DYNAMIC ADJUSTMENT OF INFORMATION TECHNOLOGY, CORPORATE GOVERNANCE, AND FIRM PROFITABILITY

Dong, John Qi, School of Business and Management, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong, john.dong@ust.hk
Karhade, Prasanna, School of Business and Management, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong, karhade@ust.hk
Rai, Arun, Robinson College of Business, Georgia State University, Atlanta, Georgia, USA, arunrai@gsu.edu
Xu, Sean Xin, School of Economics and Management, Tsinghua University, Beijing, China, xuxin@sem.tsinghua.edu.cn

Abstract

How do managers make their decisions with regard to adjustment and deployment of information technology (IT) over time? Motivated by this complex dynamics, we draw on behavioral theory of the firm and theorize a bounded rational process of managerial decision making for IT investment. In particular, we explain the dynamic adjustment of IT investment by bounded rational managers’ pursuing of satisfaction. When performance feedback of prior profitability is below their aspiration, they become unsatisfied and adjust IT investment to facilitate problemistic search directed toward innovative solutions to performance problems. As a result, performance problems will be solved and future profitability can be improved. We also deepen our understanding by theorizing the contingency of above dynamics based on the possibility of agency problems and the appropriateness of corporate governance mechanisms, which is largely omitted in behavioral theory. We further draw on agency theory and examine the moderating roles of different corporate governance mechanisms (i.e., incentive alignment versus monitoring) in the effects of IT investment on problemistic search and rent generation. By using a recent, large-scale panel data set, we find that managers are indeed bounded rational and dynamically adjust IT investment over time based on performance feedback. We also find that incentive alignment outgoes monitoring in directing managerial decision making toward innovating with and generating rent with IT investment. Novel theoretical and practical implications are discussed.

Keywords: dynamic adjustment of IT investment, dynamics of managerial decision making, IT innovation, corporate governance, behavioral theory of the firm, agency theory.
1 Introduction

Contemporary firms invest heavily in information technology (IT). The fast growth of IT investment has achieved five times the growth rate of investment in other resources in recent years, and the scale of IT investment has occupied a share of over 40% in total capital investment (Doms 2005). Even after the financial crisis, worldwide IT spending was projected to increase at a compound growth rate of 5% and reached $3.4 trillion in 2010 (Gartner 2010). With extensive use of IT, firms take advantage of technological innovation to build competitiveness and improve performance. IT value literature has long documented the impact of IT investment on a variety of organizational outcomes, such as productivity, profitability, efficiency, and innovation (Hitt and Brynjolfsson 1996, Xue et al. 2012).

Yet, a paucity of research in IS literature documents the complex dynamics of managerial decision making with regard to adjustment and deployment of IT resources over time. Particularly, in order to build competitive advantage and improve performance, how managers dynamically make their decisions toward these ends largely remains unclear. The Chicago School initiating neoclassical economic theory maintains that decision making of the firm is rational and explains the decision making as a process of optimization motivated by profitability maximization (Miller 1962). However, the Carnegie School proposes a behavioral tradition, which recognizes the cognitive constraints of decision makers in a firm and assumes they are bounded rational (Simon 1947). This assumption of bounded rationality has distinct implication for explaining the dynamic process of decision making, because optimization that rational decision makers chase for is replaced by satisfaction based on comparison between firm profitability and aspiration of bounded rational decision makers (March and Simon 1958). A behavioral theory of the firm suggests that managerial decision making is an adaptive process of organizational learning from performance feedback (Cyert and March 1963).

Until recently, Kobelsky et al. (2008) formulated a model of several IT budget determinants and found that prior profitability can impact IT investment, which in turn affects future profitability. In their study, however, the reasons why prior profitability influences IT investment and the mechanisms through which IT investment influences future profitability were still underexplored. Our theory rooted in a behavioral tradition explicitly addresses these important issues and explains the dynamic adjustment of IT investment. According to behavioral theory, bounded rational managers adjust firm resources if they are unsatisfied (Greve 2003b). If previous profitability is below aspiration level, they attend to problemistic search directed toward solutions to performance problems (Cyert and March 1963, Greve 2003a). Future profitability will be improved as a result of problem solving through search for innovation (Cyert and March 1963). Consistent with recent IT innovation literature increasingly supporting that IT resources are an important facilitator of problem solving (Joshi et al. 2010, Kleis et al. 2012), we propose a behavioral theory about dynamic adjustment of IT investment based on performance feedback of prior profitability in order to improve future profitability through problemistic search.

However, behavioral theory alone does not fully capture the complex dynamics of managerial decision making, as it assumes managers always seek for satisfactory profitability (Cyert and March 1963, March and Simon 1958). In the absence of governing agency problems, however, managers’ decisions can largely deviate from increasing firm profitability (Fama 1980). Especially, managers may divert firm resources toward inefficient investment and deployment, such as pursuit of pet projects, overspending or suboptimal investment, and shirking (Gomez-Mejia et al. 2003). Thus, appropriate corporate governance mechanisms are necessary for directing managerial decision making toward efficient adjustment and deployment of resources (He and Wang 2009).

Recently, Ho et al. (2011) examined the moderating roles of corporate governance mechanisms in the relationship between IT investment and firm profitability. They found that board monitoring and advice strengthen the profitability impact of IT investment. However, their study omitted other important corporate governance mechanisms such as incentive alignment (Tosi et al. 1997, Zajac and Westphal 1994), and was not dedicated to innovation context in which incentive alignment is particularly important. Recent corporate governance literature suggests that the influences of incentive alignment and monitoring become unequally functional in innovation context with high degree of information asymmetry (He and Wang 2009). Thus, we integrate behavioral theory and agency theory to deepen our understanding about the contingency effect of IT investment resulted from dynamic adjustment, by taking into account the possibility of agency problems and the appropriateness of corporate governance mechanisms. Since CEOs play the most critical role in decision making of firms (Balkin et al. 2000), we examine how incentive alignment and monitoring arrangement designed for CEOs may impact the effects of IT investment on innovation effort and future profitability. By utilizing a large-scale panel data set from almost 1700 observations of U.S. public firms in recent years, we test our theory and found strongly supportive evidence.
The paper is organized as follows. We develop our theory and associated hypotheses in Section 2. Then, we describe our methodology in Section 3, followed by empirical results reported in Section 4. We discuss the major contributions and limitations of this study, shed light on future research, and provide practical implications in Section 5.

2 Theory Development

2.1 Adjustment of IT Investment based on Performance Feedback

Behavioral theory of the firm holds a basic assumption that the decision makers of firms suffer from cognitive constraint and bounded rationality (Simon 1947). This assumption has important implication different with neoclassical economic theory, as bounded rational decisions look for satisfaction rather than optimization (March and Simon 1958). By comparing firm profitability with their own aspiration, managers begin to search for alternative actions if firm profitability is not satisfied (Greve 2003b). Problemistic search is a problem solving process directed toward innovative solution to specific problem (Cyert and March 1963). It is carried out when firm profitability is below aspiration, in order to solve the performance problems that a firm faces (Greve 2003b). In order to accumulate and deploy resources needed for problemistic search, organizations learn from performance feedback to dynamically adjust firm resources (Greve 2003a). For example, Greve (2003a) found that firms increasingly invest in R&D, which is a resource enabler of problemistic search, when prior profitability is below aspiration level. When the gap between prior profitability and aspiration is greater, firms tend to invest more in R&D resources. Such resources adjustment is “a truly ‘dynamic’ interacting process” in which “management tries to make the best use of the resources available” (Penrose 1959, p. 5).

Recent IT innovation research suggests that IT is an important resource enabler of innovation. Especially, Kleis et al. (2012) evidenced that IT investment, similar to R&D investment, contributes to knowledge production for innovation activity. Also, Joshi et al. (2010) found that IT resources can facilitate a firm’s absorptive capacity, which enables search for external knowledge and product innovation. Tambe et al. (2012) similarly suggested that IT investment, in conjunction with an external focus, can facilitate search for product innovation. Therefore, IT investment is expected to increase if prior profitability is lower than aspiration level, in order to facilitate problemistic search and innovation. When the gap between prior profitability and aspiration level is greater and all else being equal, more IT investment will be made to meet the needs of extensive problemistic search.

Although prior studies on IT value often exclusively focus on the scale of IT investment (e.g., Hitt and Brynjolfsson 1996, Mithas et al. 2012), it is recently suggested as critical to understand the nature of IT investment as well (Dewan and Ren 2011). Given the fact that IT is commodity-like technology, the scarcity of IT investment with respect to whether specific IT systems invested by a firm have not been widely adopted by others determines the technological advantage and rent-generating potential associated with IT investment (Hitt and Brynjolfsson 1996)\(^1\). Thus, we reckon that the scarcity of IT investment is as critical as the scale and needs to be taken into account in understanding IT resources. Scarce IT systems have larger potential to bring first mover advantage (Lieberman and Montgomery 1988), leading to preemption of advanced functionalities better supporting innovation activity (Marakas and Elam 1997). In sum, we propose that greater gap between prior profitability and aspiration level will lead to greater adjustment of IT investment in terms of both scale and scarcity, to facilitate problemistic search and improve future profitability. It leads to the following hypothesis.

\textbf{H1: Greater gap between prior profitability and aspiration level leads to greater adjustment of IT investment with increasing scale and scarcity.}

2.2 Rent-Generating Mechanisms of IT Investment

Problemistic search is a problem solving process based on knowledge recombination with new and old elements (Collins and Smith 2006). IT innovation literature suggests that IT can benefit knowledge recombination in multiple ways. First, IT such as ERP systems facilitates knowledge management practices of a firm by creating a digital platform for knowledge creation, storage, retrieval, transfer, and application (Alavi and Leidner 2001),

\footnote{The value of IT investment can be competed away if they have been widely diffused across an industry, in a form of lower price or better product quality rather than economic rent and superior profitability (Dewan and Ren 2011, Hitt and Brynjolfsson 1996).}
which thereby facilitate combination and production of knowledge in a firm (Kleis et al. 2012). Second, IT especially network and communication technologies enables critical innovative routines such as ideation, design, and launch (Nambisan 2002), embodying rich recombination of knowledge elements in innovation activity (Joshi et al. 2010). Third, IT such as SCM and CRM systems also supports knowledge acquisition, assimilation, sharing, and mutual co-creation in a boundary-spanning manner (Malhotra et al. 2007), leading to absorption of new knowledge from external environment (Tambe et al. 2012). Although managers adjust IT investment in a partial manner, the new added IT components resulted from adjustment will facilitate search and generate rent in conjunction with existing IT resources as a whole system (Fichman 2004b). After the adjustment with an aim to facilitate problemistic search based on performance feedback, the resultant IT investment will jointly have a better fit to the need of problematic search in terms of both scale and scarcity, and therefore support problematic search to be conducted. It leads to the following hypothesis.

**H2: IT investment has a positive effect on problematic search.**

Mixed findings are documented in IT value literature about the relationship between IT investment and firm profitability, which is often called as profitability paradox. Recent studies attend to resolve this paradox by investigating the mediating mechanisms through which IT investment may or may not generate rent. For example, Dewan and Ren (2011) took risk-return perspective and found that IT investment improves profitability through increased risk premium. Mithas et al. (2012) found that IT investment increases profitability through revenue growth rather than cost reduction. In this study, we draw on IT innovation literature and propose another innovation-based mediating mechanism – problematic search. As suggested earlier, IT investment resulted from adjustment can benefit problematic search. Problemistic search is directed toward the solutions to performance problems, with an aim to improve profitability through problem solving (Cyert and March 1963). In turn, problematic search will solve performance problems by innovative solutions, leading to competitive advantage and superior profitability (Collins and Smith 2006). Thus, we have the following hypothesis.

**H3: Problemistic search mediates the positive effect of IT investment on future profitability.**

We also recognize the possibility that IT investment may directly improve future profitability through other non-innovation mechanisms as a byproduct of dynamic adjustment. For example, rich and innovative IT systems may help a firm improve the quality of existing products and the efficiency of current processes (Xue et al. 2012). Adoption of innovative IT, rather than other innovation activity enabled by IT (e.g., new product development), has been thought as one way to obtain technological advantage and firm competitiveness in IT innovation literature (Fichman 2004a, Swanson and Ramiller 2004). In particular, increasing IT investment in novel functionalities may better facilitate ordinary routines, such as manufacturing, marketing and supply chain operation (Bharadwaj et al. 2007). In this situation, we should be able to observe a direct positive effect of IT investment on future profitability. It leads to the following hypothesis.

**H4: IT investment has a direct positive effect on future profitability.**

### 2.3 Rent-Generating Contingency of IT Investment

As the decision makers of firms, managers directly control the ways in which firm resources are adjusted and deployed (Cyert and March 1963, Penrose 1959). While behavioral theory ignores possible managerial hazard in managerial decision making, agency theory has suggested that inefficient investment and use of resources is a key indicator of agency problems (Fama 1980). Whether the rent-generating potential of strategic resources can be fully realized therefore depends on the effectiveness of corporate governance mechanisms in deterring unproductive resource configuration and deployment by managers (Tosi et al. 1997). Agency theory proposes two types of corporate governance mechanisms – incentive alignment and monitoring arrangement, reducing agency problems by interest inducement and contract enforcement, respectively (Zajac and Westphal 1994). Importantly, corporate governance literature increasingly suggests that these two types of mechanisms are not equally functional and incentive alignment is preferable (Tosi et al. 1997), especially in innovation context with high degree of information asymmetry (He and Wang 2009).

Since the payoff of innovation effort such as search is usually highly uncertain and benefits firm competitiveness in the long run (Nelson and Winter 1982), myopic managers often seek to maintain a good record of short term profits (Fama 1980). In order words, they tend to avoid long term investment and innovation (Mahoney et al. 1997). Thus, the long term incentives of managers play a critical role in controlling the adjustment and deployment of firm resources for innovative routines (He and Wang 2009). In particular, Balkin et al. (2000) maintained, “as resources devoted to innovation increase, the potential impact of the CEO on a firm’s relative success or failure also increases” (p. 1119). Thus, the long term incentives of CEO, often governed by long term
inncentive pay (Balkin et al. 2000, Miller et al. 2002), are expected to moderate the relationship between IT investment and problemistic search².

On the one hand, with appearance of agency problems, CEOs may overinvest or underinvest in IT simply because they pursue larger power in IT department (Ho et al. 2011), or follow the fashion of other firms in order to maintain professional reputation in career (Scharfstein and Stein 1990). These suboptimal decisions for IT investment produce mismatch between IT investment and the need of problemistic search, which therefore weakens the positive effect of IT investment on problemistic search. On the other hand, myopic CEOs also tend to disapprove innovation projects that are often characterized with long term payoff (He and Wang 2009, Miller et al. 2002). Therefore, they are less likely to deploy IT resources for conducting problemistic search. Long term incentive pay to CEO is therefore expected to mitigate aforementioned agency problems in adjustment and deployment of IT resources for problemistic search, by making CEOs more long term oriented in decision making. Thus, high long term incentive pay to CEO is expected to strengthen the link between IT investment and problemistic search, leading to the following hypothesis.

**H5: Long term incentive pay to CEO positively moderates the relationship between IT investment and problemistic search, such that the positive effect of IT investment on problemistic search is stronger when long term incentive pay to CEO is higher than lower.**

Innovation effort embedded in problemistic search is often difficult to observe, challenging monitoring to find clear signals and indicators that can reliably evaluate managerial decision making. In this innovation context, there is not clear theoretical prediction on the moderating effect of monitoring arrangement on the relationship between IT investment and problemistic search. With high degree of information asymmetry, monitoring arrangement may fail to work at all leading to a non-significant moderating effect on the one hand, or may induce misleading inference leading to a negative moderating effect on the other (He and Wang 2009). We therefore empirically examine this moderating effect instead of proposing specific hypothesis.

But, monitoring may play a salient role in non-innovation context, when information asymmetry between monitors and managers is relatively lower. Especially, Ho et al. (2011) found that the monitoring of board can strengthen the positive relationship between IT investment and firm profitability. But, when the scarcity of IT investment is also taken into account, we argue that board monitoring may not always be good. The effectiveness of board monitoring depends on the information characteristics of the specific management task that is to be monitored. While board directors can use various signals as the basis such as other firms’ typical practices to evaluate IT decisions for ordinary routines, such signals are likely to be rather noisy and sometimes misleading.

Ho et al. (2011) maintained that “evaluating managers’ IT investment decisions requires technology-related information that shareholders often lack” (p. 598). Board directors therefore usually control managers’ IT decisions on the inappropriate basis of industry consensus away from their firms’ need of IT (Ho et al. 2011). This is particularly problematic when board directors who are lack of daily operation knowledge specific to a firm monitor the deployment of novel IT systems. In order to gain competitive advantage, a firm’s use of innovative IT should be based on mindfully reasoning grounded in organizational facts and specifics (Swanson and Ramiller 2004). Otherwise, the rent generated by IT investment will be competed away by competitors’ imitation (Dewan and Ren 2011, Hitt and Brynjolfsson 1996).

Monitoring is not without costs, which can be prohibitively high if monitors have great difficulty in observing and interpreting specific decision making (Zajac and Westphal 1994). If so, it is better to grant managerial discretion instead of monitoring managers closely with a lack of solid knowledge needed for monitoring. There is evidence that unnecessary inference of monitoring arrangement such as CEO-chairperson duality will induce counterproductive results in deployment of innovative resources (He and Wang 2009). As an important structural arrangement relevant to the degree of board monitoring, CEO-chairperson duality occurs if a firm’s CEO also chairs its board of directors (Boyd 1995). Generally, if a CEO is the chairperson, the monitoring function of the board will be compromised because it is easier for the CEO to entrench the directors of the board (Finkelstein

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² While corporate governance mechanisms may moderate the relationship between performance feedback and adjustment of IT investment (the relationship in H1), we cannot theoretically predict the sign of this moderating effect and propose specific hypothesis. This is because appropriate corporate governance mechanisms may reduce either overinvestment or underinvestment in IT caused by agency problems, leading to stronger or weaker relationship between performance feedback and adjustment of IT investment. However, in either way, appropriate corporate governance mechanisms will increase the fit between IT investment and the need of problemistic search, demonstrating a positive moderating effect on the relationship between IT investment and problemistic search.
and D’Aveni 1994). Thus, CEOs serving as the chairs of boards are loosely monitored and have more managerial discretion in deployment of resources. In this case, IT resources are likely to be deployed to facilitate ordinary routines based on managers’ professional judgment of firm specifics and generate higher rent. Thus, CEO-chairperson duality is expected to strengthen the direct effect of IT investment on future profitability, leading to the following hypothesis.

H6: CEO-chairperson duality positively moderates the relationship between IT investment and future profitability, such that the positive effect of IT investment on future profitability is stronger when CEO chairs the board of directors than CEO does not.

Long term incentives make managers to maximize the sum of profits in long period of time (Balkin et al. 2000). There is not a clear theoretical prediction about how long term incentive pay will moderate the relationship between IT investment and future profitability in a specific year. In order to deploy IT resources for improving long term profitability, managers may or may not sacrify the return on IT investment in a specific year. It indicates the moderating role of long term incentive alignment in the direct effect of IT investment on profitability in a future year may be positive, negative, or non-significant (as a result of the positive and negative effects canceling out among firms). We therefore empirically examine this moderating effect instead of proposing specific hypothesis.

3 Methodology

3.1 Data

We test our theory based on a large-scale sample from U.S. public firms where owners and managers are separate, which is particularly suitable to our study as these firms are most likely to suffer from agency problems. Our data used in this study were mainly from five archival sources. First, we obtained IT data from Computer Intelligence (CI) database in 2001-2006. CI database has been widely used in IS research and generally regarded as the most comprehensive IT data source with high quality (Chewlos et al. 2010, Dewan and Ren 2011, Kleis et al. 2012, Xue et al. 2012). Second, we matched IT data from CI database to Compustat Industrial Annual database containing financial data for U.S. public firms, based on a computer algorithm and manual check of company names by one of the authors. This is a very time-consuming process took about half a year, with an aim to obtain an initial sample of public firms as large as possible. Third, we merged our initial sample to Compustat Executive Compensation database to obtain CEO compensation data. Then, we further merged the resultant data set to IRRC Directors database in order to get CEO duality data.

Similar to prior IT innovation studies (Kleis et al. 2012, Xue et al. 2012), we finally matched the data set obtained earlier to NBER Patent Citations database to construct our patent-based measure of problemistic search. NBER Patent Citations database provides detailed information about over 3 million U.S. patents granted between 1976 to 2006 and almost 24 million citations of these patents. Because our unit of analysis is the firm, we aggregated patent and citation count data to the firm level (Katila and Ahuja 2002, Rosenkopf and Nerkar 2001). After merging all of these databases, it results in a final sample of 546 unique firms in 2001-2006 with an unbalanced panel structure (about 1700 firm-year observations with a few missing values for some variables). Our sampled firms are distributed in 212 SIC four-digit industries, indicating good representativeness.

3.2 Key Measures

Profitability and Aspiration Level: We follow past literature and use ROA as the measure of profitability ($\text{PERF}_t$), which is calculated by net income over total assets (Greve 2003a, 2003b). It has been suggested that managers’ satisfaction is determined by historical comparison between current and previous profitability and social comparison between self and industry average profitability (Cyert and March 1963, Greve 2003a). To operationalize aspiration level, we use a formative measurement based on a firm’s previous profitability and the average profitability of its SIC four-digit industry\(^3\). We use recently developed technique to estimate the formative measurement of aspiration level in PLS, which will otherwise face identification problems in

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\(^3\) Because the two indicators theoretically represent distinct dimensions and do not necessarily co-vary with each other, it is appropriate to use a formative measurement (Petter et al. 2007). We found that these two indicators had low internal consistency with a Cronbach’s alpha of 0.095, much lower than the threshold of 0.7 that reflective measurement requires.
covariance-based SEM (Wetzels et al. 2009). The PLS results show a good fit of measurement with significant path coefficient ($β = 0.690, p < 0.001$). We obtain PLS construct scores as the values of aspiration level. The gap between prior profitability and aspiration level is then calculated by the absolute value of prior profitability ($PERF_{t-1}$) minus aspiration level ($ASP_{t-1}$). Because behavioral theory of the firm suggests that managers become unsatisfied only if profitability is below (rather than above) aspiration level, we follow the standard split procedure used in past literature and replace the values of gap by zero if prior profitability is above aspiration level (Greve 2003a, 2003b). Equation (1) shows how we calculate the gap of prior profitability and aspiration level ($PERFGAP_{t-1}$).

$$PERFGAP_{t-1} = \begin{cases} \lfloor PERF_{t-1} - ASP_{t-1} \rfloor, & PERF_{t-1} \leq ASP_{t-1} \\ 0, & PERF_{t-1} > ASP_{t-1} \end{cases}$$

where $ASP_{t-1} = f(PERF_{t-1}, PERF^{NC-1}_{t-1})$ (1)

**IT Investment:** Our conceptualization of IT investment requires us to measure both the scale and scarcity of IT resources that a firm accumulates. Following prior literature, we first use hedonic method\textsuperscript{4} to derive the implicit prices for a wide set of basic components of IT systems (e.g., mainframe, minicomputer, PC, LAN, etc.), and multiply their numbers used by all business units of a firm with corresponding prices to calculate the scale of IT investment for each firm (Chwelos et al. 2010). We then deflate above nominal value of IT scale by using appropriate IT price indices to 2001 U.S. dollar and scale it by total assets (Chwelos et al. 2010). To capture the scarcity of IT investment, we create an index to weight IT scale by the scarcity of IT systems adopted by a firm in its industry. We leverage the detailed business unit-level data from CI database about whether each type of IT systems $i$ (accounting, HRM, SCM, CRM and others) was adopted in each business unit of a firm (Hitt et al. 2002). We then calculate one minus the percentage of adopted business units in every SIC four-digit industry and take the average across five types of IT systems as the scarcity index varying from 0 to 1 (Spetz and Baker 1999). As equation (2) shows, our final measure of IT investment ($IT_t$) for each firm-year observation is the IT investment scale ($ITS_i$) weighted by scarcity index. We calculate adjustment of IT investment for each firm-year observation by the percentage of change in IT investment compared to that of one year before.

$$IT_t = ITS_i \times \sum_{i=1}^{5} \left(1 - \frac{\# ADOPBU^{NC-1}}{\# ALLBU^{NC-1}}\right) / 5$$

**Corporate Governance:** We measure long term incentive pay to CEO ($LTIP_t$) by the proportion of long term incentive pay in total compensation to the CEO of a firm (Balkin et al. 2000, Miller et al. 2002). CEO-chairperson duality ($DUAL_t$) is measured by a dummy variable (yes = 1, no = 0) indicating whether a firm’s CEO also chairs the board of directors (Boyd 1995, Finkelstein and D’Aveni 1994).

**Problemistic Search:** Measuring problemistic search has long been challenging (Greve 2003a), with a trend of using patent citations to infer search (Katila and Ahuja 2002, Rosenkopf and Nerkar 2001). Because a patent includes well defined technical problem and solution to that problem (Walker 1995), patent data thereby provide detailed and consistent chronology of problem solving. Because problem solving is accomplished through knowledge recombination (Katila and Ahuja 2002, Rosenkopf and Nerkar 2001), patent citations record how a firm searches knowledge elements from itself and others to solve the specific problem. Each citation can be viewed as a knowledge element processed by search for knowledge recombination toward patent invention. Thus, a reasonable proxy of problemistic search ($SEARCH_{t-1}$) would be citation counts made by a firm, reflecting how extensive problemistic search was carried out based on resources invested one year ago.

### 3.3 Control Variables

We control several important firm and industry characteristics to rule out possible confounding effects. Specifically, we control several firm variables that may be associated with a firm’s need of IT, including the size of IT department proxied by the natural logarithm of the number of IT labor, firm size proxied by the natural logarithm of total assets, intangible assets proxied by Tobin’s q, debt ratio by long term debt over total assets, diversification calculated by the total Entropy measure, R&D intensity as R&D expenditure over total assets, and

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\textsuperscript{4} Hedonic method is used to derive implicit prices of IT assets and make the measurement methods consistent across years. More details can be found in the Online Appendix A of Chwelos et al. (2010).
advertising intensity as advertising expenditure over total assets. This is because large, diversified firms with more IT labor usually have more IT investment, which may compete with other budgets for financial investment in R&D and marketing (Kobelsky et al. 2008). Moreover, industry competition and environmental dynamism may affect a firm’s IT investment (Kobelsky et al. 2008), which are controlled by a firm’s market share in SIC two-digit industry, concentration ratio proxied by the market share of the biggest four firms in SIC two-digit industry, and industry uncertainty proxied by the standard deviation of the natural logarithm of shipments in SIC two-digit industry. SIC one-digit industry and year dummies were also included in analysis to control the fixed effects of industry and time. We control R&D intensity, advertising intensity, firm size, diversification, and debt ratio that are associated with a firm’s resource base and slack in predicting problemistic search and future profitability (Cyert and March 1963, Greve 2003a). In addition, we control non-IT capital and firm growth proxied by annual percentage of change in sales, related to the input and inertia of firm growth (Penrose 1959). We additionally control patent intensity corresponding to the citation counts by the number of patents granted over total assets, in order to better address the concern of reverse causality (Kleis et al. 2012). Market share, industry concentration, and industry uncertainty, in conjunction with industry and year dummies were also included to control industry competition and dynamism influencing search and profitability (Greve 2003a).

4 Results

Due to length limit, we only provide descriptive statistics and correlations of variables for enquiry. Because our data have an unbalanced panel structure, we pool the data and control for intragroup correlation resulted from multiple observations of the same firms across year by clustering technique. We use OLS regression with clustered robust standard errors to test our hypotheses. To test H1, we estimate a model with one-year lagged adjustment of IT investment as the dependent variable. To test H2 and H4, we estimate two models by regressing one-year lagged problemistic search and two-year lagged profitability (with one-year lag to problemistic search) on IT investment and control variables. We then use Sobel test to examine the mediating effect in H3 based on regression results. We add product terms to test the moderating effects of H5 and H6. We use mean-centering approach to avoid the risk of multicollinearity.

Table 1 reports OLS results for testing H1. After adding the gap of prior profitability and aspiration level to the control model, we found a highly significant and positive relationship between the gap and adjustment of IT investment. Therefore, it supports H1 and indicates that greater gap between prior profitability and aspiration level leads to an increasing adjustment of IT investment with greater scale and scarcity.

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Note: N = 1640. * p < 0.1; ** p < 0.05; *** p < 0.01. Dependent variable is ITADJ\(_{t+1}\). Clustered robust standard errors are in parentheses. Control variables and industry and year dummies are not tabulated due to length limit.

Table 1. Regression results for adjustment of IT investment

Table 2 reports OLS results for testing remaining hypotheses. We found that IT investment had significant and positive effects on both problemistic search and future profitability. Thus, H2 and H4 are supported. We then conducted a Sobel test and found that the mediating effect of problemistic search in the relationship between IT investment and future profitability was significant (Sobel \(z = 2.188\), Aroian \(z = 2.133\), Goodman \(z = 2.247\), \(p < 0.05\)), supporting the argument of H3. In addition, we found significant and positive interaction effect between IT investment and long term incentive pay on problemistic search, supporting H5. We also found significant and positive interaction effect between IT investment and duality on future profitability, supporting H6. However, we did not observe significant moderating effect of duality on IT-search relationship and that of long term incentive pay on IT-profitability relationship. To illustrate the moderating effects of corporate governance mechanisms, we plot the moderating effects in Figure 1. It shows that, when CEOs have low level of long term incentive pay (-1SD), increasing IT investment even leads to slightly less problemistic search. When their long term incentive pay is high (+1SD), there is a rapid increase in problemistic search with increasing IT investment. If a firm’s CEO is also the chair of board, increasingly IT investment results in tremendous improvement of future
If there is not CEO-chairperson duality in a firm, we do not observe any effect of IT investment on future profitability.

Table 2. Regression results for problemistic search and future profitability

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<td>(0.639)</td>
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<td>(1.355)</td>
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<td>LTIP(_t)</td>
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<td>977.175***</td>
<td>15.179</td>
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<td></td>
<td>(0.750)</td>
<td>(0.018)</td>
<td>(346.016)</td>
<td>(9.691)</td>
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<tr>
<td>IT(_t) × LTIP(_t)</td>
<td>977.175***</td>
<td>15.179</td>
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<td></td>
<td>(346.016)</td>
<td>(9.691)</td>
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<tr>
<td>DUAL(_t)</td>
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<td>-0.004</td>
<td></td>
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<td></td>
<td>(0.180)</td>
<td>(0.005)</td>
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<tr>
<td>IT(_t) × DUAL(_t)</td>
<td>-2.440</td>
<td>3.826***</td>
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<tr>
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<td>(1.441)</td>
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<tr>
<td>SEARCH(_{t+1})</td>
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<td>0.003**</td>
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<tr>
<td></td>
<td>(0.001)</td>
<td>(0.001)</td>
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<td>Yes</td>
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<td>Adj. R(^2)</td>
<td>0.450</td>
<td>0.089</td>
<td>0.453</td>
<td>0.093</td>
<td>0.452</td>
<td>0.092</td>
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<td>F</td>
<td>63.07***</td>
<td>7.82***</td>
<td>58.86***</td>
<td>7.59***</td>
<td>58.57***</td>
<td>7.56***</td>
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</table>

Note: N = 1747. * p < 0.1; ** p < 0.05; *** p < 0.01. Clustered robust standard errors are in parentheses. Control variables and industry and year dummies are not tabulated due to length limit.

The dynamic adjustment of IT investment indicates that IT investment can be affected by profitability as well, leading to a concern of the causality between IT investment and profitability. Although we already establish temporal precedence with lagged dependent variables, endogeneity is still possible to make OLS results not consistent. To further address endogeneity issues, we conducted several robustness checks as Table 3 shows. First, we additionally controlled one- and two-year backward lagged profitability and reexamined the effect of IT investment on future profitability. We still found that IT investment had significant and positive effect on future profitability, suggesting our results are less likely biased by reverse causality and autocorrelation. Second, we selected one-year backward lagged IT investment and IT labor costs in addition to industry and year dummies as the instrumental variables (Kleis et al. 2012, Ray et al. 2009), and found a significant and positive effect of IT investment on future profitability by using 2SLS. Our instruments passed overidentification test with Hansen J = 14.089 (p = 0.295), indicating the validity of them. Third, we leveraged dynamic panel analytical technique – system GMM to control unobservable variables by using one- and two-year backward lagged values of the differences and levels of dependent variable as internal instruments (Arellano and Bover 1995). Again, IT investment showed significant and positive effect on future profitability. Finally, we used firm fixed effects model to control time-invariant unobservable variables and found that IT investment had significant and positive effect on one- and two-year lagged profitability.
Based on a perspective that managers are bounded rational and selfish in their decision making, our study makes novel contributions to IS literature. This study systematically introduces a behavioral theory to study the dynamics of managerial decision making with regard to adjustment and deployment of IT resources. We draw on behavioral theory of the firm to theorize managerial decision making for IT investment as a process of organizational learning based on performance feedback. Our results support that managers are bounded rational and selfish in their decision making, our study makes novel contributions to IS literature. This study systematically introduces a behavioral theory to study the dynamics of IT resources adjustment and deployment from a behavioral perspective. In addition, our study bridges two separate streams of IT innovation research by investigating both direct and indirect rent-generating mechanisms of IT investment resulted from dynamic adjustment. On the one hand, a stream of IT innovation research focuses on the adoption of innovative IT and its performance impact (Fichman 2004a, Swanson and Ramiller 2004). On the other hand, recent IT innovation studies increasingly examine how IT in post-adoptive stage may enable other innovation activity such as knowledge production and new product development (Joshi et al. 2010, Kleis et al. 2012, Tambe et al. 2012). In this study, we theorize both direct and indirect mechanisms by which IT investment realizes rent-generating potential and incorporate both scale and scarcity as the facets of IT investment. We believe that our weighted measure of IT investment can better reflect the amount and nature of IT investment, which is particularly suitable for IT innovation research.

This study also contributes a contingency understanding of rent-generating potential of IT investment by integrating behavioral theory and agency theory. By extending behavioral theory with an agency perspective, our theory admits possible agency problems in managers’ decisions with regard to adjustment and deployment of IT resources. Because of managerial hazard for pursuing self-interest rather than firm profitability, we highlight the importance and appropriateness of corporate governance mechanisms in rent generation of IT investment resulted from dynamic adjustment based on managers’ decisions. Long term incentive alignment is found to be more suitable to reduce myopia and encourage long term orientation of CEOs in adjusting and deploying IT resources for innovative routines, which thereby strengthens the relationship between IT investment and problemistic search. Monitoring arrangement alleviates the direct effect of IT investment on future profitability, because board directors often lack sufficient technology-related and daily operation knowledge. Our study has some limitations. First, we follow behavioral tradition and focus on the performance feedback based on firm profitability. While it is fair to assume that profitability is the ultimate and the most important management target, future research may investigate other dimensions of performance such as firm growth, market share, and market value that are controlled in this study. Second, while this study investigates two major corporate governance mechanisms of incentive alignment and monitoring, we focus our attention on those particularly designed for CEOs. Although CEOs are the final decision makers at the highest level of management hierarchy, future study may examine the mechanisms designed for other top managements such as CFOs, COOs, and CIOs. Especially, as CIOs play an increasingly important role in contemporary firms, they may directly

### Table 3. Regression results for robustness checks

<table>
<thead>
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<th></th>
<th>OLS</th>
<th>2SLS</th>
<th>GMM</th>
<th>FE</th>
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<tr>
<td></td>
<td><strong>PERF</strong>&lt;sub&gt;_t_2&lt;/sub&gt;</td>
<td><strong>PERF</strong>&lt;sub&gt;_t_2&lt;/sub&gt;</td>
<td><strong>PERF</strong>&lt;sub&gt;_t_3&lt;/sub&gt;</td>
<td><strong>PERF</strong>&lt;sub&gt;_t_4&lt;/sub&gt;</td>
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<td><strong>IT&lt;sub&gt;_t&lt;/sub&gt;</strong></td>
<td>1.078** (0.442)</td>
<td>0.740* (0.385)</td>
<td>1.799*** (0.643)</td>
<td>1.310** (0.639)</td>
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<tr>
<td><strong>PERF</strong>&lt;sub&gt;_t+1&lt;/sub&gt;</td>
<td>0.176*** (0.068)</td>
<td>0.400*** (0.111)</td>
<td>6.03*** (0.335)</td>
<td>3.15* 3.01** 2.59</td>
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<tr>
<td>Controls Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
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<tr>
<td>R&lt;sup&gt;2&lt;/sup&gt;</td>
<td>0.176</td>
<td>0.321</td>
<td>0.335</td>
<td>0.001</td>
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<tr>
<td>F/Wald Chi&lt;sup&gt;2&lt;/sup&gt;</td>
<td>15.27***</td>
<td>33.87***</td>
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<td>3.15* 6.02**</td>
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<td>N</td>
<td>1747</td>
<td>1747</td>
<td>1318</td>
<td>557</td>
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</table>

Note: * p < 0.1; ** p < 0.05; *** p < 0.01. Clustered or heteroskedasticity-consistent robust standard errors are in parentheses. Control variables and industry and year dummies are not tabulated due to length limit.
engage in the decision making with regard to adjustment and deployment of IT resources. Due to data availability, we are unable to examine the corporate governance mechanisms designed for them. Future study may collect data from CIOs and adapt our theory to investigate this interesting area. Last but not least, we used a sample from US public firms to examine our theory. While our findings are not expected to be specific to this sample, future research may collect data from private firms in other countries to test our theory.

Our study allows important practical implications for both managers and owners. Based on the data in recent years, we found that managers dynamically adjusted investment in IT, in terms of both scale and scarcity, when prior performance did not meet management expectation. This dynamic adjustment process of IT investment was positively associated with performance in the future. To achieve better performance, we found that problem solving with innovation was an important mediating mechanism, and thereby suggest managers to dynamically adjust and deploy IT resources based on performance feedback to facilitate innovation activity. From the perspective of owners, it should be understood that not all corporate governance mechanisms are functional across contexts. Even worse, inappropriate governance mechanisms may result in counterproductive outcomes under certain contexts. To better govern the dynamics of managerial decision making for IT investment, incentive alignment seems a better strategy than monitoring.

References


