The Impact of Information Technology Investments on Downside Risk of the Firm: Alternative Measurement of the Business Value of IT

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how a company's information systems and investments in technology enhance the value of a firm. Dr. Wong has published work in various journals, including *Behavioral Research in Accounting* and *Database.*

Abstract: We examine the effect that investments in information technology (IT) have on downside risk profiles of companies that made public announcements of their investments in technology. Given the limitations of financial and decision theory perspectives on risk, we adopt the strategic management perspective that stresses downside risk as an important alternative measure of firm performance. We examine whether different types of IT investments have a differential impact on firm downside risk. Drawing on the resource-based view of the firm and the real options perspective, we find evidence that IT investments and their timing influence organizational downside risk. Transformational and informational IT investments lead to a reduction in downside risk only if they lead to strategic IT investments in the industry. For competitive necessities such as IT investments that automate business functions, a reduction in downside risk is realized by investing in parity with industry participants. Our study contributes to the literature by offering an alternative perspective on the benefits of IT investments, particularly where no apparent incremental financial results may be evident. It also generates insights on IT investment strategies that may help firms keep up with or stay ahead of the competition.

Key words and phrases: downside risk, IT investment, IT strategic role, real options perspective, resource-based view of the firm.

Examining the impact of investment in information technology (IT) on organizations has had a long tradition in information systems (IS) research, and includes questions that are vital to management information systems (MIS) researchers, managers, and investors [23]. At a fundamental level, the question of whether the benefits of IT investments are realized and measured has been extensively examined. While earlier studies such as those of Loveman [37] and Roach [55] were not encouraging, more recent work by Bharadwaj et al. [7], Brynjolfsson and Hitt [11], Dehning et al. [19], and Stratopoulis and Dehning [59], among others, has found a positive association between investments in IT and firm performance. Melville et al. [44], Piccoli and Ives [48], and Wade and Hulland [63] provide comprehensive reviews and syntheses of the extant literature.

For the most part, the extant research on the business value of IT has been limited in its treatment of the risk dimension of firm performance and the risk implications of IT investments. By doing so, IS research has not provided a complete picture on the value of IT investments [61]. Some studies have found that different strategies and firm structure are associated with differences in risk, but not differences in return [27, 46]. Bromiley [10] found that a company's characteristics influence risk and return separately. It follows that risk may be managed independently of return.

To provide a more complete picture of the business value of IT investments, it is necessary to examine measures of firm performance other than positive financial returns, such as risk. Specifically, we focus on the relationship between IT investments and downside risk. From the strategic management literature, *downside risk* is defined as the possibility of a loss relative to some reference point [40, 47], and can be thought of as the standard deviation of negative excess returns (where the benchmark is the industry). This definition is also consistent with managers' concept of risk as organizational losses, especially *competitive risk,* which is the likelihood and magnitude of firm performance falling below that of competitors [61]. By focusing on the downside risk of the firm, our study offers an important measure of performance, which helps to fill the gap in the literature on the business value of IT and thus allows for a more complete picture of firm performance. We address the following research question:

> *RQ: Under what conditions do companies that have invested in IT experience reduction in the levels of downside risk?*

To answer this question, we test models that capture the impact of strategic IT investments on the downside risk of firms.

To the best of our knowledge, no other empirical study has examined the effect of IT investments on downside risk. Thus, our study makes a contribution to the IS literature by being the first to conceptualize and empirically investigate the effect of IT investments on downside risk. While some research examining IT investments and risk profile of firms has appeared in the IS literature, risk is conceptualized differently in those studies [20, 21]. As we elaborate in the next section, these risk conceptualizations do not fully capture managerial perceptions about risk. By focusing on downside risk, our study offers a unique perspective on the business value of IT that appears to be more consistent with managers' concept of risk than variance-based risk concepts that consider the variability of performance (both upside and downside outcomes). This analytical emphasis is particularly important in the context of IT investments since some IT investments confer only short-lived competitive advantages that require strategies to limit the probable downside risk—the likelihood that a firm will underperform relative to its competitors.

Specifically, our paper extends Dehning et al.'s [19] study by using downside risk as a complementary measure of firm performance. Contrary to Carr's [12] arguments, Dehning et al. found support for the effect of the strategic role of IT investments, as well as their timing on firm performance. Dehning et al. found that positive, abnormal returns are associated with announcements of transformational IT investments made by firms that belonged to industry groups having transformational IT strategic roles. Their results support the value of considering the strategic role of IT investments and provide insights into the conditions under which IT investments are likely to produce abnormal, positive returns. In extending their study, we attempt to break new ground by examining the impact of announced IT investments on the downside risk of the firm. In addition, in line with recent studies (cf.**<<STRICTLY SPEAKING, CF STANDS FOR COMPARE / IS SEE OR E.G. MEANT?>>** [14, 19, 32]), we build on the use of the event study methodology in IS research. This methodology is well established in the accounting and finance literature, and holds the potential to examine many research questions in the IS discipline.

Our study provides evidence that there is an association between reductions in downside risk and the announcements of strategic IT investments. Moreover, the reduction in downside risk associated with announcements in strategic IT investments is largely contingent on the timing of those investments by firms relative to their industry participants. Transformative IT investments made by firms are associated with a reduction in downside risk only if they lead similar investments in the industry. We also observe lower downside risk profiles for firms that make automate IT investments in parity with their industry.

The next section provides background to this study. It discusses risk perspectives from financial economics, decision theory, and strategic management, pointing out the salient differences in the conceptualization of risk in these fields. This is followed by a discussion of the theoretical framework and strategic IT investment concepts relevant to this study. This discussion is subsequently tied to the research hypotheses relating firms' investments in IT to downside risk. The event study methodology used to test the model is described, followed by the results and their discussion.

Background

Risk Perspectives

Risk is conceptualized differently in the financial economics, decision theory, and strategic management literatures. From the financial economics perspective, risk is routinely conceptualized in terms of the variance of possible outcomes associated with a given action. The financial economics risk perspective also typically decomposes risk into two dimensions: *systematic* and *unsystematic* risk [20]. Systematic risk is associated with general economic conditions or the general market. The financial economics risk perspective suggests that investors cannot reduce systematic risk because it affects all companies. Unsystematic risk is firm-specific risk that arises from circumstances unique to the firm. The financial economics perspective generally views unsystematic risk to be of no significance to shareholder valuation of a firm because it can be mitigated by holding a diversified portfolio of securities [31]. Furthermore, financial economics assumes a positive relationship between risk and return in the mean-variance framework of the capital asset pricing model [61].

The decision theory perspective also conceptualizes risk in terms of the variance of possible outcomes, but largely in terms of the probability of an outcome [3]. Decision theory typically evaluates probabilities to reduce uncertainty. From this perspective, a firm with consecutive annual losses and a probability of similar returns for the current year is not considered risky because it has consistent results with little or no variance. Similarly, a firm with consistent positive returns is not considered risky, even though its returns might be less than those of a competitor [6].

While the traditional financial economics and decision theory perspectives on risk provide valuable insights and have been the cornerstones of empirical analysis, they obscure an understanding of risk in a strategic management context [6]. The strategic management perspective on risk attempts to provide broader conceptualization of risk that is consistent with managerial views. March and Shapira [40] contend that managers have a substantially different conceptualization of risk than do financial economists and decision theorists. Managerial concepts on risk seem to focus more on organizational losses than organizational gains. Managers tend to be more concerned about downside risk than about outcome variability [57]. Some empirical evidence from the management literature also suggests that downside risk is more relevant to decision makers than the total variance of outcomes (cf.**<<E.G.?>>** [54]). Therefore, variance measures may be less relevant to managerial decision-making behavior than measures focusing on downside risk characteristics. In contrast to decision theory, which views a firm with consistent performance to be less risky, a strategic management perspective would suggest that considerable risk is associated with a firm performing consistently below the profitability of its rivals [3, 40]. The strategic management perspective of risk is rooted in the concept of competitive advantage. In a competitive environment, a better performing firm gains competitive advantage over a poor performing firm [44, 49]. Over an extended period, the firm with consistently lower returns than its rivals is in danger of failing. Thus, the strategic management perspective defines risk in terms of *relative performance* [40, 47].

While some empirical work on the relationship between IT investment and firm risk performance has started to appear in the IS literature [20], this work is still rooted in the financial economics perspective. Founded on the financial economics perspective on risk, Dewan and Ren [20] differentiate between systematic and unsystematic risk. Using several e-commerce announcement variables, including tangible versus digital goods, new versus existing initiatives, and business-to-business (B2B) versus business-to-consumer (B2C), Dewan and Ren found that tangible goods are associated with a reduction in systematic risk relative to digital goods, but had no relationship with unsystematic risk. Similarly, B2B investments are associated with a reduction in systematic risk relative to B2C investments, but have no relationship with unsystematic risk. New versus existing initiatives have no relationship with either systematic or unsystematic risk. Dewan and Ren interpret their findings to mean that e-commerce initiatives reduce systematic risk because they dampen demand uncertainty and cyclicality of sales revenues. In a more general study, Dewan et al. [21] estimate that about 30 percent of the gross return on IT investments corresponds to the riskiness of IT capital investments.

While we acknowledge the insights provided by the above studies, there is a fundamental difference between the financial economics perspective and the strategic management perspective regarding how risk can be managed. The financial risk perspective suggests that investors cannot reduce systematic risk because it affects all market participants. However, a strategic management perspective suggests that systematic risk can be managed by implementing superior strategies. Market factors may influence all firms, but the degree of impact can be mitigated by correctly aligning the firm with its environment. Furthermore, while the financial perspective holds that firm-specific risk (unsystematic risk) can be diversified away, firm-specific risk is a major concern to the strategic manager. For instance, the loss of a key technology may result in the loss of customers, ultimately leading to firm failure. Thus, managerial interventions in the form of strategic IT investments can affect the risk/return profile of a firm [61].

Modern financial theory also suggests a positive relationship between risk and return. However, a positive linear relationship between risk and return as posited by the financial economics perspective does not always hold. Some studies find that different strategies and firm structure are associated with differences in risk, but not with differences in return [34, 46]. A company's characteristics influence risk and return separately [10]. It follows that risk may be managed independently of return. Thus, a strategic management perspective suggests that managers can manipulate activities and assets simultaneously to reduce risk and increase return (or with no effect on return), implying that risk and return are not always positively related [61].

Given the limitations of financial and decision theory perspectives on risk, we adopt the strategic management perspective in this study. Salient aspects of the strategic management risk perspective include the following:

- good strategic management should lead to competitive advantage,
- risk arises from strategies that result in failure to achieve competitive advantage, and
- an appropriate measure of strategic risk may be poor performance relative to other firms.

Thus, one should conceptualize strategic risk in terms of a shortfall in firm performance relative to that of competitors, not as variance around a specified performance level. The main focus of the strategic management perspective on strategic risk is defined as "the degree to which a firm does not attain (or maintain) an advantage over its competition" [61, **<<PAGE FOR QUOTATION>>**]. In a broader context, the strategic management perspective allows risk to be conceptualized as follows:

Total risk	=	Positioning risk	+	Competitive risk	+	Operational risk
	=	Performance relative to market		Performance relative to industry		Performance relative to long run

Since the above risk measures are conceptualized in terms of relative performance, they pertain to *downside risk. Positioning risk* is similar to the systematic risk dimension of the financial economics risk perspective. This pertains to the choice of the industry in which a firm decides to conduct its activities. However, unlike the financial risk perspective that suggests that systematic risk cannot be mitigated, the strategic management perspective holds that industry positioning matters [49, 50]. Persistent differences in performance across industries can result as a result of different industry characteristics [18, 49, 52] and firm strategies that mitigate overall market phenomena [61].

Competitive risk pertains to how a firm performs relative to other firms in its industry. Managing competitive risk issues involves initiating activities that enable a firm to compete effectively in its product-market environment [45]. For instance, a firm addresses competitive risk problems when it strategically invests in IT to improve customer responsiveness and service.

Operational risk differs from competitive risk because it specifically refers to risk arising from basic business operations, whereas competitive risk refers to the risk of a loss arising from a poor strategic business decision. The business operations, which might lead to operational risk, include failed internal processes and systems and human action [17]. Specific actions of humans that might lead to operational risk include failure to comply with laws, prudent ethical standards, and contractual obligations. This could also include the risk arising from the inability to enforce a sourcing contract, resulting in an inferior quality product from the supplier [16].

We focus mainly on competitive risk since it is a major determinant of the survival of the firm. This is synonymous with strategic risk, defined as the degree to which a firm does not attain (or maintain) an advantage over its competition [61]. Thus, a firm experiences downside risk when it fails to attain (or maintain) an advantage over its competition. Since downside risk addresses a firm's performance below some target level, conceptually, the target level could be either internal or external to the firm. Operational risk would be a more relevant measure if an internal target were used. However, the problem with an internally focused target level is that the firm might think it is doing well when it achieves performance above its target, but this may still be below industry performance. In this case, a firm may be under the illusion that it is performing well and yet it is at a competitive disadvantage relative to its rivals. Thus, an external target level, such as average industry performance is more preferable from a competitive advantage perspective. Firm performance can then be compared to industry performance to assess its level of competitiveness and downside risk profile. Therefore, in our analysis, consistent with our definition of strategic risk, we define downside risk as the shortfall in firm performance relative to average industry performance.

Prior Related Event Studies

Below, we briefly review prior research on the impact of IT investment announcements on the market value of firms. Table 1 summarizes seven empirical studies that have examined the influence of announcements of IT investments on firm market value, employing different measures of IT investment and other variables. Dos Santos et al. [23] investigated the effect of IT investments on the market value of firms. Two particular attributes, industry type and IT investment type, are examined to see if either had an effect on the cumulative abnormal returns near the dates of the announcements. Evidence from the study**<<CLARIFY / DOS SANTOS ET AL.'S STUDY, OR THE CURRENT STUDY?>>** indicates that only announcements of innovative IT investments are positively associated with cumulative abnormal returns.

Im et al. [33] extended the literature by investigating whether industry size and time lag has an effect on firm market value using a larger sample of IT investment announcements over a longer period. Small firm size and announcements made in 1991 and after (time lag) were positively associated with market value effects. In addition, Im et al. found that IT investment announcements by firms in the financial industry

Table 1. Key Findings of Studies Related to Announcements of Investments in IT

Study	Measures of IT investment	Other variables	Main results
Dewan and Ren [20]	E-commerce variables: Tangible versus Digital goods, New versus Expansion of existing initiative, B2B versus B2C	Preevent risk, Preevent stock return, Firm size, Time effect dummy	E-commerce announcements have no significant impact on wealth effects. Tangible goods are associated with lower systematic risk compared to digital goods; and B2B investments are also associated with lower systematic risk compared to B2C. Firm size is negatively associated with unsystematic risk but positively with systematic risk. New versus expansion of existing initiative effect neither on systematic nor on unsystematic risk**<<MEANING OF SENTENCE UNCLEAR>>**.
Ranganathan and Brown [53]	ERP project variables: Functional scope, Physical scope, Package vendor	Industry (service versus nonservice), Size	Significant positive abnormal returns for overall sample. Positive abnormal returns for ERP functional scope and physical scope. Nonsignificant results for ERP vendor and firm size. Mixed support for industry.
Dehning et al. [19]	IT Investment type: Transformative, informate or automate. Industry IT strategic role; IT investment leads or lags industry	Industry (financial versus nonfinancial), Firm size, Time	No support for size, time, and industry on overall sample. 1.51 percent significant returns for firms making transformational investments; 1.41 percent returns for firms in industries with transform industry IT strategic role.
Hunter [32]	Exploratory versus exploitative	Industry type (retail versus nonretail), Firm size, Organizational slack, Time	No support found for size, slack, and time. Negative abnormal returns for retail firms (–0.85 percent), and exploratory (–1.11 percent), and exploitative (–0.68 percent) IT investments.

Chatterjee et al. [13]	Infrastructure versus Application	Industry (financial versus nonfinancial; service versus non-service) IT producers versus IT users, Firm size, Growth, Diversity	Some support for overall sample. Infrastructure investments yielded 2.01 percent returns, application announcements yielded 0.84 percent returns. Firm size had a negative relationship with returns. No support found for growth, diversity, industry, and IT producer versus user firms.
Im et al. [33]	IT investment (nondifferentiated)	Industry (financial versus nonfinancial firms), Firm size (large, medium, and small), Time (recent versus older announcements)	No abnormal returns on full sample. Significant positive abnormal returns for small firms (0.25 percent). Significant returns for financial firms (0.27 percent) and small firms (0.63 percent), but nonsignificant returns for nonfinancial firms and negative returns for mid-sized firms (–0.22 percent) from 1991 and thereafter.
Dos Santos et al. [23]	Innovative versus Noninnovative	Industry (manufacturing versus service)	No abnormal returns on full sample. Innovative IT investment announcements contributed to 1.03 percent abnormal returns. No support for industry type.

were positively associated with market value, but only for announcements made after 1990—the post-productivity paradox period.

Chatterjee et al. [13] examined the effects of IT infrastructure and application investments on firm market value. They found that announcements of investments in IT infrastructure are associated with higher abnormal returns than announcements of application investments. Chatterjee et al. interpreted these findings to mean that the higher returns for investments in IT infrastructure are due to the ability of such investments to create growth options for the firm.

Dehning et al. [19] built on this stream of literature by examining the relationship between the industry strategic role of IT investments and the market value of the firm. Using the IT strategic role construct conceptualized by Schein [56], the study**<<CLARIFY / DEHNING ET AL. MEANT?>>** classifies IT investment announcements as those that automate, informate, or transform an organization as well as their timing. Findings from this study**<<DEHNING ET AL.' STUDY MEANT?>>** provide evidence that the industry strategic role of IT investments does influence the market value of a firm. Specifically, firms that announce transformational IT investments, as well as firms that announce IT investments in industries in which transformational investments dominate, experience positive market value reactions from those announcements. In addition, Dehning et al. found that firms that announce transformational IT investments that lead their industry's IT strategic role experience positive market value reactions.

Hunter [32] adopted March's [39] concept of exploration and exploitation in organizational learning and categorizes IT investments as either exploratory or exploitative. Contrary to other studies**<<CITE ANY EXAMPLES?>>** that have found announcements of IT investments to be positively associated with abnormal returns, Hunter [32] found a negative association in general and that exploratory IT investments are more negatively associated with abnormal returns than exploitative IT investments. Despite the negative association, the pattern of his results is consistent with March's [39] perspective on exploration and exploitation in organizational learning.

The study by Ranganathan and Brown [53] examined the effects of announcements of ERP**<<DEFINE / ENTERPRISE RESOURCE PLANNING?>>** investments on the market value of firms. Using functional scope, physical scope, and package vendor as measures characterizing the ERP project, their study found positive abnormal returns for ERP functional scope and physical scope, but not for the ERP vendor. They argue that what is important for achieving business value from an ERP platform investment is not project size per se, but the degree to which distinct organizational units are being integrated via the ERP project.

In sum, the above studies offer some insights on the relationship between IT investments and value. However, none of them examines the effect of IT investments on downside risk—even the Dewan and Ren [20] study that examines risk conceptualizes it in terms of variance of returns. However, the notion of strategic risk that appears to be more consistent with the risk assessments of managers is the shortfall in performance relative to a target (downside risk). Variance measures fail to differentiate upside and downside outcomes [40, 47]. Our study differs from all of the previously discussed studies because it is focused on downside risk. In examining downside risk, we employ the Dehning et al. [19] typology of IT investments since it delves into the issue of strategy and competitive advantage. Using this typology, we investigate how strategic IT investments affect firm performance relative to that of the industry in which the firm operates (downside risk measure).

Theory and Hypotheses Development

Theoretical Framework

Given our conceptualization of downside risk, we draw from the resource-based view (RBV) of the firm and real options perspective to inform our analysis. The RBV theorizes that if a resource is valuable and rare, then it confers competitive advantage. In addition, if it is inimitable, nonsubstitutable, and immobile, a resource confers sustained competitive advantage [3, 44, 63]. IT resources may confer only transient competitive advantage because they can easily be imitated. Therefore, investing early to realize first-mover advantage and to build network effects may be crucial for IT investments [22]. Since we conceptualize downside risk in terms of firm performance relative to industry performance (i.e., competitive advantage of the firm), RBV is a relevant theoretical concept to motivate our study.

Another useful perspective is real options. The fundamental appeal of the real options perspective stems from the ability to decouple the relationship between downside risk and upside opportunity [1, 22, 35]. This is made possible by managerial flexibility in the timing of investments and the potential to redirect or abandon troubled investments as uncertainty is resolved [9, 19, 22]. While researchers employing the real options logic often emphasize the importance of managerial flexibility, deriving benefits from real options analysis hinges on how uncertainty is resolved. IT investments are typically associated with uncertainty about the benefits of the investment and irreversibility in the costs of deployment. Organizational learning is critical in the resolution of uncertainty and the realization of real option value [22].

As it relates to the timing of investments, real options logic suggests that if the expected payoff from an investment is low, it may be prudent to wait to invest ("wait and see" option), thus delaying potentially irreversible expenditures and preserving resources for the future. However, if the expected payoff is high, it is necessary to invest early and engage in active learning to resolve the uncertainty ("act and see" option), although most likely sequentially, to preserve the option to abandon the investment should conditions prove unfavorable [22, 28, 42].

To provide a framework for our study, we position strategic IT investment types on the uncertainty-expected payoff matrix (see Figure 1). The real options perspective implies that investment decisions are determined by the desire to mitigate the *threat* of commercial failure due to uncertainty surrounding the investment [28, 58]. The RBV of the firm, on the other hand, contends that the *opportunity* to create a sustainable competitive advantage, through the effective deployment of resources, guides investment decisions [3]. Our framework is consistent with the notion that managers

Competitive Advantage Opportunity (RBV)

Degree of Uncertainty (Real Options Perspective	Low	High
Low	Automate, Informate	⊗
High	⊗	Transform

Figure 1. Typology of Strategic IT Investments

tend to balance threats of loss (commercial failure) and opportunities for gain (e.g., competitive advantage) when making strategic investment decisions [57].

Hypothesis Development

Based on Figure 1 and the theoretical arguments presented in the preceding section, we posit that the level of uncertainty leads to differential effects of IT investments on downside risk, while timing of strategic IT investments is critical for such investments to lead to a reduction in downside risk. Our research model takes into account factors previously identified as vital in the sustainability of competitive advantage, namely, competitors' response time, resource differences among competitors, and the potential to preempt competitive responses [18].

Uncertainty and Differential Effects of IT Investments on Downside Risk

As displayed in Figure 1, strategic IT investments that *transform* the organization are associated with both high uncertainty and high potential for competitive advantage. "Transform" refers to a major shift in the way a business conducts its internal processes or relationships with customers or other business entities [19, 56]. Transformational IT investments introduce radical changes in business models that disrupt industry practices and market structures as firms scramble for competitive advantage [15]. Due to the radical changes in the business models they entail, transformational IT investments are associated with high levels of uncertainty. The uncertainty surrounding this type of IT investment is typically endogenous to the firm since the firm does not know exactly how they will affect business processes given their transformational nature. However, because the associated changes are disruptive rather than being merely incremental, transformational IT investments may lead to high and fairly sustainable firm performance and competitive advantage if successful [15]. In line with real options thinking, we argue that high levels of uncertainty increase the likelihood of failure to achieve the expected benefits [22]. Therefore, we expect transformational

IT investments to be associated with higher downside risk than either informate or automate IT investments.

Informate and *automate* IT investments are associated with relatively low levels of uncertainty and low potential for competitive advantage. "Informate" refers to the effect of IT on the flow of information through the company, either horizontally or vertically [19, 56]. Enhancing the ability of decision makers to communicate with each other in a timely manner, and to better cross-utilize information for decision support, may have positive effects on how a business utilizes its intellectual assets and knowledge base. Efficient information flow could be a form of dynamic capability [20, 55] that enables the organization to deploy resources in a way that confers competitive advantage. When implemented well, informate IT investments have the potential to confer transient competitive advantage through improvements in existing business processes [15]. Since informate investments improve existing business processes, the change is far less radical and the associated uncertainty is lower than that for transformational IT investments.

Automate investments are also associated with low uncertainty and low potential for competitive advantage. "Automate" refers to the ability to use IT to automate business processes that may have been executed in part or whole by human labor. It may be difficult for companies to maintain competitive advantage merely by automating processes, especially if this is a trend in the industry [19]. Investments in technology that automate processes may, in some instances, be a necessity for a particular company to remain in business. Given the relatively low levels of uncertainty associated with IT investments that automate business processes, their implementations are likely to be successful.

Using real options logic [22], since the uncertainty surrounding informate and automate IT investments is lower than that of transformational IT investments, we expect downside risk to be accordingly lower. Based on the above discussion, we present the following hypotheses:

> *Hypothesis 1: There is a significant and differential effect of the strategic role type of investment in IT on downside risk.*
>
> *Hypothesis 1a: Downside risk associated with investment in transformative IT will be higher than that associated with either informate or automate IT investments.*
>
> *Hypothesis 1b: There will be no significant difference in downside risk associated with informate and automate IT investment since they are both associated with lower levels of uncertainty.*

Timing of Strategic IT Investments and Downside Risk

For strategic IT investments to lead to a reduction in downside risk, their timing is critical. We contend that timing is important for two reasons: (1) to resolve uncertainty and (2) to achieve first-mover advantages and realize transient competitive advantage.

The need to learn through business experiments to resolve uncertainty and the need to achieve competitive advantage imply that organizations should initiate transformative IT investments early. By engaging in early learning, firms build exploitable absorptive capacity [22] that will enable them to successfully deploy transformational IT investments and achieve competitive advantage relative to their competitors. Although transformational IT investments create competitive advantage that may be sustained for some time or create barriers to entry for competitors, investing early is vital because as posited by the RBV logic, competitive advantage will dissipate once other firms acquire the resources needed to imitate the initiative. Furthermore, consistent with real options logic, the high upside potential of transformative IT investments alone is not sufficient to reduce downside risk. A reduction in downside risk is only possible when the firm beats the competition in resolving uncertainty and thus successfully achieving IT-enabled business process transformation [6, 19, 22].

While informate IT investments may not pose long-lasting barriers to entry or technological advantages, they may provide windows of opportunity for capturing market share and enhancing profitability by enabling some dynamic capabilities [15, 24, 62]. Given their potential in conferring transient competitive advantage, firms may realize a reduction in downside risk by leading in making informate investments. For automate investments that have neither high levels of uncertainty nor the ability to confer competitive advantage, conventional wisdom implies that firms may realize a reduction in downside risk if they undertake such investments at the same time with industry participants. Because automate IT investments are, at best, competitive necessities, their value appears to stem from enabling a firm to preserve its competitive position [19, 41, 48, 63].

Therefore, we present the following hypotheses regarding timing of strategic IT investments:

> *Hypothesis 2: There is a significant and differential effect of the timing of investment in IT on downside risk.*
>
> *Hypothesis 2a: Firms making transformative IT investments that lead their industry IT strategic role will experience a decrease in downside risk relative to firms making parity transformative IT investments.*
>
> *Hypothesis 2b: Firms making informate IT investments that lead their industry IT strategic role will experience a decrease in downside risk relative to firms making informate IT investments that either are in parity or lag their industry IT strategic role.*
>
> *Hypothesis 2c: Firms making automate IT investments that are in parity with their industry IT strategic role will experience a decrease in downside risk relative to firms making automate IT investments that lag their industry IT strategic role.*

In sum, IT investments that have high uncertainty will increase downside risk (performance relative to competitors); but timing (moving early) can help resolve the uncertainty (through learning) and reduce downside risk, particularly in cases where the investment can confer competitive advantage.

Methods

Our study employs an event study methodology, which has been widely used to examine stock market reactions to unanticipated business events. This methodology is theoretically grounded in capital markets theory and efficient market hypotheses [25]. It captures rationality in the marketplace using stock price changes observed over a relatively short period. It is therefore viewed as a complementary approach to capture linkages between managerial actions and market value creation for a firm [43]. Furthermore, to examine the robustness of our results, we use accounting-based measures of performance and downside risk.

Data: Sources and Screening

The data set used in this study consists of IT investment announcements made during the period 1985–2004, based on prior event studies [32, 33]. Our study adds an additional 194 IT investment announcements to the announcements used in prior studies. We began with the 238 IT announcements found in Im et al. [33], and the 150 IT announcements found in Hunter [32], resulting in 388 possible IT announcements. A total of 151**<<TABLE 2 SAYS 142>>** announcements were screened out because of inconsistent or incomplete data obtained from CRSP**<<IF THIS IS AN ACRONYM, DEFINE / WHAT IS IT? A DATABASE?>>** and Compustat. An additional 20 announcements were screened out because of a lack of information required to code the IT investment type. The remaining announcements, plus the additional 194 new IT investment announcements we collected comprise the 411 announcements used in our analysis (see Table 2).

We also obtained data on economic fluctuations (business cycle) from the Conference Board (www.conference-board.org) that we use to control for the effect of the state of the economy on downside risk.

Measures

Downside Risk

We operationalize downside risk as firm performance relative to industry performance. The relevant industry classification was the three-code North American Industry Classification System classification. To calculate the downside risk metric and its determinants, we employed a couple of measures: one market based and the other accounting based. For the market-based measure, two contiguous 60-day periods (–70 to –10 days and 10 to 70 days) were used. While typical event studies use very short event windows (typically less than 10 days), risk measures are known to persist over a longer period. Specifically, our choice of the 60-day window length is based

Table 2. Summary of IT Investment Announcements

	Announcements
IT announcements found in [33]	238
IT announcements found in [32]	150
New announcements collected	194
Less: announcements with incomplete CRSP or Compustat data	142
Less: announcements unable to be coded	20
Usable IT investment announcements	420

on empirical findings in the finance and accounting literature indicating that there is persistence in post-earnings-announcement drift to a large part up to 60 trading days subsequent to the earnings announcement (and even up to 120 trading days for large firms) [5]. We elected to exclude a 10-day window surrounding the announcement date to provide a reasonable assurance that any downside risk captured by our calculations would not be biased by the announcement effect and that any volatility associated with the short-term announcement is not included in our measure of downside risk.[1] For the accounting-based measure (return on assets [ROA]) of downside risk, two contiguous three-year periods (–4 to –1 years and 1 to 4 years) were used. The two three-year periods were selected to obtain sufficient data to construct the downside risk measure. We excluded the year of announcement to provide a higher degree of assurance that any changes in downside risk would not be biased by the announcement effect and that any volatility associated with the announcement is not included in our measure of downside risk.

Our study employs stock returns derived from stock prices in the calculation of downside risk for the 60-day window. Stock prices are thought to impound all available information that affects future cash flows, and should therefore reflect the market's expectations of how IT investments will affect the future cash flows of an entity. For the accounting-based measure, we use ROA. Downside risk is a probability weighted function of below-target performance outcomes. We specified downside risk as a firm's daily stock price return relative to the return to the industry that changed over time (or yearly firm ROA relative industry ROA for the accounting-based measure). In line with prior research [24, 47], we measured downside risk as a second-order root lower partial moment, expressed as

$$\textit{Downside risk} = \sqrt{\frac{1}{n}\sum_{1}^{n}\mathrm{Max}\left(0, t - R_t\right)^2}, \qquad (1)$$

where R_t is the daily firm return, t is the target return (daily industry return), and n is the number of observations in the period.

Strategic Role of IT and Timing

Dehning et al. [19] coded investment types in their sample as those made to automate, informate, or transform a company's operations. Following Dehning et al., three recognized scholars who teach and research in the area of IT were independently asked to indicate the role that IT served in the particular announcement—whether automate, informate, or transform, using the coding rules established by Dehning et al. (see Appendix A for the instrument used). The interrater reliability was 0.84 for the announcement-level coding of IT strategic role.

The raters also coded the dominant strategic role of IT in a given industry using the same coding scheme. Dehning et al. [19] had an interrater reliability of 0.83, and differences were reconciled as a group. To extend the work of Dehning et al., our study also employed a panel of experts to code announcements from 1999 to 2004 as automate, informate, or transform, and simultaneously the industry strategic roles (see Appendix B for the instrument used). An interrater reliability was 0.92 for the industry-level coding of the IT strategic role. We feel this coding scheme has been validated because it was initially used by Chatterjee et al. [14] and subsequently by Anderson et al. [2] and Dehning et al. [19]. Table 3 presents cross-tabulations of the distribution of announcements by type of IT investment used in our 60-day window.

To construct the timing variable for each announcement, our methodology follows that of Dehning et al. [19] (refer to Appendix A). We compared the IT strategic role for the announcement to the previously determined industry IT strategic role. This allowed us to determine whether a particular company led, was comparable to, or lagged the industry in IT investment type. In doing so, our determination of timing fully considered any radical transformations that might have happened in any industry during any time period (e.g., the IT strategic role in the banking sector changed from automate in the 1987–94 period to transform in the 1995–98 and 1998–2004 periods; refer to Appendix B). The coding and timing of IT investments is provided in Table 4.

Control Variables

Prior research (e.g., [29, 44]) points out that at the highest level, IT investments will be affected by (1) external environment, including government activities and policies, global economic conditions, society and cultural issues, technology, and availability and accessibility of infrastructure; (2) the industry within which an organization operates (e.g., the nature of the product in some industries makes online trading more or less feasible); and (3) organizational factors—within an organization, such as financial capital resources, physical capital resources, human capital resources, and organizational capital resources. We control for these three sets of factors that might affect the outcome of IT investments.

External Environment Factors. Environmental influences are outside the control of individual organizations and industries in which they operate. We control for *Market risk* (i.e., systematic risk), which affects all organizations alike. Following the literature (e.g., [20]), we use beta to measure market risk. In the context of our study, this, to some extent, helps us to control for positioning risk (overall performance relative to market) and enables us to see the effect of IT investments on competitive downside risk (performance relative to competition). Another external factor we control for is the

Table 3. Cross-Tabulation of Announcements by IT Strategic Role for 60-Day Securities Window (1985–2004)

	IT investment strategic role			
	A	I	T	Total
Industry IT strategic role				
A				
Count	39	83	9	131
Percentage within IndITRole	29.8	63.4	6.9	100.0
Percentage within FITRole	44.8	36.1	9.6	31.9
Percentage of total	9.5	20.2	2.2	31.9
I				
Count	39	92	73	204
Percentage within IndITRole	19.1	45.1	35.8	100.0
Percentage within FITRole	44.8	40.0	77.7	49.6
Percentage of total	9.5	22.4	17.8	49.6
T				
Count	9	55	12	76
Percentage within IndITRole	11.8	72.4	15.8	100.0
Percentage within FITRole	10.3	23.9	12.8	18.5
Percentage of total	2.2	13.4	2.9	18.5
Total				
Count	87	230	94	411
Percentage within IndITRole	21.2	56.0	22.9	100.0
Percentage within FITRole	100.0	100.0	100.0	100.0
Percentage of total	21.2	56.0	22.9	100.0

Note: IT investment type: A = automate; I = information; T = transform. ITRole**<<FITRole USED ABOVE>>** = IT investment strategic role; IndITRole = industry IT strategic role.

business cycle (i.e., upturns and downturns in overall economic activity). Drawing from prospect theory, prior research has found that more troubled firms might take greater risks and that when performance is below target, most managers are risk seeking [8, 27]. The business cycle variable helps us not only to control for the effect of overall economic shocks but also somewhat address causality issue (e.g., do failing firms with less resources for IT investments skew investments toward "cost cutting," or as prospect theory suggests, are such firms inclined to take greater risks?). Based on findings from empirical studies drawing from prospect theory, managers of failing firms and during economic downturns are likely to undertake more risky investments.

Industry Factors. In line with the event studies summarized in Table 1, we used a broad categorization of the *type of industry* in which a firm operates to control for *industry positioning* because this can have significant influences on the performance outcomes of incumbent firms [49, 51]. In addition to industry type, we used *growth potential* to control for performance differences that might arise from industry positioning, given that our analysis relies on performance differences across firms. While potential

Table 4. Coding of the Timing of IT Investments for Regression Analysis

Timing of IT investment	Firm IT strategic role	Industry IT strategic role
Leading investments	T	I
	T	A
	I	A
Parity investments	T	T
	I	I
	A	A
Lagging investments	I	T
	A	T
	A	I

Source: Adapted from Dehning et al. [19].
Note: T = transform, I = information, A = automate.

growth might appear to be a firm-level measure, industry positioning can put limits on the potential growth of the firm and as such potential growth can be taken as an industry factor. Specifically, our broad industry categorization uses two categories: service industry and other industries.

Firm-Level Factors. We use the following controls for organizational factors, following the literature (e.g., [7, 20, 21, 47]): *preannouncement downside risk, firm size, leverage, R&D intensity,* and *non-IT capital expense.* Due to risk persistence over time, we control for *preannouncement downside risk* to ensure that our analysis captures the postannouncement downside risk. Miller and Leiblein [47] point out that there is a need to control for previous downside risk since subsequent downside risk could be simply due to autocorrelation in firms' price data. Past studies have used *firm size* as a control whenever performance is being assessed—we do here**<<AND WE DO SO HERE?>>**. *Leverage* (debt-to-equity ratio) may be associated with downside risk (e.g., the inability of a firm to satisfy payments due to debt holders can result in insolvency, bankruptcy, and the eventual demise of the entity). Thus, following Chen and Lee [15], we use leverage as a control. Finally, following the literature, we include *R&D intensity* (R&D expense/sales ratio) and *non-IT capital expense* to control for determinants of firm performance, and hence postannouncement downside risk (given that downside risk in our analysis is defined in terms of relative performance).

Statistical Analysis

We employ multivariate models in this study to test the hypotheses. We use the following model to test Hypothesis 1 based on the entire sample:

$$Downside\_risk_{post} = \beta_0 + \beta_1 Downside\_risk_{pre} + \beta_2 Beta + \beta_3 Growth\_potential + \beta_4 Business\_Cycle$$

$$\beta_5 Size + \beta_6 Industry + \beta_7 Leverage + \beta_8 (R\&D/Sales) + \beta_9 (Non\text{-}IT\_capital/Sales) + \beta_j Investment\_type + \varepsilon.$$

To test to effect of timing of strategic IT investments on downside risk (H2), we employ the following model in subsample analysis:

$$Downside\_risk_{post} = \beta_0 + \beta_1 Downside\_risk_{pre} + \beta_2 Beta + \beta_3 Growth\_potential + \beta_4 Business\_Cycle$$

$$\beta_5 Size + \beta_6 Industry + \beta_7 Leverage + \beta_8 (R\&D/Sales) + \beta_9 (Non\text{-}IT\_capital/Sales) + \beta_i Timing + \varepsilon.$$

where $Downside\_risk_{post}$ = calculated measure from equation (1) for the period following the IT investment; $Downside\_risk_{pre}$ = calculated measure from equation (1) before the IT investment; *Beta* = systematic risk; *Growth_potential* = book value of equity/market value of equity; *Business_Cycle* = categorical variable for state of the economic cycle (C = contraction; E = expansion); *Size* = natural log of the total value of firm assets; *Industry* = industry affiliation–service industry (S) versus other industries (X); *Leverage* = the ratio of debt to equity (controls for whether the company could be subject to financial distress at the end of the reporting year in which the announcement was made); *R&D/Sales* = ratio of R&D expenses to sales; *Non-IT_capital/Sales* = ratio of non-IT capital to sales; *Investment type* = categorical variable describing the strategic role of the IT investment (Automate, Informate, or Transform); and *Timing* = categorical variable describing whether the particular IT investment type leads, is at par, or lags the IT strategic role of the Industry.

Results

We employ generalized linear models (GLM) and generalized estimating equations (GEE) techniques to test Hypotheses 1 and 2. The GLM technique extends analysis of variance (ANOVA) to independent observations of nonnormally distributed data, whereas the GEE technique extends generalized linear models to the analysis of correlated data [31]. In general, GLM results are similar to ANOVA results, whereas GEE results are similar to regression results. The GEE technique enables us to have a nuanced examination of the nature of the effects (subhypotheses within Hypotheses 1 and 2). Tables 5, 6, and 7 report the results used to test hypothesis 1 and Tables 8, 9, and 10 report the results used to test Hypothesis 2.

The GLM results reported in Table 5 show a significant effect of IT strategic role on downside risk for both 60-day security returns window and 3-year return on assets window ($p < 0.001$). To examine the nature of this overall effect, Table 6 reports estimated marginal means for the 60-day downside risk measure. Consistent with Hypothesis 1, the marginal means show that transformational IT investments are associated with a significantly higher risk than either informational or automation IT investments; while there is no statistically significant different between downside risk associate with informate and automate IT investments. These findings support our framework presented in Figure 1. Since GLM results do not provide insight into the

Table 5: GLM Results for 60-Day Security and 3-Year Return on Assets

	60-day security returns window			3-year return on assets window		
Source	Wald χ^2	Degrees of freedom	Significance	Wald χ^2	Degrees of freedom	Significance
(Intercept)	91.086	1	0.000	155.950	1	0.000
Downside risk (Pre)	285.217	1	0.000	16.623	1	0.000
Beta	25.937	1	0.000	1.426	1	0.232
Firm growth	4.635	1	0.031	1.391	1	0.238
Economic cycle	1.627	1	0.202	3.229	1	0.072
Firm size	7.792	1	0.005	0.480	1	0.489
Industry category	0.622	1	0.430	52.450	1	0.000
Leverage	0.347	1	0.556	4.807	1	0.028
R&D expenditure	0.118	1	0.732	67.479	1	0.000
Capital expenditure	0.007	1	0.936	1.696	1	0.193
IT strategic role	58.057	2	0.000	468.790	2	0.000

Note: n = 420 for 60-day security returns risk measure, and n = 264 for the 3-year return on assets risk measure.

Table 6. Comparisons of Estimated Marginal Means for the 60-Day Downside Risk Measure

(I) FITSRole	(J) FITSRole	Mean difference (I – J)	Standard error	Significance
Transform IT investment	Informate IT investment	0.077	0.016	0.000
Transform IT investment	Automate IT investment	0.076	0.022	0.001
Informate IT investment	Automate IT investment	–0.001	0.008	0.861

Notes: $n = 420$; overall Wald $\chi^2 = 58.057$; $p < 0.01$.**<<WHAT DOES FITSRole STAND FOR? FITRole USED IN TABLE 3 (SEE QUERY IN TABLE 3 NOTE THOUGH)>>**

nature of the effects (whether positive or negative), We report GEE results in Table 7, which are complementary to the results reported in Tables 5 and 6. As seen from the 60-day security risk results in Table 7, relative to automate IT investments (reference category), transformational IT investments are associated with higher downside risk ($\beta = 0.076$, $p < 0.01$), whereas informate IT investments are not ($\beta = –0.001$, $p > 0.05$). Among the control variables, firm size ($\beta = –0.040$, $p < 0.01$) and growth potential ($\beta = –0.002$, $p < 0.05$) are negatively associated with downside risk, whereas preannouncement downside risk ($\beta = 0.436$, $p < 0.01$) and beta ($\beta = 0.137$, $p < 0.01$) are positively associated with downside risk. Other control variables of interest, industry category ($\beta = –0.013$, $p > 0.05$) and economic cycle ($\beta = –0.009$, $p > 0.05$), have no significant effect on downside risk. The results for the return on assets risk measure are somewhat similar; however, the estimated coefficients for firm size ($\beta = –0.010$, $p > 0.05$) and growth potential ($\beta = 0.007$, $p > 0.05$) are not statistically significant, whereas that for industry category is significant ($\beta = –0.281$, $p < 0.01$).

To examine the effect of timing of IT investments on downside risk, we divided the data into three subsamples: one for transformational, informate, and automate IT investments, respectively. Because we had a smaller sample for return on assets risk measure, here we report only the results for the 60-day security risk measure. For brevity, we do not report the GLM results; we report only GEE results because they provide a better understanding of the nature of effects. The results for the timing of transformational, informate, and automate IT investments are reported in Tables 8, 9, and 10, respectively. As seen from Table 8, relative to parity transformational IT investments, leading transformational IT investments are associated with a reduction in downside risk ($\beta = –0.086$, $p < 0.01$), supporting Hypothesis 2a. Moreover, the estimated coefficient for R&D expenditure is negative and statistically significant ($\beta = –0.476$, $p < 0.01$), implying that investments in learning to resolve uncertainty lead to a reduction in downside risk. Other control variables that are associated with a reduction in downside risk include growth potential ($\beta = –0.006$, $p < 0.01$) and firm size ($\beta = –0.022$, $p < 0.01$). Given that we measure downside risk as performance relative to industry, firms with higher growth potential should obviously have lower

Table 7. GEE Results for 60-Day Security and 3-Year Return on Assets

Source	60-day security returns window				3-year return on assets window			
	β	Standard error	Wald χ^2	Significance	β	Standard error	Wald χ^2	Significance
(Intercept)	–1.834	0.2031	81.548	0.000	–1.283	0.1115	132.428	0.000
Downside risk (pre)	0.436	0.0258	285.217	0.000	0.221	0.0542	16.623	0.000
Beta	0.137	0.0270	25.937	0.000	0.078	0.0657	1.426	0.232
Firm growth	–0.002	0.0011	4.635	0.031	0.007	0.0061	1.391	0.238
Economic cycle = C	–0.009	0.0067	1.627	0.202	–0.349	0.1940	3.229	0.072
Economic cycle = E	0	—	—	—	0	—	—	—
Firm size	–0.040	0.0144	7.792	0.005	–0.010	0.0141	0.480	0.489
Industry category = S	–0.013	0.0169	0.622	0.430	–0.281	0.0388	52.450	0.000
Industry category = X	0	—	—	—	0	—	—	—
Leverage	0.016	0.0275	0.347	0.556	0.428	0.1950	4.807	0.028
R&D expenditure	–0.053	0.1537	0.118	0.732	–0.145	0.0177	67.479	0.000
Capital expenditure	0.023	0.2887	0.007	0.936	0.409	0.3138	1.696	0.193
IT strategic role = T	0.076	0.0225	11.388	0.001	0.265	0.0466	32.384	0.000
IT strategic role = I	–0.001	0.0076	0.031	0.861	0.036	0.0212	2.837	0.092
IT strategic role = A	0	—	—	—	0	—	—	—

Notes: n = 420 for 60-day security returns risk measure, and n = 264 for the 3-year return on assets risk measure. [a] Reference category; Economic cycle: C = contraction, E = expansion; Industry category: S = services, X = other; IT strategic role: T = transform, I = informate, A = automate.

Table 8. GEE Results for 60-Day Security Returns Window for Transform IT

	60-day security returns window			
Parameter	β	Standard error	Wald χ^2	Significance
(Intercept)	–1.547	0.3060	25.490	0.000
Downside risk (pre)	0.504	0.0690	53.796	0.000
Beta	0.136	0.0234	33.865	0.000
Firm growth	–0.006	0.0015	16.359	0.000
Economic cycle = C	0.053	0.0170	10.024	0.000
Economic cycle = E	0	—	—	—
Firm size	–0.022	0.0047	21.304	0.000
Industry category = S	–0.005	0.0548	0.008	0.930
Industry category = X	0	—	—	—
Leverage	0.056	0.0156	12.841	0.000
R&D expenditure	–0.476	0.0764	38.586	0.000
Capital expenditure	0.800	0.2120	14.237	0.000
Transform IT timing = lead	–0.086	0.0136	40.559	0.000
Transform IT timing = par	0	—	—	—

Notes: n = 95. Reference category; Economic cycle: C = contraction, E = expansion; Industry category: S = services, X = other; IT strategic role: T = transform, I = informate, A = automate.

Table 9. GEE Results for 60-Day Security Returns Window for Informate IT

	60-day security returns window			
Parameter	β	Standard error	Wald χ^2	Significance
(Intercept)	–1.465	0.2970	24.328	0.000
Downside risk (pre)	0.417	0.0568	53.864	0.000
Beta	0.080	0.0122	42.959	0.000
Firm growth	–0.003	0.0011	7.458	0.004
Economic cycle = C	0.049	0.0186	7.073	0.008
Economic cycle = E	0	—	—	—
Firm size	–0.073	0.0225	10.624	0.001
Industry category = S	0.022	0.0669	0.108	0.742
Industry category = X	0	—	—	—
Leverage	0.017	0.0444	0.144	0.704
R&D expenditure	–0.283	0.0508	31.091	0.000
Capital expenditure	0.367	0.3314	1.225	0.268
Informate IT timing = lead	–0.648	0.1078	36.155	0.000
Informate IT timing = par	0.126	0.0308	16.652	0.000
Informate IT timing = lag	0	—	—	—

Notes: n = 233. Reference category; Economic cycle: C = contraction, E = expansion; Industry category: S = services, X = other; IT strategic role: T = transform, I = informate, A = automate.

Table 10. GEE Results for 60-Day Security Returns Window for Automate IT

	60-day security returns window			
Parameter	β	Standard error	Wald χ^2	Significance
(Intercept)	–2.346	0.3809	37.940	0.000
Downside risk (pre)	0.321	0.0273	138.263	0.000
Beta	0.207	0.0410	25.854	0.000
Firm growth	–0.001	0.0032	0.037	0.847
Economic cycle = C	0.049	0.0397	1.524	0.217
Economic cycle = E	0	—	—	—
Firm size	–0.014	0.0243	0.317	0.574
Industry category = S	–0.039	0.0077	25.279	0.000
Industry category = X	0	—	—	—
Leverage	0.072	0.0274	6.829	0.009
R&D expenditure	–0.067	0.0623	1.169	0.280
Capital expenditure	–0.342	0.1603	4.545	0.033
Automate IT timing = par	–0.109	0.0101	117.009	0.000
Automate IT timing = lag	0	—	—	—

Notes: $n = 92$. Reference category; Economic cycle: C = contraction, E = expansion; Industry category: S = services, X = other; IT strategic role: T = transform, I = informate, A = automate.

downside risk, whereas large firms enjoy lower downside risk due to their resource endowments. Industry category has no effect on downside risk (β = –0.005, $p > 0.05$), whereas economic cycle has a positive association with downside risk (β = 0.053, $p < 0.05$).

Table 9 presents the results for the effect of timing of informate IT investments on downside risk. Relative to lagging informate IT investments, leading informate IT investments are associated with a reduction in downside risk (β = –0.648, $p < 0.01$), supporting Hypothesis 2b. **<<OTHER THAN THE FIGURES FOR THE RESULTS, THE FOLLOWING IS WORDED EXACTLY AS THE PREVIOUS PARAGRAPH / WOULDN'T IT BE BETTER TO COMBINE THE TWO PARAGRAPHS AND INDICATE, FOR EXAMPLE, (H2a: β = –0.476, *p* < 0.01; H2b: (β = –0.283, *p* < 0.01)?>>** Once again, the estimated coefficient for R&D expenditure is negative and statistically significant (β = –0.283, $p < 0.01$), implying that investments in learning to resolve uncertainty lead to a reduction in downside risk. Other control variables that are associated with a reduction in downside risk include growth potential (β = –0.003, $p < 0.01$) and firm size (β = –0.073, $p < 0.01$). Given that we measure downside risk as performance relative to industry, firms with higher growth potential should obviously have lower downside risk, whereas large firms enjoy lower downside risk due to their resource endowments. Once again, industry category has no effect on downside risk (β = 0.022, $p > 0.05$), whereas economic cycle has a positive association with downside risk (β = 0.049, $p < 0.05$).

Table 10 presents the results for the effect of timing of automate IT investments on downside risk. Relative to lagging automate IT investments, parity automate IT investments are associated with a reduction in downside risk ($\beta = -0.109$, $p < 0.01$), supporting Hypothesis 2c. Most of the control variables of interest have a statistically insignificant effect on downside risk. However, the estimated coefficient for industry category is statistically significant ($\beta = -0.039$, $p < 0.05$), implying that compared to firms in other industries, firms in the service industry are more likely to benefit from undertaking automate IT investments in parity with firms in their industry. Also statistically significant is the estimated coefficient for capital expenditure ($\beta = -0.342$, $p < 0.05$), but not that for R&D expenditure ($\beta = -0.067$, $p > 0.05$).

Discussion

Both practitioners and academic researchers of IT management have attempted to determine the value of investment in IT. Prior research employing the event study methodology has specifically focused on measuring abnormal returns in the days surrounding the announcement. However, in our study, we introduced a different metric, downside risk, for determining the impact of IT investments. Assessing the relationship between IT investments and downside risk is of strategic importance to firms. Moreover, research on conceptions of risk indicates that managers generally conceptualize risk in terms of failure to achieve targets (e.g., achieving mean industry performance). Using real options and RBV as theoretical lenses, we integrate often discussed issues of uncertainty, learning, and timing as they pertain to IT investments. We conceptualize conditions under which strategic investments in IT may lead to a reduction in downside risk.

In general, our empirical findings show that strategic IT investments have differential effects on downside risk. The following major findings and implications emerge from the study:

1. Strategic IT investments that transform business processes are associated with an increase in downside risk unless they lead the industry. In other words, strategic transformational IT investments are associated with a reduction in downside risk only when firms making these investments lead their industry IT strategic role. Given that IT investments that transform business processes involve high levels of endogenous uncertainty, the only way to resolve such uncertainty is for firms to engage in learning and business experiments ("act and see"). Furthermore, competitive advantage derived even from transformative IT investments is likely to be transient. Therefore, firms that invest early and engage in active learning may be able to resolve uncertainty sooner than the competition and achieve successful infusion of IT into business processes. Consequently, they will be able to realize short-lived competitive advantage and, hence, a reduction in downside risk relative to competitors. We would expect that over time such advantage gets competed away as competitors catch

up in the resolution of uncertainty and implementation of IT innovations for business process transformation.

2. While the downside risk associated with informate IT investments is lower than that for transformational IT investments, our results indicate that firms that lead in undertaking these IT investments realize lower downside risk compared to their industry counterparts. These results imply that firms need to capitalize on first-mover advantage by investing in learning to resolve uncertainty quicker than the competition. Moreover, competitive advantage is likely to dissipate faster in this case because lower levels of uncertainty imply that other firms can catch up sooner. For automate IT investments, there is a reduction in downside risk when firms make these investments at the same time with**<<AS?>>** other firms in the industry. Thus, IT investments that automate business processes are competitive necessities.
3. These results imply that Carr [12] was partially correct in stating that firms should follow, and not lead, in making IT investments. Carr's argument requires a little qualification, though. In some cases, it pays to lead, not follow, in making IT investments. This is particularly the case for transformational IT investments. For other types of IT investment, unlike Carr's suggestion for firms to follow, our results suggest that firms should not follow, but initiate IT investments with relatively low levels of uncertainty and expected payoff at the same time with**<<CORRECT?>>** industry participants. Such investments tend to be competitive necessities at best, and it is prudent for firms to undertake them in parity with industry participants if they are to avoid competitive disadvantage.

While there is general evidence that IT capital investments carry a risk premium [21], this study is one of the first to use downside risk as an alternative measure of firm performance. It also provides a more granular analysis of the differential effects of strategic IT investments on downside risk. The degree of uncertainty and expected returns associated with different types of strategic IT investment seem to be key factors that influence the effect of IT investments on downside risk.

We grounded our research in real options and RBV logic and the results are largely consistent with our theoretical reasoning. From the theoretical perspective, our study alerts researchers especially on the use of real options thinking to analyze the business value of IT investments made under uncertainty. While the main benefit of using real options analysis stems from the ability to reduce downside risk of investments, most prior research has discussed this generally in relation to managerial flexibility in making the investment. We draw attention to endogenous uncertainty, whose resolution requires active learning and engagement in business experiments through R&D. This not only contributes to real options thinking but also ties it to organizational learning and absorptive capacity literature. It has been pointed out that those IT investments that contribute to exploitable absorptive capacity can lead to higher payoffs in the future [22]. Our analysis also reinforces the utility of the RBV as a theoretical lens to illuminate competitive advantage–related research.

From a practical perspective, our study alerts managers to the need to understand the nature of uncertainty surrounding an IT investment. If such uncertainty is exogenous (e.g., uncertainty surrounding an emerging technology that is not yet widely utilized) or does not require extensive learning, it may be prudent to “wait and see.” However, if the uncertainty is endogenous (due to the resulting business process transformation) and extensive learning is required, it may be prudent to adopt the technology early and engage in active learning by conducting business experiments required to resolve this type of uncertainty. Of course, this will be influenced by the level of absorptive capacity of the organization. Thus, forward-looking organizations should continuously build their absorptive capacity, say, through investment in R&D. Furthermore, managers also need to evaluate whether a given IT investment contributes to competitive advantage. For IT investments that are largely competitive necessities, it is advisable to undertake such investments at the same time with industry participants to maintain competitive parity.

Limitations

Although our study is theoretically grounded, it has some limitations. First, we used a cross-sectional data set limiting our ability to uncover dynamic processes and sequential investment strategy, which are needed to contain downside risk. For example, the resolution of uncertainty through learning and business experimentation is a dynamic process, which extends, perhaps, through several periods. Future research should undertake a longitudinal study to examine the effects investigated in this study. Despite this limitation, we still found considerable support for our hypotheses. Consistent with our theorizing, transformational and informate IT investments lead to a reduction in downside risk only if they are made early. For automate IT investments, the hypothesized effect of parity timing is supported.

Second, we looked at only the strategic categorization of IT investments previously used in the literature. IT investments could be conceptualized along several dimensions; for example, applications versus infrastructure, exploratory versus exploitative, and so on. In line with real options logic, perhaps a useful categorization of IT investments could also be options-enabling versus options-creating investments. How will the level of uncertainty associated with these types of IT investments differ? How might the timing of these types of IT investments affect downside risk? What degree of organizational learning will be associated with them? These are some of the research questions that could be addressed by future research.

Third, despite the strategic orientation of our study, we were unable to investigate the effect of the strategic importance of affected business processes and how this might influence how organizations approach the resolution of uncertainty [22]. A more micro-focused study that addresses a specific technology could provide useful insights into these issues. For example, the impact of investment in ERP (a specific enterprise technology) on downside risk could be examined. ERP affects several business processes, which provides an opportunity to examine the relationship between the strategic importance of affected business processes and downside risk. This might be a fertile research area because ERP system implementations are often associated with uncertainty due to the business process transformation they entail.

Last but not least, causality is often difficult to establish with cross-sectional data. Nonetheless, our results for the economic cycle variable appear to be consistent with the predictions of prospect theory (i.e., the tendency of poorly performing or failing firms to undertake more risky investments). This lessens the possibility that failing firms, for instance, have fewer resources for IT investments, and may skew investments toward "cost cutting." This notwithstanding, future work could use longitudinal study to further test the causal structure proposed in this study.

Conclusion

This study followed a different approach than prior event studies in examining the business value of IT investments. While prior research used abnormal returns to measure firm performance associated with announcements of IT investments, in this study we used downside risk as an alternative measure. We believe that using downside risk as a measure of firm performance is not only consistent with the strategic management perspective on risk but is particularly relevant for IT investments, given their associated uncertainty. The real options logic provides guidelines on how firms might mitigate downside risk for investments made under uncertainty. Guided by real options and RBV perspectives, we developed hypotheses that examined the differential effect of strategic IT investments on downside risk. We found support for the differential effect of strategic IT investments on downside risk. Timing is important in mitigating downside risk associated with IT investments. When uncertainty is endogenous and relatively high, firms may be able to reduce downside risk *only* by investing early in order to engage in the learning and business experimentation required to resolve uncertainty.

Researchers have typically measured the impact of IT investments using traditional accounting-based upside performance metrics. We hope that the initial results from this study will encourage wider theoretical and empirical integration of downside risk in IT value research.

Note

1. The length of the event window we use is consistent with prior studies of capital market responses [18, 20, 60].

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Appendix A: Assessing Announcement-Level IT Strategic Role (Adapted from [19])

THE INSTRUMENT BELOW WAS SENT TO THE THREE EXPERT JUDGES to assess the announcement-level IT strategic role.

For each IT investment announcement, please indicate which of the following best reflects the dominant role of information technology in the IT investment announcement using the following coding rules:

1. Do not code information about IT that is embedded in industrial technology.
2. Code the announcement as "Automate" if the dominant role of the IT investment:
   a. Replaces human labor by automating business processes.
   b. Has virtually no IT-driven transformation efforts.
3. Code the announcement as "Informate" if the dominant role of the IT investment:
   a. Provides new data/information to empower management, employees, or customers.
   b. Serves as an intermediate level of IT-driven transformation efforts.

4. Code the announcement as "Transformate" if the dominant role of the IT investment:
   a. Fundamentally alters traditional ways of doing business by redefining business capabilities and/or (internal or external) business processes and relationships.
   b. Is a strategic acquisition to acquire new capabilities or to enter a new marketspace.
   c. Uses IT to dramatically change how tasks are carried out; is the move recognized as being important in enabling firm to operate in different markets, serves different customers; gains considerable competitive advantage by doing things differently.

Appendix B: Assessing Industry-Level IT Strategic Role (Adapted from [19])

The instrument below was sent to the three expert judges. The consensus response for the period 1999–2004 is also provided. The mode response value for the periods 1987–94 and 1995–98 as assessed by Dehning et al. [19] is also provided.

Please indicate which of the following best reflects the dominant role of information technology in the specified list of industries during the period 1999–2004 (review any industry association Web sites, IT analyst writings [e.g., Gartner research reports], and other resources that describe the dominant nature of role of information technology in each industry):

Rating scale: Please code each industry as Automate (A); Informate Up/Down (I); Transform (T):

- Automate: Replaces human labor by automating business processes to improve efficiency of or replace human labor.
- Informate Up/Down: Provides data/information to empower management and employees to aid in making decisions at higher and lower organizational levels.
- Transform: Is used to introduce radical business or innovative business models that break the traditional mold. When transformational IT investments dominate an industry, structural changes involving value chains and market spaces are taking place.

Table B1 **<<PROVIDE TITLE FOR TABLE AND ALSO, CITE THE TABLE IN THE TEXT FOR APPENDIX B>>**

Industry	IT role
1987—1994	
Airlines	T
Banking	A
Computer manufacturing	I
Computer software products and services	A
Diversified chemicals manufacturer	I
Diversified foods manufacturer	I
Electric equipment, electronic/scientific test, and measurement instruments manufacturer	I
Financial services	A
Fluid systems manufacturer	A
Food services	A
Health care products	A
Heavy construction	A
IT consulting services	I
Media—diversified I	I
Pharmaceutical manufacturing	A
Publishing—news services, newspapers, and periodicals	A
Retail—department stores	I
Retail—grocery stores	A
Semiconductor equipment and materials manufacturing	I
Telecommunications services	A
Transportation—ground and railroad	A
Transportation equipment manufacturing	A
1995–1998	
Accounting, bookkeeping, collection, and credit reporting	T
Advertising	T
Agricultural machinery manufacturing	I
Airlines	T
Automotive manufacturing	I
Automotive parts and service	I
Banking	T
Biotechnology products/services	I
Cleaning products manufacturing	I
Computer manufacturing	I
Computer software products and services	T
Diversified building materials manufacturing	I
Diversified chemicals manufacturer	I
Diversified foods manufacturing	I
Electrical equipment, electronic/scientific test, and measurement instruments manufacturer	I

(continues)

Industry	IT role
Financial services	T
Fluid systems manufacturing	I
Food services	I
Health care products distribution	I
Heavy construction	I
Information collection and delivery services	T
Internet and online service providers	T
IT consulting services	I
Long-term care facilities	T
Media—diversified	T
Metals (aluminum, steel) manufacturer	A
Pharmaceuticals manufacturer	I
Printing, photocopying, and graphics design	I
Publishing—news services, newspapers, and periodicals	T
Reinsurance	I
Retail—apparel/accessories and specialty products	I
Retail—department stores and discount/variety stores	I
Retail—grocery stores	I
Semiconductor equipment and materials manufacturer	I
Staffing, outsourcing, and other human resources services	T
Surety, title, and miscellaneous insurance	A
Telecommunications services	T
Telemarketing, call centers, and other direct marketing	T
Transportation—ground and railroad	A
Utilities—electric	A
Wholesaler—floral products and groceries	T
Wire and cable manufacturer	I
1999–2004	
Accounting, bookkeeping, collection, and credit reporting	T
Advertising	T
Agricultural machinery manufacturing	I
Airlines	T
Automotive manufacturing	I
Automotive parts and service	I
Banking	T
Biotechnology products/services	I
Cleaning products manufacturing	I
Computer manufacturing	I
Computer software products and services	T
Diversified building materials manufacturing	I
Diversified chemicals manufacturer	I
Diversified foods manufacturing	I

(continues)

Industry	IT role
Electrical equipment, electronic/scientific test, and measurement instruments manufacturer	I
Financial services	T
Fluid systems manufacturing	I
Food services	I
Health care products distribution	I
Heavy construction	I
Information collection and delivery services	T
Internet and online service providers	T
IT consulting services	I
Long-term care facilities	T
Media—diversified	T
Metals (aluminum, steel) manufacturer	A
Pharmaceuticals manufacturer	I
Printing, photocopying, and graphics design	I
Publishing—news services, newspapers, and periodicals	T
Reinsurance	I
Retail—apparel/accessories and specialty products	I
Retail—department stores and discount/variety stores	I
Retail—grocery stores	I
Semiconductor equipment and materials manufacturer	I
Staffing, outsourcing, and other human resources services	T
Surety, title, and miscellaneous insurance	I
Telecommunications services	T
Telemarketing, call centers, and other direct marketing	T
Transportation—ground and railroad	I
Utilities—electric	I
Wholesaler—floral products and groceries	T
Wire and cable manufacturer	I

Notes: A = automate; I = informate up/down; T = transform.**<<NOTE CORRECT AS ADDED?>>**