December 2006

IT Investment, Risk, and Firm Performance

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ABSTRACT

Evaluating the impact of Information Technology (IT) spending on firm performance has long been an issue for both managers and researchers. To date most research has focuses on the returns that IT investments can provide to firms and the results for many years showed no impact of IT investment. More recent studies have shown an abnormally positive influence. Given the large amount of IT spending and mixed results an open question is what is the impact of IT investment on firm performance? Arguments to date have posed that the reason that IT spending did not produce productivity was due to lag effects, yet has ignored why the proposed lags were decades long. Significant research outside the information systems community has shown a tradeoff between returns and risk, yet most studies to date have used incomplete measures of returns that have failed to account for risk. Bounded rationality is used in this paper to show how IT investments could reduce variability. Borrowing from financial economics I will show that ceteris paribus risk reduction provides a plausible explanation for why IT investment continued after decades of little observable impact and how this risk reduction can explain a significant portion of the abnormal returns we now see from IT investment.

Keywords

Productivity Paradox, Risk, IT investment, Volatility.

INTRODUCTION

The impact of Information Technology (IT) investment on firm performance is a central theme of information systems (IS) research for many years and remains an active topic of interest for IS researchers. For years researchers (Solow, 1987) found investment in IT to have no impact on firm profitability or productivity, this became know as the "productivity paradox". More recently (Anderson, et. al., 2003, Brynjolfsson and Hitt, 2003) IT investments have appeared to provide abnormally high returns, giving rise to what is called "the new productivity paradox". The findings of more recent studies have been used to show that IT does produce productivity gains, yet they given the time horizon of many firms this seems to leave more questions. Why would have firms continued to invest in something that seemed to have little or any measurable productive benefit after decades of investment? The majority IS literature to date on IT investment has focused on returns from IT investment. Only recently has research (Dewan, et.al. 2005; Dewan and Ren 2005; Tanriverdi H. and Ruefli, 2004) begun to address the risk-return tradeoff, but has been limited in scope to explain the abnormal returns observed more recently. This paper will address IT impact on risk in the intermediate term and develop a long-term model of firm performance. Initial findings to date have shown IT to increase firm risk and have used this to explain why we see abnormally high returns. This paper will layout a model that will shown that given a proper time horizon, this is not the case, IT reduces firm risk and this reduction in risk positively impacts firm performance both directly in the form of risk reduction and indirectly by lowering firm's borrowing cost.

Risk/return tradeoff is a concept with a long research history. Risk can be defined (Lockwood and Kadiyala, 1988) in terms of both informational uncertainty and volatility of returns. Informational risk arises in the form of informational asymmetry between economic actors or a problem search space that has not been fully explored. Volatility risk is often defined as the volatility of some form of returns. Risk of this form is the most theoretically explored type of risk. The paper will show that reducing the informational risk by IT produces returns in the form of reduced volatility and this reduction in cost-of-capitals will provide a simpler explanation for the abnormal returns to IT investment observed in recent years.

CONCEPT DEVELOPMENT

There has been a long history of researchers looking at the value of IT investment. Debate about the business value of IT investment can be traced to economist Robert Solow (1987) who noted the difficulties in determining the productivity gains from IT investment, coining the term "productivity paradox". As late as the early 1990s researchers (Brynjolfsson 1993) had difficulty finding returns from IT investment. More recently IS researchers have found positive returns from IT investment in terms of productivity (Brynjolfsson and Hitt 1996), profitability, consumer surplus (Hitt and Brynjolfsson 1996), and product quality (Mukopadhyay et. al. 1997). A more complete picture of firm value using the forward-looking measure Tobin's q was

used (Bharadwaj et. al. 1999) and found a positive relationship between IT investment and firm value. Dewan and Min (1997) look at how IT replaces other factors of production in the firm and find a positive impact of IT spending on firm production. More recently the increasing number studies of finding of abnormal returns has lead to discussions of the "new productivity paradox" (Anderson et. al. 2003) due to the excessively high returns that IT assets seem to provide and some (Bresnahan and Trajtenberg, 1995; Brynjolfsson and Hitt, 2002) have suggested time-to-implement complementary process changes as a rationale for why performance impacts from IT investment were not observed initially, but this does not explain why managers would have continued to invest if they saw no returns for decades.

Historically IS literature has looked primarily at the impact of IT investment on firm performance and ignored the impact on firm risk. IS literature has taken up looking at volatility within the framework of the real option component (Kumar, 1996; Benaroch and Kaufman, 1999; Sambamurthy et. al. 2003) of IT investments. The role of project risk (Fichman 2004) and option value was examined in context of viewing IT platform adoption as an option by looking at factors that should increase volatility and thus increase the options value of the project. While increasing the variation in possible outcomes in the presence of managerial flexibility increases firm value, increasing the variability of outcomes alone does not. Recent IS literature has begun to look at the impact of IT investments on firm risk. Early work (Hunter et. al. 2005; Dewan and Ren 2005; Dewan et. al. 2005) has shown that IT expenditure has a positive relation to firm risk. The aforementioned studies introduce control factor for firm risk that include firm leverage, industry concentration, industry, and diversification. The first conceptual study (Tanriverdi and Ruefli, 2004) that explicitly laid out a relationship between IT spending and firm risk included a moderating effect of the strategic IT vision and was framed to explain the abnormal returns being a result of firms adopting higher risk projects. No studies to date have looked at the risk aspect of IT investments over the time horizon for which IT investment data is available, but rather have sought to explain the abnormal returns of the "new productivity paradox". What is important is that variation has been studied within IS, but not adequately from a risk/return standpoint.

Two streams of research inform the present work on risk relevant to the analysis presented in this paper: Financial theory and information economics. As stated in the introduction risk can be characterized in terms of informational uncertainty and volatility. Informational risk can arise out of bounded rationality issues, where the bound (Spear, 1989) is a function of computability constraints. Rationality bounds can result in having insufficient information and can result in variation. Informational uncertainty can arise when informational search space is so large (Simon, 1955) that it is infeasible to perform an exhaustive search of possible outcomes, giving rise to situations whereby outcomes can vary significantly (Conlisk 1996; Kahneman 2003) from those predicted by rational equilibria. An example (Papadimitriou, 1994) is the well known "Traveling Salesman Problem" (TSP) which arises in a logistics context. The problem is to find the shortest path through a set of destinations, visiting each only one, and return to the place you began. TSP is very similar to how a trucking company determines the delivery routes for the drivers it employs. The computability issue arises because TSP is a combinatorial problem. The number of "feasible" routes is a factorial (n!) function of the number of destinations. As a result of the explosion of the search space heuristics are used to find a "good" route, but no optimal route. Since the route is not optimal and firms presumable are aware of the difficulty of the problem, there are other routes than can try that could be better which leads to variation. Accordingly information technology should decrease volatility of performance outcomes attributed to limited cognition by lowering search costs.

Financial theory looks at risk from the volatility standpoint. A tradeoff is inherent between risk and return, as shown in figure 1. Finance theory builds from theory by looking at securities markets, but lessons learned from theory can apply to intrafirm projects when the firm is viewed as a collection of assets. Markowitz (1952) first looked at risk of an asset as the volatility of that asset, with emphasis placed upon the timing of the returns and the impact on overall portfolio risk. The role of risk also (Modigliani and Miller, 1958) extends into determining the appropriate return rate for a firm, which is a weighted result of equity and debt used to capitalize the firm. Risk was formalized for equity in the Capital Asset Pricing Model (CAPM) by Sharpe in 1964. CAPM defined risk as firm risk relative to overall market risk with risk free returns partialed out. Options pricing theory (Black and Scholes, 1973) extended the role of risk into the pricing of options and looked at how the value of an option is impacted by the volatility of the underlying asset. The important point is there is a tradeoff between the risk of an asset and the returns that the asset provides.

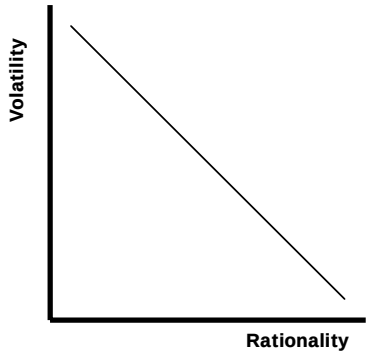

Figure 1. Rationality and volatility

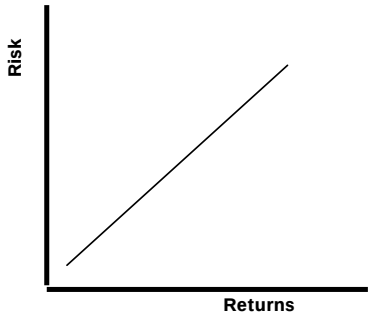

Figure 2. Risk/Return Tradeoff

The key conceptual arguments presented are that: 1) bounded rationality theory suggests that increasing the limit on information processing capability should reduce variation, and 2) there is a robust evidence to suggest a tradeoff between risk and return, 3) IT investment can reduce on firm risk, and 4) IS literature has limited explanations as to why returns to IT investments were at first undetectable for decades and are now considered abnormally large.

THEORETIC DEVELOPMENT

In order to develop a theoretical framework to study IT impacts of risk in the context of bounded rationality one must first show that moving the bound will reduce variation. Assuming that variation arises from either 1) exogenous factors or 2) internal decisions by increasing the bound of an economic actor the variation in economic output from the actor would seem to decrease. As noted in the conceptual section of the paper, increasing the available information has been shown to reduce variation from optima. As a result of this reduction, ceteris paribus increasing information available should reduce variation. IT investment is viewed as an asset that moves the bound of rationality further out and thus reduces variation from rationally optimal equilibrium. IT reducing variability of cash-flow does not imply that the firm cash-flow will not have any variation. Firms are still subject to exogenous factors, such as macroeconomic conditions, that cause significant variation in cash-flow.

Assuming that contrary to prior finding that IT investment did produce gains to the firm that were realized within a shorter time than current empirical work suggests, this leads one to develop propositions about the impact of IT spending on the risk-return relationship and ultimate impacts on firm performance:

Proposition 1: IT spending will reduce the volatility of firm performance.

As noted in the conceptual framework, increasing the rationality bound has been shown (Conlisk 1996; Kahneman 2003) to reduce variability of observed outcomes. Moving the bound on information processing ability of a firm the IT investment will lower the volatility of the firm's cash-flow, which will ultimately result in a measurable lowering of volatility in the financial markets. Current theory makes it difficult to rectify the Solowian "productivity paradox" with the "new productivity paradox" without assuming very large time span for improvement. The very nature of return volatility necessitates passage of a significant amount of time before results can be observed by outside observers. A reduction in volatility is in line with what is suggested by bounded rationality and represents a plausible explanation for why investment kept occurring in the past despite no observable returns to IT investment in the form of increased profitability.

Proposition 2: The reduction in volatility of firm performance will ultimately reduce borrowing cost to the firm.

Prior research (Minton and Schrand, 1999) has shown that reducing the volatility of cash-flows reduces firm borrowing costs. As a result of the reduction in the volatility of financial performance reduction in borrowing costs will occur over time. Given that the corporate bond market (NASD, 2005) is 4.7 trillion dollars the economic impact of reducing borrowing costs even slightly are staggering. Cost of borrowing (Damodaran, 2005) in 2001 is shown in table 1.

Rating	*Spread*	*Interest Rate on Debt*	BB	3.50%	8.50%
AAA	0.75%	5.75%	B+	4.75%	9.75%
AA	1.00%	6.00%	B	6.50%	11.50%
A+	1.50%	6.50%	B-	8.00%	13.00%
A	1.80%	6.80%	CCC	10.00%	15.00%
A-	2.00%	7.00%	CC	11.50%	16.50%
BBB	2.25%	7.25%	C	12.70%	17.70%

Table 1. Debt Spreads 2001

A reduction of debt spread of 1%, from AA to A- in 2001, represents 47 billion dollar reduction in operating cost for firms. The resulting reduction in the cost of borrowing will make the firm more profitable and explain a significant portion of the recently observed abnormally high returns from IT investment.

IMPLICATIONS

The primary research concept laid out in this paper is that IT spending impacts firm risk in different ways over time. In the short term IT spending reduces the risk by decreasing the volatility of firm cash-flows. The long-term performance impacts of IT lowering firm cost-of-capitals are mediated by these shorter-term risk effects. This piece of work represents a significant theoretic contribution to the growing, but under investigated, body of knowledge on the returns to firms from IT spending. Implications for the nature of impacts from IT investment are significant. Changes in volatility can by definition only be detected by taking several observations over time, therefore the idea IT spending reduces cost-of-capital taking significant time to manifest is quite plausible. Increased returns due to reduced borrowing costs are immensely traceable and provide a more tangible explanation as to why there was an extended period where IT investment apparently provided no return. The theory presented represents a simpler, more theoretically grounded, and more plausible argument than what is currently presented for both past and current returns to IT investment.

In order to operationalize the model presented, it is necessary to not some methodological issues that could arise in future work. Risk measures can be operationalized in several ways. Standard deviations and variance of both accounting returns and cash-flows can be calculated over several periods, probably using quarterly data to maximize sample size. CAPM also provides a measure of risk in the form of firm Beta. Firm level Beta estimates can be calculated over 200-day trading ranges, but 5-year weekly returns are more typical. In order to detect benefits from reduced cost of capital from volatility reductions cause by IT investment it is likely that long time-series data will be needed. Significant firm-level IT spending data is has been available in some form beginning around 1987, however industry commonly uses a 5-year span to calculate cost-of-capital estimates. Volatility in accounting-based returns has shown high correlation (Bowman 1979) with volatility of market returns and both should be measured. Control factors for firm risk include firm leverage, firm size, and firm diversification. Firm leverage (Bowman 1979) has been shown to positively correlate with firm risk. Firm diversification has also been used to control risk factors (Kwok and Reeb, 2000; Hunter et. al. 2003; Dewan et. al. 2005) and could be used in future work to control firm-to-firm differences.

The model proposed here suggests managers consider the impact of IT investment of the risk of the firm, which will ultimately lower the borrowing cost to the firm. By lowering borrowing costs to the firm the "hurdle rate" used in project evaluation (capital budgeting), such as NPV or IRR, should be lowered to account for this. Managers should consider that IT costs can impact cost-of-capital and make appropriate adjustments to the required rate of return in capital budgeting decisions. The implication is that firms systematically underinvest in IT by overestimating the required rate-of-return necessary for IT projects.

CONCLUSION

This paper introduced several new concepts to the work on IT investment and risk. First the paper looked at long-term versus intermediate term differences in the IT spending-risk relationship. The paper introduced the concept of IT spending reducing risk in the short-term and producing long-term returns by lowering cost-of-capital to the firm. Exploration of the risk impacts of IT investments can provide a more theoretically robust explanation as to why no returns to IT could be found for some time and now seem to provide abnormally high returns to firms.

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