A third stream, behavioral decision theory, also deals with risk and return, but at the level of the individual. Since this paper focuses on organizational level risks and returns, we will not pursue behavioral decision theory. With regard to the first stream, the most important risk paradigm to emerge in the financial economics literature during the past fifty years is based on a set of results known in that literature as the SLB Model (Sharpe,1964; Lintner, 1965; Black, 1972). In the business literature, the SLB model is known as the Capital Asset Pricing Model (CAPM) (Malkiel, 1989). As Fama and French (1992: 427) note:

> "The central prediction of the model is that the market portfolio of invested wealth is mean-variance efficient in the sense of Markowitz (1952). The efficiency of the market portfolio implies that (a) expected returns on securities are a positive linear function of their market βs (the slope in the regression of a security's return on the market return), and (b) market βs suffice to describe the cross-section of expected returns."

Thus, the financial economics stream treats risk and return in *ex ante* terms and postulates a positive linear relationship between risk and return (See Figure 1). The *ex ante* concept of risk is that of a distribution of a random variable (expected return).

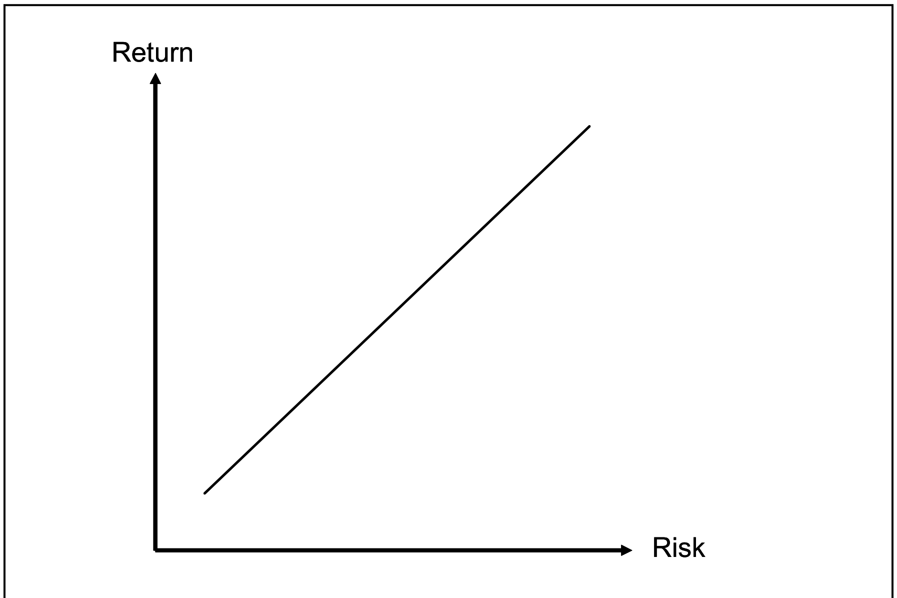

Figure 1. Hypothesis of Finance Theory

While financial economists emphasize risk, investors, and market efficiency, strategy researchers are more immediately concerned with the relationships among risk, superior levels of performance, strategic management, and organization. Some strategy researchers follow the financial economics approach (see Ruefli, Collins and Lacugna, 1999: 174-176), but most make the assumption (sometimes implicitly) that managerial decisions and actions can affect the risk/return relationship. Bowman (1982), in discussing his risk/return paradox (Bowman, 1980), presented two explanations of ways managers might affect the risk/return relationship: (1) exceptionally skilled strategic decision making might well increase return at the same time it lowers risk; and (2) managers of "troubled" firms, that is, firms experiencing below median returns, may actively seek risky, high return projects to augment sagging performance. In the strategic management literature, the nature of the risk/return relationship was found to be contingent on a number of factors, all subject to managerial discretion: prior firm performance (Fiegenbaum and Thomas, 1986; Chang and Thomas, 1989), diversification pattern (Bettis, 1981; Bettis and Mahajan, 1985), industry membership (Bowman, 1980; Bettis and Mahajan, 1985), strategic focus and decision discretion (Jemison, 1987) or firm structure (Hoskisson, 1987). So, in Figure 2 the positive risk/return relationship is the result of a generally positive association between a set of risk/return points. From a point, **X**, in the risk/return space, managers may be able to find alternative investments and activities that would permit them to reduce risk for a given level of return (movement in the direction of **B**), improve return for a given level of risk (movement in the direction of **A**), or simultaneously reduce risk and improve return (movement in the direction of **C**). Of course, if managers chose or implement their investments unwisely, risk/return position of the firm may worsen (e.g., movements in directions **A'**, **B'**, **C'**).

Drawing from the financial economics literature, we assume that in *ex ante* terms risk and return have a positive relationship. However, departing from this literature, we do not assume that the relationship is linear—or even monotonic. Following the majority of the strategic management literature, we assume that managerial decisions and actions can have an affect on the risk/return relationship. In particular, we examine the notion that managerial interventions in the form of IT investments and activities can affect the risk/return profile of a firm. Such interventions would have the objective for a given level of return of reducing the chance of loss or the magnitude of loss—or both.

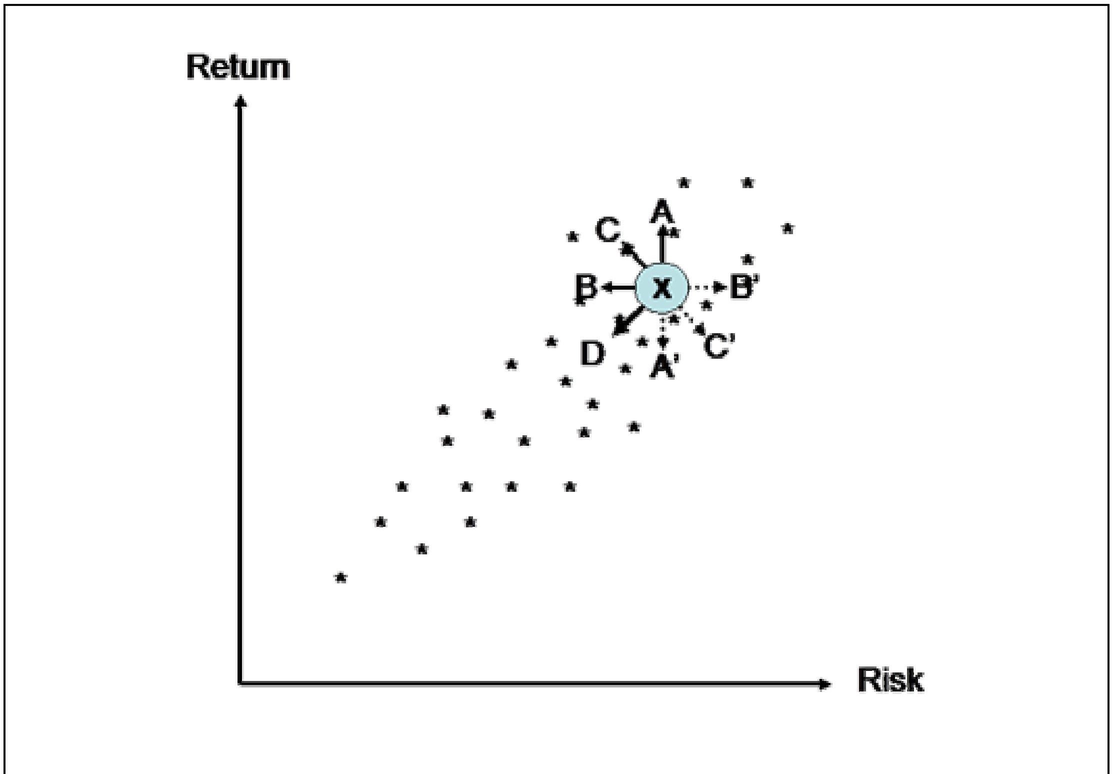

Figure 2. Hypothesis of Strategy Literature

With these assumptions in mind—particularly that concerning the possible efficacy of managerial impacts on the risk/return relationship—the next section reviews the economic theory of complementarities and proposes some extensions that, by introducing risk as a factor, provide a coherent theoretical basis for examining the role of information technology and its possible effects on firm performance.

Economic Theory of Complementarities and the Role of IT in Risk/Return Relation of Firms

IS researchers have built on the economic theory of complementarities to understand how IT interacts with other organizational design variables, and how the interactions among IT and non-

IT design variables influence the performance of firms (Barua, Lee, and Whinston, 1996; Brynjolfsson and Hitt, 1996; Brynjolfsson and Hitt, 1998). The central thesis of the theory of complementarities is that the value of changing two or more complementary organizational design variables in the right directions simultaneously is higher than the sum of the values derived by making the same changes in one design variable at a time. IS researchers view IT as an element of a set of complementary organizational design variables and argue that IT investments must be complemented with investments in the non-IT design variables (e.g., business processes, incentives, and control systems) to have an effect on firm performance. Empirical studies supported the complementarities between IT and non-IT design variables by showing that higher levels of IT usage are associated with higher levels of decentralized decision rights and investments in workforce skills and education (Hitt and Brynjolfsson, 1997). Complementarity of IT and non-IT design variables is also linked to firm performance. Barua, Lee, and Whinston (1996) proposed a multi-level model of business value of IT, which shows the relationships between design variables and performance measures at various levels within the organization. At the lowest level of the model, IT-related factors complement business strategies, processes, incentives, human skills, and so forth. These complementarities enhance performance measures at intermediate levels, which, in turn, increase the overall business value of the firm.

Background on the theory of complementarities

Milgrom and Roberts developed their theory of complementarities in the context of manufacturing firms in order to better explain "substantial and closely coordinated" changes in strategy and operations of firms in that sector (1990: 513). Their theory was based on extensions of the traditional microeconomic concept of goods that are inputs to a production process. The extensions that Milgrom and Roberts made to traditional microeconomic theory were: (1) to consider not just the complementarity of input factors but also the complementarity of activities within the firm, and (2) to treat complementary activities not just in a pair-wise fashion, but in multiples as groups of complementary activities (ibid.: 514).

According to Milgrom and Roberts, the key characteristic of groups of complementary activities is that, prompted by a fall in the relative price of one or more inputs: "if the levels of any subset of the activities are increased, the marginal return to increases in any or all of the remaining activities rises. It then follows that if the marginal costs associated with some activities fall, it will be optimal to increase the level of all of the activities in the grouping" (ibid., 514).

Figure 3 illustrates how Milgrom and Roberts conceptualize relations between a set of complementary organizational activities and the resources (input factors) that they use. Starting on the left-hand side of the figure, the process unfolds as follows:

1. Price declines in a resource that is used by a subset of complementary activities attract investments into the resource: e.g., CAD/CAM technology;
2. Increasing investments in the resource also increase levels of the subset of activities that utilize the resource: e.g., increasing investments in the CAD/CAM technology increase new product design activity;
3. Increases in the levels of the subset of complementary activities lead to increases in the remaining complementary activities: e.g., increasing new product design activity increases flexible manufacturing activity;

4. Increases in complementary activities, in turn, make it more attractive for the firm to invest in other resources used by the complementary activities: e.g., increases in flexible manufacturing activity motivate the firm to also invest in automated production systems.

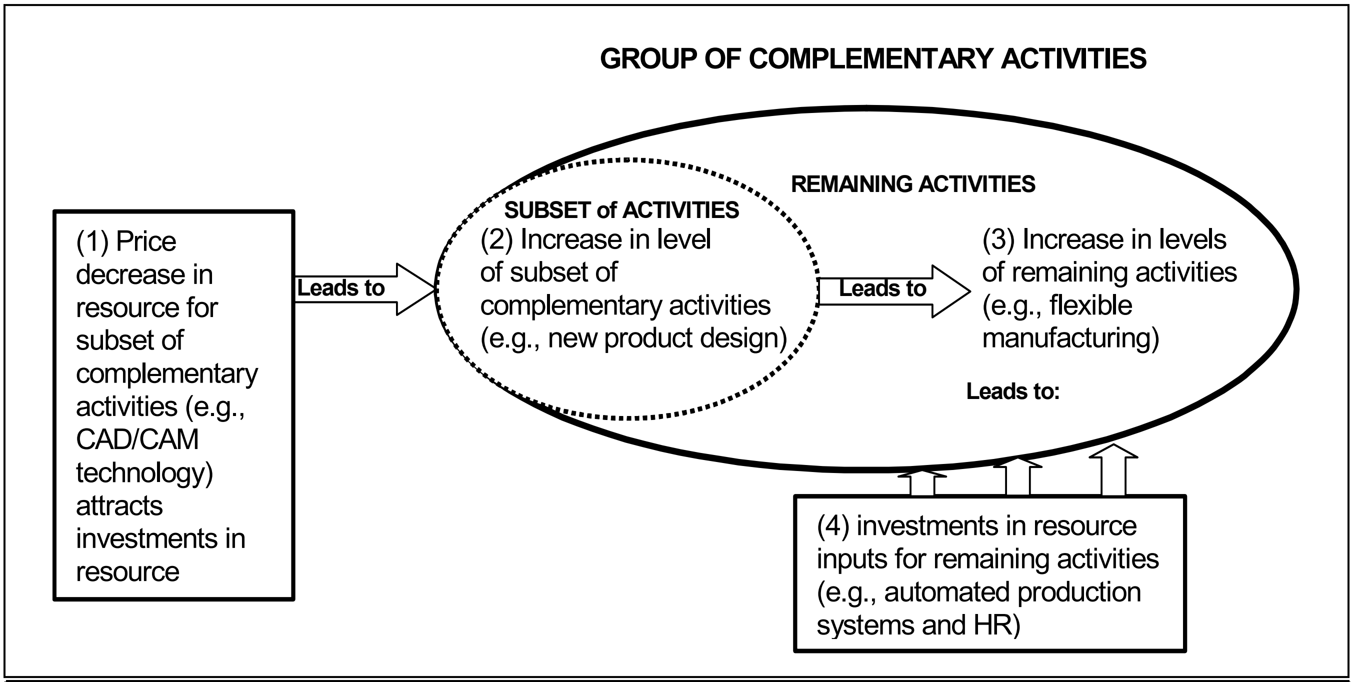

Figure 3. Milgrom and Roberts' Process

Note that resource inputs in stages (1) and (4) seem to be complements because they are correlated: an increased investment in CAD/CAM technology is accompanied by an increased investment in automated production systems. But without reference to the activities that employ these inputs, it is a challenge to rule out the possibility that the correlation is spurious. Milgrom and Roberts made a contribution by distinguishing between "input complementarities" and "activity complementarities" and explaining that whether the inputs are complementary or not can be inferred from the complementarity of the activities that they support.

If we focus on examples of complements given in economic textbooks, such as the complementarity of popcorn and soft drinks, or the complementarity of pizza and beer, Milgrom and Roberts have made little contribution. These examples focus on inputs to the same activity. Milgrom and Roberts focus not only on inputs to the same activity but also on different inputs to different activities. In the latter case, without Milgrom and Roberts' theory, motivating the direct complementarity between inputs may be non-trivial. To illustrate, consider three input technologies: (I1) CAD/CAM, (I2) distance learning, and (I3) automated production equipment; and two organizational activities: (A1) new product development activity, and (A2) flexible manufacturing activity. When considered apart from A1 and A2, it is not immediately clear if the inputs I1, I2, and I3 complement each other or not. When we focus on organizational activities that deliver value to customers, such as new product development activity (A1) and flexible manufacturing activity (A2), though, we have a better context for assessing the complementarity of the inputs. For example, new product development activity (A1) employs CAD/CAM applications (I1) to empower employees in new product design activities. It also employs distance learning technologies (I2) to access, train, and coordinate the skills of employees located in different geographical locations. Similarly, flexible manufacturing activity (A2) employs CAD/CAM applications (I1) and distance learning technologies (I2) to allow geographically dispersed employees to enter their design data into automated production equipment (I3). The complementarity of A1 and A2 also provides a rationale for assessing the complementarity of inputs they employ (I1, I2, and I3). Since organizational activities are more closely connected in a logical sense to the delivery of value to the customer (Barua, Lee, Whinston, 1996), they are more amenable to a logical analysis of complementarities. The context provided by the complementarity of activities can minimize confusions between truly complementary inputs and inputs that are related merely by spurious correlation.

Because complementarities among groups of inputs and groups of activities may not have smooth or even continuous functional relationships, the relation between complementary goods and activities and performance may have non-convexities that mean that optimal performance may occur in a discontinuous fashion relative to levels of inputs and activities—ruling out a simple functional form. Conceptually, this means that in the presence of groups of complementary activities, firm performance cannot necessarily be increased by elevating only a subset of input or activity levels. All of the activities in a complementary group must have their input and activity levels increased proportionately to their interaction effects for optimal performance to be realized.

In fact, increasing only a subset of levels and neglecting to adjust levels of complementary activities sufficiently may result in a worsening of firm performance—and the possible beginning of a downward performance spiral for the firm. For example, introducing CAD/CAM into the firm's design activity and making no other changes may mean that the benefits from CAD/CAM cannot be realized, resulting in a net loss on the return side. Further, adding in flexible manufacturing equipment may not be sufficient—unless HR training in the combination of systems is also made available. All of the complementary inputs and activities must be considered for the firm to reap the benefits. In fact, the relation between complementarities and returns has been shown to be a supermodular function (Topkis, 1978, 1995; Milgrom and Roberts, 1990; Barua, Lee and Whinston, 1996) which means that the returns for the firm with complementarities are greater than the sum of returns for independent activities. (For complementarities and costs the relation is submodular—meaning that in the presence of complementarities, firm costs are lower than the sum of isolated activity costs.)

Distinguishing between input complementarity and activity complementarity: implications for IT

Milgrom and Roberts' distinction between "input complementarities" and "activity complementarities" is critical for understanding the role of IT in the risk/return performance of the firm. Unlike other organizational design factors, IT is not an ordinary input factor that supports a single activity. IT permeates almost all activities along the value chain of the firm (Porter, 1996). Thus, IT is an input into many organizational activities simultaneously. In addition to serving as an element of a set of complementary variables within organizational activities, IT also plays a coordination role across different types of organizational activities. This makes IT central to the identification and realization of complementarities within and across activities.

Although Milgrom and Roberts distinguish between input complements and activity complements, they treat IT mainly as an input factor. While they provide a plausible explanation as to how the acquisition of a new IT system (e.g., CAD/CAM technology) can have an impact on marginal costs and marginal returns of a set of complements within an organizational activity (e.g., new product design), they are silent on the roles of IT in identification and coordination of complementarities within and across organizational activities. Similarly, most IS studies that build on the theory of complementarities treat IT as an input factor. They examine whether the complementarity of firm's IT and non-IT investments influence firm performance.

A multi-level model of the firm

Although Milgrom and Roberts (1990;1995) assume a one-level firm with resources and activities as its elements, Barua, Lee and Whinston (1996) and Barua and Mukhopadhyay (2000) argue that the firm should be conceptualized in multiple levels because investments into resources and activities are converted into firm level performance outcomes through several intermediate levels. IT plays a role in all levels of the firm, from investments through intermediate levels to ultimate risk/return performance. Thus, the first extension we need to make to the theory of complementarities before incorporating risk is to posit a multi-level model of the firm.

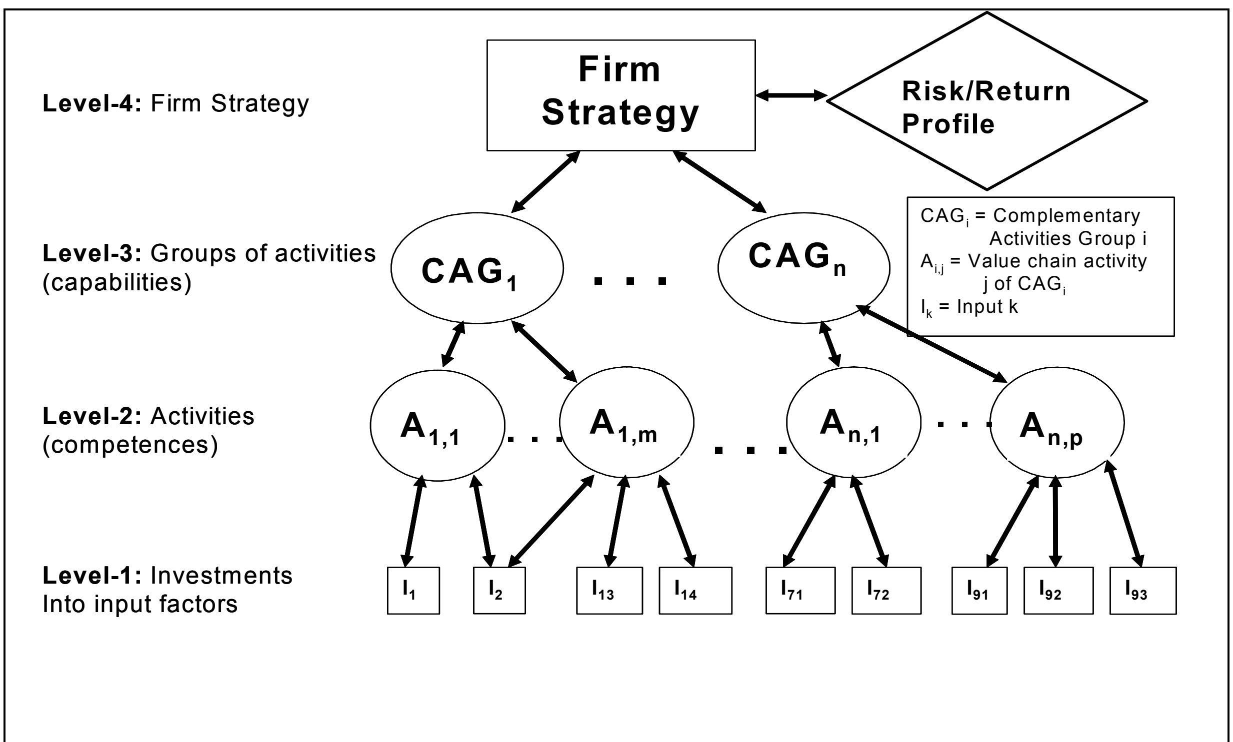

Figure 4. Four-level Model of the Firm

In this study we propose a four-level firm model as shown in Figure 4. The first level contains investments into input factors such as technologies and production skills. The second level contains organizational activities (a.k.a. competences) that integrate and coordinate multiple streams of technology and production skills (input factors) at specific points along the value chain (Hamel and Prahalad 1990). The third level contains groups of complementary activities (a.k.a. capabilities) that deliver value to customers of the firm (Stalk, et al. 1992; Barua, Lee and Whinston, 1996). Stalk et al. (1992:65) distinguish capabilities from competencies by noting that: "…competence emphasizes technological and production expertise at specific points along the value chain, capabilities are more broadly based, encompassing the entire value chain." The fourth level contains the firm's strategy, which identifies and coordinates groups of complementary activities that are likely to have an impact on the risk/return profile of the firm. We adopt Porter's (1996) definition of strategy, which consists of taking a position, making tradeoffs, and forging a fit. Extending this definition to cover risk in the context of complementarities implies choosing a risk/return profile as part of the position, making the risk/return tradeoffs, and forging fit by identifying complementarities and realizing their benefits. Figure 4 depicts the four-level model of the firm and illustrates the logical hierarchy of complementarities through which investments influence the risk/return profile of the firm. Table 1 summarizes focal concepts/constructs at each level of the model.

Table 1. Four-level Model of the Firm

Levels	Focal concept/construct	Definition/Description
4	Firm Strategy	Establish position, make tradeoffs, forge fit (Porter, 1996). Identification and coordination of complementary organizational capabilities that are relevant to risk/return profile of the firm
3	Groups of complementary activities (Capabilities)	Groups of complementary activities that deliver value to customers of the firm (Stalk, et al. 1992).
2	Activities (competences)	Activities that integrate and coordinate input factors (e.g., technology and production skills) at specific points along the value chain (Hamel and Prahalad 1990).
1	Investments	Expenditures into input factors that support activities along the value chain of the firm.

Note that the direction of causality in the four-level model can be bottom-up or top-down. At lower levels of the model, the needs of activities (2nd level) can trigger a set of investments in input factors (1st level). Conversely, the ability of the market to supply input factors at lower prices (1st level) can trigger changes in activities (2nd level). At higher levels of the model, senior management can specify a strategy to improve the risk/return position of the firm (4th level), which can in turn provide guidance to lower level managers in deciding which activities (2nd level) and groups of activities (3rd level) they should enhance. Alternatively, lower level managers who are closer to the phenomenon can discover and act on potential complementarities within specific activities (2nd level) or groups of activities (3rd level), which in turn improve the risk/return profiles of activities, groups of activities, and eventually the risk/return profile of the firm.

Although the causality can run both ways, a deliberate firm strategy at the top that seeks to exploit complementarities at lower levels is more likely to generate a more favorable risk/return profile for the firm. The presence of a strategy can provide general direction to lower level managers and help the firm to coordinate complementarities within and across the levels (Milgrom and Roberts, 1995). In the absence of such a strategy, managers may still act on potential complementarities within their own units, but it becomes more difficult to identify and coordinate complementarities spanning multiple units and levels.

Incorporating risk into the theory of complementarities

In their analysis of complementarities, Milgrom and Roberts assume a single measure of performance: return—no direct mention is made of risk. Since their model is based on the assumptions of microeconomic theory, which holds that risk is a fixed and linear function of return, for Milgrom and Roberts the addition of risk would add nothing to their theory in that context. The IS literature building on the theory of complementarities is also silent on risk as an aspect of firm performance.

While arguments have been made that risk should be included as a measure of firm performance in general (Jemison, 1987), in the presence of IT investments in activities that are organized into groups of complements, the arguments are even more compelling. The addition of risk as an additional aspect of performance in a structure of complementary activities is not just a mere embellishment of the theory for its own sake. Risk, as chance and magnitude of loss, captures an aspect of performance that is not captured by return or by cost.

In our extension of the theory of complementarities, there is a hierarchy of risk that follows the four levels in Figure 4: investment risk, competence risk, capability risk, and strategy risk. Investment risk is the chance and magnitude of shortfall below expected performance of an investment in a resource; competence risk is the chance and magnitude of a firm competence (e.g., a help desk service) falling below the expected levels of performance; capability risk is the probability and degree to which a firm capability (e.g., mass customization) does not perform as required; and strategy risk is the probability and degree to which a firm does not attain (or maintain) an advantage over its competition. Barua, Lee and Whinston (1996) and Barua and Mukhopadhyay (2000) discuss the complex fashion by which returns at lower organizational levels result in firm return; the complexities of risk in the organizational context are analogous. Risk associated with investments is largely in terms of the chance of inputs failing by an expected magnitude to meet the operational specifications (performance, timing, and cost) required by the activities in which they are employed—for example, that there is a 10% chance that a distance education application will scale only to 1000 students per week rather than the required 1500. Quite differently, risk at the level of competencies is in terms of the chance of activities failing by some level to fulfill the objectives associated with the design variables— for example, that there is a 20% probability of a call center being able to resolve the average customer problem within 20 minutes rather than the 10 minutes desired. At the next higher level, capability risk is associated with the level of probability of groups of complementary activities failing by some amount to reach the desired level of an intermediate variable, thus failing to yield the value required to satisfy the customer—for example, that there is a one-in-twenty chance that the firm's customization capability will miss its performance goals of being able to deliver any of 250 different designs to the customer in under 5 days. Finally, strategic risk is associated with the chance that strategic position and fit in the various markets in which it operates will fall short of that required to remain competitive—for example, the probability of 15% that the announced market share growth will be 2% less than promised. Note that all of the foregoing risk examples are framed in terms of chance and magnitude of loss.

In general, risk reduction (increase) for an activity has horizontal impacts that improve (worsen) decision making for complementary activities at the same level if only because contingent risk for the complementary activities has been reduced (increased). For example, if the chance and magnitude of loss associated with flexible manufacturing processes are reduced (increased) then the risk associated with new product introduction (NPI) is also reduced (increased) because NPI risk is partially contingent on manufacturing risk. Risk reduction (increased) at a given organizational level also has vertical impacts that affect decision making at the next lower and at the next higher level in the organization—again because contingent risk has been reduced (increased). So, for example, if flexible manufacturing risk is reduced (increased), then risk associated with inputs to that process is also reduced (increased) since the latter is partially contingent on the former. Similarly, the risk associated with the capability to customize customer orders is reduced (increased) because it, also, is partially contingent on manufacturing risk. In both the horizontal and vertical cases, the improvement (worsening) comes from the ability (failure) to identify and realize complementarities. Barua, Lee and Whinston (1996: 425) have established the analytic conditions for complementarities at different hierarchical levels to be consistent at the firm level; these conditions are generalizable to the case where risk is included.

The role of IT in managing complementarities for a better risk/return position

Information technologies can help firms to identify, coordinate, and realize complementarities within and across the four-levels of the firm. We identify three major mechanisms through which information technologies can facilitate the management of complementarities for a better risk/return position for the firm:

(1) IT helps firms to identify potential complementarities within and across organizational activities. Firms invest in different types of information technologies for the purpose of automating, informating, or transforming their organizational activities (Dehning, Richardson, and Zmud, 2003). Since investment in new IT systems requires intimate knowledge of the organizational activity it will support, when a firm invests in a new IT system to support an organizational activity (e.g. a transaction management system), during the systems analysis and design phase, the firm is likely to discover organizational design variables (e.g., decision rights, internal control processes, incentives, etc.) that could possibly impact the implementation success of the new IT system. Investments in firm-wide information technologies such as SAP or ERP are likely to reveal information about complementarities across groups of organizational activities. Thus, investments in new IT systems can provide early information to the firm about potential complementarities within and across organizational activities. By building on such information, managers can gain insights into both “activity complementarities” and “input complementarities.”

The ongoing process of identifying potential complementarities within and across organizational activities, investing in new information technologies, observing the implementation of the new IT systems, learning more about the associated complementarities, and revising the firm’s understanding of complementary organizational activities also helps the firm to align its business and IT strategies. The business strategy of the firm informs the firm's IT strategy by identifying complementary organizational activities among which the firm aims to forge fit. Activity complementarities inform which IT-related input complementarities are needed. IT strategy, in turn, supports the business strategy by enabling the firm to learn further about the complementary organizational activities. This reciprocal reinforcement enhances the alignment between business and IT strategies of the firm.

(2) IT helps firms to coordinate complementarities within and across organizational activities. A key role of IT within organizations is to serve as a coordination mechanism (Dedrick, Gurbaxani, and Kraemer, 2003). Thus, after the implementation, IT systems can help firms to coordinate among potential complementarities that were identified during the systems analysis and design phase. Elements of a system of complements have significant multi-way interactions with each other (Milgrom and Roberts, 1995). IT can facilitate such interactions and enhance the coordination of complementarities within and across organizational activities. Successful coordination among the elements of a complementary system helps the firm to realize potential complementarities within and across its organizational activities.

(3) IT improves information quality and decision making speed in systems of complements. In terms of managerial decision making, higher risk is generally associated with less accurate information (or information that is of uncertain accuracy), information that is less timely, or information that is of limited scope. Conversely, lower risk is generally associated with more accurate and timely information that has the wider scope that allows it to be placed in a broader context that facilitates coordination. In terms developed by Eisenhardt (1989:571) in her studies of strategic decision making in high velocity environments, lower risk can be achieved with better real time information, consideration of multiple simultaneous alternatives, and integrated decisions (coordinated decisions across activities). IT investments that aim to "informate-up" provide information to senior management about business activities. IT investments that aim to "informate-down" provide information about business activities to employees across the firm (Dehning, Richardson, and Zmud, 2003). Such IT investments can accelerate cognitive processing, provide better information, give confidence to act, improve group decision processes, result in faster decision processes, and by doing so they can help managers to better manage different types of risks across the four-level model. Conversely, the absence or weakness of such information technologies can slow down decision processes and increase associated risks.

Implications of the extended theory of complementarities for business value of IT

Currently, IS studies that build on the theory of complementarities posit that complementarity of investments in IT and non-IT organizational design variables is positively associated with returns of firms. The research model implied by this proposition is depicted in Figure 5a. The extensions we made to the theory of complementarities in this study have important implications for the independent variable (IV), the dependent variable (DV), and the causal link between the IV and DV in a business value of IT research model. To reiterate, this study made two extensions to the original theory of complementarities: (1) it developed a four-level model of the firm and explained how different types of complementarities within and across the four levels are related to each other; and (2) it recognized risk as an important dimension of firm performance, and incorporated risk considerations (in addition to return considerations) into the theory. Based on these extensions, we propose a revised research model as depicted in Figure 5b.

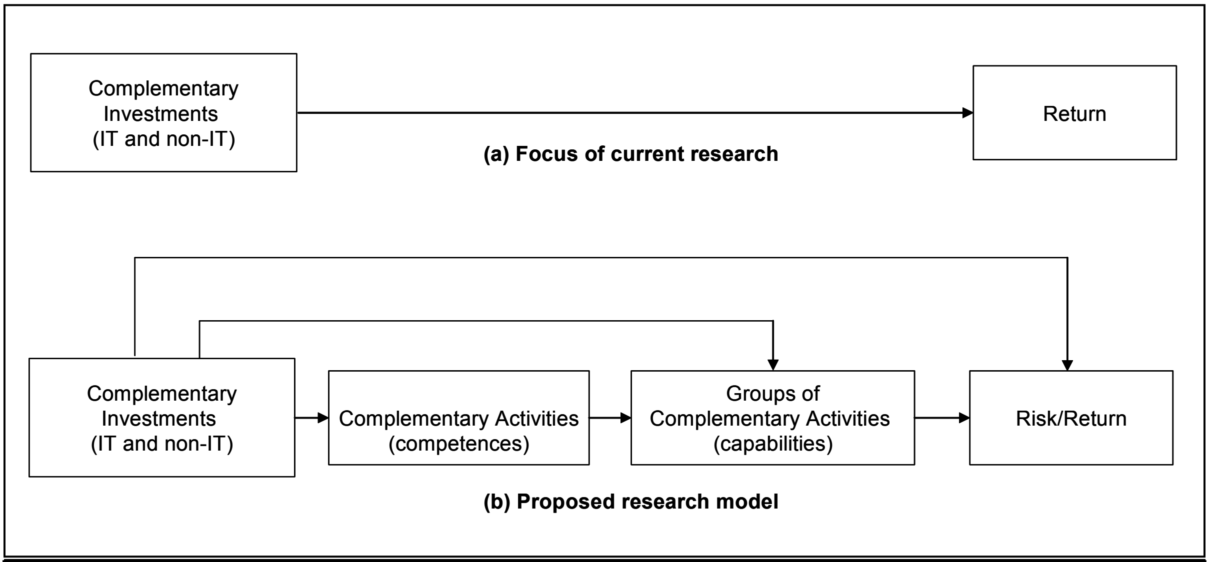

Figure 5. Current and Proposed Research Models

Independent variable: The four-level firm model developed in this study implies that complementary investments (in IT and non-IT factors) do not automatically translate into risk/return outcomes at the firm level. They need to be converted into competences (complementary organizational activities) and capabilities (groups of complementary organizational activities) before they can have an impact on the risk/return profile of the firm. Firms make complementary investments in IT and non-IT factors to exploit "potential complementarities" that they perceive within and across their organizational activities. Making complementary investments does not guarantee that the firm will be able to convert the "potential" into "actual" and realize the benefits promised by "potential complementarities."

There are two major hurdles that a firm needs to overcome to realize the benefits of complementarities. First, ex-ante, the firm may not have a precise understanding of the complementarity structure among its activities or inputs employed by the activities. Lack of a precise understanding of complementarities inhibits realization of them. Investing in input factors that do not turn out to be complementary can also waste resources and reduce the performance of the firm (Siggelkow, 2002).

Second, assuming that the firm has a precise understanding of complementarities, it still faces implementation hurdles. To realize benefits of a system of complements, the firm has to successfully implement all elements of the system. Due to the complementarities among the elements, partial implementation success is not sufficient for the success of the system as a whole (Porter, 1996). Implementation failures in one or more elements can propagate horizontally within a level and vertically across the four levels to ultimately have a negative effect on the risk/return profile of the firm.

Thus, our extension of the theory of complementarities suggests that the use of *"complementarity of IT and non-IT investments"* as an independent variable in studies examining the firm level performance effects of IT may not be appropriate. For these investments to have positive effects on risk/return positions of firms, potential complementarities that they target (in competences and capabilities) must be successfully converted into realized complementarities (RC). The causal link from complementary investments (in IT and non-IT factors) to the risk/return performance of the firm is too long. The difficulty of detecting a significant relationship increases with the length of the causal link between independent and dependent variables. Thus, empirical tests of the posited relationship may produce inconsistent findings. The implication for IS research is that researchers should either reconsider their independent variable or the dependent variable in an effort to shorten the causal link. For example, researchers interested in the effects of complementary investments (in IT and non IT factors) on organizational competences can focus on realized complementarities within the 2nd level of our model as their dependent variable. Researchers interested in the effects on organizational capabilities can focus on realized complementarities within the 3rd level of our model. Studies that are interested in the effects of IT on firm performance can use realized complementarities within the 3rd level as their independent variable.

Dependent variable(s): Our incorporation of risk into the theory of complementarities also suggests that studies seeking to understand the performance effects of complementarities (between IT and non IT factors) should focus on risk/return relations of firms rather than returns per se. In Figure 6, the three ellipses show risk/return relationships of firms that respectively achieve a high level of realized complementarities (RC_{high}), a medium level of realized complementarities (RC_{medium}), and a low level of realized complementarities (RC_{low}). Small dots within the ellipses represent risk/return positions of individual firms. In the middle ellipse, the arrows pointing away from risk/return position X show how the risk/return profile of an average firm can potentially change after the firm invests in IT—assuming that other factors remain the same. If the firm invests in IT to reduce risks in an organizational activity, but it does not invest in complementary design variables, risks may decline, but so will the returns as shown by arrow D. If the firm also makes complementary investments within the immediate organizational activity, it is likely to increase its returns while reducing its risks, as shown by arrow C. But since the complementary investments are confined to one activity only, and not extended into groups of complementary activities, the realized complementarities of the firm will be moderate (RC_{medium}) and the firm will not be able to make a dramatic switch from (RC_{medium}) to (RC_{high}) as implied by arrow E. If the firm does not invest in any complementary design variables even within the immediate organizational activity, it is likely to face implementation problems and move to a less favorable risk/return position: risks will increase, returns will decline as shown by arrow C'. But the worsening of the risk/return profile will not be as severe as implied by arrow F because the changes undertaken by the firm are confined to one organizational activity only. If the firm invests in complementary design variables in groups of activities, but the implementation fails, the risk/return profile of the firm can worsen (RC_{low}) as shown by arrow F.

By identifying and acting on complementary organizational factors revealed by the initial IT investments, the firm can enhance organizational activities along its value chain, which in turn can enhance groups of activities. As a result, the firm can reduce its risks and increase its returns. Instead of just moving within its current risk/return region (RC_{medium}), the firm can switch to a more favorable risk/return region (RC_{high}). While the proposition that "*Complementarity of IT and non-IT business investments is positively associated with returns of firms"* seems to hold in this scenario to some extent, it misses the point that the risks of the firm have also gone down, and the impact of complementary investments was not on returns per se but on the risk/return position of the firm. Thus, the business value of IT research can gain a better understanding of IT payoffs by studying the risk/return implications of IT instead of the return implications only.

To illustrate why focusing only on return implications of complementary IT and non-IT investments may produce misleading results, consider three firms, which make the same level of complementary investments in IT and non-IT factors, but achieve different risk/return positions (RR1, RR2, and RR3 in Figure 6) due to differing levels of implementation success in realizing the potential complementarities. Suppose all three firms achieve the same level of return, but for different levels of risk (Risk1, Risk2, Risk3).

Clearly, the performance effects of the complementary investments are different for the three firms. Firm 1 achieved the most favorable risk/return performance (RR1) because it achieved the same level of return with the lowest level of risk (Risk1) whereas Firm 3 has the worst risk/return performance (RR3) since it achieved the same level of return with the highest level of risk (Risk3). If we had focused only on the return implications of complementary investments, we would not have been able to distinguish performance differences among these three firms.

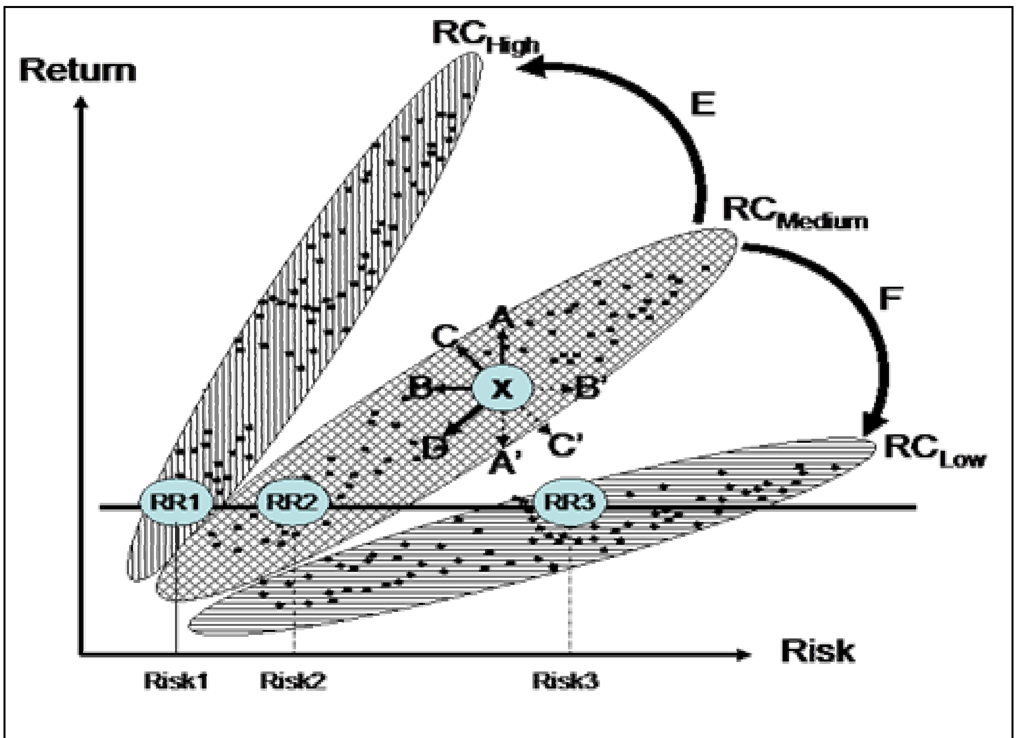

Figure 6. Hypothesis of This Study

Relationships between independent and dependent variables

The extensions made in this study also have implications for the nomological relationships among complementary investments (IT and non-IT), organizational competences, organizational capabilities, and the risk-return relations of firms. Although the potential of complementary investments is converted into actual risk/return outcomes over a period of time through the mediating roles of organizational competences and capabilities, at the time of the investments, there can also be immediate direct effects on the competences, capabilities, and the risk-return relation of the firm, as depicted in Figure 5b. To advance propositions about these effects, it is useful to first distinguish among different types of IT investments.

In examining the relation between complementary investments (IT and non-IT) and firm performance, prior studies used a single "IT investment" figure per firm, assuming that a firm's investments in different types of IT can be aggregated into a single figure. Recent research questions this assumption by identifying four types of IT investments and showing that they have different implications for firm performance: (a) automate, (b) informate-up, (c) informate-down, and (d) transform type of IT investments (Dehning, Richardson, and Zmud 2003). Building on this research, we also distinguish among the four types of IT investments and develop propositions about their potential impacts on organizational competences, capabilities, and risk-return relations of firms.

Automate type IT investments aim to replace human labor and improve the efficiency of existing organizational activities (Dehning, Richardson, and Zmud 2003). These investments are targeted to well-understood organizational activities. The firm is likely to have knowledge of complementarities involved within those activities; thus, implementation risk is low. By producing more timely and accurate information, automation also helps the firm to lower risks in complementary activities (competences) and groups of complementary activities (capabilities). But since automation is easy to understand and imitate by competitors, the overall performance benefits are not likely to be sustainable (Dehning, Richardson, and Zmud 2003). Thus, automation's impact on the overall risk-return relation of the firm will be positive but small. For the same reason, variance of outcomes will be low across a sample of firms making automate-type IT investments.

Informate-up type IT investments support decision making and decision taking at the senior management levels (Dehning, Richardson, and Zmud 2003). They enable senior managers to better understand groups of complementary activities and develop a risk/return strategy at the 4th level of the four-level firm model. The presence of a firm level risk/return strategy guides and encourages lower levels of the firm to invest in complementary organizational activities in a systematic fashion. Implementation risks are higher, but informate-up investments provide greater opportunities for reducing risks within and across levels—i.e., investment risk, competence risk, capability risk. They positively affect the overall risk-return relations of firms due to radically better and quicker decisions across all four-levels of the firm.

Informate-down type IT investments support decision making and decision taking at lower-levels of the organization (Dehning, Richardson, and Zmud 2003). They inform lower-level employees about complementarities involved in organizational activities. Thus, the scope of actions taken on complementarities is limited to local activities in the 2nd level of the four-level firm. Improvements within the 2nd level are likely to have some positive spill-over effects on the 3rd level complementarities as well, but the strength of the effects will be less compared to the effects obtained under the guidance of a firm-level risk/return strategy enabled by informate-up type of IT investments.

Transform type IT investments introduce radical business models that disrupt industry practices and market structures (Dehning, Richardson, and Zmud 2003). They redefine existing complementarities within the firm. Since the firm does not know about the new complementarities, the chance of misperceiving them is high. Due to the associated complexities and uncertainties, implementation risk is very high. The potential for increasing returns (Dehning, Richardson, and Zmud 2003) and lowering risks of the firm is also high. Whether the firm will obtain negative or positive risk-return outcomes from transform type IT investments is contingent on the firm's existing IT capability—i.e., the firm's ability to mobilize and deploy IT-based resources in combination with other resources and capabilities (Bharadwaj, 2000). If the firm has a strong IT capability, it is likely to successfully implement the transformative IT investments and achieve positive risk-return outcomes. If the IT capability of the firm is weak, the implementation is likely to fail and negatively impact the risk-return relation of the firm.

Table 2 provides a summary of the definitions/descriptions of the four types of IT investments, how they may influence complementarities at different levels of the four-level firm model, and our propositions on the likely impact of a given type of IT investment on competences, capabilities, and the overall risk-return relation of the firm.

Example: The Blue Rhino Corporation

To illustrate the point that IT has implications for both the risks and returns of the firm, we will examine a case in which risk figures prominently as a driver. Consider the recent wave of IT investments firms are making to comply with the Sarbanes-Oxley bill. This legislation requires executives to be accountable for the accuracy of their firms' quarterly and annual financial statements by signing off on those statements. Since executives cannot personally check all possible details of the financial statements, especially in large firms, IT systems are critical for collecting the relevant data from different parts of the firm, putting together the financial statements, and checking for their accuracy, reliability, and consistency before the executives can sign off on them. Many firms whose IT systems have been historically inadequate for doing so have recently been investing in IT with the objective of minimizing their legal (regulatory) risks, i.e., potential litigation due to failure to comply with the Sarbanes-Oxley bill. That is, they are attempting to reduce their expected risk—which under traditional finance theory (Figure 1) would have them also reduce their expected returns, thus moving in direction D in Figure 2 (Barua, Lee, and Whinston, 1996: 418). Thus, increased IT investment would not be associated initially with an increase in return. However, because of the existence of groups of complementary activities, these investments, if properly made and managed to take advantage of those complementarities, may also have positive implications for returns of the firms. Thus investments to reduce the chance and magnitude of loss associated with failure to comply with the law, in contrast to financial economic theory, may simultaneously increase returns via investments in complementary sets of activities identified through analysis of IT systems for those activities.

Table 2. Propositions

Type of IT investment	Definition/Description	Implications for complementarities along the 4-level firm model	Propositions
Automate	replace human labor in business processes	Automation is applied to well-understood organizational activities. We can assume that the firm already knows the complementarities involved in these activities and that it will implement them as part of the automation effort. Thus, implementation risk of automate type IT investment is low. More timely/more accurate information produced by automate-type IT investments will also lower risk in complementary activities. Since automation is easy to understand and imitate by competitors, overall performance benefits are not likely to be sustainable. The impact on the overall risk-return relation of the firm will be positive but small. For the same reason, in a sample of firms making automate-type IT investments, variance of outcomes will be low across firms	1. have a positive effect on organizational competence (complementary organizational activities) 2. have a positive effect on organizational capabilities (groups of complementary organizational activities) 3. lower risk for organizational competences—with low variance across firms 4. have a small positive moderating effect on the risk-return relation of the firm—with low variance across firms
Informate-up	provide information about business activities to senior management	Informate-up enables senior managers to better understand complementarities involved in organizational activities. Thus, it allows the senior management to develop a risk/return strategy at the 4th level of the four-level firm model, which in turn guides investment decisions at lower levels of the firm. The firm is likely to make investments in complementary organizational activities at all levels. Implementation risks are higher than for informate-down or automate investments. But informate-up type of IT investments provide greater opportunities to reduce risk in complementary groups of activities (capabilities) and overall risk-return of firms	1. have a positive effect on organizational competence 2. have a positive effect on organizational capabilities 3. considerably lower risk for organizational capabilities—but with high variance across firms 4. have a substantial positive moderating effect on the risk-return relation of the firm—but with high variance across firms
Informate-down,	provide information about business activities to employees across the firm	Informate-down informs only lower-level employees about complementarities involved in organizational activities. Thus, unlike in the case of informate-up, the scope of actions taken on complementarities will be limited to local organizational activities in level-2 of the model. Improvements in level-2 are likely to have positive effects on level-3 and level-4 as well, but the strength of effects will be less compared to the effects of the top-down risk/return strategy implied in informate-up type of IT investments. Due to limited scope of the investments, implementation risks are lower than for informate-up investments, and opportunities for lowering risks in complementary activities (competence) are moderate	1. have a positive effect on organizational competences 2. have a positive effect on organizational capabilities, but the effect will be significantly less compared to the effects of informate-up type of IT investments 3. moderately lower risk for organizational competences—with moderate variance across firms 4. have a significant positive moderating effect on the risk-return relation of the firm, but the effect will be significantly less compared to the effect of informate-up type of IT investments
Transform	fundamentally redefine business and industry processes and relationships	Transformation disrupts the status quo and redefines complementarities. The firm does not know about the new complementarities. The risk of implementation failures is very high, but there are also more opportunities for substantially increasing returns and lowering risks of the firm. Whether the firm obtains negative or positive risk-return outcomes depends on the firm's IT capability. In firms with strong IT capability, transformative IT investments are likely to achieve positive risk-return outcomes whereas in firms with weak IT capability, they are likely to have a negative impact on the risk-return relations.	Contingent on the firm's IT capability (high/low): 1. have a (positive/negative) effect on organizational competences 2. have a (positive/negative) effect on organizational capabilities 3. considerably (lower/increase) risky for organizational capabilities—with very high variance across firms 4. have a (positive/negative) moderating effect on the risk-return relation of the firm—with very high variance across firms

Consider the case of the Blue Rhino Corporation, which undertook a self-admitted overdue overhaul of its disparate IT systems across its value chain for the purpose of reducing potential legal risks posed by the Sarbanes-Oxley bill. Making an investment in business process management software, the company undertook an integration project to link formerly isolated spreadsheet-based financial systems across different parts of the company into a coherent and easily auditable system. Note that the trigger for IT investments was not a decline in the relative price of IT (the business process improvement software). Rather, the trigger was regulation, which increased the firm's regulatory non-compliance risk and required a change in the firm's financial reporting activity. Note also that the financial reporting activity had complementarities with other activities of the firm.

Blue Rhino's IT investments in the financial reporting activity uncovered many previously undiscovered problems in groups of related activities and presented improvement opportunities in the business processes and activities of the firm. While the initial purpose of the project was to reduce legal (regulatory) risks by complying with the Sarbanes-Oxley bill, since IT permeated the whole activity system and complemented the business activities of the firm, increases in the level of IT benefited other areas as well. In addition to reducing risk by providing better information, the IT also reduced the marginal costs associated with complementary activities and made it more attractive for the firm to increase the levels of IT investment in the complementary business activities. In the course of streamlining the financial IT systems, the firm developed more accurate information on logistics, suggesting opportunities for reducing inventory by two or three days, found ways of cutting down the non-productive period of new employees by several days, and automated the purchasing process. In terms of corporate risks, by complying with the Sarbanes-Oxley bill, the firm not only lowered its legal risk, i.e., exposure to sanctions and lawsuits, but also it lowered its competence risks by improving accuracy and minimizing redundant costs in its financial activity system, and it reduced its capability risks by improving the accuracy of information in purchasing as well as by streamlining and integrating various components of its HR activity system and by enabling chief executives to confidently approve and sign off on the financial statements.

Blue Rhino also reduced its strategic risks because its competitors have yet to rationalize IT systems across their value chains (Rothfeder, 2004). At the same time, the firm improved its return by reducing costs, by providing a better value proposition to its customers, and by improving productivity. In terms of expected returns from this effort, "by automating work flow and business processes, Blue Rhino hopes to keep both the cost of sales and administration—10.9 percent of revenues in fiscal 2003—and personnel levels flat while annual revenues are expected to grow at a double-digit rate. That, says CEO Prim, could improve net earnings by about 25 percent a year for the next three to five years" (Rothfeder, 2004). Referring to Figure 2, what Blue Rhino accomplished by recognizing the risk/return trade-offs and by taking advantage of complementary groups of activities was to move the firm in direction C: toward a more favorable risk/return trade-off line. Anecdotal evidence that the overall risk/return profile was affected by these complementary investments is given by the pre-investment characterization of the company as being "entrepreneurial and freewheeling" (Rothfeder, 2004: 1) in comparison with its post-investment acknowledgement that , "it will have to be a more deliberate organization for the foreseeable future" (op. cit., 3-4). Thus, as an integral part of the firm's activity system and complementary set of business capabilities, IT has major implications for firm level risks and returns simultaneously.

Discussions and Conclusion

Implications for research

A major implication of this study is that research studies cannot develop a complete understanding of the performance effects of IT by focusing on returns and ignoring the risks of IT initiatives. There is a non-trivial association between risk and return. An initiative that initially looks attractive because it has a potential to generate high returns may become less attractive when managers realize that there are also high risks associated with the initiative. A lower return, lower risk initiative may be a more plausible choice if managers are willing to trade off higher returns for lower levels of risk. Studies that examine the business value of IT only from the return perspective are overlooking risk/return tradeoffs. Incorporating risk into the analysis is critical for developing a more complete understanding of the performance effects of IT. At a minimum, studies focusing on the return implications of IT should control for associated risks.

Studies of the IT and return relation can most directly be extended to become studies of the IT and risk/return relation by adding risk as a moderating variable in a regression of IT expenditures on returns. Such studies would provide preliminary evidence of the existence and nature of the IT and risk/return relation and would form the basis for moving research forward in this area. Because of the multiple independent variables and dependent variables in the IT and risk/return relation, the next step in a research program would be to use multi-attribute models to obtain more precise estimates of the nature and complexity of the relation. Such studies might employ data envelopment analysis (DEA) with IT investment, type of IT, and estimates of IT risk as inputs and firm risk and return as outputs. Alternate DEA models would provide estimates of the technical and managerial relationships between and among the inputs and outputs. A variety of measures of return (ROX, TRS, market share, Tobin's q) and risk (semi-variance, leverage, Z-score, ordinal risk (Collins and Ruefli, 1992)) might be employed.

Another implication of this study is for the economic theory of complementarities. The economic theory of complementarities explains why a set of complementary organizational variables generates higher returns than the sum of the returns provided by individual variables. But it remains silent about the risk implications of the complementarities and risk/return tradeoffs involved in managing a set of complementary variables. By incorporating risk into the analysis, this study extends the economic theory of complementarities. Second, the economic theory of complementarities and its applications in the IS field have treated IT as an ordinary variable among a set of complementary organizational design variables. This study argues that IT is a special organizational design variable that helps managers to identify potential complementarities among other organizational design variables and manage these complementarities such that they are realized. Since IT permeates and coordinates almost all activities, processes, and systems of the firm, the analysis and design of a new IT system is likely to reveal which organizational factors are likely to be affected, and in what directions they need to be changed for the success of the new system. By utilizing this information, managers can identify potentially complementary organizational factors. Further, the coordination role played by IT in managing complementarities is critical for the realization of potential complementarities. Thus, IT is not an ordinary organizational design variable. It integrates complementary variables, coordinates their multi-way interactions with each other, and helps the firm to realize potential synergies among them.

This study also makes contributions by challenging and improving some of the implicit assumptions of prior IS studies that build on the economic theory of complementarities. Prior studies assume that a firm's investments in different types of IT can be aggregated into a single "IT investment" figure. They hypothesize that the complementarity of investments in IT and non-IT organizational design variables will improve firm performance. Put differently, they use a one-level model of the firm that comprises investments only. This study challenges the assumptions of prior IS studies by explaining that the causal link from investments to performance is too long, and that there are intermediate levels through which complementary investments are converted into performance outcomes. This study extends prior studies by using a four-level model of firm performance and explaining that there are different types of complementarities within and across the four levels. Complementarity of investments at the first level influences the risk/return performance of activities at the second level; complementarity of activities at the second level influences the risk/return performance of groups of activities at the third level; and complementarity of groups of activities at the third level influences the overall risk/return performance of the firm at the fourth level. Each type of activity may need a different type of IT. For example, supply chain management (SCM) activities may need *automate*-type IT investments, whereas new product development (NPD) and customer relationship management (CRM) activities may need *informate*-type IT investments. Groups of activities may need IT systems that coordinate across individual activities. When assessing whether and to what extent a firm is managing complementarities, it is important to distinguish among different types of complementarities within and across the four-level model. When different types of IT investments are pooled into a single, firm-level IT investment figure, researchers cannot separately examine different types of complementarities and how they influence firm performance. For example, pooled IT investment data do not distinguish between a firm that exploits complementarities within SCM activity by investing 100% of its IT budget into *automation* only and a firm that tries to exploit complementarities within and across various activities by allocating the same amount of IT budget across *automate*, *informate*, and *transform* type of IT investments along the value chain. The present study suggests that the performance effects of complementarities can be better understood if researchers distinguish different types of complementarities and the roles of different types of IT in realizing them.

Implications for Practitioners

Our extensions to the economic theory of complementarities also have implications for general managers. As Barua, Lee and Whinston (1996: 411) indicate, senior management must have an enhanced vision regarding the overall business model of the firm to be able to exploit benefits of complementarities across the firm. The four-level model of the firm developed in this study suggests that as part of this vision, senior managers should identify a preferred risk/return profile for their firms, and use that profile for providing general direction to lower levels of the firm in selecting risk/return characteristics of investments (inputs into organizational activities), activities (competences), and groups of complementary activities (capabilities). A key task of general managers is to devise and create capabilities that yield a competitive advantage for the firm (Stalk, Evans, and Shulman, 1992). The theory presented here indicates that managers can develop such capabilities by identifying and realizing potential complementarities among groups of organizational activities. Corporate strategy is about taking positions, making tradeoffs, and forging fit across the activity system of the firm (Porter, 1996: 68ff). Here, we emphasize that the risk/return position taken at the top level of the firm is important for guiding risk/return tradeoffs and forging fit at lower levels of the firm. Risk/return tradeoffs made at the lower levels ultimately have an influence on the overall risk/return position of the firm.

According to the original theory of complementarities, IT is an ordinary organizational design variable whose main role is to decrease marginal costs and improve marginal returns of organizational activities. Our extensions of the theory inform general managers that IT has additional roles in identification, coordination, and realization of potential complementarities within and across the four levels of the firm. As illustrated in Figure 3, in a system of complementary activities, investments in an IT system that increase levels of a subset of the activities, in turn prompt the management to increase levels of the remaining complementary activities, which in turn prompts the management to also invest in the input factors of those activities. By enabling managers to notice and utilize the strength of the mechanism of complementarities, IT enables managers to invest in inputs and activities, at each prompt, that are necessary for developing organizational competences and organizational capabilities, which are subsequently necessary for improving the risk/return positions of their firms.

Another major implication of the proposed research model for practice is that managers must not view the risk implications of IT only from the perspective of the IT function. Currently, academic and practitioner writings on the risk implications of IT have a predominant focus on the effects within the IT function such as IT investment risks, IT/Software development risks, IT implementation risks, IT failure risks, IT security risks, IT outsourcing risks, and so forth. (e.g., Weill and Broadbent, 1998; Benaroch and Kauffman, 1999; Keil, Cule, Lyytinen, and Schmidt, 1998; Lyytinen, Mathiassen, Ropponen, 1998). This focus implies that firms view the risk implications of IT as an operational matter rather than a strategic matter. This study highlights the notion that IT has major implications for corporate level risk/return tradeoffs. Thus, relegating the corporate level risk/return implications of IT to the IT function or business units is potentially a misleading approach. Corporate level risks and returns are strategic matters, and they should be managed as such.

Given that IT permeates the whole activity system of a firm, the executives of the IT function or the executives of strategic business units may not be able to control all decisions over IT investments across the value chain. Hence, the firm may not be able to make complementary investments and simultaneous adjustments in IT. Even if a single operational-level executive has control over all IT investment decisions, it may be difficult to justify a full suite of strategic IT investments that support complementary activities across various strategic business units of the firm. Traditional cost-benefit metrics may be biased toward isolated IT projects and IT investments within a single business unit or function. They may miss the strategic importance of making IT investments not just for isolated organizational activities, but also for groups of complementary activities. They may also resist and fail to justify the cost-benefit of such investments. Therefore, IT investments across the activity system of the firm cannot be treated as an operating matter and left to operational-level executives. The CEO is in a better position for focusing the attention of the entire company on making IT investments that improve the risk/return positions of a firm's activities, competences, and capabilities.

Chief executive officers have always had a professional and moral responsibility to shareholders with respect to the financial performance of their firms. The Sarbanes-Oxley bill now also requires them to be legally responsible for the validity and accuracy of their firms' financial statements. The efforts to comply with the bill are already raising the awareness of CEOs that IT is not just an isolated operational function, but also the proverbial glue that holds together the firm's activity system. The immediate concern of CEOs is for IT to produce accurate and reliable financial statements that they can sign off on. As the Blue Rhino case indicates, achieving this objective requires IT to not only support individual elements of the activity system, but also to integrate well among them. IT plays a major role in streamlining the activity systems of firms. In addition to generating accurate and reliable financial statements, streamlined activity systems can minimize risks, maximize returns, and allow the firm to achieve a more favorable risk/return tradeoff. Thus, the theoretical extensions in this paper can provide guidance to CEOs in analyzing the complementarity structure within the activity systems of their firms and in justifying IT investments that support the complementarities.

Adopting a risk/return perspective is important for both researchers and practicing managers because doing so provides them with a different view of the organization. While a return perspective directs attention to benefits and their relation to (usually direct) costs, a risk perspective promotes a focus on the uncertainty of the future, consideration of alternatives (both alternative futures and alternative actions), and consideration of opportunity costs. Combining the two perspectives, a risk/return point of view invites consideration of the tradeoffs between benefits and costs—both fully construed—and adds a richness to the analysis of the firm and IT's role in that setting. In conclusion, this paper makes a theoretical contribution by explaining how IT impacts corporate risk/return performance of firms.

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Journal of the Association for Information Systems

ISSN: 1536-9323