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ABSTRACT
We find evidence that the conventional wisdom, among both managers and researchers, that information technology (IT) investments are risky is incorrect. IT managers are increasingly asked to justify IT investments in financial terms in order to gain project approval. Researchers have moved beyond productivity in an attempt to "open up the black box" of the returns to investment in IT. Using a sample of 653 firm-years for the years 1991-1996, this study finds that IT reduces systematic risk in the five-year period after the IT investment. The implication for managers is that, while implementation of IT projects is risky in the near term, managers should use lower return requirements for IT investments due to the longer-term impact of IT upon firm-level systematic risk. For researchers, the implication is that part of the reason for excessively high estimates of returns attributed to levels of IT capital may be that prior investment in IT may have reduced systematic risk and borrowing cost to the firm.

Key Words: Business Value of IT, Systematic Risk

INTRODUCTION

Information technology (IT) investments are more and more treated the same as any other capital investment, like a machine or building, and are thus becoming increasingly subject to the same approval process. Financial theory informs us that there is an inherent tradeoff between the risk and expected returns for investments. For managers, this often manifests in terms of a "hurdle rate" of internal return necessary to justify a given investment. The organizational-level examination of the impacts of IT is an area of inquiry with a long research history in Information Systems (IS). Research on the organization-level impacts of IT often takes the form of examining impacts in financial and economic terms. Research on financial returns to IT in IS has remained relatively focused upon the return aspect of the investment, while for the most part ignoring the risk aspect of investment. As a result of both contemporary managerial reality and the desire of IS researchers to express IT impacts in economic terms, an examination of impact of IT on firm risk is desirable.

The study of risk in the information systems literature has been a long standing object of examination for IS researchers. The examination of risk has been however limited to primarily the project level of analysis. This paper attempts to examine IT related risk from an organizational perspective specifically through an economic lens. Our examination attempts to build upon the extant literature revolving around the productivity paradox solved by Brynjolfsson and Hitt (1996), Mukopadhyay et al (1997) and others.

These authors have specifically examined how investments in information technology at the organizational level have resulted in positive returns. Nevertheless, as Tanriverdi and Ruefli (2004) note, there is a risk return relationship in play at the organizational level. They note risk has been previously ignored by other IT researchers when examining the possible returns from IT investments. Furthermore Dewan, et. al. (2007) present empirical evidence for the argument that IT impacts firm risk. Using data on IT capital stock from the years 1987-1994, they find that IT increases firm risk in the near term and that about 30% of the returns to IT can be associated with an increase in risk. This study examines systematic risk. Systematic risk is defined as how the changes in the value of a firm's equity change relative to changes in the overall market. Systematic risk is used to determine firm cost-of-capital. Thus, the goal of this paper is to extend the literature on information technology investments by empirically examining the role of risk in determining the future cost of capital.

CONCEPT DEVELOPMENT

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". The results of more recent studies of the returns to IT has lead to discussions of the "new productivity paradox", due to the excessively high returns IT assets seem to provide (Anderson et. al. 2003).

Markowitz (1952) first examined the 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 and how that risk can be reduced through diversification or counter correlated timing of returns. Modigliani and Miller (1958) extend the role of risk in determining the appropriate return rate for a firm which is the weighted result of equity and debt that is 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. The tradeoff between risk and return is among the most important concepts in financial economic theory and has had arguably the greatest practical impact of all research performed in business academia. The concept is shown graphically in figure 1.

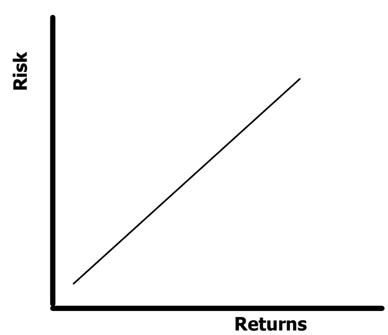

Figure 1. Relationship between risk and expected returns

From an IT perspective, researchers such as Brynjolfsson and Hitt (1997) examine returns from IT investment using the assumption that the IT function as a whole is an organizational asset (i.e. the IT function provides the organization with a future economic benefit) that organizations invest heavily in. Brynjolfsson and Hitt (1997) find IT investments do increase organizational productivity as well as build on the productivity paradox research and find abnormally high returns for IT investment. Nevertheless none of the studies, as Tanriverdi and Ruefli point out, incorporate the risk return tradeoff that is explicitly modeled in the financial literature. Furthermore, Dewan et. al. (2007) incorporate risk in that they examine how IT investments impact the organizational risk-return profile. Using a near-term lens, they conclude part of the reason for high estimates of the returns to IT are that IT projects are risky and that the excessive returns are somewhat the result of moving up the risk/reward tradeoff. The following will give a brief overview of how the notion of risk is a key component in organizational IT investment decisions.

Risk is a key factor in organizational success or failure regardless of the type of investment. Decisions regarding organizational investments are the result of managerial actions that are determined by the possibility of organizational success or failure. From an IT perspective, investment decisions on the part of managers are key, due to the fact that spending on IT has risen to more than half of all administrative costs in many organizations (Maizlish and Handler 2005). Therefore IT specific risk at the organizational level can be viewed as managerial uncertainty regarding the possibility and magnitude of losses due to IT investment. Thus, as a result of managerial uncertainty organizations must employ internal controls in order to attempt to mitigate systematic risk to reasonable levels.

THEORETIC DEVELOPMENT

IT impacts systematic risk in two ways. First, IT necessitates the formation of intangible organizational assets which insulate the firm from equity market conditions. The intangible capital argument is essentially a neoclassical capital formation argument using a theory of production lens. Finally, IT improves internal controls, which reduces systematic risk. The argument that IT improves internal controls and in turn reduces systematic risk is from a transaction cost economics (TCE) lens. We conceptualize IT investment in terms of IT intensity. Consistent with prior literature, we define IT intensity as the ratio of IT expenditure to total revenue (Bharadwaj, et. al., 1999).

Production factors

From a theory of production standpoint, investments in large IT projects have been shown to result in large levels of intangible organizational capital. This organizational capital, while not included in formal accounting measures, are important factors of production (Brynjolfsson and Hitt, 2003). Investments such as enterprise resource planning (ERP) or customer relationship management (CRM), are often associated with both large scale process changes and a great deal of organizational learning. Both the process changes and organizational learning are a form of organizational capital that represents an additional intangible asset to the organization, not accounted for by simply the IT investment figure (Brynjolfsson and Hitt, 2003) that is formed when organizations pursue large IT projects. The organizational capital associated with modern IT investments have been shown to increase organizational agility, enabling firms to respond to changes in external environment quicker (Sambamurthy, et. al., 2003). An investigation into an organizations' marketing function, shows that the impact of other forms of intangible capital, such as brand equity and R&D, have been shown to reduce systematic risk by insulating firms from negative shocks in their external environment (McAlister, et. al., 2007).

Transaction cost factors

Transaction costs economics shows that to reduce managerial uncertainty, organizations codify and enact an internal control structure (Radner, 1992). Internal controls serve as a means to monitor employees (i.e. reduce agency costs) and ensure employees are acting toward an organizations' goals (Jensen and Meckling, 1976). With the increased capabilities of information technology, managers have a greater ability to digitize internal controls such that the ease in which employees are monitored greatly reduces agency costs for the organization (Simon, 1973). Furthermore by enacting internal controls supported by information technology, labor efficiency can greatly improve which will in turn benefit the entire organization and its stockholders. For instance, by giving a factory employee a scanner to scan each job they work, this will not only keep better control of inventory, but it also gives managers an opportunity to monitor each employee (Gurbaxani and Whang, 1991). Thus agency costs are reduced through the proper enactment of internal controls supported by information technology. When internal controls reduce agency costs, this also lowers the systematic risk. Given the two-fold impact of IT upon both intangible asset formation and internal controls, we propose the following:

Hypothesis 1: Increased IT intensity will be negatively associated with firm-level systematic risk.

METHODOLOGY

Data

Firm-level IT spending information was obtained from the Infoweek500 IT spending survey from 1991-1996, which has been used in prior studies (Bharadwaj, et. al. 1999) on IT business value. The remaining firm-level data comes from COMPUSTAT and CRSP. After matching the IT data to the necessary financial data an unmatched panel of 653 firm years resulted. The panel is not matched because Infoweek does not include the same firms every year. Since the study uses both forward and backward looking measures, we were unable to match firms due to either mergers or delisting in either the trailing or forward five years.

Measures of systematic risk were computed consistent with Sharpe's (1964) formulation, where firm risk is measured relative to the market as whole. Firm-level systematic risk (R) is calculated as a covariance between firm-level market returns (r_f) and market returns (r_m), such that systematic risk (R) $= \text{cov}(r_m, r_f)$. We calculated the risk measures using weekly returns over a five year period. Consistent with prior literature, the S&P 500 index is used as a proxy for the overall market. As noted in the theory development section above, we define IT intensity as the ratio of IT expenditure to total revenue (Bharadwaj, et. al., 1999). A summary of the data used in this study is presented in table 1.

Table 1. Summary statistics

	Mean	Median	St. Dev	Kurtosis	Skew	Min	Max	N
Systematic Risk (B_f)	0.864	0.839	0.451	1.944	0.647	-0.487	2.869	653
IT intensity (ITINT)	0.023	0.018	0.036	375.289	17.388	0.000	0.816	653
Trailing risk (B_t)	0.989	1.041	0.487	19.827	-2.507	-3.683	2.304	653
Cash flow volatility (CF)	474.032	233.707	894.873	87.293	7.831	0.000	12471.580	653
Earnings volatility (EF)	134.064	76.130	173.536	24.924	3.946	2.534	1912.427	653
Leverage (LEV)	0.415	0.444	0.205	3.005	0.273	0.001	1.579	653
Liquidity (LIQ)	1.426	1.238	0.654	4.256	1.643	0.000	5.062	653
Advertising intensity (ADV)	0.011	0.000	0.026	19.842	3.956	0.000	0.228	653
R&D intensity (RD)	0.021	0.004	0.038	27.589	3.742	0.000	0.453	653
Sales (SIZE)	8455.4	4732.2	11479.3	53.6	5.5	211.5	160121.0	653

Regression analysis

The objective of the model is to explain differences in firm-level systematic risk over the five years after the IT measure in question. None of the forward or backward looking measures we use are include the year of the IT data, to avoid identification issues that can prove confounding when using contemporaneous cross-sectional data. Our data is not a balanced set of firms, but effects vary from time frame-to-time frame and firm-to-firm. We control for firm-level differences using an adjustment for the firm's systematic risk for the fives years preceding the IT investment. Given our data was not a matched set, we were unable to run a pooled analysis to control for time-specific effects. We controlled for time-specific effects using a variable to indicate the year.

In formulating the model to test our hypothesis we started with a simple model to include IT effects. The objective was to show that a basic relation exists between IT and systematic risk. The first model includes factors that are known to be significant predictors of systematic risk from the literature. We used the recent McAlister et. al. (2007) study to form the basis of which covariates to include, because the study was recent and included all the factors listed in the older benchmark study (Beaver, et. al., 1970) on the subject. Finally, the third model includes indicators to control for industry-specific variation. The regressions a shown in equation form in table 1.

Table 2. Regression models

I. $R_f = \alpha_0 + \alpha_1 ITINT + \alpha_2 R_t + \alpha_3 Year + \varepsilon$

II. $R_f = \beta_0 + \beta_1 ITINT + \beta_2 R_t + \beta_3 CF + \beta_4 EF + \beta_5 LEV + \beta_6 LIQ + \beta_7 ADV + \beta_8 RD + \beta_9 SIZE + \beta_{10} YEAR + \mu$

III. $R_f = \gamma_0 + \gamma_1 ITINT + \gamma_2 R_t + \gamma_3 CF + \gamma_4 EF + \gamma_5 LEV + \gamma_6 LIQ + \gamma_7 ADV + \gamma_8 RD + \gamma_9 SIZE + \gamma_{10} YEAR + \gamma Ind + \mu$

Where:
R_f = systematic risk in the five years after the IT investment, ITINT = IT investment as a percent of sales, R_t= systematic risk in the five years before the IT investment, CF = volatility of cash-flow for the five years after the IT investment, EF = volatility of earnings for the five years after the IT investment, LEV=financial leverage, LIQ=liquidity, ADV=advertising spending as a percent of revenue, RD=research and development spending as a percent of revenue, SIZE = form sales, YEAR = year of the investment, and Ind = binary variable indicating the industry and the 2-digit NAICS level.

RESULTS

Results from all three models support the hypothesis that higher levels of IT expenditure is negatively associated with systematic risk, and the temporal nature of the data supports the idea that the relationship is causal in nature. Relative to prior studies (McAlister, et. al., 2007), overall model fit was good. Given the nature of risk as a dependent variable, explained variance is typically much lower than in a typical econometric model, such as a Cobb-Douglas production function. As an example the study of McAlister et. al. (2007) explained between 16% and 5% of overall variance, depending upon the model specification in question. Our simplest model was able to explain 6% of variance using 3 covariates and our most elaborate explained 24% of the variance.

As a reality check on model specification, results for the control factors generally appear consistent with prior literature. As would be expected trailing risk was positively significant. Cash-flow volatility, R&D, and firm size were all significant directionally consistent with prior literature.

Due to the cross-sectional nature of the data the White test for heteroskedasticity was performed to see if the homoskedasticity assumption was violated. Given the amount of independent variables the White-test was performed using no cross-terms. Heteroskedasticity was found to be present in all three models and was corrected for using the Huber-White robust standard errors correction (White, 1980). Results from all model support the idea that IT reduces firm-level systematic risk going forward.

As a final robustness check, we also performed a least absolute deviation (LAD) regression. LAD is also known as median or quintile regression. LAD allowed us to check for impacts from outliers or normality violations without excluding or modifying data, such as would be done by trimming or winsorizing (Hogg, 1979). Results from the LAD were consistent with OLS findings, but could not be presented due to space constraints. The results are presented in table 2.

Table 3. Model results

	Model I	Model II	Model III†
IT intensity (ITINT)	-0.06(0.00)***	-0.27(0.00)***	-0.25(0.00)***
Trailing risk (R_t)	0.26(0.06)***	0.15(0.06)***	0.15(0.05)***
Cash flow volatility (CF)	N/A	0.16(0.00)***	0.17(0.00)***
Earnings volatility (EF)	N/A	0.04(0.00)	0.07(0.00)
Leverage (LEV)	N/A	-0.02(0.09)	-0.02(0.13)
Liquidity (LIQ)	N/A	-0.02(0.03)	-0.05(0.03)
Advertising intensity (ADV)	N/A	-0.02(0.45)	0.00(0.50)
R&D Intensity (RD)	N/A	0.33(0.54)***	0.28(0.62)***
Size	N/A	-0.12(0.00)***	-0.16(0.00)***
Year	-.06(0.07)***	-0.07(0.01)*	-0.08(0.01)**
R-squared	0.087	0.174	0.241
F	20.57	13.50	7.36
Prob > F	0.000	0.000	0.000
Root MSE	0.43	0.41	0.40
N	653	653	653

Note: *,**,*** represent α=.10, .05, and .01 respectively. † in Model III industry controls are not presented due to space constraints

CONCLUSION

Using a theory of production and transaction cost argument, this study presents empirical evidence that IT reduces firm-level systematic risk. This result is contrary to conventional logic among both researchers and managers. The implication for managers is that managers should not fixate upon the short-term risks of implementation and use lower return requirements for IT investments, which take into account the longer-term benefits of IT upon firm-level systematic risk. An empirical model was presented to explain differences in systematic risk between firms, which had significantly greater explanatory power than similar studies in other fields. The temporal nature of the data supports the notion that the association between IT and risk is causal in nature and not the result of contemporaneous confounding.

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