Executive Compensation and Strategic Risk-Taking in IT

Completed Research Paper

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Abstract

This study examines how the risk-taking incentive of top executives drives the strategic risk-taking in corporate IT implementation. We use the risk incentive provided in executive compensation to capture top executives' risk-taking incentive, and develop measures of aggressive IT implementation to capture strategic risk-taking in IT implementation. Our analysis provides empirical evidence that the risk incentive of executive compensation drives aggressive IT implementation. We also consider how firm diversification may influence the relationship between the risk incentive of top executives and aggressive IT implementation. Our finding indicates that the relationship between the risk incentive of top executives and aggressive IT implementation is stronger in focal firms' primary industries than in their secondary industries, which suggests that diversification supports IT risk taking by providing risk-seeking executives more opportunities in the areas that are less familiar to them.

Keywords: Executive compensation, managerial incentives, risk taking, information technology, Diversification

Introduction

Both practitioners and scholars have recognized the risk associated with investments in Information Technology (IT). For example, a recent report by Gartner indicates that in business organizations 20% of small IT projects (<$350,000 in budget), 25% of midsize IT projects ($350,000~$1M), and 28% large IT projects (>$1M) eventually fail (i.e., deliver no return at all) (Mieritz 2012). The finding is consistent with many earlier studies that suggest that nearly a quarter of IT projects in business organizations fail completely (Levinson 2009). Moreover, a recent study by McKinsey Quarterly reveals that large IT projects often deliver less return than expected, even when they do not fail. Half of IT projects with budgets of over $15 million dollars run 45% over budget, are 7% behind schedule and deliver 56% less functionality than planned. This means that at least half the time — achieving at least $15 million in benefits, requires spending $59 million (Bloch et al. 2012). Academic research also suggests that IT investments often lead to uncertainty in firms' operational and market performance (Dewan and Ren 2011; Tanriverdi and Ruefli 2004), and the risk of IT investments is often higher than that of other investments (Dewan et al. 2007).

Given the risky nature of IT, it is imperative to understand what drives organizations to take the risks to implement IT projects. Most prior studies on risk-taking in IT adoption are project-level or individual-level studies which explain risky behavior mainly from the perspective of individual risk perception (Keil et al. 2000; Palvou and Gefen 2004; Nicolaou and McKnight 2006). However, the corporate-level studies on what motivates strategic IT risk-taking are scant. In this research, we explore IT risk taking from the perspective of executive compensation. Our main proposition is that the compensation structure is a key mechanism to influence the risk-taking incentives of top managers, and it will also affect firms' strategic choices of investing in riskier IT assets.

The relationship between executive compensation structure and corporate risk-taking has been studied extensively in the finance (e.g., Coles et al. 2006), accounting (e.g., Rajgopal and Shevlin 2002) and strategy management literature (e.g., Eisenmann 2002). In general, prior studies find that when compensation structure is designed to motivate risk-taking of top executives, more risky firm strategies are likely to be observed. The risky firm strategies examined in the literature includes R&D expenditure, business focus, corporate leverage, resource exploration, corporate derivative holding, etc. (Cohen et al. 2000; Knoph et al. 2002; Rajgopal and Shevlin 2002; Coles et al. 2006). Executive compensation is also found to influence the overall firm risk (e.g., stock return volatility) (Guay 1999). All of these findings suggest that executive compensation is a key driver of corporate-level strategic risk taking. However, so far there is no research examining the link between executive compensation and corporate IT risk-taking. A number of prior studies in the Information Systems (IS) literature, mainly drawing upon the upper-echelon theory, have suggested that top management plays a major role in shaping corporate IT strategies (Clemons and Row 1988; Jarvenpaa and Ives 1991; Armstrong and Sambamurthy 1999). Based on this logic, the top executives' risk-taking incentives should foster corporate strategies of IT risk-taking. When top executives are motivated by the compensation structure, it is likely to observe more risk-taking initiatives in corporate IT implementations. This study bridges this gap in the literature by explicitly examining the relationship between top executive compensation and the corporate IT risk taking.

Another key issue considered in this study is the influence of firm diversification on IT risk taking. The existing research has mainly focused on how firm diversification affects overall corporate risk taking. However, it is not clear when firms diversify into various business areas, how their risk taking actions differ in different areas. In this study, we use more detailed IT data to examine this issue in the context of IT risk taking. Specifically, we consider how the risk incentive provided in top executive compensation leads to different levels of IT risk taking in the firm's primary industries (i.e., core business areas) and secondary industries (i.e., other business areas that the firm diversifies into).

A key issue in studying the impact of executive compensation on risk taking is to characterize the risk incentive (i.e., the incentive that motivates risk taking) in compensation and distinguish it from the performance incentive (i.e., the incentive that motivates performance enhancement). Although many prior studies use option compensation as an indicator of managerial risk-taking incentive, it is worth remarking that option compensation essentially provides both risk incentive and the performance incentive. However, the risk incentive and performance incentive may have different implications for risk taking. The classic principal-agency model used to study corporate governance (Grossman and Hart 1983; Jensen and Murphy 1990) assumes a risk-neutral principal (owner) and a risk-averse agent (executive).

The performance incentive of compensation, which ties the agent's income with the uncertain performance of the firm and thus exposes the agent to firm risk, may eventually discourage risk-taking by the agent. Therefore, many recent studies (e.g., Guay 1999; Core and Guay 2002; Coles et al. 2006) separate the risk incentive and performance incentive in option compensation so as to better assess how executive compensation influences the incentive of managers to seek risk.

In this study, we follow the existing literature to use option *vega* to evaluate the risk incentive of executive compensation. Option vega refers to the sensitivity of the executive's option portfolio value to stock return volatility (the market risk of firm). Higher vega means that top executives gains more by pursuing more market risk in making strategic decisions. Therefore, designing compensation structure with high vega enables firm owners to motivate more risk-taking behavior in executives. A number of prior studies in the finance and accounting literature (Guay 1999; Coles et al. 2006; Knoph et al. 2002; Rajgopal and Shevlin 2002) have used vega to explicitly capture the risk-taking incentive of top executives, and distinguish it from the performance incentive that generally ties executive income with firm performance (e.g., option delta). We therefore employ vega to study how executive compensation may motivate strategic IT risk-taking.

Another key issue is to characterize IT risk-taking. As IT is a general-purpose technology (Brynjolfsson and Hitt 1998), not all IT decisions are driven by strategic risk-taking motives. In this study, we develop measures that capture the extent to which firms aggressively outpace their industry competitors in increasing their IT implementation (we name them measures of *aggressive IT implementation*). Aggressive IT implementation reflects the intention of firms to strategically deviate from the industry norm by using more IT to digitize their business processes. Considering the typical challenges in IT implementation (e.g., technological uncertainty, managerial complexity, etc.), firms need to bear high risk if they deviate from the established patterns (or, the industry norm) to implement more IT. In this regard, we use the measures of aggressive IT implementation to capture the strategic risk-taking in IT. We also validate the use these measures by showing how these measures of aggressive IT implementation actually contribute to firm risk. We then examine how top executive compensation may influence the aggressive IT implementation, and how this influence may differ in the focal firm's primary and secondary industries.

This study provides important findings that contribute to multiple streams of research. First, our study provides direct evidence that higher vega of executive compensation leads to more aggressive IT implementation by firms. This result provides clear support to the arguments in the IS literature on how top management plays an important role in shaping the corporate IT strategies. It also complements the existing finance and accounting literature on how top executive compensation structure influences corporate risk-taking strategies. Second, our results suggest that the relationship between vega and aggressive IT implementation is stronger in focal firms' primary industries than in their secondary industries. The implication is that diversification supports IT risk taking by providing risk-seeking executives more opportunities in the areas that they are less familiar with and thus is associated with more uncertainty for them. This new insight better explains how firm diversification fosters corporate risk-taking, and this explanation has not been well developed in the existing literature.

Theory and Hypothesis Development

Theoretical Background: Executive Compensation and Corporate Risk-Taking

The main theoretical foundation in most of the existing research on executive compensation is the principal-agent theory. The basic framework of principal-agent models (Grossman and Hart 1983; Jensen and Murphy 1990) assumes that the risk-neutral principal (shareholders) needs to design compensation structure to align the incentive of risk-averse agent (executives) with their own. A common practice is to make executive compensation based partially on certain observable signals of firm performance, such as stock price. In this way, executives are provided with the incentive to improve firm performance (named *performance incentive* hereafter). However, the side effect of performance incentive is that executives are exposed to firm risk and their risk-aversion drives them to forego risky firm strategies. The existing literature has provided evidence on the negative relationship between performance incentive and risky action choices, such as R&D (Dechow and Sloan 1991).

To correct executives' incentives on risk taking, option compensation is often conceivable because the convex payoff structure it offers should offset the concavity of the utility function of risk-averse executives (Jensen and Meckling 1976; Smith and Watts 1992; Core and Guay 1999). However, it is worth noting that option compensation provides both performance incentive and risk incentive. When options are in-the-money (i.e., the exercise price is lower than the share price), their value change with both the performance (stock price) and the risk (stock return volatility). Therefore, the fluctuation of option value caused by the stock price movement may still be a concern for risk-averse managers (who dislike the uncertainty in income), and such concern may discourage risk-taking. On the other hand, option value may also increase in the stock price volatility. Such feature is reflected by the measure of vega. Vega has been defined as the sensitivity of the executive's option value to stock return volatility (or market risk) (Guay 1999), and positive vega means that the option is of more valuabl when stock price becomes more volatile or the market risk of the firm becomes higher. In this sense, higher vega may eventually correct the risk-aversion of executives and motivate them to seek risk by adopting more risky firm policies and taking on more risky projects. Although the measure vega can also be derived for the executive's stock holding, past research has shown that option vega is many times higher than stock vega (Guay 1999). Consequently, option vega has been commonly used in the literature to measure the overall compensation incentive that motivates executives to take risk (Coles et al. 2006; Knoph et al. 2002; Rajgopal and Shevlin 2002). In this study, we follow these prior studies to use option vega as a proxy for the overall risk incentive provided in executive compensation.

A number of studies in the existing literature have provided empirical evidence on the positive relationship between vega and various firm risk-taking strategies. For example, higher vega has been found to be associated with higher corporate leverage (Cohen et al. 2000), higher stock return volatility (Guay 1999), more R&D expenditure (Coles et al. 2006), more resource exploration effort (Rajgopal and Shevlin 2002), and less use of risk-hedging derivatives (Knoph et al. 2002). These findings support the view that compensation structure with high vega provides the incentive for executives to adopt high-risk strategies in improving the firm performance.

IT and Firm Risk

IT is considered as riskier asset because it often leads to uncertainty of operational and market performance. For example, prior studies have found that IT is often associated with uncertain future cash flow (Hunter et al. 2008). Consequently, traditional accounting approaches may not be enough to assess the value of IT investment and justify IT investment (Tallon et al. 2000). Also, the strategic value of IT may not be anticipated by equity investors in the financial market, and therefore the launch of IT initiatives may lead to uncertain market reactions, increasing the market risk of the firm (Dewan and Ren 2007). All of these evidence indicates that IT is likely to be directly associated with high firm risk. In addition to the direct impact on firm risk, IT may also indirectly contribute to firm risk through other strategic movements. For example, prior studies have shown that IT is often used to support other risky firm strategies such as R&D (Kleis et al. 2012; Xue et al. 2012). In this regard, IT is also likely to contribute to firm risk through other risky actions.

Despite the overall risk effect of IT, not all IT decisions may be driven by strategic risk-taking motives. As a general-purpose technology, IT is used to support various organizational activities (Brynjolfsson and Hitt 1998), including low-risk routine operations. Therefore, instead of considering overall IT investment and implementation, we focus on the portion of IT implementation that better reflects risk-taking in IT. We develop a construct named aggressive IT implementation (AITI). AITI is defined as the extent to which focal firms exceed their industry peers and competitors in increasing their IT implementations, controlling for the operational growth of their businesses. In other words, AITI captures the increase in IT implementations that are not explained by the regular needs of operational scale and the common IT implementation practices in the focal firm's industry environment. For example, suppose a firm operates in a business environment that typically needs 70 PCs to support every 100 employees. When the firm establishes a new business unit with 100 more employees and similar revenue generation capability as other existing units, if the firm increases its PCs by 70, it is likely that the firm increases IT to support the regular expansion of its existing business practices. In this case, the value of the increase in IT implementation can be easily justified by the regular operational needs and there is less uncertainty associated with it. If, on the other hand, we observe that the firm increases its total PCs by 120 along with a similar operational growth, then the 50 additional PCs can be considered as aggressive IT implementation, as such increase exceeds the industry-norm and is not justified by its operational needs. For example, the firm may digitize more of its business processes and increase the IT usage per employee. The firm may also utilize the increased IT for more radical innovation in new product/service development, for example, the implementation of new in-store technologies. In this case, there is uncertainty associated with the value of this aggressive IT implementation as it cannot be explained by the traditional measure of operations.

By strategically using more IT to develop capabilities beyond the existing business scale, firms essentially build digital options that enable them to respond to unexpected opportunities and dynamic changes. Such strategic agility allows firms to reap benefits from environmental uncertainties. However, by deviating from their existing IT practices and industry norms, firms risk facing problems with uncertain solutions. In this regard, aggressive IT implementations are a manifestation of strategic risk-taking. Faced with uncertainties, risk-averse managers are likely to follow the industry norm of IT implementation and usage, as they may believe that imitating the norms can make them less vulnerable to being singled out and subject to blame, if their IT implementation decisions are proven to be sub-optimal later (Mithas et al. 2013). Industry norms and the actions of competitors provide observable benchmarks to firms for their IT implementation decisions, and enable firms to learn from others whom they perceive as successful. Strategic deviation from industry norms, in contrast, forces firms to risk losing resources as well as support. Prior studies on institutional influence in IT implementation also suggest that firms often choose to imitate industry norms in IT implementations in order to minimize risk and experimental cost. Therefore, we consider aggressive IT implementations as indicative of IT risk-taking and expect that firms engaging in aggressive IT implementations bear more risk. More risk-oriented firms, however, choose to strategically take risk through aggressive IT implementations to build long-term competitive advantages. Thus, we develop and test the following hypothesis:

H1: There is a positive relationship between the extent of aggressive IT implementation and firm risk.

Executive Compensation and IT Risk Taking

Based on the upper-echelon theory, the IS literature has long argued that top executives exert important influence on a firm's IS strategy. Prior research also indicates that as IT has become imperative to support organizational operations and industry competition, senior executives' views and influence on IT investment are instrumental in shaping IT strategies and usage in firms (Bakos and Treacy 1986; Clemons and Row 1988; Jarvenpaa and Ives 1991; Armstrong and Sambamurthy 1999; Chatterjee et al. 2002; Liang et al. 2007).

Despite the risky nature of IT and the well-recognized influence of executive compensation on risk taking, the IS literature has paid limited attention to the potential impact that executive compensation may have on IT risk-taking. In the few studies that relate executive compensation to IT, the focus has mainly been on the performance incentive, not the risk incentive of the compensation structure. For example, Talmor and Wallace (1998) found that the use of stock-based compensation in the computer industry boosted long-term firm growth. Similarly, Anderson et al. (2000) present evidence that firm performance (stock returns) increase with the incentive-payment in executive compensation (i.e., the holdings of options). Likewise, Anderson et al. (2002) showed that IT CEOs' exercisable stock options had stronger performance-enhancing effect in the down market of 2000 (compared to the up market in 1990s') but their unexercisable options had weaker performance-enhancing effect. Masli et al. (2007) found that firms use performance-based compensation (equity compensation) to motivate IT spending and shield CEO cash compensation from the income-decreasing effects of IT spending. The extant literature, however, does not say much about whether the risk incentive provided in the compensation (e.g., vega) drives executives to undertake more IT initiatives, especially high-risk IT projects.

Consistent with the logic of upper-echelon theory, we expect that the risk-seeking incentive of top executives drives firms' high-risk IT initiatives. Due to their position and broad perspective about the organization, top executives may have unique views about the long-term value of IT which cannot be justified by the traditional performance measures (e.g., ROI), especially in the early stages of IT investments (Tallon et al. 2000). For example, in order to gain long-term competitive advantage, executives may strategically push for more aggressive IT adoption than their competitors, hoping to more radically reengineer their business processes (Jarvenpaa and Ives 1991). Consequently, top executives' willingness to take risks is critical for the undertaking aggressive IT implementation projects, which may be associated with uncertain outcomes. Since the vega of compensation provides top executives the incentive to seek risk, we expect a positive association between vega and the aggressive IT implementation.

H2: There is a positive relationship between vega and the extent of aggressive IT implemenation.

Diversification, Executive Compensation and IT Risk Taking

Firm diversification has long been recognized in the literature as a key factor influencing corporate risk taking (Williamson 1975; Hoskisson and Hitt 1988; Baysinger and Hoskisson 1989; Eisenmann 2002). Prior studies suggest that diversification may have a complex effect on the overall corporate risk taking because it influences various organizational aspects differently. For example, some research argues that diversification inhibits corporate strategic risk-taking since divisional managers are likely to avoid risky projects so as to meet their local financial performance targets (Hoskisson and Hitt 1988). Other research suggests that diversification supports corporate risk-taking as diversification enables firms to allocate resources more effectively through their internal capital markets to fund risky strategies across business units (Williamson 1975).

Similarly, conflicting views also exist regarding how diversification may influence the relationship between top executives and corporate risk taking. Diversification affects top executives' information processing in decision making (Williamson 1975). Highly diversified firms have information processing constraints that prevent corporate executives from obtaining sufficient knowledge about the strategic issues facing various individualdivisions (Dundas and Richardson 1982; Hill and Hoskisson 1987). In addition, competing demands from various divisions often disallow top executives to spend enough time collecting and processing information about the secondary industries. Such information processing constraints may result in top executives' loss of control over risky projects in secondary areas. As a result, top executives in diversified firms are likely to forgo risk-taking initiatives, such as R&D, due to the concern about loss of control (Baysinger and Hoskisson 1989). However, there is also an opposite view regarding the impact of the information processing effect of diversification (e.g., Eisenmann 2002). In diversified firms, much of the information received by top executives is in the form of summary reports (Hoskisson et al. 1991). The abstract information prevents top executives from more rationally ruling out the unlikely outcomes of risky projects, especially those projects in areas they are not familiar with. As a consequence, compared to projects in the primary industries, projects in the secondary industries are often associated with higher variance of prospective outcomes (i.e., higher risk). For top executives with risk-taking incentive, diversifying into unfamiliar secondary areas provides them more opportunities for seeking risk. Therefore, risk-seeking top managers in diversified firms may be more willing to take risk than those in focused firms (Eisenmann 2002).

One way to resolve this conflict is to explicitly examine how top executives' risk-taking incentive may lead to distinct risk-taking behavior in the focal firm's primary and secondary industries. Such examination helps shed light on whether the information processing effect of diversification essentially enhances or impedes corporate risk taking. Prior studies, however, have mostly used data on corporate-level overall risk-taking and are thus not able to distinguish between risk-taking actions in primary industries and those in secondary industries. In this study, we use establishment-level IT data to generate more refined insights on this issue. Specifically, we consider focal firms' aggressive IT implementation in their primary industries as well as in their secondary industries. If the risk incentive of top executives is associated with more aggressive IT implementation in secondary industries than in primary industries, it suggests that the information processing effect of diversification fosters risk-taking strategies. Top executives use the unfamiliar areas (secondary industries) as a key territory to pursue IT risk (e.g., adoption of more IT innovation, more radical business transformation using IT). On the other hand, if the risk incentive of top executives is associated with less aggressive IT implementation in secondary industries, it suggests that the effect of top executives concerns about the loss of control caused by information processing constraints dominates. In that case, they prefer to focus their strategic IT risk-taking in the primary business areas in which they have better knowledge and control. Therefore, we develop the following two opposite hypotheses:

H3a: Vega is associated with a higher level of aggressive IT implementation in focal firms' secondary industries than in their primary industries;

H3b: Vega is associated with a lower level of aggressive IT implementation in focal firms' secondary industries than in their primary industries.

Data and Measurement

Data

We used Harte-Hank's Computer Intelligence (CI) database to obtain data on establishment-level IT implementation. We obtained IT implementation data on establishments from 1999 to 2009. Out of the entire sample of unique establishments, we were able to acquire the corresponding firm-level information of 199,348 unique establishments, which formed a sample of 10,241 unique firms. We used Compustat and Compustat Segment databases to obtain firm-level financial data, and used CRSP to obtain stock market data.

We used the Execucomp database to obtain data on CEO and other top management compensation. Execucomp provides data on salary, bonus, and total compensation for the top five executives (ranked annually by salary and bonus). Following prior studies (Coles et al. 2006), we consider other top managers as those ranked in top five excluding CEO. We also followed the prior literature to eliminate firms in the utility, finance and insurance industries as these firms are subject to high regulation and therefore incentive payments play a less important role (Coles et al. 2006; Smith and Watts 1992). Limited by the availability of executive compensation data, the size of our firm-level sample further reduced to 9509 firm-year observations, with 1492 unique firms. We use Compustat database to obtain other firm accounting data used to construct control variables.

Variables

Regarding IT risk-taking, we use available data from CI database to develop measures on IT implementation in three key areas of IT: decentralized computing equipment (DCE), centralized computing equipment (CCE), and network communication equipment (NCE). Following the existing IT business value literature (Kleis et al. 2012; Chwelos et al. 2010), we use the number of PCs and workstations as a proxy for DCE, the number of servers as a proxy for CCE, and the number of network nodes as a proxy for NCE. We first assess the aggressive implementation of DCE, CCE and NCE at the establishment-level. The idea here is that large diversified firms often have different establishments in different industries. Each establishment may have its own IT needs based on its operational scale and industry environment. To assess whether a firm aggressively implements IT in a certain establishment, we need to take into account the establishment's specific operational scale and industry context. Therefore, using establishment-level measures of DCE, CCE, and NCE, we run the following regression model for each (2 digit) industry-year subsample of establishments,

$$\frac{\Delta IT_{i,t}}{E_{i,t-1}} = \alpha_0 + \alpha_1\left(\frac{1}{E_{i,t-1}}\right) + \beta_1\left(\frac{R_{i,t-1}}{E_{i,t-1}}\right) + \beta_2\left(\frac{\Delta R_{i,t}}{E_{i,t-1}}\right) + \beta_3\left(\frac{\Delta E_{i,t}}{E_{i,t-1}}\right) + \varepsilon_{i,t} \quad (1)$$

where $E_{i,t}$ is the size (measured by the number of employees) of establishment *i* in year *t*, $\Delta E_{i,t}$ is the increase of establishment employees in year *i* and $\Delta E_{i,t}=E_{i,t}-E_{i,t-1}$, $R_{i,t}$ is the revenue of establishment *i* in year *t*, $\Delta R_{i,t}$ is the increase of establishment revenue in year *i* and $\Delta R_{i,t}=R_{i,t}-R_{i,t-1}$. $IT_{i,t}$ is one of the three measures of IT implementation of establishment *i* in year *t*, i.e., $IT_{i,t}=\{DCE_{i,t}, CCE_{i,t}, NCE_{i,t}\}$, and $\Delta IT_{i,t}$ is the increase of establishment IT implementation in year *i* and $\Delta IT_{i,t}=IT_{i,t}-IT_{i,t-1}$.

The regression in (1) characterizes the general pattern that establishments in a specific industry and a given year increase their IT implementation (on a per capita basis for normalization purpose) along with their growth of operational scale (measured by establishment revenue) and establishment size (measured by establishment employee number). In other word, the regression line of (1) captures the normal level of establishment IT increase in each industry in a given year. We use the regression residuals from (1) to represent the establishment aggressive implementation of DCE, CCE, and NCE, denoted by AIDCE, AICCE, and AINCE, respectively. The central idea here is that a large residual value captures an "abnormal" increase in establishment IT implementation that cannot be explained by the establishment's growth of business operations, given this establishment's specific industry characteristics. The firm may aggressively implement more IT at an establishment level to strategically differentiate itself from the competitors in the same industry. For example, the firm may digitize more of the establishment's business processes so as to achieve IT-enabled competitive advantage in this industry. However, in doing so, the firm needs to take the risk of investing in high-risk IT assets and face more technological uncertainty and managerial complexity in uncommon IT practices. Therefore, the aggressive increase in IT implementation reflects strategic risk-taking in IT. It is worth remarking that our approach of capturing abnormal IT increase is essentially similar to the approach used in the literature to study other types of abnormal operational activities of firms. For example, the literature on earnings management (e.g., Roychowdhury 2006) has employed a similar industry-based regression approach to assess the extent to which individual firms strategically use abnormal production activities to boost earnings.

We then aggregate the establishment-level aggressive IT implementation measures into the firm-level, weighted by revenue shares of establishments. Firm-level measures capture the extent to which firms exceed their corresponding industry norms in increasing their IT implementation. To validate the use of these variables as measures of strategic risk taking in IT, we use a firm risk model to explicitly examine the extent to which these aggressive IT implementation strategies contribute to firm risk. As explained in more details below, we regress the market risk of firm against these three measures of aggressive IT implementation, controlling for several other firm characteristics that potentially cause firm risk. The market risk is measured using one-year volatility of monthly stock return. We focus on the market risk of the firm as the incentive compensation of executives is usually tied to the market performance and risk of firms. The control variables in the risk model include the commonly used variables in studying firm risk (e.g., Guay 1999; McAlister et al. 2007; Low 2009), such as R&D expenditure, advertising expenditure, capital investment, firm leverage, lagged risk, market risk, diversification, and firm sales (nature logarithm).

Regarding executive compensation, we adopt the one-year approximation approach developed in Core and Guay (2002) to derive the vega and delta of the executive's option portfolios. The approach of Core and Guay (2002) relies on the Black-Scholes (1973) option valuation model, as modified by Merton (1973) to account for dividends, to assess the value of different types of options (e.g., newly granted and previously granted options, exercisable and unexercisable options) in the executive's portfolio. Vega is defined as the change in the executive's overall option value for a 0.01 change in the annualized standard deviation of stock returns. Option Delta is defined as the change in the executive's overall option value for a one percentage change in underlying stock price. This approach has been used extensively in the finance and accounting literature (e.g., Coles et al. 2006; Roulstone 2003) to study managerial incentives. Details of this approach are in the Appendix.

The control variables that we use as determinants of IT risk-taking are all based on existing literature. Specifically, we include total delta and cash compensation (defined as the sum of base salary and bonus) to control for the impact of performance incentive and non-incentive compensation, respectively, of top executives (Coles et al. 2006). Total delta is the sum of option delta and equity delta (the sensitivity of total stock holding to a one-percent change in stock price). CEO tenure and CEO turnover (whether the CEO changed) were included to control for the potential impact of CEO personal characteristics on risk-taking. We include Market-to-Book ratio and sales growth to control for investment and growth opportunities as such opportunities may influence firms' risky investment policies (Coles et al. 2006). We include other investments that may drive risky IT initiatives, such as R&D expenditure, advertising expenditure, and capital expenditure (Dewan et al. 2011). To control for firms' cash available to finance new projects, we included a measure of surplus cash as developed in Richardson (2006). Firm diversification was included as it is a key factor influencing corporate risk-taking. Finally, to control for firm size, we include the logarithm of sales. We also used industry dummies and year dummies to control for the industry fixed effect and the year fixed effect. Table 1 presents the descriptive statistics of key variables. Due to space limit, the correlation table is not included here but is available from the authors upon request.

Empirical Models

We first examine the relationship between aggressive IT implementation and firm risk using an IT risk model. This approach is analogous to the analysis used in other studies on IT risk (e.g., Dewan et al. 2007): regress overall firm market risk against risky IT strategies along with other control variables. In our case, we consider the aggressive implementation of three types of IT equipment (decentralized computing equipment, centralized computing equipment, and network communication equipment) as risky IT strategies. This model is also employed to verify the contributions of aggressive IT implementation to firm risk, so as to validate the use of these three measures of aggressive IT implementation to capture risk taking. We focus on firm market risk mainly because the incentive compensation to executives is usually based on the market performance of the firm. The specification of the IT risk model is as follows:

$$\text{Firm Risk}_{i,t} = \alpha_0 + \alpha_1 \text{AIDCE}_{i,t-1} + \alpha_2 \text{AICCE}_{i,t-1} + \alpha_3 \text{AINCE}_{i,t-1} + \eta[\text{Controls}]_{i,t-1} + \varepsilon_{i,t} \quad (2)$$

We next examine the extent to which vega induces top executives to implement IT aggressively. As we consider three measures of aggressive IT implementation, we specify a system of three equations as follows,

$$\text{AIDCE}_{i,t} = \beta_{01} + \beta_{11} \text{Vega}_{i,t-1} + \lambda_1 [\text{Controls}]_{i,t-1} + \upsilon_{i,t} \quad (3)$$

$$\text{AICCE}_{i,t} = \beta_{02} + \beta_{12} \text{Vega}_{i,t-1} + \lambda_2 [\text{Controls}]_{i,t-1} + \sigma_{i,t} \quad (4)$$

$$\text{AINCE}_{i,t} = \beta_{03} + \beta_{13} \text{Vega}_{i,t-1} + \lambda_3 [\text{Controls}]_{i,t-1} + \tau_{i,t} \quad (5)$$

Table 1a. Variable Definition and Descriptive Statistics

Variable	Notation	Definition	Mean	Std.
Aggressive IT Implementation	AIDCE	The extent to which the increase of PCs and workstations exceeds the industry-norm level.	-0.001	0.411
	AICCE	The extent to which the increase of servers exceeds the industry-norm level.	0.000	0.038
	AINCE	The extent to which the increase of network nodes exceeds the industry-norm level.	-0.003	0.432
Vega	VEGA	Sensitivity of option value to a 1% increase in standard deviation of stock return.	241.69	515.09
Delta	DELTA	Sensitivity of option and share holding value to a 0.01 increase in share price.	1,722.8	2,440.5
Cash Compensation	CASH	The sum of base salary and bonus.	4,545.6	3,289.6
Firm Risk	RISK	Standard deviation of monthly stock return in the subsequent year.	0.116	0.066
R&D Expenditure	R&D	Research and development expenditure to total assets.	0.028	0.058
Advertising	ADV	Advertising expenditure to total assets.	0.025	0.053
Capital Investment	CAPX	Capital investment to total assets.	0.055	0.050
Leverage	LVRG	Total debts (long-term debt + debt in current liabilities) to total assets.	0.240	0.203
CEO Tenure	TENU	CEO's number of years in the firm.	5.858	5.383
CEO Turnover	TNOV	Indicator: 1 if CEO is replaced, 0 otherwise.	0.149	0.356
Market-to-Book	MTB	Total market value to total book value of assets.	1.929	1.196
Diversification	DIV	Entropy measure of firm diversification.	0.823	0.537
Sales Growth	SG	One-year sales growth rate.	0.062	0.247
Surplus Cash	SPLS	Cash from assets-in-place to total assets, as in Richardson (2006).	0.081	0.099
Market Risk	MKT	Standard deviation of monthly return of the value-weighted return index from CRSP.	0.043	0.017
Firm Size	SIZE	Nature logarithm of total sales.	21.395	1.522
DCE Intensity	DCEI	Total PCs and workstations per employee.	0.399	0.394
CCE Intensity	CCEI	Total servers per employee.	0.021	0.042
NCE Intensity	NCEI	Total network nodes per employee.	0.391	0.416

Note: 1. The aggregate values of the top five executives are used for vega, delta and cash compensation; 2. Vega, delta, and cash compensation are in thousand 2009 dollars.

We include the lagged value of *vega* and other control variables as independent variables in the model to better capture how vega and other factors drive the decisions of aggressive IT implementation. We estimate the system of equations using different approaches, including OLS and seeming unrelated regression (SUR) (to take into account the potential correlation between these measures). As stated earlier, we expect that higher vega will result in higher levels of aggressive implementation of decentralized computing equipment, centralized computing equipment, and network communication equipment.

To examine the potential differential impact of vega on IT risk-taking in the focal firm's different industries, we distinguish between the aggressive IT implementation in the primary industries and that in the secondary industries. Specifically, we aggregate separately the aggressive IT implementation in the primary-industry establishments and the aggressive IT implementation in the secondary-industry establishments. For example, for a focal firm's decentralized computing equipment (DCE), we construct two measures: the aggressive implementation of DCE in the primary 2-digit industry (denoted as AI_P_DCE) and that in the secondary 2-digit industries (denoted as AI_S_DCE). We then use seemingly unrelated regression to examine how vega influences both AI_P_DCE and AI_S_DCE, based on the same model specification as in eq. (3). We also use a similar approach to examine the aggressive implementation of centralized computing equipment and network communication equipment in the primary and secondary industries. We remove the firms with unavailable IT implementation information in the secondary-industry establishments. The sample size for this analysis reduces to 6685 firm-year observations.

Results

Table 2 reports the estimation results of the IT risk model using OLS, fixed-effect and random-effect models. As Table 2 indicates, the estimated coefficients of AIDCE, AICCE, and AINCE are positive and significant in all specifications, supporting H1. These results suggest that focal firms face more market risk when they differentiate themselves from industry peers by implementing more IT than that is needed to simply support their operational growth. The aggressive implementation of decentralized computing equipment, centralized computing equipment and network communication equipment may be driven by the firms' intention to pursue long-term strategic IT initiatives (e.g., building more digitally-enabled business models). However, the technological uncertainty, managerial complexity and potential organizational changes associated with aggressive IT implementation may also cause unexpected outcomes and negatively affect the market performance of the firm. Turning to the estimates on other firm characteristics, the coefficients are generally consistent with expectations, including the positive coefficients of R&D expenditure (which in general represents riskier investments) and negative coefficients of capital investment (which in general represents safer investments (Core et al. 2006)).

Table 2. IT Risk Model

	OLS	Fixed Effect	Random Effect
Intercept	0.149*** (0.041)	0.193*** (0.049)	0.152*** (0.041)
AIDCE	0.017*** (0.002)	0.014*** (0.002)	0.017*** (0.002)
AICCE	0.068*** (0.014)	0.053*** (0.015)	0.063*** (0.014)
AINCE	0.022*** (0.002)	0.022*** (0.002)	0.022*** (0.001)
R&D	0.046*** (0.010)	0.081*** (0.020)	0.053*** (0.011)
Advertising	0.005 (0.010)	0.030* (0.012)	0.011 (0.010)
Capital Investment	-0.013 (0.012)	-0.038* (0.016)	-0.020 (0.012)
Leverage	0.014*** (0.003)	0.025*** (0.004)	0.016*** (0.003)
Diversification	-0.002* (0.001)	0.003 (0.002)	-0.001 (0.001)
Mkt. Risk	0.782 (0.731)	1.783* (0.748)	1.116 (0.721)
Lagged Risk	0.399*** (0.009)	0.206*** (0.011)	0.343*** (0.009)
Size	-0.005*** (0.000)	-0.008*** (0.001)	-0.006*** (0.000)
Industry dummies and year dummies are used…			
R^2	0.407	0.349	0.404

Note: (1) † p<0.1; * p<0.05; ** p<0.01; *** p<0.001; (2) N=9509; (3) In parentheses are standard errors.

In Table 3, we present results on whether executive compensation structure affects the decision to pursue aggressive IT implementation. To the extent that aggressive IT implementation increases firm risk, we expect that higher vega will lead to higher levels of aggressive IT implementation. As Table 3 indicates, the coefficients of vega are positive and significant in all the three equations for decentralized computing equipment, centralized computing equipment, and network communication equipment. These results support H2, which suggests that higher risk-taking incentive provided in executive compensation (reflected by higher vega) drives firms to more aggressively implement IT than their competitors.

While our main focus is on vega as the primary explanatory variable, the results on other aspects of compensation and other control variables are also worth noting. The coefficient estimates of delta are in general not significant across all the three equations. This suggests that the performance incentive provided in compensation does not drive the aggressive implementation of IT. These results are in line with the risk aversion assumption for top executives. As higher delta ties more executive compensation to performance, it also exposes executives to more firm risk (i.e., the uncertainty of performance). Risk-averse executives should therefore have no incentive to further pursue more aggressive IT implementation. The negative coefficients of cash compensation suggest that executives compensated with more salary and bonus are even less likely to pursue aggressive IT implementation. A potential explanation is that executives relying more on cash compensation are more concerned about the short-term earning-decreasing effect of IT and therefore choose to maximize their cash compensation incomes by minimizing IT spending (Masli 2009).

Table 3. Aggressive IT Implementation

	AIDCE	AICCE	AINCE
Intercept	0.392** (0.115)	0.008 (0.012)	0.130 (0.125)
Vega	0.005** (0.002)	0.001** (0.000)	0.005** (0.002)
Delta	-0.003 (0.004)	0.000 (0.000)	-0.003 (0.004)
Cash Compensation	-0.032*** (0.009)	-0.002** (0.001)	-0.027** (0.009)
CEO Tenure	0.001 (0.001)	0.000 (0.000)	-0.001 (0.001)
CEO Turnover	0.013 (0.011)	0.001 (0.001)	-0.009 (0.012)
Market-to-Book	0.006 (0.004)	0.001† (0.000)	0.004 (0.004)
R&D	0.273*** (0.075)	0.010 (0.008)	0.066 (0.082)
Advertising	0.073 (0.069)	0.024** (0.007)	0.059 (0.075)
Capital Investment	0.057 (0.081)	0.008 (0.008)	0.281** (0.088)
Leverage	-0.021 (0.019)	0.001 (0.002)	-0.033 (0.021)
Sales Growth	0.018 (0.015)	0.007*** (0.002)	0.008 (0.017)
Surplus Cash	-0.010 (0.045)	-0.008† (0.005)	-0.053 (0.049)
Diversification	-0.015 (0.010)	-0.001 (0.001)	-0.012 (0.008)
Lagged Risk	0.310*** (0.060)	0.006* (0.003)	0.515*** (0.065)
Size	0.001 (0.004)	0.000 (0.000)	0.008* (0.004)
DCE Intensity	0.044*** (0.009)		
CCE Intensity		0.130*** (0.009)	
NCE Intensity			0.090*** (0.010)
Industry dummies and year dummies are used…			
R^2	0.299	0.126	0.245
χ^2	4079.36***	1399.06***	3155.12***

Note: (1) † p<0.1; * p<0.05; ** p<0.01; *** p<0.001; (2) N=9509; (3) In parentheses are standard errors; (4) Log values are used for Vega, Delta, and Cash Compensation.

Table 4 presents the results on the comparison between primary and secondary industries. In the models on decentralized computing equipment and network communication equipment, the coefficient of vega in the equation for secondary industries are positive and significantly higher than that in the equation for primary industries. These findings support H3, suggesting that higher vega results in more aggressive implementation of decentralized computing equipment and network communication equipment in focal firms' secondary industries than in primary industries. Regarding centralized computing equipment, the coefficients in both equations are positive but not significantly different from each other. A potential explanation is that the investment decisions on centralized computing equipment are more based on the overall corporate-level computing needs, and therefore the industry difference between establishments matters less. In general, the findings support the hypothesis that the risk incentive provided in executive compensation result in more strategic IT risk taking in in focal firms' secondary industries than in primary industries.

Table 4. Aggressive IT Implementation In Primary and Secondary Industries

	AIDCE		AICCE		AINCE	
	Primary	Secondary	Primary	Secondary	Primary	Secondary
Intercept	0.612*** (0.124)	0.503*** (0.156)	0.004 (0.011)	0.029* (0.015)	0.486*** (0.135)	0.391* (0.176)
Vega	0.004* (0.002)	0.008** (0.002)	0.001* (0.000)	0.001* (0.000)	0.004* (0.002)	0.010*** (0.003)
Delta	-0.003 (0.004)	-0.013** (0.005)	0.000 (0.000)	-0.001 (0.000)	-0.003 (0.004)	-0.008 (0.006)
Cash Compensation	-0.028** (0.010)	-0.024** (0.012)	-0.002* (0.001)	-0.003* (0.001)	-0.026* (0.011)	-0.027* (0.014)
CEO Tenure	0.000 (0.001)	0.000 (0.001)	0.000 (0.000)	0.000 (0.000)	-0.002† (0.001)	-0.001 (0.001)
CEO Turnover	0.020 (0.012)	0.001 (0.015)	0.001 (0.001)	0.001 (0.001)	0.006 (0.013)	-0.023 (0.017)
Market-to-Book	0.004 (0.003)	0.005 (0.004)	0.001* (0.000)	0.000 (0.000)	0.006 (0.004)	-0.004 (0.005)
R&D	0.347** (0.100)	0.244* (0.125)	-0.003 (0.009)	-0.010 (0.012)	-0.091 (0.109)	0.205 (0.142)
Advertising	0.104 (0.076)	0.051 (0.096)	0.003 (0.007)	0.021* (0.009)	0.038 (0.083)	0.032 (0.108)
Capital Investment	-0.045 (0.092)	-0.025 (0.115)	0.007 (0.008)	0.012 (0.011)	-0.033 (0.100)	-0.007 (0.130)
Leverage	-0.029 (0.023)	-0.016 (0.029)	0.000 (0.002)	-0.001 (0.003)	-0.024 (0.025)	-0.059† (0.033)
Sales Growth	0.029† (0.017)	0.032 (0.022)	0.005** (0.001)	0.005* (0.002)	0.023† (0.019)	0.025 (0.024)
Surplus Cash	-0.013 (0.051)	-0.035 (0.065)	-0.005 (0.004)	0.002 (0.006)	0.099 (0.056)	-0.018 (0.073)
Diversification	0.007 (0.009)	-0.011 (0.011)	-0.001† (0.001)	-0.000 (0.001)	0.001 (0.009)	-0.024† (0.012)
Lagged Risk	0.091* (0.042)	0.124* (0.053)	0.002 (0.006)	0.009† (0.005)	0.002 (0.080)	0.123* (0.054)
Size	-0.008* (0.004)	-0.004 (0.005)	0.001 (0.000)	0.000 (0.000)	-0.003 (0.004)	0.003 (0.006)
DCE Intensity	0.031** (0.011)	0.034* (0.014)				
CCE Intensity			0.046*** (0.009)	0.073*** (0.013)		
NCE Intensity					0.039*** (0.011)	0.063*** (0.015)
Industry dummies and year dummies are used...						
R^2	0.162	0.213	0.096	0.084	0.158	0.213
χ^2	1287.80***	1809.75***	397.15***	308.43***	1256.30***	1804.81***

Note: (1) † $p<0.1$; * $p<0.05$; ** $p<0.01$; *** $p<0.001$; (2) N=6685; (3) In parentheses are standard errors.

Discussion and Conclusion

This study makes two key contributions to the existing literature. First, our results shed light on a direct relationship between the characteristics of top executives and corporate IT strategies in the context of risk taking. This finding helps better explain the upper-echelon perspective on how top management influence is critical for corporate IT implementation (Clemons and Row 1988; Jarvenpaa and Ives 1991; Armstrong and Sambamurthy 1999). Moreover, our study also adopts a corporate governance perspective. By examining the compensation of executives, our study suggests that offering top executives the risk taking incentive of fosters corporate IT strategies that entail high risk. The existing literature on IT risk has clearly indicated the positive association between risk and return of IT (Dewan et al. 2007; Tanriverdi and Ruefli 2004; Dewan and Ren 2011). However, when risk-averse managers are exposed to firm risk (e.g., through performance incentive in their compensation), they may forgo risky IT projects and consequently the long-term strategic return of IT may be difficult to realize. Therefore, an important managerial implication from this study is that corporate owners can design the risk incentive in compensation structure to motivate top executives and corporate IT risk taking so as to realize the long-term strategic benefits of IT.

The second key contribution of this study is to provide a deeper understanding of how firm diversification influences corporate risk-taking. Although the extant literature has recognized that firm diversification may negatively affect the information processing capacity of top executives, conflicting views exist regarding how this information processing effect eventually influences managerial risk-taking. While some research argues that firm diversification mitigates the risk-taking as top managers are concerned about the loss of control due to information asymmetry (e.g., Baysinger and Hoskisson 1989); other research argues that diversification provides top executives more opportunities for pursuing risky strategies in the secondary business areas that they are less familiar with (e.g., Eisenmann 2002). Prior studies were not able to resolve this issue as most of them have focused on firm-level overall diversification and risk-taking and therefore could not distinguish between risk-taking behaviors in different business areas. This research uses establishment-level IT data to better examine this issue. We compare IT risk taking in the primary industries of focal firms with that in the secondary industries. Our results indicate that the risk incentive of top executives is associated with more aggressive IT implementation in the secondary industries (than in the primary industries) of focal firms. The insight is that motivated by risk incentives, top executives adopt secondary industries as the areas to realize more IT risk-taking. Therefore, our study provides clearer evidence to support the view that diversification into less familiar areas supports the risk-taking of top executives.

This study also has some limitations that are need to be acknowledged. First, in assessing IT risk taking, our measures of aggressive IT implementation mainly capture the investment in internal hardware infrastructure. Although hardware infrastructure implementation accounts for a significant portion of corporate IT budget and we also validate our measures by explicitly showing that they contribute to firm risk, we have to acknowledge that these hardware-based measures are not sufficient to characterize all aspects of IT risk taking. IT may also be caused by the failure of other IT initiatives, such system implementation (e.g. ERP, CRM, SCM, etc). In this regard, in order to better understand the overall risk taking in IT, other risky IT initiatives are worth considering. Second, our study focuses on the market risk of the firm. The main reason is that the incentive compensation of executives is usually tied to the market performance of the firm. However, the incentive for seeking operational risk is not easily assessed using the available compensation data. Therefore, it is not clear to what extent top executives are also motivated by compensation to seek operational risk. Third, due to the nature of our data, we are not able to observe the exact roles of these top executives in IT decision making.

There are many promising areas for future research. First, using other research approaches (e.g., survey), future research may specifically measure the risk-taking intention of top executives and further explore how compensation structure motivates the IT risk-taking decisions. Second, future research may examine different types of risky IT initiatives, especially those in the new technological areas such as social media, mobile computing and cloud computing. More evidence is needed to show if compensation motivates corporate executives to strategically adopt these emerging technologies. Third, in addition to diversification, future research may also consider how the relationship between executive compensation and IT risk-taking may be influenced by many other organizational factors, such as corporate hierarchical organization, board structure, and demographic characteristics of top executives.

Appendix: Derivation of Vega and Delta

As in Core and Guay (2002), stock option value is calculated based on the Black-Sholes (1973) formula for valuing European call options, as modified to account for dividend payouts by Merton (1973). Specifically,

$$OV = Se^{-dT}N(Z) - Xe^{-rT}N\left(Z - \sigma T^{(1/2)}\right)$$

where $Z = [\ln(S/X) + T(r - d + \sigma^2/2)]/\sigma T^{(1/2)}$, N(.) is cumulative probability function for the normal distribution, S is the price of the underlying stock at fiscal year-end, X is the option exercise price, σ is the expected stock return volatility estimated using 5-year annualized volatility of stock return prior to the fiscal year, r is the risk-free interest rate, T is the time to maturity of option, d is the expected dividend yield estimated using 5-year average dividend yield rate as of the fiscal year. The vega and delta measures are the option value's sensitivity with respect to a 0.01 change in stock return volatility and a 1 percent change in stock price, respectively. Therefore,

$$\text{Vega} = (\partial OV/\partial \sigma) \times 0.01 = e^{-dT} N'(Z) S T^{(1/2)} \times 0.01; \quad \text{Delta} = (\partial OV/\partial S)(S/100) = e^{-dT} N'(Z)(S/100)$$

where N'(.) is the normal probability density function.

We obtain/calculate S, σ and d using data from CRSP. r is also estimated using Treasury yields from CRSP. Regarding X and T, we followed Core and Guay (2002) to distinguish between newly granted options, previously granted exercisable options, and previously granted unexercisable options. X and T for new grants are obtained directly from Execomp. For previously granted options (exercisable as well as unexercisable), we estimate their X by subtracting the realized values (excess of stock price over exercise price) of exercisable options and unexercisable options from the stock price. T of previously granted options is determined based on whether or not there were new grants in the most recent fiscal year. If there were new grants, T of previously granted unexercisable options is set to one year less than the T of recent grants. Otherwise, T of previously granted unexercisable options is set to nine years. T of previously granted exercisable options is set to three years less than that of previously granted unexercisable options.

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