The Effects of Investments in Information Technology on Firm Performance: An Investor Perspective

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ABSTRACT

Analyzing the beneficial effects of investments in information technology (IT) is an area of research that interests investors and academics. A number of studies have examined whether investments in IT have a positive effect on some measure of earnings or other form of financial return. Results from these studies have been mixed. This paper extends the literature by adopting an investor’s perspective on firm performance when IT investments are made, using the preservation of capital as a performance measure. The authors examine companies that made public announcements of their investments in technology to see if they were able to mitigate losses to investors by reducing their downside risk to investors. This study further discusses whether different types of IT investments have different impacts on firm risk from an investor’s viewpoint. Findings suggest that IT investments impact a firm’s downside risk, and the authors offer an alternative perspective on the benefits of IT investments, particularly where no positive incremental financial results are evident.

Keywords: Downside Risk, Event Study, Firm Performance, IT Investment, Preservation of Capital

INTRODUCTION AND BACKGROUND

Comprehensive evidence of the impact that investments in information technology (IT) have on firm performance continues to elude researchers and investors (Mittal & Nault, 2009). Labeled the “productivity paradox” by Nobel Laureate Robert Solow, this phenomenon has been blamed on a number of factors, including the mismanagement of IT resources and the use of the wrong performance measures. Carr (2003) has even suggested that investments in IT have become so commonplace that they are now similar to other ordinary business investments that offer no distinguishable competitive advantage.

A majority of the studies that have examined the relationship between IT investments and firm performance have used traditional measures of firm performance (i.e., productivity and profitability) that best meet the needs of...
management (Kohli & Davaraj, 2003). However, results of these studies have been mixed. For example, Brynjolfsson and Hitt (1993), Bharadwaj, Bharadwaj, and Konzynski (1999), and Stratoupolis and Dehning (2000), among others found a positive association between investments in IT and firm performance. On the other hand, researchers such as Loveman (1994) and Roach (1987) found a significantly negative association between investments in IT and resulting firm performance.

We contribute to the literature by examining the relationship between investments in IT and a firm’s risk profile using a non-traditional measure of firm performance that is not captured in either productivity gains or increased profitability. Although IT investments may allow firms to achieve superior profits relative to their competitors, we believe that IT investments also serve to reduce a firm’s financial risk profile, or its downside risk. Downside risk has been proposed by economists as the perspective that characterizes investor sentiment towards making investments (Nawrocki, 1999). Economists have posited that the disutility incurred by a loss outweighs the utility of a gain of the same amount. Our research should be of interest to both researchers and investors (Heine, Grover, & Malhotra, 2003; Melville, Kraemer, & Gurbaxani, 2004).

Our study provides evidence that there is an association between reductions in downside risk following the announcement of IT investments. We also find evidence that suggests the type of IT investment affects the degree of downside risk following the announcement of the investment, as well as whether the firm is a leader in defining IT strategies for their industry.

In the following section, we briefly discuss literature related to IT investments relevant to this study. The next section develops our hypotheses relating firms’ investments in IT to downside risk and discusses the model we use to test these hypotheses. We then focus on methodological issues and discuss the results of our study. We conclude and summarize the paper, comment on limitations of our study, and discuss and directions for future research in the final section.

LITERATURE RELATED TO IT INVESTMENTS AND FIRM PERFORMANCE

Prior literature relating investments in IT to the effect on firms has focused primarily on positive outcomes such as productivity gains or financial returns. Kohli and Davaraj (2003) and Melville et al. (2004) have noted that the results of studies focusing on the specific organizational performance and productivity improvements have been mixed. Given the mixed results of past studies, our use of the investor’s perspective provides an alternative explanation about how IT investments may have a positive effect on firm performance. We will briefly discuss some of the key studies related to measuring the impact of IT investments on firm performance and then explain why using downside risk as an alternative measure makes sense.

Research has documented a positive performance associated with the announcements of certain types of IT investments. Dos Santos, Peffers, and Mauer (1993) investigated the effect of IT investments on the market value of firms. Two particular attributes, industry type and IT investment type, were examined to see if either had an effect on the cumulative abnormal returns (CARs) near the dates of the announcements. Evidence indicates that only announcements of innovative IT investments were (positively) associated with CARs. Im, Dow, and Grover (2001) extended the literature by investigating whether industry size and time lag had an effect on firm market value using a larger sample of IT investment announcements over a longer time period. Small firm size and announcements made from 1991 and after (time lag) were found to be positively associated with market value effects. Additionally, Im et al. (2001) found that IT investment announcements in the financial industry were positively associated with market value, but only for announcements made after 1991.
Dehning, Richardson, and Zmud (2003) built upon this stream of literature by examining the relationship between the industry strategic role of IT investments and firm value. Using the IT strategic role construct conceptualized by Schein (1992), IT investment announcements were classified as those that automate, informate, or transform an organization. Dehning et al. (2003) tested the associations between market value and the classification of IT investment announcement by firms. Findings from this study 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, and firms announcing IT investments in industries in which transformational investments dominate the industry experience positive market value reactions from those announcements. Additionally, Dehning et al. (2003) found firms that announce IT investments, and are leaders in their industry, experience positive market value reactions.

Recent studies have sought to further refine the circumstances under which firms experience positive returns on IT investments. Stone, Good, and Baker-Eveleth (2007) found that in certain situations, IT can have a positive effect on a firm’s marketing performance, which can in turn, enhance revenue generation. Mittal and Nault (2009) find evidence that IT affects certain firms in different ways. The effects of IT tend to be indirect on IT intensive firms, while direct effects are associated with non-IT intensive firms. Chari, Devaraj, and Parthiban (2008) posit that investments in IT pay off when firms own and operate businesses in multiple industries because IT facilitates control and coordination.

While studies prior to ours have focused on measuring the positive impact of IT on performance, our paper extends the literature by employing a measure that captures a different aspect of performance than preceding studies (e.g., Stone et al., 2007; Mittal & Nault, 2009; Chari et al., 2008; Dos Santos et al., 1993; Im et al., 2001; Dehning et al., 2003). The downside risk performance measure focuses on mitigating losses instead of focusing on positive returns, thereby complementing the studies previously discussed. Our study provides a deeper understanding about the influence that IT investments ultimately have on what is important to investors.

The concept of risk as a measure of performance is absent from much of prior research. One long-standing method to measure business risk is the volatility of returns. Two of the methods used to operationalize the volatility of returns are the mean variance and downside risk. The mean variance considers both positive and negative fluctuations of returns relative to some target level, whereas downside risk focuses on the negative fluctuations. It has been argued that the mean variance has deficiencies as a measure of risk because it is based upon utility functions that are unlikely to reflect the true attitudes of investors, that is risk neutrality (Grootveld & Hallerbach, 1999).

Downside risk is considered by some to be the most consistent with investors’ perceptions of risk. As discussed in Nawrocki (1999), an investor has to make a trade-off between risk and return. Roy (1952) felt that investors will prefer safety of principal first, and then desire some minimum level of return that will preserve the principal amount. Roy’s concepts would prove fundamental to the ultimate development of the downside risk measures that allow investors to minimize the probability of the portfolio falling below some target rate of return. Tversky and Kahneman (1992) find that the disutility of losses are weighted about twice that of the utility of gains. Veld and Veld-Merkoulova (2008) found in their experimental study that the most common risk measure used by investors was downside risk. Therefore, we chose the investor’s perspective of risk, downside risk, as a measure to evaluate one of the effects that IT investments may have on firm performance. Details on how we operationalized the downside risk metric are discussed in a later section.

**Hypotheses Development and Model Specification**

The beneficial effects of investments in IT that allow a business to maintain current or
forecasted levels of profitability will not necessarily be manifested in incremental profitability. Instead, the risk to decreases in a company’s future stream of earnings may have been mitigated. One measurement that can capture this risk mitigation is downside risk, the risk that actual financial performance is less than a target level. Behavioral decision theory (Lant, 1992; Lant & Montgomery, 1987), finance research (Harlow & Rao, 1989; Sortino & Price, 1994), and management studies on risk (Miller & Leiblein, 1996; Reuer & Leiblein, 2000) have employed downside risk measurement. We test the following hypothesis to see if there is a relationship between downside risk and investments in IT:

H1: A firm’s investment in IT will be inversely related to its downside risk.

It is feasible that the impact on downside risk will depend on the type of IT investment made. Recent research has examined the impact of different kinds of investments in technology on financial returns to the companies making these investments. Dehning, Dow, and Stratopoulos (2003) examined the association between cumulative abnormal stock returns and investments in technology that fell into three broad categories. The categories indicated the intent of the investments to “automate”, “informate”, or “transform” a company’s operations. Automate refers to automating business processes that may have been executed in part or wholly by human labor. As discussed in Dehning et al. (2003), it may be difficult for companies to maintain competitive advantages merely by automating processes, especially if this is a trend in the industry that a company belongs to. Investments in technology that automate processes may, in some instances, be a necessity to for a particular company to remain in business at best. If these investments require significant sums of money, it is possible that there is a net negative impact on earnings. Accordingly, we predict that there will be no effect on downside risk made by IT investments intended to automate company processes.

Informate refers to enriching the flow of information through the company either horizontally or vertically. 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. Therefore, we predict that there will be a negative association between investments in IT to informate and downside risk. This notion is consistent with Chari et al. (2008) who posit that IT facilitates coordination and control of diversified entities.

Transform refers to a major shift in the way a business conducts its internal processes or relationships with customers or other business entities. Investments in IT to transform may be part of a broader re-engineering or strategy shift. We suspect that these investments are not made independent of deploying significant amounts of other resources in the transformational effort. It is possible that the transformational efforts of a company will create competitive advantages that may be sustained for some time, or create barriers to entry for competitors. Accordingly, we predict that there will be a negative association between investments in IT to transform. We test the following hypothesis to see if different investment types have a differential effect on downside risk:

H2: The strategic role of investment in IT affects downside risk in different ways.

Moreover, we predict that the leadership role firms play within their respective industries in terms of making IT investments will be related to downside risk. We classify the role of firms based on whether they lead, follow, or lag behind their industry in the announcement of their IT investments. We posit that firms that lead their industry in announcing IT investments will exhibit a significant reduction in downside risk relative to firms that either follow or lag behind industry leaders. We classify the strategic role of firms into three categories: those who lead, are the same as, or lag their industry in
the timing of making strategic IT investments. The industry context is likely to be important to how investors perceive IT events for any particular firm, since factors which can positively (negatively) impact one company may have similar effects on other participants of the industry. We acknowledge that leadership in IT investments may not pose long lasting barriers to entry or technological advantages, but may provide windows of opportunity for capturing market share and enhancing profitability. Additionally, they may be perceived as corroborating evidence of the innovative nature of a business that fosters success. Therefore, we assert that firms which lead their industry in making strategic IT investments will be associated with decreased downside risk, relative to their peers who make strategic investments at the same time as or behind the industry. We test this assertion with the following hypothesis:

H3: Firms that lead their industry will experience more of a decrease in downside risk than firms that either lag or are the same as their industry when investments in IT are announced.

We analyze the effect of IT investment announcements on downside risk by examining downside risk when IT investment announcements are made, relative to before the announcements have been made. Our model employs various controls to better isolate the incremental change in downside risk attributable to the IT investment announcements, and takes the following form:

\[ \text{Downside risk}_{\text{post}} = \beta_0 + \beta_1 \text{Downside risk}_{\text{pre}} + \beta_2 \text{Investment type} + \beta_3 \text{Lead} + \beta_4 \text{Leverage}_{\text{post}} + \beta_5 \text{Growth Potential}_{\text{post}} + \beta_6 \text{Size}_{\text{post}} + \beta_7 \text{Time Period} + \beta_8 \text{Industry} + \beta_9 \text{Organizational Slack}_{\text{post}} + \varepsilon \]

where:

- Downside risk = post-investment measure calculated based on equation 1.
- Investment type = categorical variable for the type of IT investment (automate, informate, or transform).
- Lead = categorical variable for the IT strategic role of the firm within its industry (leads, follows, or lags).
- Industry = industry affiliation (see the Appendix).
- Time period = categorical variable indicating whether the IT announcement occurred during or after the productivity paradox period.
- Leverage = categorical variable indicating whether the company could be subject to financial distress at the end of the reporting year in which the announcement was made.
- Size = natural log of the market value of shareholder equity.
- Organizational slack = AR/Sales, INV/Sales, and SGA/Sales at the end of the reporting year in which the announcement was made.

The control variables in the model were included in an attempt to isolate the incremental effect of IT investment announcements on downside risk. The controls were based on previous studies mentioned in our literature review that examined the effect of IT investments on firm performance (e.g., Dos Santos et al., 1993; Im et al., 2001; Dehning et al., 2003). Publicly available data at the end of the year in which the IT investment announcement was made was used to calculate the control variables.

All event studies must employ a time window on or about the time that the event occurs, in this case the announcement of an IT investment. Our study used a window of two contiguous 40-day periods (-50 to -10 days and 10 to 50 days) was used to calculate the downside risk metric and its determinants. This window allows us to obtain sufficient time series data to construct the downside measure.

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We excluded a 10 day window surrounding the announcement date to provide a reasonable assurance that any downside risk captured by our calculations would not be contaminated by the announcement effect. This exclusion also provides some assurance that any volatility associated with the short term announcement is not included in our measure of downside risk. The next section provides more specific detail about the measures used in the model and the sample employed in this study.

SAMPLE AND MEASURES

Downside risk is defined as a firm’s daily stock price relative to its industry’s mean stock price (Barth, Beaver, Hand, & Landsman, 1999). To calculate downside risk, our study uses stock returns derived from stock prices. Since stock prices are believed to impound all available information affecting future cash flows, stock prices should reflect market expectations of IT investment impact on future cash flows of an entity.

Downside risk is operationalized as a probability weighted function of below-target performance outcomes. This differs from measures of volatility because only below-target performance is measured as opposed to any deflection from the target performance. Specifically, we measure downside risk as a firm’s daily stock price return relative to a target level that changed over time. Target level is specified as the mean stock price return for a firm’s industry (Barth et al., 1999). Downside risk is measured as a second-order root lower partial moment, and can be expressed as:

\[ \text{Downside Risk} = \frac{1}{n} \sum_{i=1}^{n} \text{Max}(0, t - R_i)^2 \]

where,

- \( R_i \) is the firm return during the time period
- \( t \) is the target return (industry mean return during the period)
- \( n \) is the number of observations in the period

(1)

To classify the investments in IT into a particular category, we follow the method used in Dehning et al. (2003). Accordingly, IT investments in our sample are coded as those made to informate, automate, or transform a company’s operations. Dehning et al. (2003) relied upon a panel of experts to categorize IT investments, taking into consideration the timing and particular industry making those investments. Responses from the experts independently queried had a high degree of agreement.

Factors in addition to investments in IT may affect a firm’s downside risk. To isolate the incremental effect that IT investments may have on downside risk, our model contains covariates (control) variables to represent the firm size, industry affiliation, time period, organizational slack, growth potential, leverage, and liquidity of the firm.

The timing of an IT investment announcement captures whether the investment was made before or after the productivity paradox time period. During this period researchers were unable to find a consistent pattern of associations between investments in IT and firm performance. Two variables that proxy for firm size are total assets and total liabilities, each scaled by total sales. We include both variables because assets alone may under-represent size if outsourcing is a material part of operations.

Leverage influences the financial risk of an entity. The debt-to-equity ratio is used as a measure of financial leverage (Chen & Lee, 1993). The inability of a firm to meet their obligations to debt holders results ultimately in insolvency, bankruptcy, and the eventual demise of the entity. We employ a categorical variable to indicate whether the company was experienced relatively high levels of total debt to the total market value of equity. A debt-to-equity level equal to or greater than 4:1 was chosen as the benchmark to indicates a high level of leverage. Firms with debt-to-equity ratios greater than 4 were classified as having a high level of leverage and firms with debt-to-equity ratios of less than 4 were classified as not having a high level of leverage.

Organizational slack represents the cushion of excess resources available to be used in a
discretionary manner. These resources allow firms to buffer themselves from adverse effects when their performance is below targeted levels. It is represented by resources that are accumulated during periods where firms perform above their targeted levels. Miller and Leiblein (1996) posit that slack will mitigate subsequent downside risk.

Our analysis includes a variable to control for the affect growth potential may have on stock price. Book-to-market ratio measures the relationship between the accounting value of a company and the value of its stock. This measure is considered as a proxy for the future growth potential. Since the market value of a company’s stocks impounds expectations for future cash flows, the book-to-market ratio represents the expectations for growth.

The particular industry a firm belongs to may affect the downside risk of the firm. To control for this, we include a variable representing the class of industry. Our study classifies firms into twelve different categories ranging from companies manufacturing goods to service sector and financial companies. Refer to the Appendix for more detail on the industry classifications used in this study.

The ability of a company to meet the financial obligations of current liabilities from resources generated by operations is captured by liquidity. Low levels of liquidity may indicate financial distress, and greater risk levels for a firm. This study employs the current ratio (current assets / current liabilities) as a measure of a firm’s liquidity.

This study employs a sample consisting of organizations that announced significant investments in IT from the period 1981-1997 (Hunter, 2003; Im et al., 2001). The sample time frame was chosen to maximize the amount of data prior to the build-up and subsequent burst of the “tech bubble”. Speculative inflation of stock prices appears to have occurred from early 1998 through February 2000 (Ofek & Richardson, 2003). Though the tech bubble phenomenon is attributed to stocks of internet companies, the effects were pervasive to other industry sectors (Anderson, Brooks, & Katsaris, 2005). Because of the potential distortions in calculating downside risk during this tech bubble period, our sample date stops at 1997. Anecdotally, examining a graph of the S&P 500 over time reveals that prices of the index do not return to pre-bubble levels until after 2001. The events of September 11, 2001, and subsequent recession in 2002 and 2003 hold the potential to distort or mask findings in our study. Therefore, our sample time frame terminates at the end of 1997.

To screen our sample, we began with the 238 IT announcements found in Im et al. (2001) and the 150 IT announcements found in Hunter, resulting in 388 possible IT announcements. 137 announcements were dropped because of inconsistent or incomplete data obtained from CRSP for the individual firms or problems in constructing the industry returns. Additionally, the inability to determine the investment type because the announcement was missing or the announcement did not provide enough information about the nature of the IT investment prevented some firms from being included in our sample. We estimated the downside risk measures using the remaining 251 IT investment announcements (Table 1).

Descriptive statistics for the total sample can be seen in Table 2. The average firm had sales of $20 billion with an average net income of $785 million. Firms’ total assets averaged $31 billion and ranged from $49 million to $272 million. Table 3 presents correlations for the continuous variables examined in this study.

RESULTS

We used analysis of covariance (ANCOVA) to compare the change in downside risk before and after the IT announcements. In this ANCOVA formulation, the dependent variable is the downside risk of the firm following the IT investment announcement. Investment type and IT strategic role were random factors in the model. Our model explained nearly 60 percent of the variance in the downside risk of the sample firms.
Table 1. IT investment announcements

<table>
<thead>
<tr>
<th>Announcements</th>
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<tbody>
<tr>
<td>IT Announcements found in Im et al., 2001</td>
</tr>
<tr>
<td>IT Announcements found in Hunter, 2003</td>
</tr>
<tr>
<td>Total possible IT Investment Announcements</td>
</tr>
<tr>
<td>Less: Firms with incomplete CRSP data</td>
</tr>
<tr>
<td>Less: Firms unable to be coded</td>
</tr>
<tr>
<td>Usable IT Investment Announcements</td>
</tr>
</tbody>
</table>

Table 2. Descriptive statistics for study variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Downside risk&lt;sub&gt;pre&lt;/sub&gt;</td>
<td>0.0324</td>
<td>0.0901</td>
<td>0</td>
<td>0.8299</td>
</tr>
<tr>
<td>Downside risk&lt;sub&gt;post&lt;/sub&gt;</td>
<td>0.0301</td>
<td>0.0766</td>
<td>0</td>
<td>0.6862</td>
</tr>
<tr>
<td>Assets&lt;sub&gt;post&lt;/sub&gt; (in $000,000’s)</td>
<td>31,285</td>
<td>43,858</td>
<td>49.481</td>
<td>272,402</td>
</tr>
<tr>
<td>Sales&lt;sub&gt;post&lt;/sub&gt; (in $000,000’s)</td>
<td>20,151</td>
<td>27,335</td>
<td>81.664</td>
<td>165,370</td>
</tr>
<tr>
<td>Net Income&lt;sub&gt;post&lt;/sub&gt; (in $000,000’s)</td>
<td>785.07</td>
<td>1,163</td>
<td>-1985</td>
<td>7,280</td>
</tr>
<tr>
<td>Total Debt&lt;sub&gt;post&lt;/sub&gt; (in $000,000’s)</td>
<td>9,914</td>
<td>19,431</td>
<td>0</td>
<td>162,406</td>
</tr>
<tr>
<td>Leverage&lt;sub&gt;post&lt;/sub&gt;</td>
<td>2.438</td>
<td>8.513</td>
<td>0</td>
<td>51.43</td>
</tr>
<tr>
<td>Growth Potential&lt;sub&gt;post&lt;/sub&gt;</td>
<td>5.679</td>
<td>8.862</td>
<td>0.0020</td>
<td>105.186</td>
</tr>
<tr>
<td>Market Value of Equity&lt;sub&gt;post&lt;/sub&gt;</td>
<td>32,540</td>
<td>86,845</td>
<td>3.541</td>
<td>1,036,061</td>
</tr>
<tr>
<td>Organizational Slack&lt;sub&gt;post&lt;/sub&gt;</td>
<td>1.743</td>
<td>2.376</td>
<td>0</td>
<td>9.796</td>
</tr>
</tbody>
</table>

Table 3. Correlation Matrix for variables in downside risk ANCOVA model

<table>
<thead>
<tr>
<th></th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Downside Risk&lt;sub&gt;pre&lt;/sub&gt;</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Downside Risk&lt;sub&gt;post&lt;/sub&gt;</td>
<td>0.690**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Leverage</td>
<td>0.139**</td>
<td>0.190**</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Growth Potential</td>
<td>0.107*</td>
<td>0.122*</td>
<td>0.028</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Size</td>
<td>-0.417**</td>
<td>-0.365**</td>
<td>-0.059</td>
<td>0.371**</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Liquidity</td>
<td>0.197**</td>
<td>0.123*</td>
<td>0.103</td>
<td>-0.138*</td>
<td>-0.286**</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>7. Organizational Slack</td>
<td>-0.151**</td>
<td>-0.153**</td>
<td>-0.027</td>
<td>-0.182**</td>
<td>-0.055</td>
<td>-0.122*</td>
<td>1</td>
</tr>
</tbody>
</table>

** p<0.01
* p<0.05
Hypothesis 1 predicted that investment in IT will result in a reduction in organizational downside risk. Although we predicted firms that made significant investments in IT would experience less downside risk after the announcement date, downside risk increased significantly for all firms. At first it appears that H1 is not be supported. However, further examination of the data reveals the result that IT investment announcements prior to 1991 resulted in increased downside risk whereas later announcements resulted in a decrease in downside risk thereby suggesting that there might be a temporal nature to the events that were used in this study. Therefore, we cannot fully reject the first hypothesis. The fact that downside risk decreased significantly after the productivity paradox period suggests that the growing evidence at that time about the positive impact of IT investments on firm productivity led to a shift in investor perceptions (Brynjolfsson, 1993; Im et al., 2001).

Hypothesis 2 predicted a differential effect of investment type on downside risk. The hypothesis appears to be supported because the ANCOVA coefficient for this variable was statistically significant. Further investigation using linear contrasts (the Tukey test for multiple comparisons) indicated that transformational IT investments do have a differential effect on downside risk resulting in higher levels of downside risk for those investments relative to IT investments that are either automate or informate. There was no statistical difference between automate and informate IT investment announcements. Thus, there appears to be empirical evidence that suggests the type of IT investment does have an impact on a firm’s level of downside risk. Specifically transformational IT investments appear to have a more beneficial impact on downside risk than either automate or informate IT investments.

Hypothesis 3 predicted that leaders of IT investments will experience more beneficial effects of downside risk than will their counterparts. The results of the ANCOVA analysis (shown in Table 4) indicate that there is a significant difference in the change in downside risk after implementing IT. As can be seen in Table 4, the change is partially determined by the IT strategic role of the investment and whether the IT investment leads the IT Strategic Role of the industry. Therefore, the results of the ANCOVA analysis appear to support hypothesis H3.

Investigation using linear contrasts (the Tukey test for multiple comparisons) indicated that firms that lead their industry IT strategic role have a differential effect on downside risk than those firms that either lag or are the same as their industry IT strategic role. Specifically, firms that lead their industry IT strategic role enjoy lower levels of downside risk relative to the other firms. There was no significant difference in firms that lag their industry IT strategic role and firms that are investing in the same type of technology as their industry IT strategic role. Therefore, H3 is only partially supported.

Analysis of the covariates reveals that five covariates were also significantly related to changes in downside risk. They are: (1) leverage; (2) growth potential; (3) size; (4) liquidity; and (5) the time period in which the investment takes place (in the productivity paradox period or not). Firms that announced IT investments prior to 1991 showed significant increases in downside risk whereas firms that announced IT investments after 1991 showed significant decreases in downside risk. The remaining control variables were not statistically significant in the downside risk model.

**DISCUSSION, LIMITATIONS, AND DIRECTIONS FOR FUTURE RESEARCH**

Academic researchers and investors remain keenly interested in determining how investments in technology affect firm performance. We contribute to the literature by taking the investor perspective and using downside risk as an alternative measure the value made by IT investments. The prior work in this area has focused on measuring abnormal returns or some earnings-based metric in the days sur-
rounding the announcement. However, research on perceptions of risk indicates that investors generally conceptualize risk in terms of failure to achieve performance targets. They value the preservation of capital. The findings of this study provide a compelling argument to consider downside risk as a complement to traditional performance metrics when conducting research on how investments in IT ultimately affect firm performance.

Our results suggest that a number of variables influence the level of downside risk associated with IT investment announcements. For example, firms that were the first in their industry to make announcements of significant IT investments experienced significantly less downside risk than those firms that followed or lagged behind them. We acknowledge that industry leadership in IT investments does not insure continued technological supremacy but may provide windows of opportunity for capturing market share and enhancing profitability. As noted by Dos Santos et al. (1993), firms that exploit new IT capabilities perform significantly better than firms that only explore their current IT capabilities.

We found that firms making IT investments facilitating major shifts in their internal processes and/or external customer/competitor relationships experienced significantly less downside risk than those that automated business processes or invested in IT that improved decision support systems. Transformational investments in IT are likely to be part of a broader re-engineering or strategic shift requiring the deployment of significant amounts of other resources as part of the transformational effort. As a result, transformational investments in IT may create sustainable or prolonged competitive advantages over competitors.

One of the more interesting findings of our study was the relationship between the time frame associated with the productivity paradox and the level of downside risk associated with a firm’s stock price. As noted above, this time frame moderated the relationship between IT investment announcements and the level of downside risk. Our findings are consistent with the literature on the value of IT. The literature provides evidence that prior to the early 1990s investors penalized firms that announced significant investments in IT. Subsequent evidence supported the notion that investments in IT favorably impacted the efficiency of internal business processes, and investors updated their

<table>
<thead>
<tr>
<th>Source</th>
<th>DF</th>
<th>Type III SS</th>
<th>Mean Square</th>
<th>F-Value</th>
<th>Significance</th>
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</thead>
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<td>0.00328</td>
<td>102.25</td>
<td>&lt;.0001</td>
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<td>0.00017</td>
<td>0.000083</td>
<td>2.58</td>
<td>0.0783</td>
</tr>
<tr>
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<td>0.00017</td>
<td>0.000083</td>
<td>2.58</td>
<td>0.0783</td>
</tr>
<tr>
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<td>Growth Potential</td>
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<td>0.00030</td>
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<td>0.00014</td>
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<td>0.76</td>
<td>0.6634</td>
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<tr>
<td>Organizational Slack</td>
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<td>0.000096</td>
<td>0.000096</td>
<td>3.00</td>
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<td>Error</td>
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<td>0.00514</td>
<td>0.00003</td>
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<tr>
<td>Total</td>
<td>246</td>
<td>0.01506</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

R²=0.587
investment protocols. It is possible that this is an example of a market that is ultimately efficient.

The event study methodology proved to be a viable way to examine the relationship between important firm-related decisions and downside risk. However, the methodology has its limitations. For example, event studies may be prone to over or underestimate an outcome unless the event window is well calibrated. Nonetheless, event studies are an excellent method for examining the outcomes associated with corporate policy decisions such as the decision to make significant investments in IT.

Future research could examine how different types of IT investments might have a stronger impact on downside risk, as opposed to the different categories of IT investments (automate, informate, and transform) used in this study. For example, the impact of ERP investments on downside risk could be examined. This might be a fertile research area because several of the selling points of ERP system implementations were the efficiency and productivity gains that might be realized from the investment, particularly when associated with process reengineering.

Another idea for future research might involve a multi-dimensional approach to measure benefits firms reap from IT investments. A single productivity or risk measure may not fully capture the benefits of IT investments, and a more holistic approach might be more fruitful. Future studies might examine multiple performance measures. One idea might involve jointly examining the impact of IT investments on both the cumulative abnormal returns and the downside risk of the stock returns.

REFERENCES


Jeffrey Wong, PhD, CPA, is an associate professor at the University of Nevada at Reno. He received his PhD from the University of Oregon. Professor Wong has published work in journals including, Behavioral Research in Accounting, Database, International Journal of e-Collaboration, and Internal Auditor. His research interests focus on understanding how a firm’s strategic decisions and actions ultimately map to financial results. This research focus has most recently examined how a company’s information systems and investments in technology enhance the value of a firm.

Kevin E. Dow is an assistant professor at the University of Alaska, Anchorage. He received his PhD from the University of South Carolina. His research lies at the intersection of information systems and accounting and focuses on the design and use of accounting information for managing costs and evaluating business value. His papers have appeared in journals including Journal of Information Systems, the European Journal of Information Systems, Information Systems Research, Database for Advances in Information Systems, the International Journal of Accounting Information Systems, the International Journal of eCollaboration, Management Accounting Quarterly, Issues in Accounting Education, AIS Educators Journal, and the International Journal of Information Systems and Social Change.

### APPENDIX

#### Industry Classifications for Firms in Study

*Table A1. Industry definitions (adapted from Barth et al., 1999)*

<table>
<thead>
<tr>
<th>Industry</th>
<th>Industry Name</th>
<th>SIC Codes</th>
</tr>
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<tbody>
<tr>
<td>A</td>
<td>Food</td>
<td>2000-2111</td>
</tr>
<tr>
<td>B</td>
<td>Textiles &amp; Printing/Publishing</td>
<td>2200-2780</td>
</tr>
<tr>
<td>C</td>
<td>Chemicals</td>
<td>2800-2824, 2840-2899</td>
</tr>
<tr>
<td>D</td>
<td>Pharmaceuticals</td>
<td>2830-2836</td>
</tr>
<tr>
<td>E</td>
<td>Extractive</td>
<td>1300-1399, 2900-2999</td>
</tr>
<tr>
<td>F</td>
<td>Durable Manufacturing</td>
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<tr>
<td>G</td>
<td>Computers</td>
<td>3570-3579, 3670-3679, 7370-7379</td>
</tr>
<tr>
<td>H</td>
<td>Transportation</td>
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<tr>
<td>I</td>
<td>Utilities</td>
<td>4900-4999</td>
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<tr>
<td>J</td>
<td>Retail</td>
<td>5000-5999</td>
</tr>
<tr>
<td>K</td>
<td>Financial Institutions</td>
<td>6000-6999</td>
</tr>
<tr>
<td>L</td>
<td>Services</td>
<td>7000-7369, 7380-8999</td>
</tr>
</tbody>
</table>

*Note: The industries for Agriculture and for Mining and Construction have been removed from this classification because there were no announcing firms in these industries.*