

Information Technology and Firm Boundaries: Impact on Firm Risk and Return Performance

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In this paper, we empirically investigate the impact of information technology (IT) investment on firm return and risk financial performance, emphasizing the moderating role of the firm boundary strategies of diversification and vertical integration. Our results indicate a sharp contrast between the direct and interactive effects of IT on both the return (profitability) and risk (variability of returns) dimensions. While the direct effect of IT capital is to increase firm risk for a given level of return, we find that suitable boundary strategies can moderate the impact of IT on firm performance in a way that increases return and decreases risk, at the margin. This interaction effect is strongest in service firms, in firms with high levels of IT investment intensity, and in more recent time periods. Our results are robust to alternative proxies for firm risk, including an ex ante risk measure (variability of analysts' earnings estimates), and alternative risk-return specifications. Put together, our results provide new insights into how IT and firm boundary strategies interact to affect the risk and return performance of firms.

Key Words: IT investments; risk and return; firm boundaries; diversification; vertical integration; strategic use of IT

1. Introduction

Investments in information technology (IT) by U.S. firms has grown at a fast pace over the last two decades, with the annual growth in real investment peaking at an average of 24% in the 1995 to 2000 period, some five times the growth rate of investment in other types of equipment (Doms 2004). IT investment as a share of total equipment and software (E&S) investment stands at 41% by the end of 2004 (Doms 2005), making IT the biggest component of capital investment by U.S. firms. In light of the growing scale of IT investment, a key question faced by individual firms is whether and how these investments are contributing to competitive advantage and profitability of the firm — which was also the topic of intense debate surrounding the “Does IT Matter?” question posed by Carr (2003). While most IS researchers reject the claims of Carr (2003), the issue of *how* IT investments can be combined with firm

strategies to yield improved firm performance remains a substantive research issue, and one that motivates this work.

In the IT business value literature (see Dedrick et al. 2003 and Melville et al. 2004 for reviews), researchers have used various approaches and output measurements to examine the impact of IT investments on firm performance. While there is by now definitive empirical evidence that IT investments are associated with increased firm output and productivity, there is a lack of clear evidence with respect to the contributions of IT investment to profitability, prompting Dedrick et al. (2003) to coin the term “profitability paradox” to describe our state of knowledge. One explanation for the paradox is that while IT creates value in the form of increased efficiency or productivity, firms find it difficult to capture that value in profits due to the dissipative effects of competition in the product market (Hitt and Brynjolfsson 1996). These countervailing effects underlying IT value creation and capture imply that the link between IT investment and profitability is ultimately an empirical question. Contrary to earlier efforts, very recent research by Mithas et al. (2008), based on a proprietary data set, has presented interesting new results of a positive and significant link between IT investment to firm profitability, mediated more through revenue enhancement than through cost savings.

Apart from the impact of IT investment on *average* profitability, there are rich and open research questions about the specific mechanisms by which firms might capture the value created from IT investments. That is, it is worth investigating how the impact of IT investments on firm performance vary with firm characteristics and strategic choices, due to the managerial implications such results would entail. Prior research has examined this issue and documented evidence on how IT can contribute to profitability through its interaction with other firm resources (Ravichandran and Lertwongsatien 2005, Powell and Dent-Micallef 1997), structural differences between firms (Clemons and Row 1991), how customer satisfaction mediates IT returns (Mithas et al. 2005), the moderating role of investments in complementary organizational resources (Brynjolfsson et al. 2002). Our research is in the same spirit, emphasizing the moderating role of firm boundary strategies, motivated by the stream of research on IT and firm boundaries (e.g., Malone et al. 1987, Gurbaxani and Whang 1991, Dewan et al. 1998, Hitt 1999,

Afuah 2003, Ray et al. 2006). Our research objectives are closest to Chari et al. (2008) and Liu and Ravichandran (2008), but the scope of our research goes beyond diversification alone to also consider vertical integration and other firm characteristics, and it incorporates both the return and risk dimensions of firm performance.

The motivation to consider both return and risk is based on the emerging research in the IS literature suggesting the importance of the risk impacts of IT investments (Dewan et al. 2007, Dewan and Ren 2007, Tanriverdi and Ruefli 2004, Hunter et al. 2003).¹ Specifically, Dewan et al. (2007) found that IT capital is substantially riskier than non-IT capital, and that the IT risk premium constitutes about 30% of the gross returns on IT investment. Motivated by these findings, we consider the interaction of IT and business strategy in terms of both the return and risk dimensions of firm performance — an essential element of our research design. Our key research questions are as follows: How do IT investments interact with firm boundaries — an important component of overall business strategy — in affecting firm performance on both return and risk dimensions? How does the moderating effect vary with firm and industry characteristics? How does the nature of IT investments interact with boundary strategies in affecting firm performance? Answers to these questions would help us understand the impact of IT on firm performance, in a more comprehensive manner relative to prior research.

Our results suggest a strong moderating effect of firm boundaries on the relationship between IT investment and firm performance. Specifically, our results suggest a complementarity between IT investments and diversification, stronger for related diversification as compared to unrelated diversification. The complementarity is such that increased IT investments combined with greater firm diversification results in higher returns and lower risk, over and above the direct effects of IT investments on firm risk and return performance. These results are analogous to the moderating effects reported in Cool et al. (1989), whereby the organizational variables market share and operational efficiency are also shown to increase returns and decrease returns, at the margin.

¹ In terms of anecdotal evidence, a study by the Standish Group of more than 8,000 IT projects found that about 72% of projects either failed outright, or suffered budget overruns, delays, or ended up with fewer features than promised (*BusinessWeek* 2001).

Our analysis of the interaction between IT investments and vertical integration is more nuanced. We argue on theoretical grounds that IT investments can be synergistic with either increased or decreased vertical integration, so that the net effect is theoretically ambiguous, and ultimately an empirical issue. It turns out that our empirical results are consistent with a positive interaction between the *scale* of IT investments and vertical integration. We also analyze the interaction between vertical integration and the *nature* of IT investments, and here theory and evidence (based on a different and more current data set) are consistent in pointing towards a positive association between externally-oriented IT investments and decreased vertical integration (i.e., strategic focus). We further find that the moderating influence of firm boundaries, on IT's impact on firm risk and return, is relatively stronger in the service sector (as compared to the manufacturing sector), in firms with relatively high IT-intensity (as compared to low IT-intensity firms) and in more recent time periods (as compared to older time periods).

We conducted a battery of tests to verify the robustness of our results. Specifically, we re-estimated our results using alternative proxies for firm risk, including an *ex ante* measure of risk: variability of analysts' earnings forecasts, as suggested by Bromiley (1991). We also tried alternative risk-return specifications, following the approaches followed in prior work, and found that the qualitative nature of the results was consistent across the specifications.

The rest of the paper is structured as follows: In Section 2, we briefly review the literature streams that are relevant to this study. Section 3 proposes our research framework and empirical hypotheses, and Section 4 describes our empirical model and data set. Our results are presented in Section 5, and Section 6 concludes.

2. Background and Literature Survey

This paper is at the confluence of three distinct streams of the IS literature: (i) business value of IT; (ii) risk and return of IT investments; and (iii) IT and firm boundaries. In what follows, we describe how our work relates to each of these streams, starting with work on IT business value.

2.1. Business Value of IT

The growing investments in IT capital (Doms 2004) is ultimately driven by expectations of value commensurate with the level of investments. The value added from IT investments are obtained from the automation of business processes, better information for more effective decision making, and the transformation of business processes and business models resulting in new forms of value creation (Zuboff 1988). There is by now definitive evidence of IT value creation, as reflected in efficiency and productivity improvements both at the process (e.g., Barua et al. 1995) and firm (e.g., Brynjolfsson and Hitt 1996) levels. If anything, there is evidence of “excess returns” on IT investment (Dewan and Min 1997). There is mixed evidence, however, about the extent to which firms are able to *capture* the value created by IT investments. While past research has not been able to document a positive link between IT and profitability (e.g., Hitt and Brynjolfsson 1996, Rai et al. 1997), a recent study by Mithas et al. (2008) found evidence of a significant and substantial link between IT investments and profitability, channeled through revenue enhancement rather than cost savings.

Apart from the average *direct* effect of IT investment on profitability, considerable research attention has also been focused on the *indirect* effects of IT on profitability, in terms of the interaction of IT investments with firm and industry characteristics. Prior research has examined this issue and documented evidence on how IT can contribute to profitability through its interaction with other firm resources, such as customer satisfaction (Mithas et al. 2005), the moderating role of investments in complementary organizational resources (Brynjolfsson et al. 2002), the mediating role of organizational agility (Setia 2005), and complementarities between IT resources and IT capabilities (Ravichandran and Lertwongsatien 2005).

In the same spirit as the above research, we investigate the moderating role of firm boundary strategies in shaping the relationship between IT investments and firm performance, where we consider the interaction between IT investment, diversification and vertical integration. At the same time, we consider both return and risk dimensions of firm performance, motivated by the emerging literature on IT risk and return, as we describe next.

2.2. Risk and Return of IT Investments

Risk considerations have been largely ignored in IT business value research, until recently. In the first empirical study of the IT risk-return relationship, Dewan et al. (2007) develop empirical proxy measures of IT risk and incorporate them into production function and market value specifications — the primary models for measuring IT returns. Their results suggest that IT capital investments are substantially riskier than non-IT capital investments, and the IT risk premium is about 30% of gross IT returns. Tanriverdi and Ruefli (2004) discuss the importance of incorporating risk into the IT business performance analysis and propose a conceptual research model to study the impact of IT investments on the risk-return relations of firms. Focusing on the interaction between risk and return, Dewan and Ren (2007) conduct a unique event study to simultaneously examine the wealth and risk effects associated with electronic commerce initiatives. They find that the abnormal returns documented in prior research are no longer significant when contemporaneous risk changes are taken into account. Similarly, Fornell et al. (2006) study the impact of customer relationship management (CRM) investments on the stock price of firms, finding that such announcements are associated with higher stock returns and lower volatility.

2.3. IT and Firm Boundaries

In the IS literature, there is a considerable body of research focused on the relationship between IT investment and firm boundaries. In their seminal piece that has served as the foundation for this research stream, Malone et al. (1987) argue that the adoption of information technologies reduces market coordination costs, leading to a relatively greater use of markets as compared to hierarchies. Extending that analysis, Gurbaxani and Whang (1991) investigate the impact of IT on both external boundaries of the firm as well as internal allocation of decision rights, based on the useful distinction between internal and external coordination costs (more on these costs below).

Building on the analysis of Gurbaxani and Whang (1991), Dewan et al. (1998) find that related diversification demands greater IT investments than unrelated diversification, and less vertically integrated firms have higher level of IT investments. Hitt (1999) finds that IT investments are associated with substantial decreases in vertical integration and weak increase in diversification. Extending prior research, Ray et al. (2006) examine how the relationship between IT and firm scope is moderated by firm

asset characteristics — tangible assets vs. intangible assets. Our research objectives are closest to Chari et al. (2008) and Liu and Ravichandran (2008), who examine the interaction between IT investment and product diversification, but the scope of our research goes beyond diversification alone to also consider vertical integration and other firm characteristics (manufacturing versus service, degree of IT intensity, and recency effect), and it incorporates both the return and risk dimensions of firm performance.

2.4. Relation to Existing Literature

This study relates to the existing literature in the following respects. First, it contributes to the emerging research of IT risk and return by conducting empirical examination on the direct and interactive effects of IT investments on firm risk-return performance. It is useful to discuss how this paper relates to Dewan et al. (2007), abbreviated to DSG. The primary objective of DSG was to develop proxy measures of IT risk from accounting data, and use them to provide an IT risk explanation for the empirical evidence of excess IT returns. By contrast, the present paper studies how firm boundary strategies of diversification and vertical integration moderate the impact of IT investments on firm risk and return performance. While “risk” is at the center of the analysis in both papers, IT risk is the primary independent variable in DSG, but firm risk is both an independent variable (to explain firm returns) and one of the two key dependent variables in the present paper. The key independent variables are IT and IT Risk in DSG, while IT and firm boundary variables, and their interactions, are the key explanatory variables in the present paper. The two papers largely share the same data set, although part of the analysis in the present paper is based on much more recent IT data obtained from Harte Hanks Corporation (see Section 4.2). DSG draws on real options theory and production economics, while the theoretical foundation of the present paper rests on strategic management theory, agency theory and transaction cost economics. Overall, the primary contribution of DSG was to develop a measure of IT risk and use it to explain IT returns, whereas the present paper demonstrates how the risk-return performance impacts of IT investments are moderated by firm boundaries.

Accordingly, this study also relates to the literature on IT and firm boundaries. While strategy research examines the impact of firm boundaries on firm performance, and IS research examines the

relationship between firm boundaries and IT investments, in this paper we examine the joint effect of IT and firm boundaries on firm risk and return performance. Third, the IT business value literature has inconclusive findings of IT profitability, as we discussed in Section 2.1. By studying both direct and interactive effects of IT on firm performance, we are able to shed light on the mechanisms by which IT investments impact firm performance.

3. Development of Hypotheses

We start by describing our conceptual research framework, illustrated in Figure 1, which provides the context for our hypothesis development, and also provides a “roadmap” for visualizing our hypotheses. The focus of our analysis is on the link between IT investments and firm risk-return performance, and how it is moderated by the firm boundary strategies of diversification and vertical integration, while controlling for other key industry and firm characteristics. Within this analytical framework, we first develop hypotheses about the average effect of IT investments on firm return and risk performance, followed by empirical predictions about how this effect is moderated by the boundary strategies.

Our analysis draws on the theoretical framework developed by Gurbaxani and Whang (1991) based on transaction cost economics and agency theory, wherein the choice of horizontal and vertical boundaries (diversification and vertical integration, respectively) optimizes the coordination costs faced by the firm. Since these coordination costs are at the center of our analysis as well, it is useful to say a few words about them. *Internal* coordination costs refer to the opportunity costs associated with decision making within an enterprise. These include the costs of processing and communicating information, the opportunity costs of poor information, and the losses (agency costs) due to incentive conflicts in delegated decision settings. *External* coordination costs refer to the costs of conducting transactions in the market, as opposed to within the hierarchy of the firm, and include operational costs (such as search, transportation and communication costs) and contractual costs of writing and enforcing contracts with other business entities. To the extent that IT is an essential coordination technology in the modern economy, the choice of firm boundaries has implications for the scale and nature of IT investments, and for the impact of IT on firm performance.

Within the realm of firm boundaries, our analysis focuses on the boundary strategies of diversification and vertical integration. Diversification refers to the extent to which the firm chooses to operate in multiple lines of business or product markets, while vertical integration is the extent to which value chain activities are conducted inside the firm as opposed to contractually with business partners. The choices of diversification and vertical integration clearly have implications for internal and external coordination costs (Dewan et al. 1998). As the scope of the firm changes, so does the need for coordination, and the type of coordination. To the extent that business processes support product decisions and value chain activities, and business processes are increasingly enabled by IT, one would expect the scope of product lines and value chain activities to affect the scale and impact of IT investments. We develop specific hypotheses about the moderating impacts of firm boundaries, but before doing so we outline our expectations with respect to the direct effects of IT investments on firm risk and return performance.

3.1. IT and Firm Return and Risk Performance

The ability of a firm to capture the value created by their IT investments, and translate it into profitability, depends not only on the firm's business and IT strategies, but on industry structure, especially competition. As noted by Hitt and Brynjolfsson (1996) the value created by IT investments (total surplus) is split between the investing firms (producer surplus) and the end users (consumer surplus), and the distribution of gains is in part a function of the intensity of competition. It is conceivable that all of the IT value is competed away so that the value from IT investments is transferred entirely to consumers in the form of lower prices or higher product quality or variety, as has historically been the case in the banking sector (Steiner and Teixeira 1990). To the extent that markets are not perfectly competitive, however, firms have some market power, and should be able to convert some of the IT value into profitability. Therefore, after controlling for the level of competition (as we do in our empirical analysis), we can predict at least a weakly positive link between IT investments and profitability.

Turning to the risk dimension of firm performance, we predict that IT investments will be associated with higher firm risk, on average.² There are a number of factors that contribute to the riskiness of IT investments, as succinctly categorized by Benaroch (2002). First, there are firm-specific risks, reflecting factors internal to the firm which result in varying success in terms of realizing the potential of IT investments. Then, there are competition risks arising from the possibility of competitors imitating IT innovations before firms are able to recoup the anticipated returns on their investments. Rather than gaining competitive advantage, IT innovations might become strategic necessities required for staying in business (Clemons and Row 1991). Finally, IT investments are subject to market risks, reflecting uncertainties about customer demand, market regulations, and the pervading risk of technological obsolescence which sometimes results in an unanticipated reduction in the service life of IT assets, which are relatively short to begin with (Dewan and Min 1997). Put together these factors contribute to the ex ante uncertainty about costs and benefits associated with specific IT investments, resulting in a positive association between IT investments and firm risk.

The analysis above leads to the following set of hypotheses:

HYPOTHESIS 1A. *IT investments are associated with higher returns (i.e., profitability).*

HYPOTHESIS 1B. *IT investments are associated with higher risk (i.e., variability of profitability).*

3.2. Interaction Between IT and Diversification

Diversification refers to the extent to which a firm operates in multiple lines of business, in response to “excess capacity” in resources, such as knowhow or a specialized indivisible asset, that cannot be efficiently sold in the market (Montgomery 1994). Accordingly, diversified firms seek to benefit from scope economies that accrue from sharing the resources across multiple lines of business — albeit at the cost of increased costs of coordinating the use of the resource across multiple products.

Scope economies from diversification can be realized on the revenue or cost side. Revenue scope economies allow diversified firms to generate higher levels of revenue for a given level of marketing

² Some types of IT investments in theory could stabilize earnings and thereby reduce earnings variability in some industries (Hunter et al. 2003). This is confirmed by the empirical analysis of Dewan et al. (2007), but they find that in the majority of the industries IT investments are associated with higher firm risk.

effort. A case in point is “one stop shopping” available from multiproduct firms, which attracts customers through reduced search and transaction costs, while expanding opportunities for the firm to cross-sell different products and services to the same customers. Cost scope economies arise when multiproduct firms enjoy lower marginal or average cost as they engage in additional lines of business, due to the fact that the fixed cost of common resources are shared across multiple lines of business.

The benefits of the scope economies are available in return for increased coordination costs. As analyzed in Dewan et al. (1998), diversification results in a net increase in internal coordination costs, while leaving external coordination costs essentially unchanged (for a given firm size and level of vertical integration). Specifically, the sharing of resources such as intellectual capital, managerial expertise or specialized physical assets creates new interdependencies within the organization, calling for higher levels of coordination and control — and a net increase in internal coordination cost.

IT has a role to play both on the benefit and cost side of diversification in that it can be used to enhance scope economies, while reducing the “unit cost” of internal coordination. Starting with the former, IT can enhance scope economies in a number of ways, as illustrated by the following examples. On the revenue side, IT can be the key to executing the complex logistics required to execute on the strategy of “one stop shopping” (Clemons and Row 1988), as in the case of diversified financial supermarkets such as Citigroup. Customer sales data collected for one product or service can be leveraged to cross-sell other products and services. Specifically, investments in data warehouses and analytics can enable direct marketing and other forms of personalization to better target products and services to finer segments of customers (Loveman 2003, Davenport 2006). Diversification also enables a firm to leverage its core IT resources and capabilities across multiple product lines and business units, increasing the contribution of IT to earnings for a given level of IT investments (Chari et al. 2008, Liu and Ravichandran 2008).

Turning to the impact of IT on the unit cost of internal coordination, the value (and marginal value) of any coordination technology is likely to be increasing in the number of interdependencies — analogous to Metcalfe’s Law in the context of network effects, where the value of a communication technology is

increasing in the number of communication links. The level of interdependence is generally increasing in the level of diversification, because the leveraging of common resources across multiple lines of business calls for joint action, and the decisions of one unit affect those of the other (Dewan et al. 1998). To the extent that IT is a key coordination technology in the modern, we should expect a positive relationship between the level of diversification and IT returns. Diversification also entails added requirements for control of the shared resources across organizational units and product lines. Monitoring is one such control mechanism, which has its own information processing requirements, that are increasingly fulfilled in firms using IT-based solutions.³ In such a setting, the key role of monitoring is to track and report key performance metrics associated with productive resources. The sharing of such resources under diversification introduces correlation in the states of nature across product lines and organizational units, which in turn increases the effectiveness of the monitoring control mechanisms put in place. To the extent that control and monitoring are increasingly dependent on IT, this argument also supports a positive association between the level of diversification and IT returns.

Turning to the risk dimension of firm performance, we expect the interaction between diversification and IT to reduce firm risk. The sharing of common IT resources across organizational units allows one unit to benefit from the learning efforts of another, reducing both cost and benefit uncertainties associated with deploying the IT resources, for example, by not repeating the same mistakes that resulted in bad outcomes in the past. From an agency-theoretic perspective (Jensen and Meckling 1976), IT-enabled monitoring mechanisms (as discussed above) result in more effective risk sharing between the center (such as head quarters) and decentralized organizational units, reducing the overall risk exposure of the firm. Finally, the research on the portfolio approach to IT investments (see, e.g., Bardhan et al. 2004) suggests that the incremental earnings from IT investments in a diversified firm accrue from a portfolio of diversified IT applications across the firm, which also reduces the variability of earnings and firm risk.

³ See Gurbaxani and Whang (1991) for a discussion of how Point of Sale systems in retail settings are not only productivity-enhancing tools but effective monitoring mechanisms as well.

We turn now to the substantive difference between related and unrelated diversification. Related diversification involves expansion into similar product lines, whereas unrelated diversification seeks to achieve economies in the allocation of financial capital across distinct lines of business within the firm. Dewan et al. (1998) analyze differences in coordination and control between related versus unrelated diversification, concluding that the former is relatively more coordination-intensive than the latter, for two key reasons. First, the nature of interdependence is pooled in unrelated diversification, but reciprocal under related diversification, which is relatively more coordination-intensive. Second, unrelated diversification relies on incentives-based control, but related diversification calls for monitoring-based control, which requires a relatively higher level of information processing and coordination. While related diversification calls for higher levels of internal coordination, it also provides greater scope economies as well. The similarity of the product lines means a greater ability to exploit the synergies.

Related diversification provides more ample opportunities for the application of IT, both for enhancing scope economies and reducing the unit cost of internal coordination, as illustrated by the following examples. IT solutions for one product line can be “ported over” to other similar product lines, amplifying the returns on IT investments. Economies of scale in coordination activities also increase the returns on IT investment; e.g., common suppliers reduces the number of contracts, or common components reduce the bull whip effect in supply chains. Also IT-enabled joint procurement enables volume discounts, etc, increasing the returns on the IT investment. As IT solutions are applied to additional product lines, there is decreasing ex ante uncertainty about the costs and benefits of the IT applications, which reduces the risk implications. No such learning economies under unrelated diversification.

Based on these arguments, we hypothesize that:

HYPOTHESIS 2A. The moderating impact of product diversification on the link between IT investment and firm performance tends to increase returns, ceteris paribus.

HYPOTHESIS 2B. The moderating impact of product diversification on the link between IT investment and firm performance tends to decrease risk, ceteris paribus.

HYPOTHESIS 2C. *The above moderating impacts are stronger for related diversification as compared to unrelated diversification, with respect to both (i) returns and (ii) risk.*

3.3. Interaction Between IT and Vertical Integration

Vertical integration refers to the extent to which successive activities in a value chain are conducted within a firm. In choosing to vertically integrate firms seek to economize on market transaction costs such as the contractual costs of writing and enforcing contracts with outside parties and operational costs of search, transportation and logistics. As discussed by Gurbaxani and Whang (1991) and Dewan et al. (1998) these savings in external coordination costs are only available at the price of increased internal coordination costs. Indeed, vertical integration is one of the most expensive strategies to coordinate because it is based on sequential interdependence where resource flows from one division to the next must be coordinated (Jones and Hill 1988). As more activities are conducted inside the firm's hierarchy, there is a corresponding increase in internal coordination costs in the form of higher agency costs and decision information costs (Gurbaxani and Whang 1991). In fact, internal and external coordination costs move in opposite directions as value chain activities are moved across the boundaries of the firm: increased vertical integration (focus, respectively) is associated with decreased (increased, respectively) external coordination costs, but increased (decreased, respectively) internal coordination costs.

IT can be used in ways to support both internal and external coordination (Gurbaxani and Whang 1991). As we discussed for diversification above, IT can enable internal coordination by lowering the cost of communicating and processing information for decisions within the firm's hierarchy, and it can enable monitoring and control, which reduces agency costs. Indeed, the role of IT in supporting internal coordination is well-known, going back to Porter and Millar (1985), who relate IT to the value chain and argue that the main strategic purpose of IT is to coordinate activities in the chain. At the same time, IT can reduce external coordination costs by reducing search costs (Bakos 1997), helping substitute information for inventory and thereby reducing logistics costs (Cachon and Fisher 2000), and enabling information sharing and linkage between business partners, thereby reducing contractual costs with external business partners and customers (Gurbaxani and Whang 1991).

To the extent that IT can be used in ways to reduce both internal and external coordination costs, IT investments can be associated with either increased or decreased vertical integration. Brynjolfsson et al. (1994), Dewan et al. (1998) and Hitt (1999) document empirical evidence of increased IT investments correlated with reduced vertical integration, but Afuah (2003) and Fernandez and Nieto (2005) argue that in circumstances where IT has a bigger impact on internal rather than external coordination costs, greater IT investments might be associated with increased vertical integration. Although much of the empirical evidence is consistent with a reduced vertical integration hypothesis, theoretical predictions about the link between the scale of IT investments and degree of vertical integration are inherently ambiguous — in the end, this is largely an empirical question.

While predictions about the impact on returns of the interaction between the *scale* of IT investments and vertical integration are theoretically ambiguous, we can make sharper predictions regarding the *nature* of IT investments. Suppose a firm is considering to decrease the level of its vertical integration, or increase its strategic focus. Since this will involve moving certain in-house transactions outside the firm, there will be an attendant increase (decrease, respectively) in external (internal, respectively) coordination costs. A firm that anticipates this change in the cost structure, will combine the choice of increased strategic focus with added investments in IT that are specialized towards reducing the unit cost of external coordination — such as electronic data interchange (EDI) systems, supply chain and customer management applications, or other inter-organizational systems that enable information sharing and linkage with outside parties and markets. Indeed, the greater the investment in “externally oriented” IT assets, the greater the reduction in external coordination costs, and the higher the synergy between IT investments and the strategic focus strategy. Similarly, a firm contemplating a vertical integration strategy would be better off targeting IT investments that are oriented towards economizing on internal coordination costs.

We turn now to the risk dimension of firm performance and how it is affected by the interaction between IT investment and vertical integration. We first observe that the direct effect of vertical integration is to reduce firm risk. As noted by Gurbaxani and Whang (1991) “when facing an ever-

changing environment, a firm is relatively more capable (than a market) of immediately and costlessly restructuring decision rights, redeploying resources, and internally resolving possible disputes.” This greater control over internally-mediated transactions will translate into more predictable firm performance, and reduced firm risk. IT investments can increase the control on internal transactions by enhancing information flows and monitoring capabilities, thereby further reducing firm risk. Also, similar to our arguments above for diversification, we expect that as common IT resources and capabilities are shared across multiple value chain activities, the economies of learning would reduce uncertainties in costs and benefits, again reducing firm risk. Finally, while vertical integration results in deeper business processes and increased variability in process performance, IT applications that provide end-to-end integration of the processes can not only reduce the mean process performance, but also the variability of process performance (see, e.g., Hammer and Champy 1994, Schmidt 1997). In sum, we predict that the interaction of IT investment and vertical integration will tend to lower firm risk.

Put together our arguments above lead to our next set of hypotheses:

HYPOTHESIS 3A. The moderating impact of vertical integration on the link between IT investments and firm performance tends to decrease firm risk, ceteris paribus.

HYPOTHESIS 3B. The higher the external orientation of IT investments the stronger the financial performance of a reduced vertical integration (i.e., increased focus) strategy, with respect to both (i) returns and (ii) risk.

3.4. Other Firm Characteristics

We now turn to the question of what types of firms would have a stronger interactive effect between IT investments and boundary strategies. In theory, given our analysis above, we would expect the strength of IT-boundary interactive effects to be higher in settings where internal and external coordination costs are more sensitive to IT investments. While it is difficult to characterize the variation in IT sensitivity of coordination costs, we can point to two extremes. At one end of the spectrum would be the dot.com firms of the new economy, with fully digitized business processes, where one would clearly expect coordination costs and organization structure to be thoroughly shaped by information technology (see, e.g., Barua et al.

2000, BarNir et al. 2003). The other extreme would be traditional firms in “low tech” industries that rely entirely on traditional means of coordination, such as meetings and physical monitoring. Needless to say, neither of these extremes is represented in our data set. However, interpolating between these extremes, it would be logical to conclude that coordination costs would be more responsive to IT in firms where business processes are more IT-enabled or digitized. While we don’t have direct proxies for digitization of business processes, we hypothesize three types of firms that would have a higher level of process digitization: service firms as compared to manufacturing firms; firms with high IT intensity as compared to firms with low IT intensity; and more recent time periods, as opposed to earlier time periods.

Starting with the distinction between manufacturing and service firms, one would expect a relatively greater reliance on physical assets in the former as compared to information and knowledge assets in the latter. Further, business processes in manufacturing firms would involve a higher degree of physical flows, as opposed to information flows in service firms. Accordingly, we would expect business processes in service firms to be more IT-enabled, even digitized, as also argued by Mithas et al. (2005) in their analysis of the impact of IT on customer satisfaction. Similarly, firms that have a higher level of IT intensity will tend to favor IT-enabled coordination and control mechanisms, as compared to non-IT based mechanisms (such as meetings), so that business processes in IT-intensive firms are likely to be relatively more IT-enabled than those in less IT-intensive firms. Finally, along with increased investments in IT capital (Doms 2004), the substitution of IT capital for other factors of production (Dewan and Min 1997), and the growing sophistication of IT-enabled process improvement (Davenport 1993, Hammer and Champy 1993) over time, we can expect an increasing degree of IT-enablement and digitization of business processes over time. These arguments lead to our final hypothesis:

HYPOTHESIS 4. The moderating impact of boundary strategies on the link between IT investments and firm risk-return performance is relatively stronger in:

4A. Service firms, as compared to manufacturing firms, for both (i) returns and (ii) risk;

4B. Firms with high IT-intensity, as compared to firms with low IT-intensity, for both (i) returns and (ii) risk; and

4C. More recent time periods, as compared to older time periods, for both (i) returns and (ii) risk.

4. Empirical Model and Data

4.1. Empirical Specifications

Our key dependent variables are firm return and firm risk, and the set of predictor variables includes IT capital, degrees of diversification and vertical integration, along with other firm and industry control variables. Our empirical specification is as follows:

$$\begin{aligned} Ret_{i,t+1} = & \alpha_0 + \alpha_1 DIV_{it} + \alpha_2 VI_{it} + \alpha_3 IT_{it} + \alpha_4 IT_{it} * DIV_{it} + \alpha_5 IT_{it} * VI_{it} + \alpha_6 Risk_{i,t} + \alpha_7 K_{it} + \alpha_8 R \& D_{it} \\ & + \alpha_9 Adv_{it} + \alpha_{10} Size_{it} + \alpha_{11} Leverage_{it} + \alpha_{12} IndConc_{it} + \alpha_{13} IndCI_{it} + \alpha_{14} IndQ_{it} + \alpha_{15} IndReg_{it} \quad (1) \\ & + (Year) + u_{it} \end{aligned}$$

$$\begin{aligned} Risk_{i,t+1} = & \beta_0 + \beta_1 DIV_{it} + \beta_2 VI_{it} + \beta_3 IT_{it} + \beta_4 IT_{it} * DIV_{it} + \beta_5 IT_{it} * VI_{it} + \beta_6 K_{it} + \beta_7 R \& D_{it} \\ & + \beta_8 Adv_{it} + \beta_9 Size_{it} + \beta_{10} Leverage_{it} + \beta_{11} IndConc_{it} + \beta_{12} IndCI_{it} + \beta_{13} IndQ_{it} + \beta_{14} IndReg_{it} \quad (2) \\ & + (Year) + v_{it} \end{aligned}$$

Thus, our empirical model includes two equations (1) and (2), characterizing the firm return and firm risk, respectively. The dependent variables $Ret_{i,t+1}$ and $Risk_{i,t+1}$ denote firm return and firm risk, respectively, for firm i at year $t + 1$, where we use both accounting-based and market-based measures. Average return on assets (ROA) is used as the accounting-based measure of firm return, and the standard deviation of ROA is used as the accounting-based measure of firm risk. Average ROA is calculated by dividing income before extraordinary items by total assets, using quarterly data over the year following the year of the observation (i.e., four observations). Here, firm risk is measured by the standard deviation of quarterly ROA over the same year used for calculating average ROA. The market-based measures of firm return and firm risk are average monthly stock returns and the standard deviation of monthly stock returns, respectively, calculated over the course of the year following the year of the data (i.e., 12 observations). Besides accounting-based and market-based measures of firm return and firm risk, we also use an ex ante measure of firm risk, following Bromiley (1991). Ex ante measure of firm risk reflects the prior assessments of anticipated uncertainty of a firm's earnings stream, which is a better reflection of the actual decisions faced by the firm or its managers, as opposed to the realized variability of returns

captured by the ex post measures such as variability of returns. As in Bromiley (1991), the ex ante measure of risk that we use is the standard deviation of analysts' forecasts of earnings per share (EPS).

Key independent variables include: IT_{it} = IT capital stock, normalized by total assets; DIV_{it} = level of diversification, using the entropy measure employed by Palepu (1985) and used in prior IS research (Dewan et al. 1998). The reason for using entropy measure is that it allows the distinction between related and unrelated diversification while other measures of diversification do not. Moreover, a study by Hoskisson et al. (1993) shows that entropy measures have more advantages in terms of statistical validity and accuracy, as compared to other measures of corporate diversification. VI_{it} = vertical integration, which we measure two different ways. The first measure is the ratio of value added to sales, as originally used by Adelman (1955). This measure is easy to calculate, but sensitive to industry structure differences. As a measure of robustness, we also use an alternate measure developed by Fan and Lang (2000), and used by Ray et al. (2006). These two measures of vertical integration reflect different aspects of vertical integration. In the model specifications (1) and (2), moderating effects of firm boundaries are operationalized through the interaction terms $IT_{it} * DIV_{it}$ and $IT_{it} * VI_{it}$. We include lagged firm risk, $Risk_{i,t}$, as an independent variable in the firm return model specification in equation (1).

We also include a variety of firm and industry controls. Firm-level variables are: non-IT capital investment normalized by total assets (K_{it}), R&D expenses normalized by annual sales ($R \& D_{it}$), advertising expenses normalized by annual sales (Adv_{it}), firm size proxied by the logarithm of firm market value ($Size_{it}$), and firm leverage measured by long-term debt divided by total assets ($Leverage_{it}$). Following Bharadwaj et al. (1999) and Dewan et al. (2007), we include four industry level control variables, defined at the 2 digit SIC level: industry four-firm concentration ratio ($IndConc_{it}$); industry capital intensity ($IndCI_{it}$); industry q ratio ($IndQ_{it}$); and industry regulation dummy ($IndReg_{it}$). We also include year dummies (seven dummy variables for the eight observation years). The

equation disturbances u_{it} and v_{it} in (1) and (2) might be correlated with each other, due to omitted factors that influence both firm return and firm risk.⁴ So, our model is estimated using seemingly unrelated regression (SUR) (see Zellner 1962).

4.2. Data

Turning to our data, we obtain firm-level IT stock data from the Computer Intelligence Infocorp (CII) database, which covers the years 1987-1994 and includes over 500 unique *Fortune 1000* firms. This database is generally regarded as the most authoritative source of firm-level IT investment data, aggregated from establishment-level survey data. And the IT capital stock includes all computer systems such as mainframes, peripherals, minicomputers, and PCs. Our accounting and firm boundary measures are derived from the COMPUSTAT database, wherein the segment level data is used to compute the entropy measures of firm diversification and Fan and Lang's (2000) vertical integration index. Market financial data are obtained from the Center for Research in Security Prices (CRSP). Data for the ex ante measure of firm risk is obtained from the Institutional Brokers Estimate System (IBES).

Our analysis of the hypothesis about the interaction between the *nature* (i.e., external orientation) of IT investments and vertical integration is based on a different data set from the rest of the analysis. It is the *Harte Hanks* data base, constructed from a survey of IT assets of Fortune 1000 companies, at the establishment level. While the target audience and nature of this data base is virtually identical to that of our main *CII* data base, there are some key differences. The time frame of the Harte Hanks data base is 2003 to 2007 (as compared to 1987 to 1994 for the CII data base) and the data is at the establishment level, although the data can be rolled up to the firm level. And while there is considerable detail about investments in hardware, software, managed services and telecom assets, there is no aggregate dollar figure available for the market value of IT assets, as there is in the CII data base. This is the reason we are unable to move our entire analysis to the new data set, but we are able to shed light on the interaction between vertical integration and the nature of IT investments, which we feel is a new and unique

⁴ Our empirical estimates of the baseline model of equations (1)-(2) suggest that the cross model correlation between two equations is -0.383.

contribution of this research.⁵ In terms of specifics, we are able to roll up the establishment level data up to 1,824 firm-year observations. We construct a new variable, which we call REITO, for Relative External IT Orientation, defined as the ratio of customer relationship and supply chain users to total enterprise software users, restricted to firms with at least one user of customer relationship or supply chain management software. Additional details about the new variables derived from the Harte Hanks data base are provided in the notes below Table 6. All the other industry and firm variables are constructed in an identical manner to the main CII data base, as we describe next.

We discard observations with missing values for the key independent variables (firm performance *Ret* and *Risk*, and firm boundary variables *DIV* and *VI*). Missing values for other independent variables are replaced by industry averages. To deal with outliers, we follow the standard winsorization procedure, as in prior research using this data set (Dewan et al. 2007), that replace the values in bottom and top one percentiles with the 1st and 99th percentile values. To avoid potential collinearity problems between the interaction terms and the constituent independent variables (*DIV*, *VI* and *IT*) we centered the independent variables.⁶ Our final sample consists of 3,100 observations for 557 unique companies.

The descriptive statistics are provided in Table 1. The mean level of firm return is positive (0.013 for average of ROA and 0.013 for average of stock returns), with a wide dispersion around these mean values. For firm risk, the standard deviation of stock returns (0.079) is much higher than the standard deviation of ROA (0.009), and the standard deviation of analysts' forecasts of EPS is 0.104. The share of IT capital in the firm total assets is 0.006 on average, ranging from 0.00004 to 0.044. The mean level of firm diversification is 0.540, with a range of 0 (non-diversified) to 1.665. The mean level of vertical integration is 0.419 (measured by value added divided by sales) and 0.010 (IO-based measure). The average firm size in market value of equity in our sample is \$1.67 billion, indicating that the firms in our sample are relatively large companies. A correlation matrix of the main variables is provided in Table 3.

⁵ We should acknowledge that the associate editor and one of the reviewers provided the impetus for this line of inquiry, for which we are grateful.

⁶ After centering the variables, the VIF index is below 2 for all the variables in all the following analyses.

Our subsample analysis considers three sets of comparative subsamples. The first set distinguishes between manufacturing (SIC2 in the 20-39 range) and non-manufacturing industries — even though H4 is stated as a comparison between manufacturing and service firms, the results are qualitatively similar when the service category is expanded to include other non-manufacturing industries. Examples of manufacturing industries that have higher frequency in our data set include chemicals and allied products, industrial and commercial machinery and computer equipment, electronic and other electrical equipment and components. Examples of non-manufacturing industries that have higher frequency in our data set include electric, gas and sanitary services industry, insurance carriers, and wholesale trade for non-durable goods industry. The second set partitions the data based on IT intensity, defined as the ratio of IT capital to total assets. The subsample of low (high, respectively) IT-intensity firms includes firms in the bottom (top, respectively) 33 percentile of the full sample. Finally, the third set of subsamples distinguishes between the years 1987-1990 and 1991-1994 in the data set.

Descriptive statistics for the above subsamples are shown in Table 2. Note that firms in the manufacturing subsample have relatively higher average firm return and higher level of diversification than firms in non-manufacturing industries. R&D intensity and advertising intensity are also much higher in the manufacturing sector than non-manufacturing sectors. High IT-intensity firms have relatively higher firm return than low IT-intensity firms; but the average firm risk is also higher for the former compared to the latter. There are no significant differences in firm size across the subsamples.

5. Empirical Results

In this section we discuss the baseline results from the estimation of equations (1)-(2), along with a variety of robustness tests. The results are presented in Tables 4-8 and a summary of the hypothesis tests is provided in Table 9.

5.1. Full Sample Analysis

Our main regression results are consolidated into Table 4, where we present estimates from the return model and the risk model in separate columns. There are three pairs of columns, corresponding to the following hierarchical analysis: (1) a reduced model with only the direct effects of *IT*, *DIV* and *VI*; (2) our

main baseline model with the interactive effects $IT*DIV$ and $IT*VI$ included; and (3) a model that distinguishes between related diversification $RDIV$ and unrelated diversification $UDIV$. The table includes 95% confidence intervals (in addition to standard errors) for the coefficients of the interaction terms, which are the ones of primary interest.

Starting with (1), the coefficient on IT is positive but insignificant, so that H1A is not supported. This is not unexpected, given our theoretical arguments in Section 3.1 that the link between IT investments and profitability depends in part on whether or not producer surplus gets dissipated due to competition in the product markets; this is therefore an empirical question. The coefficient on IT risk is positive and significant, so that H1B is supported ($p < 0.01$), consistent with the results of Dewan et al. (2007). Diversification (DIV) is negatively associated with both returns and risk, with both coefficients significant at 1%. This is consistent with research in strategic management that has examined the impact of diversification on firm risk-return performance (see, e.g., Chang and Thomas 1989). Vertical integration (VI) has a positive coefficient ($p < 0.01$) in the returns model but a negative coefficient ($p < 0.05$) in the risk model. The relationship between firm boundaries and returns is consistent with prior work (see, e.g., Capon et al. 1990). The coefficient estimates of other firm characteristics, such as non-IT capital, and industry control variables are consistent with expectations.

Turning to our main baseline model (2), the direct effects are all largely consistent with the direct effects model (1). The two interaction terms $IT*DIV$ and $IT*VI$ are jointly and significantly different from 0, in both the return ($F = 10.31, p < 0.01$) and risk ($F = 8.05, p < 0.01$) models, confirming the significant moderating impact of firm boundaries on firm risk-return performance. Looking at the individual interaction terms, $IT*DIV$ is positive ($p < 0.01$) in the returns model and negative in the risk model ($p < 0.05$), consistent with H2A and H2B, respectively. $IT*VI$ is positive and significant ($p < 0.01$) in the returns model, and negative and significant ($p < 0.01$) in the risk model, so that H3A is supported. Recall, we had hypothesized a positive or negative interactive effect in the returns model. The positive result might imply that IT impact is stronger on internal coordination costs, or that IT investments tended to emphasize internal more than external coordination.

Given the insignificant direct effect of IT on firm return, but positive and significant interactive effects, one might wonder about the net total effect of IT on returns, when the direct and interactive effects are combined. Note that the total return on IT is now a function of the level of *DIV* and *VI*. A common benchmark for the total effect is to evaluate it at the median values of the moderator variables. We did this and found that the total return on IT investment (at the median values) is still insignificant. When we evaluated the total return at the various quartiles of the moderator variables, we found that the total effect of IT on firm returns is positive and significant beyond the third quartiles of the moderator variables.

In model (3), which distinguishes between related and unrelated diversification, the coefficients on *RDIV* and *UDIV* are similar to each other and with total diversification *DIV* in models (1) and (2). The interaction terms *IT*RDIV* and *IT*UDIV* have the same signs as *IT*DIV* in model (2), but there is a difference in magnitudes. In the return model, coefficient on *IT*RDIV* is larger than that on *IT*UDIV* and the *F* test for coefficient difference is significant at 10% with *F* value 2.97. The difference between the coefficients in the risk model is not statistically significant. To facilitate the comparison of the magnitudes of the coefficients we present the results of the regressions with standardized variables (i.e., zero mean and unit standard deviation) in Table 5, which also includes 95% confidence intervals for the coefficients of the interaction terms. Briefly, what we see (Column 1) is that the moderating impact of diversification on returns is stronger than that of vertical integration. Further (Column 2), the moderating impact of related diversification on returns is substantially stronger than unrelated diversification. The difference in coefficients in the risk model is not statistically significant.

We turn now to our analysis of the link between vertical integration and the nature of IT investments (Hypothesis 3B), based on the Harte Hanks data base. The results are provided in Table 6. As discussed in Section 4.2, we operationalize the notion of external orientation of IT assets through the *REITO* (Relative External IT Orientation) variable, defined as the ratio of customer relationship and supply chain management users to the total number of enterprise software users. This variable is clearly increasing in the fraction of users that are involved in the key external coordination activities of customer relationship

management and supply chain management. This variable is truly a proxy for the extent of external coordination in the firm, going beyond the nature of the industry the firm is in, because we include a comprehensive set of industry characteristics defined at the 2-digit SIC level. We interact the *REITO* variable with *VI*, and use the total number of enterprise users as a proxy for *IT* (we tried a number of other proxies for IT, such as the total number of PCs, with similar results).

The main finding is that the interaction term *REITO*VI* is negative and significant in the return model (but insignificant in the risk model). We present the results both with and without the direct effect of *REITO* included in the regression, but the coefficient on *REITO*VI* is virtually identical. To interpret the negative coefficient on the interaction term, it is useful to keep in mind that decreased vertical integration is equivalent to an increased *focus* in the scope of value chain activities. Accordingly, our results suggest that the profitability of strategic focus is increasing in the external orientation of IT assets. This is consistent with H3B and provides evidence in support of the predictions from coordination theory (Malone et al. 1987, Gurbaxani and Whang 1991) for the interaction between IT investments and the boundaries of the firm — as it applies to vertical integration.

To ensure the validity of our baseline results, we conduct a variety of robustness checks, including (1) use of market-based measure of firm return and risk, instead of the accounting-based measure; (2) use of ex ante measure of firm risk; (3) use of Fan and Lang's (2000) IO-based vertical integration index; (4) consistent with the risk-return model specifications in Oviatt and Bauerschmidt (1991), firm risk and firm return are simultaneously interrelated so that firm risk and firm return are endogenous variables and three stage least squares (3SLS) regression is used to address the simultaneity issue.⁷ The results from these robustness checks are presented in Table 7. As can be seen in the table, the qualitative nature of our results is unchanged across the various risk measures and risk-return specifications.

5.2. Results from Sample Split Analysis

⁷ In fact, besides the five robustness checks listed above, we conducted several other robustness checks such as White's heteroskedasticity adjustment; 1-digit and 2-digit SIC dummies in place of our four industry control variables. Results from these robustness checks are uniformly consistent with our main findings. For sake of brevity, we omit these additional robustness checks, and only report the four robustness checks in Table 7.

To examine the differences in IT impacts across different segments of our sample, we conduct sample split analyses, following the three types of classifications described in Section 4. Table 8 shows the results from these analyses. Overall, our results tend to confirm the propositions underlying H4. Specifically, the non-manufacturing subsample (as we mentioned in Section 4.2 the results for the service sector are qualitatively similar to the broader category of non-manufacturing firms) displays stronger IT-boundary interaction effects, as compared to the manufacturing subsample. For non-manufacturing firms, both $IT*DIV$ and $IT*VI$ have significant (at the 1% level) positive association with firm return and significant (at the 10% and 1% level for $IT*DIV$ and $IT*VI$ respectively) negative association with firm risk. However, manufacturing firms do not have significant interactive effects, except for $IT*DIV$ on firm risk at the 10% level of significance. We also conduct t tests for the differences in the coefficient estimates of IT complementarities ($IT*DIV$ and $IT*VI$) between the two subsamples, finding that the differences in the interaction terms across the subsamples are statistically significant.

Looking at the results for our second classification, based on IT intensity, our sample-split results show that the high IT-intensity segment has stronger IT-boundary interaction effects, while in the low IT-intensity segment, these effects are generally not significant. The t tests for differences in coefficient estimates between two subsamples are also significant. Our last classification is based on recency. We find that the interaction effects are stronger in the more recent time period of 1991-1994, as compared to the earlier time period of 1987-1990. All the interaction terms have the right sign and significance, and t tests confirm significant differences in IT-boundary interaction effects across the two subsamples. Put together, our results are supportive of H4.

5.3. Implications of Results

To think about the implications of our results, it is useful to view them from the lens of the resource-based view (RBV) of the firm (see, e.g., Wernerfelt 1984), and specifically its application by Mata et al. (1995) to explaining how information technology could be a source of sustained competitive advantage. Mata et al. (1995) examine several different potential sources of IT-based competitive advantage — access to IT capital, proprietary IT technology, technical IT skills and managerial IT skills — and their

RBV analysis suggests that managerial IT skills is the only such IT attribute that can be a source of sustained competitive advantage. They define managerial IT skills as the “ability to conceive of, develop, and exploit IT applications to support and enhance other business functions.” The primary insight from Mata et al. (1995) is that the key to unlocking IT value lies in the synergy between IT investments and business strategy — not in the attributes of the IT investments by themselves.

Our analysis focuses on a fundamental set of business strategies, having to do with the choice of the boundaries of the firm, specifically, diversification and vertical integration. The analog of “managerial IT skills” in our context is the ability of managers to align their IT investments with changes in the scope of the firm, either in terms of product-line diversification or integration of their value chains. In this regard, our results suggest that while IT investments by themselves tend to increase firm risk (for a given level of returns), when additional IT investments are strategically combined with changes in firm boundaries then the adverse impact on firm risk can be mitigated, while increasing firm returns at the margin. That is, the unique skills embodied in the proper synchronization of IT strategy and firm boundary strategies can improve the risk-adjusted performance of the firm and potentially be a source of sustained competitive advantage. Related to this key insight, our results suggest that the direct and moderated impacts of IT investment on firm risk are at least as important, if not more important, than the impacts on firm returns, so that managers should consider the impacts of IT investments not just on firm returns, but also on the risk profile of the firm. Further, in justifying new IT investments, managers should carefully analyze not just the scale of the investments but the nature of the investments as well, and specifically how the investments would enable internal versus external coordination required by their choice of firm boundaries.

6. Conclusions

This paper contributes at the intersection of the literatures on firm boundaries and the business value of IT, especially the stream focused on the risk and return of IT investments. Our analysis looks at the direct and moderated impacts of IT investment on firm risk-return performance, emphasizing the interaction between IT investments and the boundary strategies of diversification and vertical integration. Our results

suggest that, on average, the association between IT investments and firm returns is insignificant, but positive and significant with respect to risk; i.e., IT investments are associated with increased firm risk. However, IT interacts with boundary strategies in a way to increase returns and decrease risk, at the margin.

This study makes at least three key contributions to the IT value literature. First, our results help make sense of the mixed results on IT profitability in the literature to date, by shedding light on the underlying mechanisms by which IT allows firms to create and capture value. Specifically, boundary strategies significantly moderate the impact of IT investments on firm risk and return performance, and these results carry important managerial implications with respect to the strategic use of IT in achieving profitability. Second, we contribute to the emerging research on IT risk and return (see, e.g., Dewan et al. 2007, Tanriverdi and Ruefli 2004, Dewan and Ren 2007) by showing that it is important to consider both dimensions of IT impact on firm performance. A new insight emerging from our study is that while IT investments are by themselves quite risky, strategic use of IT in leveraging firm resources (boundary strategies) can result in lower firm risks. Finally, our analysis sheds new light on how the synergy between IT and boundary strategies is dependent on the *nature* of the IT assets, specifically based on the implications of vertical integration for internal versus external coordination costs.

This work is not without limitations. First, our main data set is a bit dated, running only until 1994, although we are able to mitigate this to some extent by supplementing our main results with additional analysis based on a very current data set, running over 2003-2007. Still, one might wonder if the type of IT-scope complementarity studied here remains important today. In this regard, the increasing trend for the globalization of work and IT-enabled outsourcing and offshoring suggests that, the importance of IT-led boundary strategies is only growing in importance. Further, the ever-increasing investments in IT (some estimates suggest that one out of every two dollars of capital investment goes towards IT) imply that the reliance on IT and exposure to IT risk is only growing, so that the impact of IT on firm risk-return profile likely remains relevant. Another limitation is that our main data set provides only total investment in IT, without any additional information on the types of IT applications and services — although the

latter detail is available in the supplementary results based on the 2003-2007 new data set. Finally, our research design is unable to go too much beyond the scale of IT investments, to consider factors such as IT competency, due to data limitations.

In terms of future research, first of all, it would be most useful to try and overcome some of the data limitations discussed above, to examine more recent data, systematic industry-level differences, and to explore the role of different types and classes of IT investment in the context of the risk-return profile of firms. Perhaps a firm-level detailed survey could provide the right granularity and recency of data. It would also be useful to conduct in-depth field studies to gain richer insights into the link between IT investments, firm scope and risk-return performance. Finally, it would be valuable to extend the analysis to other strategic choices that firms make, going beyond firm scale and scope, in order to create a broader understanding of the strategic use of IT.

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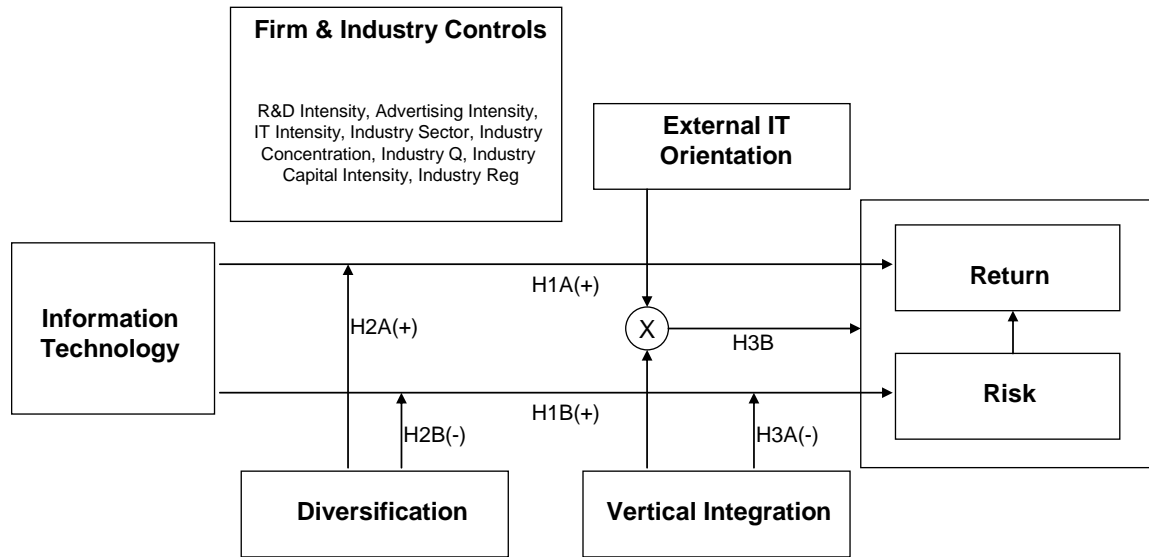
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Figure 1 **Conceptual Framework**



Additional Hypotheses:
 H2C: Related Vs. Unrelated Diversification
 H4: Firm Characteristics

Table 1 Descriptive Statistics

Variable	Description	Mean	Std Dev	Minimum	Maximum
<i>Ret</i>	Average of Quarterly ROA	0.013	0.015	-0.043	0.057
	Average of Monthly Stock Returns	0.013	0.026	-0.054	0.092
<i>Risk</i>	Std Dev of Quarterly ROA	0.009	0.012	0.0003	0.075
	Std Dev of Monthly Stock Returns	0.079	0.037	0.029	0.234
	Std Dev of Analysts' Forecasts of EPS	0.104	0.143	0	0.799
<i>DIV</i>	Entropy Measure of Firm Diversification	0.540	0.509	0	1.665
<i>VI</i>	Value-Added / Sales	0.419	0.173	0.054	0.842
	Fan and Lang's (2000) IO-based Vertical Integration Index	0.010	0.028	0	0.165
<i>IT</i>	IT Capital / Total Assets	0.006	0.007	0.00004	0.044
<i>K</i>	Non-IT Capital / Total Assets	0.368	0.222	0.005	0.845
<i>R&D</i>	R&D Expenses / Sales	0.020	0.030	0	0.133
<i>Adv</i>	Advertising Expenses / Sales	0.025	0.036	0	0.161
<i>Size</i>	Log (Market Value of Equity)	7.421	1.436	3.433	10.506
<i>Leverage</i>	Long-Term Debt / Total Assets	0.207	0.149	0	0.707

Notes: All variables have 3,100 observations, except the ex ante measure of risk, which has 2335 observations. The accounting-based *Ret* is the average of quarterly ROA (= Income before Extraordinary Items/Total Assets) over one year following the date of the observation. The market-based *Ret* is the average of monthly stock returns over one year following the date of the observation. The accounting- and market-based *Risk* variables are calculated as the standard deviation of the corresponding *Ret* measures. The ex ante measure of *Risk* is the standard deviation in stock analysts' forecasts of a firm's earnings per share. *DIV* is firm diversification using the entropy measure. *VI* is firm vertical integration measured by firm value-added divided by sales and the IO-based measure in Fan and Lang (2000).

Table 2 Descriptive Statistics of Subsamples

Variable	Manufacturing		Non-Manufacturing		Low IT-Intensity		High IT-Intensity		1987-1990		1991-1994	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
<i>Ret</i>	0.015	0.015	0.010	0.012	0.011	0.013	0.014	0.016	0.013	0.015	0.013	0.015
<i>Risk</i>	0.008	0.011	0.007	0.010	0.007	0.010	0.010	0.013	0.009	0.012	0.009	0.012
<i>DIV</i>	0.615	0.503	0.418	0.494	0.563	0.517	0.472	0.509	0.580	0.511	0.505	0.504
<i>VI</i>	0.430	0.140	0.401	0.215	0.394	0.184	0.439	0.169	0.435	0.170	0.404	0.174
<i>IT</i>	0.006	0.007	0.006	0.008	0.001	0.001	0.014	0.009	0.007	0.007	0.006	0.007
<i>K</i>	0.346	0.165	0.404	0.288	0.403	0.271	0.329	0.174	0.373	0.220	0.363	0.223
<i>R&D</i>	0.028	0.031	0.007	0.021	0.012	0.023	0.029	0.036	0.019	0.028	0.021	0.031
<i>Adv</i>	0.034	0.041	0.011	0.016	0.023	0.036	0.021	0.030	0.024	0.035	0.026	0.037
<i>Size</i>	7.364	1.428	7.515	1.445	7.613	1.394	7.163	1.457	7.227	1.416	7.598	1.432
<i>Leverage</i>	0.194	0.139	0.230	0.162	0.225	0.158	0.182	0.133	0.210	0.149	0.205	0.149
N	1922		1178		1023		1023		1477		1623	

Notes: The definition and measurement of the variables are the same as in Table 1. The accounting-based *Ret* and *Risk* are reported in this table. *VI* is measured by value-added divided by sales. The subsample of manufacturing includes firms SIC2 in the 20-39 range. IT-intensity is defined as the ratio of IT capital to total assets. The subsample of low IT-intensity includes firms in the bottom 33 percentile of the full sample, while the subsample of high IT-intensity includes firms in the top 33 percentile of the full sample.

Table 3 Pearson Correlation Matrix of Selected Variables

	<i>Ret</i>	<i>Risk</i>	<i>DIV</i>	<i>VI</i>	<i>IT</i>	<i>IT*DIV</i>	<i>IT*VI</i>	<i>K</i>	<i>R&D</i>	<i>Adv</i>	<i>Size</i>	<i>Leverage</i>
<i>Ret</i>	1											
<i>Risk</i>	-0.340 ($<.0001$)	1										
<i>DIV</i>	-0.090 ($<.0001$)	-0.098 ($<.0001$)	1									
<i>VI</i>	0.013 (0.482)	-0.038 (0.036)	0.025 (0.166)	1								
<i>IT</i>	0.008 (0.676)	0.121 ($<.0001$)	-0.128 ($<.0001$)	0.111 ($<.0001$)	1							
<i>IT*DIV</i>	0.068 (0.001)	-0.084 ($<.0001$)	0.093 ($<.0001$)	0.021 (0.239)	-0.268 ($<.0001$)	1						
<i>IT*VI</i>	0.028 (0.113)	-0.001 (0.940)	-0.026 (0.155)	0.053 (0.003)	0.473 ($<.0001$)	-0.134 ($<.0001$)	1					
<i>K</i>	-0.020 (0.275)	-0.015 (0.413)	-0.148 ($<.0001$)	0.199 ($<.0001$)	-0.105 ($<.0001$)	0.042 (0.018)	-0.014 (0.451)	1				
<i>R&D</i>	0.197 ($<.0001$)	0.072 ($<.0001$)	-0.033 (0.062)	0.124 ($<.0001$)	0.258 ($<.0001$)	-0.078 ($<.0001$)	0.091 ($<.0001$)	-0.194 ($<.0001$)	1			
<i>Adv</i>	0.227 ($<.0001$)	0.064 (0.0004)	-0.029 (0.111)	-0.077 ($<.0001$)	-0.069 (0.0001)	0.011 (0.548)	-0.044 (0.015)	-0.058 (0.001)	0.079 ($<.0001$)	1		
<i>Size</i>	0.317 ($<.0001$)	-0.119 ($<.0001$)	0.085 ($<.0001$)	0.064 (0.0004)	-0.204 ($<.0001$)	0.078 ($<.0001$)	-0.097 ($<.0001$)	0.163 ($<.0001$)	0.173 ($<.0001$)	0.127 ($<.0001$)	1	
<i>Leverage</i>	-0.358 ($<.0001$)	0.013 (0.459)	0.025 (0.169)	0.137 ($<.0001$)	-0.083 ($<.0001$)	-0.004 (0.835)	-0.073 ($<.0001$)	0.340 ($<.0001$)	-0.287 ($<.0001$)	-0.143 ($<.0001$)	-0.189 ($<.0001$)	1

Notes: p-values are shown in parentheses. The definition and measurement of the variables are the same as in Table 1.

Table 4 Main SUR Regression Results

Variable	(1) No Interactions		(2) Baseline Model		(3) Related Vs. Unrelated Diversification	
	Return Model	Risk Model	Return Model	Risk Model	Return Model	Risk Model
Intercept	-0.006*** (0.002)	0.014*** (0.002)	-0.006*** (0.002)	0.014*** (0.002)	-0.006*** (0.002)	0.015*** (0.002)
<i>DIV</i>	-0.004*** (0.0005)	-0.002*** (0.0004)	-0.004*** (0.0005)	-0.002*** (0.0004)		
<i>RDIV</i>					-0.003*** (0.001)	-0.001 (0.001)
<i>UDIV</i>					-0.004*** (0.001)	-0.002*** (0.001)
<i>VI</i>	0.005*** (0.001)	-0.003** (0.001)	0.005*** (0.001)	-0.003** (0.001)	0.005*** (0.001)	-0.002* (0.001)
<i>IT</i>	0.014 (0.034)	0.160*** (0.031)	-0.013 (0.039)	0.192*** (0.035)	0.018 (0.041)	0.197*** (0.037)
<i>IT*DIV</i>			0.210** (0.064) [0.086, 0.226]	-0.137* (0.057) [-0.151, -0.123]		
<i>IT*RDIV</i>					0.423*** (0.115) [0.395, 0.648]	-0.111 (0.103) [-0.314, -0.086]
<i>IT*UDIV</i>					0.159* (0.090) [0.137, 0.181]	-0.132* (0.081) [-0.291, -0.112]
<i>IT*VI</i>			0.608*** (0.195) [0.560, 0.655]	-0.561*** (0.175) [-0.604, -0.518]	0.509*** (0.195) [0.126, 0.892]	-0.325* (0.176) [-0.669, 0.020]
<i>Risk</i>	0.044** (0.021)		0.049*** (0.021)		0.047** (0.021)	
<i>K</i>	0.004*** (0.001)	0.001 (0.001)	0.003*** (0.001)	0.001 (0.001)	0.003*** (0.001)	0.001 (0.001)
<i>R&D</i>	-0.007 (0.010)	0.018** (0.009)	-0.006 (0.010)	0.017* (0.009)	-0.008 (0.010)	0.013 (0.009)
<i>Adv</i>	0.038*** (0.007)	0.021*** (0.006)	0.038*** (0.007)	0.020*** (0.006)	0.040*** (0.007)	0.020*** (0.006)
<i>Size</i>	0.003*** (0.0002)	-0.001*** (0.0002)	0.003*** (0.0002)	-0.001*** (0.0002)	0.003*** (0.0002)	-0.001*** (0.0002)
<i>Leverage</i>	-0.030*** (0.002)	0.002 (0.002)	-0.029*** (0.002)	0.002*** (0.002)	-0.029*** (0.002)	0.003 (0.002)
<i>IndConc</i>	0.0001 (0.001)	0.0001 (0.001)	0.0003 (0.001)	-0.00001 (0.001)	0.0001 (0.001)	-0.001 (0.001)
<i>IndCI</i>	0.000004 (0.00003)	0.0001*** (0.00003)	0.000004 (0.00003)	0.0001*** (0.00003)	0.00001 (0.00003)	0.0001*** (0.00003)
<i>IndQ</i>	0.001*** (0.0003)	-0.0002 (0.0003)	0.002*** (0.0003)	-0.0003 (0.0003)	0.001*** (0.0003)	-0.0002 (0.0003)
<i>IndReg</i>	-0.006*** (0.001)	-0.002*** (0.001)	-0.006*** (0.001)	-0.002*** (0.001)	-0.006*** (0.001)	-0.002*** (0.001)
System Weighted R ²	0.209		0.212		0.210	
N	3100	3100	3100	3100	3100	

Notes: All regressions are estimated using seeming unrelated regression. The cross model correlation between Return Model and Risk Model, for baseline model, is -0.383. Standard errors are in parentheses. 95% confidence intervals for coefficients of the interaction terms are in brackets. ***, ** and * denote significance at 1%, 5% and 10%, respectively, for two-tailed test. For Return Model, F test for coefficient difference between *IT*RDIV* and *IT*UDIV* is significant at 10% level, with F value 2.97. For Risk Model, F test for coefficient difference between *IT*RDIV* and *IT*UDIV* is insignificant with F value 0.02. Year dummies were included in the regressions but their estimates are not shown for the sake of brevity.

Table 5 Standardized SUR Regression Results

Variable	(1) Baseline Model		(2) Related Vs. Unrelated Diversification	
	Return Model	Risk Model	Return Model	Risk Model
Intercept	0.004 (0.015)	0.003 (0.018)	0.005 (0.015)	-0.001 (0.018)
<i>DIV</i>	-0.117*** (0.016)	-0.077*** (0.019)		
<i>RDIV</i>			-0.050*** (0.016)	-0.031* (0.018)
<i>UDIV</i>			-0.106*** (0.016)	-0.086*** (0.019)
<i>VI</i>	0.050*** (0.017)	-0.046** (0.019)	0.052*** (0.017)	-0.042** (0.019)
<i>IT</i>	0.022 (0.019)	0.114*** (0.021)	0.026 (0.019)	0.113*** (0.022)
<i>IT*DIV</i>	0.059*** (0.017) [0.027, 0.092]	-0.033* (0.019) [-0.038, 0.004]		
<i>IT*RDIV</i>			0.079*** (0.018) [0.043, 0.114]	-0.021 (0.021) [-0.062, 0.019]
<i>IT*UDIV</i>			0.032* (0.018) [-0.003, 0.067]	-0.034* (0.020) [-0.074, 0.005]
<i>IT*VI</i>	0.025* (0.016) [0.022, 0.029]	-0.041** (0.018) [-0.076, -0.006]	0.026* (0.016) [0.023, 0.057]	-0.035** (0.018) [-0.071, -0.0004]
<i>Risk</i>	0.037** (0.015)		0.028* (0.015)	
<i>K</i>	0.052*** (0.018)	0.025 (0.021)	0.052*** (0.018)	0.019 (0.021)
<i>R&D</i>	-0.011 (0.020)	0.039* (0.022)	-0.013 (0.020)	0.036 (0.023)
<i>Adv</i>	0.092*** (0.017)	0.063*** (0.019)	0.095*** (0.017)	0.060*** (0.019)
<i>Size</i>	0.274*** (0.018)	-0.110*** (0.020)	0.267*** (0.018)	-0.112*** (0.020)
<i>Leverage</i>	-0.289*** (0.018)	0.025 (0.020)	-0.288*** (0.018)	0.032 (0.020)
<i>IndConc</i>	0.004 (0.019)	-0.003 (0.022)	0.002 (0.019)	-0.011 (0.022)
<i>IndCI</i>	0.003 (0.017)	0.081*** (0.019)	0.005 (0.017)	0.078*** (0.019)
<i>IndQ</i>	0.082*** (0.018)	-0.015 (0.021)	0.079*** (0.018)	-0.013 (0.021)
<i>IndReg</i>	-0.164*** (0.020)	-0.060*** (0.022)	-0.169*** (0.020)	-0.069*** (0.023)
System Weighted R ²	0.210		0.210	
N	3100		3100	

Notes: All variables except interaction terms are standardized, while the interaction terms are the product of standardized corresponding variables. All regressions are estimated using seeming unrelated regression. Standard errors are in parentheses. 95% confidence intervals for coefficients of the interaction terms are in brackets. ***, ** and * denote significance at 1%, 5% and 10%, respectively, for two-tailed test. Year dummies were included in the regressions but their estimates are not shown for the sake of brevity.

For baseline model, F test for difference in absolute magnitude between direct effect of IT and interactive effects of IT (i.e., *IT*DIV+IT*VI*) is significant at 5% level, with F value 5.20 for Return Model, and 1.22 insignificant for Risk Model. For related vs. unrelated diversification, F test for coefficient difference between *IT*RDIV* and *IT*UDIV* is significant at 10% level, with F value 3.10 for Return Model, and insignificant with F value 0.18 for Risk Model.

Table 6 SUR Regression Results Relating External Orientation of IT and Vertical Integration

Variable	w/o <i>REITO</i> as Independent Variable		w/ <i>REITO</i> as Independent Variable	
	Return Model	Risk Model	Return Model	Risk Model
Intercept	-0.084 ^{***} (0.015)	0.086 ^{***} (0.017)	-0.089 ^{***} (0.015)	0.088 ^{***} (0.018)
<i>DIV</i>	-0.005 (0.004)	-0.005 (0.004)	-0.005 (0.004)	-0.005 (0.004)
<i>VI</i>	-0.011 ^{**} (0.005)	0.011 [*] (0.006)	-0.012 ^{**} (0.005)	0.011 [*] (0.006)
<i>IT</i>	-0.0004 (0.001)	0.003 ^{**} (0.001)	-0.001 (0.001)	0.003 ^{**} (0.001)
<i>REITO</i>			-0.013 ^{**} (0.006)	0.004 (0.007)
<i>IT*DIV</i>	0.007 ^{***} (0.002)	-0.007 ^{***} (0.002)	0.007 ^{***} (0.002)	-0.007 ^{***} (0.002)
<i>REITO*VI</i>	-0.054 ^{***} (0.017)	0.010 (0.021)	-0.055 ^{***} (0.017)	0.010 (0.021)
<i>Risk</i>	0.130 ^{**} (0.057)		0.132 ^{**} (0.057)	
<i>K</i>	0.020 ^{**} (0.010)	-0.020 [*] (0.012)	0.020 [*] (0.010)	-0.020 (0.012)
<i>R&D</i>	-0.013 ^{***} (0.004)	0.010 ^{**} (0.005)	-0.014 ^{***} (0.004)	0.011 ^{**} (0.005)
<i>Adv</i>	-0.046 ^{**} (0.020)	0.038 (0.024)	-0.047 ^{**} (0.020)	0.038 (0.024)
<i>Size</i>	0.004 ^{***} (0.001)	-0.002 (0.002)	0.005 ^{***} (0.001)	-0.003 (0.002)
<i>Leverage</i>	-0.047 ^{**} (0.012)	0.039 ^{***} (0.014)	-0.047 ^{**} (0.012)	0.039 ^{***} (0.014)
<i>IndConc</i>	-0.003 (0.008)	0.006 (0.010)	-0.003 (0.008)	0.006 (0.010)
<i>IndCI</i>	-0.0003 ^{**} (0.0001)	0.0002 (0.0001)	-0.0003 ^{**} (0.0001)	0.0002 (0.0001)
<i>IndQ</i>	-0.0002 (0.0001)	-0.0001 (0.0002)	-0.0002 (0.0001)	-0.0001 (0.0002)
<i>IndReg</i>	0.005 (0.004)	-0.005 (0.005)	0.005 (0.004)	-0.004 (0.005)
System Weighted R ²	0.097		0.099	
N	1824		1824	

Notes: Results are from seemingly unrelated regression estimation. Standard errors are in parentheses.

***, ** and * denote significance at 1%, 5% and 10%, respectively, for two-tailed test. Year dummies were included in the regressions but their estimates are not shown for the sake of brevity.

IT, in this analysis, is defined as the logarithm of firm total enterprise application users.

REITO, i.e., Relative External IT Orientation, is defined as the ratio of firm CRM and SCM application users to firm total enterprise application users.

Definitions of all other variables are the same as the baseline model.

Table 7 Robustness Checks

Variable	(1) Market-Based Measure of <i>Ret</i> and <i>Risk</i>		(2) Ex Ante Measure of <i>Risk</i>		(3) IO-Based Measure of Vertical Integration		(4) 3SLS Regression w/ <i>Ret</i> and <i>Risk</i> as Endogenous Variables	
	Return Model	Risk Model	Return Model	Risk Model	Return Model	Risk Model	Return Model	Risk Model
<i>DIV</i>	-0.001 (0.001)	-0.007*** (0.001)	-0.003*** (0.001)	0.011 (0.007)	-0.003*** (0.001)	-0.002*** (0.0005)	-0.003*** (0.001)	-0.001** (0.0004)
<i>VI</i>	0.002 (0.003)	-0.006* (0.004)	0.004*** (0.002)	-0.054** (0.021)	-0.026*** (0.009)	-0.001 (0.009)	0.005*** (0.001)	-0.004*** (0.001)
<i>IT</i>	-0.212*** (0.071)	0.316*** (0.095)	-0.042 (0.043)	-0.800 (0.582)	0.064* (0.037)	0.223*** (0.034)	-0.057 (0.040)	0.193*** (0.035)
<i>IT*DIV</i>	0.271** (0.122)	-0.622*** (0.164)	0.140** (0.069)	-3.814*** (0.937)	0.214*** (0.071)	-0.188*** (0.065)	0.238*** (0.062)	-0.193*** (0.057)
<i>IT*VI</i>	1.018*** (0.339)	-1.410*** (0.454)	0.587*** (0.215)	-2.599 (2.920)	5.645*** (1.851)	-5.116*** (1.718)	0.733*** (0.192)	-0.723*** (0.174)
<i>Risk</i>	0.129*** (0.013)		-0.018*** (0.002)		0.044** (0.020)		0.268*** (0.061)	
<i>Ret</i>								0.279*** (0.023)
System Weighted R ²	0.286		0.209		0.221		0.230	
N	3100		2335		3100		3100	

Notes: Results are from seemingly unrelated regression estimation. Standard errors are in parentheses. ***, ** and * denote significance at 1%, 5% and 10%, respectively. Only the estimates of key independent variables are reported in the table.

Column (1) uses stock market based measure of firm return and risk.

Column (2) uses ex ante measure of firm risk (see Bromiley 1991).

Column (3) uses Fan and Lang's (2000) IO-based vertical integration index.

Column (4) has firm risk in the Return Model, and firm return in the Risk Model. Firm return and firm risk are endogenous variables, and 3SLS regression is used to address the simultaneity issue. One-year lagged values of the two endogenous variables and all other exogenous variables are used as instrumental variables.

All above robustness analyses include the same year, firm and industry control variables as the baseline model does. For the sake of brevity, this table only provides estimates of key variables.

Table 8 Sample Split Analyses (SUR Regressions)

Variable	Industry Type				IT Intensity				Data Recency			
	Manufacturing		Non-Manufacturing		Low IT-Intensity		High IT-Intensity		1987 - 1990		1991 - 1994	
	Return Model	Risk Model	Return Model	Risk Model	Return Model	Risk Model	Return Model	Risk Model	Return Model	Risk Model	Return Model	Risk Model
<i>DIV</i>	-0.004*** (0.001)	-0.002*** (0.001)	-0.004*** (0.001)	-0.0005 (0.001)	-0.007* (0.004)	-0.003 (0.004)	-0.005*** (0.001)	0.0002 (0.001)	-0.004*** (0.001)	-0.001 (0.001)	-0.004*** (0.001)	-0.003*** (0.001)
<i>VI</i>	0.011*** (0.002)	-0.006*** (0.002)	-0.002 (0.002)	-0.00002 (0.002)	-0.003 (0.006)	0.010** (0.005)	-0.003 (0.004)	0.003 (0.003)	0.003 (0.002)	-0.003 (0.002)	0.006*** (0.002)	-0.003* (0.002)
<i>IT</i>	-0.009 (0.057)	0.203*** (0.049)	0.091 (0.057)	0.149*** (0.058)	1.549*** (0.513)	0.482 (0.469)	-0.121* (0.066)	0.179*** (0.061)	-0.004 (0.061)	0.093* (0.054)	-0.027 (0.051)	0.269*** (0.046)
<i>IT*DIV</i>	0.038 (0.086)	-0.143* (0.074)	0.476*** (0.095)	-0.173* (0.095)	-0.554 (0.969)	-0.323 (0.887)	0.200* (0.104)	-0.233** (0.095)	0.250*** (0.097)	-0.083 (0.087)	0.184** (0.084)	-0.178** (0.075)
<i>IT*VI</i>	0.121 (0.311)	-0.221 (0.266)	0.850*** (0.243)	-0.769*** (0.244)	-1.157 (1.331)	3.569*** (1.221)	1.782*** (0.325)	-1.064*** (0.299)	0.467 (0.298)	-0.009 (0.268)	0.903*** (0.263)	-1.056*** (0.234)
<i>Risk</i>	0.026 (0.026)		0.088*** (0.033)		0.074* (0.040)		0.040 (0.035)		0.050 (0.032)		0.045 (0.028)	
System Weighted R ²	0.232		0.177		0.276		0.204		0.200		0.238	
N	1922		1178		1023		1023		1477		1623	

Notes: Results are from seemingly unrelated regression estimation. Standard errors are in parentheses. ***, **, and * denote significance at 1%, 5% and 10%, respectively, for two-tailed test.

The manufacturing subsample includes firms with SIC2 in 20-39.

For Return Model, t statistics for *IT*DIV* and *IT*VI* differences between manufacturing and non-manufacturing subsamples are 132.22 and 68.63, respectively, both significant at 1% level for two-tailed test. For Risk model, t statistics for *IT*DIV* and *IT*VI* differences between manufacturing and non-manufacturing subsamples are -9.81 and -57.43, respectively, both significant at 1% level for two-tailed test.

IT-intensity is defined as the ratio of IT capital to total assets. The Low IT-intensity subsample includes firms in the bottom 33 percentile of the full sample, while the High IT-intensity subsample includes firms in the top 33 percentile of the full sample.

For Return Model, t statistics for *IT*DIV* and *IT*VI* differences between Low IT-intensity and High IT-intensity subsamples are 24.75 and 68.61, respectively, both significant at 1% level for two-tailed test. For Risk Model, t statistics for *IT*DIV* and *IT*VI* differences between Low IT-intensity and High IT-intensity subsamples are 3.23 and -117.88, respectively, both significant at 1% level for two-tailed test.

For Return Model, t statistics for *IT*DIV* and *IT*VI* differences between 1987-1990 subsample and 1991-1994 subsample are -20.30 and 43.27, respectively, both significant at 1% level for two-tailed test. For Risk model, t statistics for *IT*DIV* and *IT*VI* differences between 1987-1990 subsample and 1991-1994 subsample are -32.64 and -116.10, respectively, both significant at 1% level for two-tailed test.

All above sample split analyses include the same year, firm and industry control variables as the baseline model. For sake of brevity, this table only provides estimates of key variables.

Table 9 **Summary of Hypothesis Tests**

Hypothesis	Description	Supported or Not	Significance
H1A	IT → higher returns	Not Supported	--
H1B	IT → higher risk	Supported	$p < 0.01$
H2A	IT*DIV → higher returns	Supported	$p < 0.01$
H2B	IT*DIV → lower risk	Supported	$p < 0.05$
H2C (i)	Related > Unrelated for returns	Supported	$p < 0.10$
H2C (ii)	Related > Unrelated for risk	Not Supported	--
H3A	IT*VI → lower risk	Supported	$p < 0.01$
H3B (i)	REITO*(↓VI) → higher returns	Supported	$p < 0.01$
H3B (ii)	REITO*(↓VI) → lower risk	Not Supported	--
H4A (i)	Returns Moderation: Service > Manufacturing	Supported	$p < 0.01$
H4A (ii)	Risk Moderation: Service > Manufacturing	Supported	$p < 0.01$
H4B (i)	Returns Moderation: Hi IT > Low IT	Supported	$p < 0.01$
H4B (ii)	Risk Moderation: Hi IT > Low IT	Supported	$p < 0.01$
H4C (i)	Returns Moderation: Recent > Old	Supported	$p < 0.01$
H4C (ii)	Risk Moderation: Recent > Old	Supported	$p < 0.01$