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A Viable Approach for Measuring the Risk-Return Relationship of IT Investments

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ABSTRACT

The importance of managing the risk-return balance of information technology (IT) investments has become clearer than ever. Yet, quantitative assessment of IT investment risk and return based on financial measures remains a major challenge. Recently scholars have used event study analysis to measure the value created via IT investment, by examining the abnormal changes in shareholder wealth around the time a specific IT investment is announced. The abnormal *return on equity* due to such an event is considered a good proxy for the economic value of that event. In the same spirit, this research proposes estimating several forms of IT investment risk, by combining event study analysis with the use of arbitrage pricing theory. In so doing, this research contributes towards the development of an integrated approach for quantifying the risk-return relationship for IT investment so that practitioners can make more informed investment decisions.

Keywords

IT investment; risk assessment; market risks; event study analysis; risk premium.

INTRODUCTION

A recent survey of 241 senior finance executives shows that 27% of them believe that IT investments did not produce expected return and 30% were not sure (CFO-IT, 2004). With the continued economic downturn, today's CIO is required to use the language of CFOs to justify IT investments while competing against other business initiatives (Girard 2004, Berinato 2004). This emerging trend has fueled the need to quantify the risk-return relationship for IT investments. Returns from investment in IT are influenced by various risk factors that are endogenous or exogenous to the firm. The Financial theory, which defines risk as the variance of expected return, suggests that investors expect higher returns for risky investments (Brealey & Myers 2003). Dewan et al (2003) showed empirically why it is necessary to quantify the risk-return relationship for investments in IT so as to enable executives to manage IT investments more effectively.

In pursuit of this endeavor, we see a multitude of issues that need to be answered. For example, (1) what is a pragmatic risk taxonomy amenable to financial analysis? (2) what is an appropriate model for linking various risks to expected return from IT investment? (3) how to determine the exposure level (sensitivity) of an IT investment to a specific risk? and, (4) how much excess return (i.e., risk premium) is expected for bearing one unit of that risk? Recently Alter and Sherer (2004) consolidated extant IS research on IT risks and concluded that we still lack a comprehensive taxonomy of IT investment risk. However, all risk factors could be said to fall into three broad classes of risk factors (which we define later): software development risks, organizational risks, and market risks (Benaroch 2002). Software development risks influence the cost of IT investments, market risks influence the payoff of IT investments, and organizational risk factors influence both.

Since addressing risk measurement issues for all forms of risks is beyond the scope of a single paper, this research focuses on market risks and seeks to answer the questions:

  (1) What is an appropriate model for formalizing the risk-return relationship for IT investments?

  (2) How to determine the level of risk exposure (or sensitivity) of a specific IT investment to market risk factors?

  (3) How to estimate the expected risk premium for bearing one unit of a specific form of market risk?

To answer these questions, this research builds on the extant IT risk literature, arbitrage pricing theory, and the event study methodology. The research makes two key contributions to IS research. First, grounded in a strong theoretical base, it

formalizes the relationship between risk and return for IT investment. Second, it demonstrates the viability of quantifying the formalized risk-return relationship.

The paper proceeds as follows. We first briefly review research on IT investment risk and its shortcomings vis-à-vis risk measurement. Then, we propose formalizing the risk-return relationship for IT investment based on arbitrage pricing theory, and subsequently propose a simple methodology based on event study analysis to estimate parameters of market risk factors. We conclude with limitations and directions for future research.

STATE-OF-THE-LITERATURE: IT RISK AND EVENT STUDY

IT Investment Risk

Traditionally IS scholars have defined risk in terms of negative consequences (Barki et al. 1993, Boehm 1989); e.g., lack of skilled analyst could lead to poor system design. However, risk may also reflect positive opportunities (Benaroch 2002; Vitale 1986); e.g., unexpected increase in customer response can lead to higher market share. Thus, risk must be viewed as the variation in attainment of goals, according to the rational decision theoretic view of risk (Bernstein 1996). The sources of this variation are known as risk factors, which are characteristics of the IT investment and its contextual environment.

Alter and Sherer (2004), based on methodical review of past IT risk research, critiqued the literature as a jumble of diverse and often overlapping risk taxonomies. The risk taxonomies vary from 'top *n* risks' (McFarlan 1974, Boehm 1989) to empirically validated risk factors (Barki et al. 1993, Jiang et al. 2002). A key drawback of these taxonomies is that most risk factors are related to software development, with the exception of Clemons (1991) and Benaroch (2002) who studied other forms of risk that influence payoff from IT investments.

We hence suggest using a high-level risk taxonomy that spans the risk factors most commonly identified by earlier research (see Figure 1) and is amenable to financial analysis. In this taxonomy, IT risks are classified into firm-specific risks (software development risks and organizational risks) and firm-independent risks (market risks). Firm-specific (*independent*) risks are those arising due to different factors endogenous (*exogenous*) to the investing firm and affect its ability to realize the IT investments and expected payoffs from them. Firm-specific risk factors are within the firm's control, unlike market risk factors affecting all firms that consider (or have already made) the same IT investment.
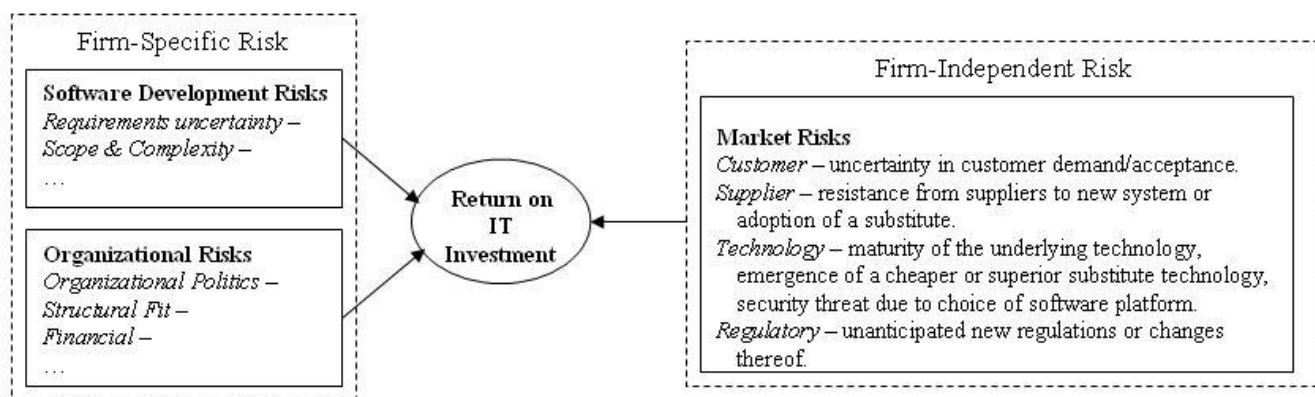

Figure 1: Broad classes of IT investment risks (adapted from [Benaroch 2002])

Assessing Market Risks of IT

The increasing trend of under realization of IT investment payoffs (CFO-IT 2004) raises the need to quantify the effect of risks on returns from IT investment. Yet, quantification of IT investment risks continues to be a challenge to researchers. Early research (Boehm 1989, Barki et al 2001) often used qualitative techniques to assess risk factors, based on the concept of *risk exposure* (defined as product of probability of undesired outcome and potential loss due to undesired outcome), and prioritize them for mitigation during development activities. Recently Boehm et al (2002) incorporated risk factors, having an influence on development cost and economy of scale, into cost estimation models applicable to different types of IT projects. The latter research focuses on cost implication of software risk factors without relating them to the return of IT investments.

Dewan et al (2003) suggest that the difficulty lies in developing operational measures for IT risks that can be related to returns. Indeed, very limited research accounts for organizational and market risk factors, but even this research has clear problems. The following are two good examples. First, to assess the market risk associated with an underlying technology, such as JAVA, Erdogmus (2000) developed a stock portfolio of JAVA based technology vendors. However, the proxy risk measure they arrive at reflects the technology risk alone and not other forms of market risk factors (see figure 1). Moreover, since many investments involve a mixture of several technologies, identifying tracking portfolios for the majority of IT investments would be rather complex. Second, Voshmgir (2002) measured market risks differently, as a function of the bargaining power of a company with its customers, suppliers and the company's market position. However, his approach gives only a subjective risk measure that does not have a financial interpretation.

Event Study and its application in IT Research

To overcome the above problems, we propose using event study analysis to quantify the risk-return relationship for market risks based on public data on firms making similar IT investments. The accounting and the finance literature have used event study analysis to quantify the economic value of an event (Binder 1998). The analysis (under the efficient market hypothesis) assumes that investors continually adjust stock price by accommodating new information (Fama et al 1969). In the IS field, scholars have used event study analysis to establish the economic value of IT investment announcements (Chatterjee et al. 2002, Dewan et al. 2003, Dos Santos et al. 1993, Ettredge & Richardson 2002), ecommerce announcement (Subramani & Walden 2001), hackers attack (Hovav & D'Arcy 2003), and announcement of newly created CIO positions (Chatterjee et al. 2001). This stream of research has shown that the stock market does react to IT investment related events and recognizes change in firm's risk profile.

The extensive IS research involving event study, including that of Hovav & D'Arcy (2003), suggests that certain risk factors can be quantified and that it is feasible to establish their risk-return relationship for IT investments. In this research we consider the bi-annual publication of GomezPro ScoreCard™, one of the leading benchmarks for online financial services (banks, insurance, mortgage, brokerage and credit cards). This scorecard is used by the financial industries to manage investments in the online services channel (PR Newswire 2003). As our research is based on stock market reaction to firms that have made similar IT investments rather the technology vendors, we argue that our risk measurement estimates would be better proxies for market risk factors.

QUANTITATIVE MODEL AND ESTIMATION METHDOLOGY

In this section, we propose a generic risk-return model based on arbitrage pricing theory (APT), and then lay out a methodology for estimating risk parameters for market risk factors.

General Risk-Return Model for IT Investment

According to APT, the expected return, in excess of the risk free interest rate, from an investment having exposure to {J} risk factors (Ross 1976) is given by:

$$R = \lambda_1 b_1 + \lambda_2 b_2 + \ldots\ldots \lambda_j b_j + \ldots\ldots \lambda_J b_J \tag{1}$$

where b_j is the sensitivity of investment to the jth risk factor, and λ_j is the expected return (or risk premium) when the investment is exposed to exactly one unit of the jth risk factor (i.e., $b_j=1$ and $b_k = 0$ for $k \neq j$). Henceforth we refer to these two as the parameters of risk factors.

For IT investments, the risk premium λ_j·s are common to all firms, whereas the sensitivity b_j is unique to each firm. In general, the excess expected return for an IT investment that is exposed to software development, organizational and market risks would be:

$$R = \sum_{i \in Development\ Risks} \lambda_i b_i + \sum_{j \in Organizational\ Risks} \lambda_j b_j + \sum_{k \in Market\ Risks} \lambda_k b_k \tag{2}$$

Estimating the risk parameters for software development risks and organizational risks in the context of specific IT investment would require internal firm-specific data. By contrast the majority of market risk factors could be quantified based on publicly available market data. To offer a proof-of-concept of the methodology, we focus hereafter only market risks.

Based on the risk taxonomy in Figure 1, market risk is a function of customer acceptance *C*, supplier adoption *S*, technology uncertainty *T*, and regulatory risk *R*. Therefore from (2) the expected return due to market risks ($\tilde{r}_M$) will be:

$$\tilde{r}_M = \lambda_C b_C + \lambda_S b_S + \lambda_T b_T + \lambda_R b_R \tag{3}$$

where b_*'s are the sensitivities of an IT investment to individual market risk factors and λ_*'s are their risk premiums.

Methodology for Estimating Parameters of Market Risks

In this section we briefly discuss the methodology to be used for estimating the risk parameters of IT market risks. The methodology involves first computing the market adjusted returns in excess of the risk free rate (MARIER) on a firm's equity and then deriving the risk premium and the sensitivity of each firm to specific market risk factors. Our proposed methodology hence consists of following steps:

(1) Identify the event(s) and variable(s) that capture one or more type of market risks related to IT investments of interest.

(2) Identify the publicly traded firms associated with these events who had undertaken similar IT investment.

(3) Determine the MARIER for every firm at the event dates using event study analysis.

$$MARIER_{i,t} = (R_{i,t} - R_{f,t}) - [b_0 + b_i(R_{m,t} - R_{f,t})] \tag{4}$$

where $R_{i,t}$ and $R_{m,t}$ are daily returns of a firm and market index; $R_{f,t}$ is the risk-free rate, and b_0 and b_i are ex-post estimates of the CAPM model.

(4) Adjust for firm-specific characteristics: regress the MARIERs on firm specific characteristics (see equation 5), namely firm size (log [market value]), growth option (market to book value ratio), industry (IND) and diversification (entropy measure or Herfindahl Index).

$$MARIER_{i,t} = \beta_{fs,i} Ln[MV_{i,t}] + \beta_{go,i} GO_{i,t} + \beta_{ind} IND_{i,t} + \beta_{div,i} DIV_{i,t} + \varepsilon_{i,t} \tag{5}$$

(5) Estimate the sensitivity (b_*): regress the residuals of equation -5, adjusted residual returns (ARR) against market risk variables (see equation 6). The regression coefficient would estimate sensitivity of firms to customer risk, technology risk, and regulatory risks.

$$ARR_{i,t} = b_{i,C} C_{i,t} + b_{i,S} S_{i,t} + b_{i,T} T_{i,t} + b_{i,R} R_{i,t} + \xi_{i,t} \tag{6}$$

where $\xi_{i,t}$ is random error

(6) Estimate the risk premium (λ_*): regress ARRs on the obtained sensitivity estimates to obtain the risk premiums.

$$ARR_i = \lambda_C \beta_{i,C} + \lambda_S \beta_{i,S} + \lambda_T \beta_{i,T} + \lambda_R \beta_{i,R} + \zeta_i \tag{7}$$

where ζ_i is random error

Data Analysis

In this section, we illustrate the methodology in the context of IT investments made by firms in the Financial Services Sector (FSS) that provide online services to their customers (e.g. banks, insurance, and mortgages). The exploding growth in customers using Internet services (Nielsen/ NetRatings 2003) and the provision of several functionalities free of charge makes such investments a suitable case for investigation. Several third party agencies like WatchFire, Jupiter, and comScore have developed benchmark ratings to evaluate the performance of such customer centric online services (PR Newswire 2003). Several corporate announcements in PR Newswire of the firms rated by these third party agencies indicate that these firms use such ratings to manage their IT investments, influence customer loyalty, and promote investor relationships.

For empirical demonstration purposes we quantify *customer risks* using biannual announcements of GomezPro ScoreCards™ from WatchFire, comprising of four categories: functionality, ease of use, privacy & security, quality & availability. Firms receive an overall weighted score (40% functionality, 35% ease of use, 15% privacy & security, 10% quality & availability) based on a scale of 1 – 10. From November 2004, GomezPro has changed the computation of overall score and hence we

limit ourselves to the period Oct-99 to Oct-04 (see figure 2 for summary statistics on market to book value ratio (MBV), total assets, and Gomez score of firms). The demographic and relevant financial data of firm are collected from COMPUSTAT, CRSP and EDGAR databases.

Firm Type	Statistic	MBV	Total Assets (M$)	Gomez Score	MBV	Total Assets (M$)	Gomez Score
Banks		Date (# Firms): 10/19/1999 (15)			Date (# Firms):11/20/2003 (23)		
Banks	Average	2.416	213,014	5.177	2.355	220,222	6.067
Banks	Min.	1.536	1,258	3.95	1.476	482	5.04
Banks	Max.	3.926	716,937	6.16	4.041	1,264,032	7.41
Brokerage Discount		4/21/1999 (17)			5/14/2003 (12)		
Brokerage Discount	Average	8.08	159,538	5.91	2.33	281,832	5.77
Brokerage Discount	Min.	2.11	8.5	4.22	0.484	39.9	4.81
Brokerage Discount	Max.	25.23	689,600	7.55	3.71	1,187,035	7.09
Brokerage Full Service		6/8/2000 (4)			9/18/2003 (11)		
Brokerage Full Service	Average	4.145	419,666	5.794	2.221	489,150	5.401
Brokerage Full Service	Min.	2.077	86,349	4.91	1.2	2,381	4.51
Brokerage Full Service	Max.	6.642	804,286	6.8	4.075	1,264,032	6.98
Credit Cards		5/16/2000(15)			7/24/2003(14)		
Credit Cards	Average	3.653	206,154	5.482	2.182	342,095	4.654
Credit Cards	Min.	1.082	802	3.52	0.575	1,411	3.55
Credit Cards	Max.	8.12	791,333	6.85	3.903	1,208,923	5.87
Insurance		7/6/2000 (9)			10/7/2003 (12)		
Insurance	Average	4.48	135,103	5.582	1.662	149,918	5.422
Insurance	Min.	1.52	3,251	3.02	1.03	1,737	2.68
Insurance	Max.	12.15	431,141	6.72	3.596	678,346	7.04
Mortgages		10/13/1999 (5)			2/23/2004 (12)		
Mortgages	Average	3.353	273,563	5.146	2.574	243,078	5.392
Mortgages	Min.	0.98	153	3.23	1.821	173	4.15
Mortgages	Max.	6.575	716,937	7.94	5.38	1,317,591	7.3

Figure 2: Summary Statistics of FSS firms

We expect to report on the completed analysis results at the conference.

LIMITATIONS AND CONCLUSIONS

This research makes two important contributions to the IT risk literature. First we propose a formal risk-return model for IT investment. Second, we propose a viable methodology to estimate parameters of market risk factors. Successful application of this methodology to estimate market risk factors could lead to development of industry specific risk measures for IT investment that can enable effective management of IT investments.

Our proposed methodology has its own limitations. First, event study analysis can be performed only for publicly listed firms leading to a biased sample. Second, the methodology can be applied only to those IT investments for which stock market reaction can be observed. In the future, we plan to extend the research, to estimate other IT risk factors, namely: software development risks, and organizational risks. Future research may also replicate this study for a different class of IT investment, such as ERP, for which GomezPro like ratings are available.

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