A Longitudinal Study of Market and Firm Level Factors Influencing ERP Systems Adoption and Post-Implementation System Enhancement Options

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Abstract

We examine whether firms' investments in ERPS, including the initial adoption decision and subsequent system enhancements are consistent with economic determinants and a real options perspective. We model ERPS adoption and subsequent enhancements (in the form of upgrades or add-ons) as two separate but related decisions on the exercise of real options in a continuous implementation process. We find that ERPS adopting firms are more likely to operate in highly concentrated industries, be industry leaders, and have lower investment opportunities and higher free cash flows than non-adopters. The findings are consistent with a real options lens suggesting that the adoption of ERPS spawns growth options by creating barriers of entry, enhancing competitiveness, and providing the flexibility needed to adapt to new opportunities. In contrast, subsequent system enhancement decisions are affected by how quickly companies begin to reap the benefits they sought to accomplish in the initial ERPS adoption and by the use of high-quality post-implementation activities (as posited by Nicolaou 2004a and examined in Nicolaou and Bhattacharya 2008) that relate to project planning, strategy, and process integration. These findings suggest that the implementation and use of ERPS may enable flexibility and organizational capabilities which, in turn, allow management to optimally reconfigure the investment in ERPS by exercising operational options to enhance the system in the post-implementation period. Overall, our evidence is consistent with the adopted real options theory lens and suggests that firms should embed real options value in ERPS investments.

Keywords: IT investments, ERP systems adoption, ERP systems post-implementation review, system enhancements, market effects, firm effects, longitudinal study, real options theory.

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I. INTRODUCTION

The implementation of enterprise resource planning systems (ERPS) often results in failures, and prior surveys have shown that a 30 percent failure rate is not unusual (The Standish Group 2001), while as many as 80 percent of such projects run over their initial budgets (Walkerden and Jeffery 1997). In such situations, where a high risk of failure exists due to ERPS adoption and subsequent implementation problems, it is important not just to recognize the future value of the system as just a single project, but also to assess potential future choices in system implementation which may enhance the strategic value of the system. In this paper, we conduct a longitudinal study of ERPS project decision-making, including initial adoption and subsequent post-implementation choices, from a real options perspective.

The real options theory logic best applies in situations involving ERPS implementation and long-term use, as they deal with irreversible decisions under high uncertainty. A real option is synonymous to flexibility. The holder of an option has the right, but not the obligation to take ownership of an underlying asset at a future point in time. Because management will only exercise a real option if its expected outcome has incremental value over other planned benefits, real options always add value to a project (Barnett 2005; Copeland 2001; Trigeorgis 1996). An increase in flexibility when investing in IT infrastructure, for example, has been shown to have a positive influence on the value of IT investments (Benaroch and Kauffman 2000; Taudes et al. 2000). Real options theory offers a lens through which we can examine whether organizations recognize opportunities to create options in ERPS implementations, value these options, predict how such valuations affect

decision choices, and recommend how ERPS implementations should be managed in order to realize this value.

Extant information systems (IS) research on real options has, to date, focused mainly on prescriptives regarding the evaluation of options and the active management of investment risks (e.g., Bardhan et al. 2004; Benaroch and Kauffman 2000; Benaroch 2002; Benaroch et al. 2006; Benaroch et al. 2007; Clemons and Gu 2003; Fichman 2004; Kumar 2004; Schwartz and Zozaya-Gorostiza 2003; Taudes et al. 2000). Only limited research has examined whether management decisions about information technology (IT) investments are consistent with real options theory. Tiwana et al. (2006, 2007) show in an experimental setting that managers tend to intuitively associate real options with the evaluation of troubled projects and projects with low quantifiable benefits. Benaroch et al. (2006) empirically examine whether managers appear to control investment-specific risks using real options. They too find that IT managers indeed follow the logic of real options in managing IT investment risk, albeit purely based on intuition. However, these studies only use experimental or project-level data and offer little insights into the specific real options presented in large IT projects such as ERPS and their management.

The adoption and enhancement decision choices in ERPS present a unique context in which both growth and operating real options can be examined.[1] First, initial investments in ERPS enable strategic growth options as ERPS provide new opportunities for future initiatives that may enhance a firm's strategic agility and competitive flexibility or innovativeness (Benaroch 2002; Sambamurthy et al. 2003). Building ERPS provides for scalability in a firm's information infrastructure (Kumar, 2004), which is necessary for a firm to attain efficiency and competitiveness in both its internal as well as its external information supply chains (Johnston and Vitale, 1998; Nicolaou, 2008; Patnayakuni et al., 2006). ERPS

[1] Benaroch (2002) distinguishes between two classes of real IT options: operating options that allow to flexibly change investment configuration features (timing, scale, scope, etc.), and strategic growth options that spawn new investment opportunities.

also spawn additional investments in complementary organizational resources such as business process (re)design, work flow, and other IT-related complementarities (Melville et al., 2004).

Second, the resulting information infrastructure from the initial ERPS implementation can, in turn, enhance organizational capabilities and yield a number of new ERPS-related operating options, such as the option to defer, the option to change scale, the option to switch use, the option to abandon or the option to stage. Nicolaou and Bhattacharya (2006) have classified post-implementation system changes as modular additions, upgrades, abandonments, and switches. They find that system enhancements increase (reduce) the potential for gains (losses) on the base project. Further, Nicolaou (2008) suggests that embedding operating options in ERPS, enhancements in particular, can contribute to the investment value by enhancing the flexibility for further deployment of ERPS and/or add-on applications.[2] System enhancements can take the form of either modular additions to the original implementation or upgrades that occur as a result of vendor-supported version changes[3]. Our examination therefore focuses on system adoption and system enhancements in the long-term use of ERPS.

In this study we develop cross-sectional models that examine the optimal exercise of these ERPS-related options. We track firms announcing initial ERPS implementation decisions during the 1989–1998 period, and also examine their system enhancement choices for a 10-year post adoption period (till 2008). Since companies actively manage ERPS-related options to enhance the investment value throughout the investment life-cycle (e.g.,

[2] Prior research also suggests that system enhancement options provide organizations with the flexibility to alter or expand the initially planned application capabilities, thereby increasing investment payoffs (Benaroch, 2002; Benaroch et al., 2006; Taudes et al., 2000).

[3] Two other ERPS-related operating options, system switchings and system abandonments, are not included in our examination because they are both rare and less publicized. Those decisions typically involve prior implementation failure or significant prior implementation difficulties (Nicolaou and Bhattacharya 2006; 2008).

Nicolaou and Bhattacharya 2006; Nicolaou 2008),[4] we model ERPS adoption decisions and subsequent enhancement choices as two separate and distinct, yet related, decisions on the exercise of real operating options in a continuous implementation process. This approach represents a departure from Benaroch et al. (2006), who examine various option types (defer, pilot, prototype, stage, abandon, contract, and outsource) presented in different IT projects from a single organization. In contrast, we examine the adoption and enhancement options specifically related to an ERPS investment. Because investments in ERPS are expensive and irreversible, a question of interest relates to differences in the economic determinants driving ERPS adoption choices. Furthermore, because ERPS are modular and implemented over the long term, we also examine how such choices at the adoption stage affect subsequent system enhancement events.

We develop predictions and test determinants of ERP adoption decisions. We expect that adoption of ERPS will be positively associated with increased demand for competitive flexibility and growth opportunities. Consistent with our expectation, we find that ERPS adopting firms are more likely to operate in highly concentrated industries, be industry leaders, and have lower investment opportunities and higher free cash flows than non-adopters. These findings suggest that ERPS adoption events embed future growth options leading to competitive advantage by creating barriers of entry and providing the flexibility needed to adapt to new growth opportunities, and are also consistent with past related findings (e.g., Nicolaou, 2004b, 2008; Subramani 2004).

Further, and consistent with the modular nature of ERPS, we also find that the financial performance effect of the initial ERPS implementation combined with the use of high-quality post-implementation review (PIR hereafter) activities, as posited by Nicolaou

[4] Surveys show that ERPS implementations differ from other IT projects in that they are not single events (Faleti, 2001; Willis and Willis-Brown, 2002). Research also shows that the degree to which an ERPS implementation is successful is moderated by various factors or decision choices during the ERPS implementation process (Nicolaou, 2004a, b; Nicolaou and Bhattacharya, 2006, 2008; Ranganathan and Brown, 2006).

(2004a) and further validated by Nicolaou and Bhattacharya (2008), significantly increase the probability of subsequent system enhancements. System enhancement options tend to be exercised during the medium-term of the ERPS implementation period (3 to 5 years post-adoption), and follow positive initial performance outcomes. These improvements in performance are found to be associated with firms which follow such well-planned PIR practices as project planning, strategy, and process integration. As a result, the value-generating effect of ERPS adoption is contingent on high-quality PIR practices, *ex-post*. These findings suggest that the implementation and use of ERPS enhances financial flexibility and organizational capabilities which, in turn, enable management to optimally reconfigure the investment in ERPS using various operational options. Our findings also lend support to the argument that proactively embedding flexibility into risky IT investments is value maximizing (Amran and Kulatilaka, 1999; Benaroch, 2002; Benaroch et al., 2006).

Overall, our findings suggest that some firms, as a consequence of their innate characteristics, are *a priori* more prone to invest in ERP systems, and more capable of building future flexibility into such investments. Their subsequent actions, modeled as exercises of system enhancement options, further their lead vis-à-vis their peers. Our evidence is consistent with economic determinants of differences in ERPS investments, and with the real options perspective which suggests that proactively embedding options (flexibility) into risky IT investments can add relative long term value (Amran and Kulatilaka 1999; Benaroch 2002; Benaroch et al. 2006).

The remainder of the paper is organized as follows. Section II reviews literature on factors affecting the implementation of ERPS, and develops the research hypotheses for this study. Section III develops cross-sectional models for the optimal exercise of ERPS-related operating options as two separate but related decisions. Section IV presents our empirical findings and Section V concludes the study.

II. BACKGROUND AND HYPOTHESES DEVELOPMENT

The theory of irreversible investments suggests that if risk-neutral firms cannot dispose of installed capital, uncertainty regarding demand or competition reduces current investments due to high switching costs (e.g., Arrow, 1968). In this approach toward risk, the internal rate of return and discounted cash flow (DCF) of initially projected values constitute the preferred methods to evaluate the efficacy of long-term investments (Graham and Harvey 2001). However, these methods do not consider any value due to the flexibility of management to alter the scope or enhance a project as it progresses. Real options exist in the long-term implementation of ERPS, regardless of whether their value is realized and incorporated in decision making. An irreversible investment, such as an ERPS project, creates real options because it offers the flexibility of changing such investment configuration features as postponing the project, changing its scale, or staging implementation so as to partially dispel uncertainty via new information.

The exercise of ERPS real options is costly to the firm and should be carefully planned (e.g., Nicolaou 2004a, Nicolaou and Bhattacharya 2008). Viewing each ERPS project as a portfolio of real options, we empirically examine managerial decisions related to the growth and operational options in ERPS investments. We argue below that ERP-related real options may have different implications for firms with varying characteristics of competition, market power, financial flexibility, and system implementation practices. We then perform an empirical analysis of these features using longitudinal firm-level data.

Guiso and Parigi (1999) suggest that the effect of uncertainty on an irreversible investment varies by the degree of competition in the product market. We expect firms with substantial market power to be more likely to adopt ERPS for purely strategic advantages, continuing to act as market leaders and embracing new opportunities for growth. Investments

in ERPS can present follow-up growth opportunities as ERPS entail future initiatives that enhance a firm's strategic agility and competitive flexibility or innovativeness (Sambamurthy et. al., 2003). Research shows that intensive investment in technology reflects a firm's efforts to differentiate itself and mitigate competition from new entrants and existing competitors (Kamien and Schwartz, 1975). One interpretation is that high IT investment intensity could imply high monetary and technical barriers to entry and lower competition from the industry to which a firm belongs. This suggests a potential for the firm to earn economic rents. In other words, industries with lower competition enjoy greater entrance barrier benefits by investing in ERPS. Conversely, the materialization of competitive risks can result in project abandonments, i.e., the killing off of an investment and the redirecting its resources to alternate uses (Clemons and Weber, 1990).

A second interpretation of the theory of irreversible investments as it relates to ERPS may be that leaders in an industry have greater incentives to invest in technology than followers in order to enhance and cement their leadership in the market.[5] If the investments in ERPS pay off, then a leader can keep or increase its current market share in the future. Prior literature examining IT capability suggests that leaders in IT enjoy strategic benefits from increased organizational capabilities and long-lasting operational efficiencies (Bharadwaj, 2000; Clemons and Row, 1991; Mata et al, 1995).[6]

[5] This argument contrasts but is not contrary to the view of Arrow (1962), who suggests that, on average, incumbents have lower incentives to invest in technology (i.e., R&D) than outsiders due to lower entry pressures. We argue that difference exists between industry leaders and followers due to leaders' quests for staying one step ahead of the competition.

[6] For example, Intel has successfully implemented an ERPS environment that is based on industry-standard servers and supports more than 10,000 active users. Intel's competitor strategy is to remain innovative and always a step ahead of the competition. It created the "Intel Inside®" brand that is the symbol of quality and it has formed an alliance with Microsoft to complement its product offerings. It realized early on that increased demand for faster chips would not come about from software advancements alone; and that a needed push could come from video. As a result, Intel has also created alliances with other software providers to create virtual reality video games and with telecommunication providers to increase the capacity of fiber optic networks over which data is transmitted. Its focal alliance with Microsoft has thus been greatly complemented by these other alliances, as they have not only pushed up the demand for faster chips but also for new software applications that take advantage of superfast processing cycles (Brandenburger and Nalebuff, 1996; see also Intel's 2009 White Paper on information technology, "Deploying ERP on Cost-effective Industry-standard Servers", available at http://download.intel.com/it/pdf/321373.pdf).

Prior literature also indicates that system enhancements (e.g., upgrades and add-ons) that are carried out in a timely manner might also help an organization differentiate itself from competitors and gain higher differential returns (Kremers and Van Dissel, 2000, p.56). Kremers and Van Dissel (2000) suggest that the choice of an enhancement is more likely to be a contingent corrective action in response to observed conditions. It is possible that firms exercise enhancement choices in response to unexpected increases in demand (Benaroch 2002).

Based on the above, we expect that the degree of competition in a firm's industry and the strength of the firm's market power affect both the initial ERPS adoption and its subsequent enhancement decisions. We, therefore, state our first set of hypotheses in the alternative form as follows:

H1a: Ceteris paribus, the exercise of the option to adopt ERPS is negatively related to the degree of competition in a firm's industry and positively related to the strength of the firm's market power.

H1b: Ceteris paribus, the exercise of the option to enhance ERPS is negatively related to the degree of competition in a firm's industry and positively related to the strength of the firm's market power.

Since ERP systems are modular and implemented over the long term, we expect the performance effects of the initial ERPS adoption along with various project implementation factors to further affect post-implementation enhancement choices. For example, Nicolaou (2004b) reports that expected benefits of ERPS implementation are clustered into improved productivity and decision making, external integration, and internal integration/improved customer service. In the same vein, Subramani (2004) suggests that collaborative support capabilities offered by ERPS can help level the competitive field in a firm's environment. In Seddon et al.'s (2010) model on organizational benefits, the more immediate benefits from implementing systems that match needs and are accepted by users, translate into successful business improvement projects, similar to our conceptualization of system enhancements. Nicolaou (2008) argues that the use of ERPS can ease inter-firm tensions and facilitate a

firm's potential to enhance performance via strategic alliances. Recent evidence from supply chain logistics relationships suggests that active balancing, rather than entirely competitive or cooperative stances, positively impact strategic information flows through customized IT, promote mutual trust, and enhance performance (Klein et al., 2007). Prior research, thus, has successfully demonstrated that the adoption and use of ERPS has a potentially significant influence on the adopting firm's financial performance outcomes (Hunton et al., 2003; Nicolaou, 2004b; Poston and Grabski, 2001).

However, as mentioned above, we cannot expect all ERPS to have the same value potential due to implementation variations that influence the integration potential and thus the option value of the initial ERP investment (Nicolaou, 2004b; Ranganathan and Brown, 2006; Seddon et al. 2010). For example, Ranganathan and Brown (2006) report that the choice of implementation site and choice of modules are two key project decisions that significantly influence market reactions to ERPS investment announcements. Nicolaou (2004b) suggests vendor choice, implementation goal, module choice, and length of implementation to be moderators of attained performance effects of ERPS use. Seddon et al. (2010) argue that functional fit, or the extent to which functional capabilities of the system match organizational needs, is a major component of a project's on-going improvement and affects realized benefits.

Firms adopting ERP systems are likely to scale up their subsequent development efforts or operations if post-implementation reviews suggest both tangible and intangible benefits associated with the adoption and use of these systems. On the other hand, an expansion budget is likely to not be approved if reviews suggest that these systems have not been well-integrated, have not been well-accepted within the organization, or have not been able to improve profitability or lower personnel, inventories, or systems maintenance costs to the extent anticipated. Therefore, we expect the extent to which the decision to use ERPS

"matches" the organization's needs and generates positive returns to affect subsequent enhancement decisions. We state this in our second hypothesis in the alternative form as follows:

H2: Ceteris paribus, the exercise of the option to enhance ERPS is positively related to the extent to which the decision to use ERPS "matches" the organization's initial needs and the satisfying of its short-term post-implementation goals.

Prior research (Brown and Vessey, 2003; Nicolaou 2004a; Ragowsky et al., 2005) has examined the need for and the manner in which ERPS adopting firms plan and conduct PIR activities in order to maximize the benefits derived from ERPS implementations. Based on the Nicolaou (2004a) framework of PIR quality and its role in affecting ERPS performance outcomes, we also examine the association between high-quality PIR practices and post-implementation enhancements in companies that implement ERP systems. We expect high-quality PIR activities to increase the probability of subsequent enhancement choices for two primary reasons. First, high-quality PIRs act as moderators of attained performance effects (Nicolaou, 2004b), especially as they relate to the occurrence of system implementation planning and business process effectiveness activities (Nicolaou and Bhattacharya, 2008).

Second, Benaroch (2002) argues that since real options are not inherent in IT investments, they must be planned and intentionally embedded in a target IT investment so as to enable a beneficial configuration. Flexibilities can often be built by pursuing such risk countermeasures as over-engineering, information hiding designs, fault tolerant architectures, competitive designs, paired programming, cross training of IT personnel, more room for verification and validation, resource reservation and over-staffing. From this perspective, a primary goal of the PIR is to formulate a set of conditions that would enable an organization to build an adequate information infrastructure based on the ERP systems functionality. Further, an organization that follows a well-planned, high-quality PIR process would also be expected to expand on the basic ERP infrastructure and create opportunities for sustainable

future growth beyond any initial benefits that are anticipated. Therefore, it follows that firms that adopt high-quality PIR practices would be able to exercise a number of operating options during the PIR period, as well as be able to identify and assess in advance a planned set of growth options. We state this in our third hypothesis in the alternative form as follows:

H3: Ceteris paribus, the exercise of the option to enhance ERPS is positively related to high-quality PIR practices conducted by an organization.

Finally, we consider the optimal timing of systems transformation during the post-implementation period. Discrete changes may occur over several periods beyond the initial implementation and the timing of the option exercise may affect the returns that accrue to the option holder. The timing of system transformation is, therefore, a strategic choice as the changes are expected to help surface implementation issues that affect subsequent use of and success from the use of ERP systems (Nicolaou and Bhattacharya, 2006). Prior research on the performance effect of ERPS suggests that late enhancements are more likely to signify that necessary adjustments to the system were not performed in a timely manner, which, in turn, may be indicative of less than optimal control by the firm over its ERP processes. This would be expected to result in performance deterioration (Kremer and Van Dissel, 2000). In contrast, according to Nicolaou and Bhattacharya (2006), firms that initiate early enhancements in the form of either add-ons or upgrades, enjoy superior differential financial performance in comparison to other ERP-adopting firms' differential performance (Nicolaou and Bhattacharya, 2006).

Nicolaou and Bhattacharya (2006) define "early" as the year of systems completion and the year immediately following system completion. As most firms typically spend two to five years on their ERP implementation efforts following the initial adoption (e.g., Nicolaou, 2004b), we consider an early exercise to occur within five years of the year of initial ERPS adoption. Based on the above discussion, we expect the early exercise of enhancement

options to have a valuable beneficial implication for ERP systems transformations. We state this in our fourth hypothesis in the alternative form as follows:

H4: Ceteris paribus, the exercise of the option to enhance ERPS is more likely to occur during the early to medium term following the initial adoption.

III. RESEARCH METHOD

Sample

We use the original Nicolaou (2004b) data set to identify an initial sample of 247 firms announcing an ERP implementation from 1989 to 1998. The disclosed year of inception is coded as "t_0" to indicate the year of adoption. For the 247 ERP-adopting firms, we search the Lexis/Nexis database for post-ERP implementation enhancements using upgrade and add-on as search terms for the 10-year period post adoption (till 2008).[7] As discussed earlier, while add-ons to ERP systems typically take the form of modular additions to the original implementation, upgrades occur as a result of vendor supported version changes. Enhancements may also occur when other-vendor add-ons embellish systems. While these add-ons are not original vendor supported, they typically improve the ERPS' functionality in customer-specific ways.

For each of these 247 firms, we also used the company name and the term ERP or enterprise resource planning to search for announcements that relate to post-implementation review (PIR) activities. We used the initial adoption year as the base year and conducted a search for 10 years beyond that date (for details on this sample selection effort, refer to Nicolaou and Bhattacharya, 2008). We read each one of the announcements and coded the

[7] We also searched for abandonments and switches. However, we found abandonments and switches more difficult to trace—with the former being several degrees more difficult than the latter. This situation arose because both ERP vendors and their customers have vested interests in minimizing publicity related to ERP abandonments. While switches are not as stigmatizing as pure-play abandonments, they are, nevertheless, often viewed as precursors and predictors of unfavorable ERPS-related events. Hence, these were also relatively more difficult to surface when compared to the more favorable enhancement and upgrade criteria. Eventually, we identified 182 discrete changes with the breakdown of 148 add-ons, 15 upgrades, 11 switches and 8 abandonments. Only a few switches and abandonments remain in our sample after imposing the data requirement described later. Therefore, we restrict our analysis to only upgrades and add-ons.

information using the 14 PIR activities reported in the Nicolaou (2004b) PIR-Quality framework (see Table 1). A binary code was used wherein a "1" indicated the presence of a high-quality activity in a specific firm prior to and during the year of the enhancement and "0" indicated the absence thereof. We identified 79 ERPS-adopting companies that reported use of some PIR activities. In total, these 79 firms were found to have carried out a total of 171 high-quality PIR activities. The most frequently used activities included process integration (n = 33), project planning and attainment of benefits (n = 26 each), infrastructure and strategy (n = 20 each), and others with relatively lower frequencies.

We require the adopting firms to have the necessary financial statement variables available from Compustat. We retain 181 firms with required data for the year before adoption, year of adoption, and/or a minimum of three years following the adoption. To conduct the initial adoption test, we match each adoption firm with all non-adopting firms within the same two-digit SIC industry with sufficient data on COMPUSTAT at the year preceding the ERPS adoption year. We identify non-adopting firms as those without disclosures about ERPS adoptions based on our search of the Lexis/Nexis Newswires, Global Disclosure database, and websites of major ERP vendors, as described in Nicolaou 2004b. The above procedures yielded a control group of 20,168 non-adopting firms matching the 181 adopters in the final sample.

The sample for the system enhancement options tests also includes the 181 ERPS adopting firms, across the 10 years we used as the relevant post-implementation period for system enhancements and PIR activities. This resulted in 1,415 firm-year observations. The final number of observations (firm-years) is not an exact multiple of the 10 years due to higher frequency of missing data beyond the three year post-adoption requirement we imposed for the adoption test. The 181 firms finally included in the sample had exhibited a

total of 34 unique firm-year enhancement events. Panel A of Table 1 summarizes the sample selection, while Panel B presents the distribution of our sample firms by industry.

<Insert Tables 1 and 2 about here>

Research Model for the ERPS Initial Adoption Decision

We assume the ERP systems adoption decision to be characterized in the following form:

$$ADOPT_t = f\ (\text{Industry competitiveness}_{t-1};\ \text{Market power}_{t-1};\ \text{Firm size}_{t-1};\ \text{Profitability}_{t-1};\ \text{Investment opportunity set}_{t-1};\ \text{Cash flow}_{t-1};\ \text{Leverage}_{t-1};\ \text{Risk}_{t-1};\ \text{Years};\ \text{Industries}) \quad \textit{(1)}$$

where, period t is the year of initial ERPS implementation and all variables are defined as of the beginning of the ERPS adoption year unless otherwise specified.

The research model in Eq. (1) allows us to assess whether, in the cross-section, there is an association between demand conditions (industry competitiveness and market power) and ERPS adoption decisions (ADOPT) while also controlling for other factors that were previously shown to influence managers' investment decisions. This model addresses the predictions made in research hypothesis H1a. To conduct this analysis, we use the group of 181 ERPS adopting firms and the matched group of control firms, as described in our sample selection procedures and shown in Table 2.

Table 3 describes in detail how each of the variables in Eq. (1) is measured. We use the Herfindahl index to measure the competitiveness of an industry (Tirole 1988). This is defined as the sum of the squares of the market shares of each individual firm in an industry. Decreases in the Herfindahl index generally indicate an increase in competition, whereas increases imply the opposite (Tirole, 1988). We use market share to measure the concentration of market power (i.e., the ability of a market participant to manipulate prices), although the limitations of market shares as proxy of market power are widely acknowledged (see Boulding and Staelin, 1990). We expect both measures to be positively associated with

the probability of an ERPS adoption as the expected investment value of such a potential growth option is likely to be greater for firms with substantial market power.

We control for other factors affecting firms' incentives and ability to conduct a long-term large IT investment. We include firm size (logarithm of the market value of equity) and profitability (ROA), as smaller and less profitable firms have more volatile earnings and cash flows and thus greater uncertainty about their ability to fully fund the investment (see Benaroch, 2002). We also control for the effects of investment opportunity sets and the free cash flow problem on ERPS adoption decisions. Our primary proxy for expected investment opportunities is the market-to-book ratio (a rough proxy for Tobin's Q), calculated as the ratio of the market value of total assets to the book value of total assets (Fama and French, 2002). Prior research suggests that Q has a small, but significant positive effect on company investment (Blundell et al., 1992). We use sales growth as an additional proxy for expected investment.

The free cash flow hypothesis (Jensen, 1986) suggests that managers in firms with high cash flow and low investment opportunities tend to waste free cash flow (the excess of cash earnings over growth opportunities) on perquisites and bad investments (e.g., takeovers, leveraged buyouts). Firms that have the free cash flow problem have greater incentives to adopt ERPS as they have more need for the elimination of inefficiencies in an effort to mitigate agency concerns and to adapt to new opportunities. Following Lang et al. (1991), we measure the free cash flow problem as the three-year average of operating cash flow less common and preferred dividends, scaled by total assets, if the firm has a book-to-market assets ratio greater than one (a proxy for low growth opportunities), and zero otherwise. We also consider the components of cash flows, cash flow from operations and net external financing (e.g., Lang et al., 1996; Bradshaw et al., 2006). We calculate cash flow from operations as earnings before depreciation minus working capital accruals scaled by average

assets (Bushman et al., 2008). We calculate net external financing as the sum of net equity financing and net debt financing scaled by average assets (Bradshaw et al., 2006).

We also consider leverage and firm idiosyncratic risk as additional risk factors affecting ERPS adoption. The association between leverage and investments is less clear as financial leverage creates incentives for managers to assume excessively risky projects on behalf of shareholders ex post after the debt has been sold (Harris and Raviv, 1991; Leland, 1998), while high leverage reduces a firm's ability to finance growth through a liquidity effect (e.g., Myers, 1977). Idiosyncratic return variance is used as an alternative proxy for uncertainty in the uncertainty-investments association literature (e.g., Leahy and Whited, 1996). However, this returns-based measure tends to be noisy as it essentially captures all relevant source of risk (e.g., Guiso and Parigi, 1999). We measure a firm's idiosyncratic risk as the standard deviation of residuals from a regression of its daily excess stock returns (i.e., raw returns less the riskless rate) on the market factor (i.e. the value-weighted market return less the riskless rate).

Research Model for the ERP System Enhancement Decision

We assume the ERP systems post-implementation system enhancement decision to be characterized in the following form:

$$\text{ENHANCE}_{t+i\ (i=1,\ldots,10)} = f(\Delta\text{Industry competitiveness}_{t-1,\,t+i-1};\ \Delta\text{Market power}_{t-1,\,t+i-1};\ \text{System match}_{t};\ \text{Initial performance}_{t,t+1};\ \text{High-quality PIR}_{t,\,t+i};\ \text{Early}_{t+i};\ \text{Medium}_{t+i};\ \text{Firm size}_{t+i-1};\ \text{Investment opportunity set}_{t+i-1};\ \text{Cash shortage}_{t+i-1};\ \text{Loss}_{t+i-1};\ \text{Years};\ \text{Industries}) \quad \textit{(2)}$$

Eq. (2) models the determinants of adopters' enhancement decisions over a 10-year period after initial adoption. The determinants in Eq. (2) are primarily motivated by prior studies of the performance outcome and the effective operation of post-adoption ERPS (e.g., Nicolaou, 2004a, b; Nicolaou and Bhattacharya, 2006, 2008). As posited in research

hypothesis H1b, these early-stage implementation factors are central to the ability to optimally reconfigure an ERP investment using a follow-up enhancement option.

We predict that the exercise of the option to enhance ERPS is positively associated with the extent to which a firm attained the benefits it sought to accomplish with ERPS adoption. Nicolaou (2004b) has shown that these performance benefits typically accrue to ERP-adopting firms within approximately two years from the date of original rollout. CosgroveWare (2003) also suggests that while most adopting firms do not realize the anticipated benefits within the first year of implementation, they do begin to reap these benefits from the second year on. Therefore, we use the initial performance (average ROA) during the year of and the year immediately after the initial ERPS adoption to measure the immediate after-effects of ERP implementations (see table 5 for a detailed description of how all variables in Eq. (2) are measured; the variables are defined as of beginning of the change year unless otherwise mentioned).

In research hypothesis H2, we predict that the option to enhance ERPS will be positively related with the extent to which the system 'matches' needs and satisfies post-implementation goals. It might be the case, however, that ERPS adoption and use are endogenous choices, with the net benefits varying with the extent to which the initially planned ERPS implementation "matches" the organization's needs. Our sample used to estimate ERPS enhancement probabilities is censored since only firms adopting ERPS are observed to exercise their options to expand. Heckman (1979) has shown that censored samples can lead to biased estimates, if, in our example, the sample selection rule is correlated with the errors in the enhancement probability equation. In our case, it is possible that a firm is likely to not implement new ERP options if there is a mismatch between the initial ERPS adoption and the firm's innate characteristics. We assume that the estimated probability for adoption from Eq. (1) represents the extent to which the initial adoption is a

good match for the company. We control for the difference between match and mismatch firms by including an indicator variable for firms that show a match between ERPS use and fundamental characteristics (i.e., firms with the estimated probability from Eq. (1) greater than the mean estimated probability of adoption) in Eq. (2).[8] This determinant in the model addresses our research hypothesis H2.

Following Nicolaou's (2004a) framework of PIR quality (empirically examined in Nicolaou and Bhattacharya 2008), we predict that well-planned high-quality PIR activities will also be positively associated with the presence of an enhancement option. The Nicolaou (2004b) model proposes 14 different PIR activities, as shown in table 1. Nicolaou and Bhattacharya (2008) show that differences in the nature of PIR are associated with the performance effect of ERPS. Specifically, ERPS firms demonstrate improved differential performance due to the use of post-implementation activities that relate to project planning, strategy, and process integration shortly after implementation of the ERPS. In contrast, system deployment-related post implementation activities (these typically occur at later stages) appear to have deteriorating performance effects. Therefore, we use an indicator variable for high-quality PIR equaling to one if the firm has project planning, strategy, and process integration related PIR practices prior to the enhancement event, and 0 otherwise.[9]

In order to test research hypothesis H4, we also examine the timing of the ERPS enhancement decisions by including two time indicator variables. Early term equals one if the system enhancement occurs shortly after the initial system implementation (i.e., years 1 and 2), and 0 otherwise. Medium term equals one if the system enhancement occurs during the medium ERPS implementation period (years 3-5), and 0 otherwise.

[8] We note that in our case the standard Heckman procedure is not applicable to address the selection issue since the structure exposed to potential sample selection bias has a qualitative dependent variable (Boyes et al. 1989; Greene 2002).

[9] We also consider the possibility that use of PIR activities and system enhancement could be endogenous events; however, results from the Hausman's (1978) test for exogeneity failed to reject the null, thus allowing us to validly test this hypothesis. We do test for this possibility, nevertheless, in our statistical analysis.

Changes in industry competitiveness and market power (rather than their levels) are included in Eq. (2) to proxy for any change in demand and competition since the launching of the ERPS platform. Positive coefficients on these two variables are consistent with firms exercising enhancement choices in response to unexpected increases in demand (Benaroch 2002).

We also control for the effect of firm fundamental characteristics on ERPS enhancement decisions as these characteristics may proxy for a firm's inherent ability to realize an enhancement opportunity. We predict that the decision to exercise an enhancement option is positively associated with firm size and growth opportunities as both suggest flexibility in creating capabilities and opportunities for follow-up investments.[10] Further, we predict the enhancement choice to be negatively associated with the degree of cash constraints. Fazzari et al. (1987) suggest that investment can be excessively sensitive to contractions in cash flow for financially constrained firms. Following prior research (e.g., Core and Guay, 1999), we measure the degree of cash flow shortfall as the three-year average of common and preferred dividends plus cash flow used in investing activities less cash flow from operations divided by total assets. In addition, Joos and Plesko (2004) suggest that persistent losses typically contain large negative cash flow. We also use an indicator variable equal to one if the firm reports a loss in any of the previous three years, and zero otherwise.

For both Eq. (1) and Eq. (2), we include year dummy variables for each sample year and industry dummy variables for each two-digit industry that has at least 100 observations and estimate logistic regressions with standard errors clustering by firm.

[10] We measure firm size with log (sales) as annual sales may arguably be a less noisy measure than market value, to proxy for the operation scale of the firm.

IV. RESULTS

The Decision to Adopt ERPS

Table 3 presents descriptive statistics for the variables in Eq. (1) for our ERPS adopting firms compared to matched non-adopting firms. Panel A also reports test statistics of the differences in means and medians for each of the variables under two-tailed t-tests and Wilcoxon rank sum tests, respectively. Combined, the number of observations for all variables except sales growth (GROWTH), idiosyncratic risk (RISK), net external financing (EXT_FIN), and cash flow from operations (CFO_OP) is 20,349; and the number of observations for GROWTH, RISK, EXT_FIN, and CFO_OP is 12,622. Panels A and B present the distributional properties of our measures of industry competitiveness, market power, and fundamental characteristics for adopting and non-adopting firms, respectively. In addition, we report the test statistics for mean and median differences between the two samples in Panel A.

The means and medians of the industry Herfindahl Index (HERFINDAHL) suggest similar industry distribution between adopters and non-adopters. The mean (median) values of market share (MKT_SHR) for the adopting sample and the non-adopting sample are 1.2 percent and 0.3 percent (0.3 percent and 0 percent), respectively. The differences of both the mean and median MKT_SHR are statistically different from zero (two-tailed p-values significant at 1 percent or better), consistent with our expectation.

Panel A also reveals that, on average, ERPS adopters tend to be larger, more profitable, have lower idiosyncratic risk (RISK), and face fewer growth opportunities (suggested by the lower market-to-book-asset (MB) ratio and sales growth (GROWTH)), compared to their industry peers. These companies are also more likely to have the free-cash-flow problem, as captured by both higher FREE_CFP and higher operating cash flow (CFO_OP). On the other hand, the finding that ERPS-related options are less likely to be

available for smaller and less profitable firms is consistent with high monetary risk involved in ERPS implementation (Benaroch, 2002). It is vital to control for these innate firm characteristics in our multivariate tests as such characteristics may have a direct effect on the adoption decisions.

Panel C reports the correlations among variables, with the Pearson (Spearman) correlations on the upper (lower) diagonal. We discuss the Pearson correlations, but note that the Spearman rank-order correlations are consistent with the Pearson results. Consistent with our research expectations, the ADOPT indicator variable is positively correlated with MKT_SHR, FIRM_SIZE, PROFITABILITY, FREE_CFP, and CFO_OP, and negatively correlated with MB and RISK (two-tailed p-values significant at 1 percent or better). We note that several independent variables have relatively large correlations, in particular those correlations with FREE_CFP (its largest correlation coefficient being 0.784, with PROFITABILITY). Despite the large correlations among those independent variables, the highest variable inflation factor (based on OLS) for the control variables used in the multivariate regression is 1.64, suggesting that multicollinearity is not a problem.

<Insert Table 3 about here>

To examine whether the above-mentioned variables affect the ERPS adoption decisions, we report the results from several logistic regression tests using Eq. (1) in Table 4. We cluster standard errors by firm and include year and industry indicators. The three columns on the left present the estimations for the full sample of 20,349 observations, including either PROFITABILITY, FREE_CFP, or both. The probit model for the adoption decision has significant explanatory power (p-value < 0.001), with pseudo-R-squared values ranging from 9.2 to 9.5 percent. Consistent with H1a, the coefficients on HERFINDAHL and MKT_SHR are consistently positive and highly significant (two-tailed p values significant at 1 percent or better) after controlling for other firm-level characteristics. This indicates that the

probability of adoption is negatively related to the degree of competition in a firm's industry and positively related to the strength of the firm's market power. This finding suggests that the expected investment values of ERPS growth options (e.g., entrance barrier and competitive advantage) could be greater for firms with substantial market power. The result is also consistent with ERPS providing new opportunities for future initiatives that enhance a firm's strategic agility, competitive flexibility, and innovativeness (Bharadwaj, 2000; Clemons and Row, 1991; Mata et al, 1995; Sambamurthy et al., 2003).

Among the control variables, we find that the likelihood of adoption is positively associated with larger firms, firms that have higher profit levels, higher market-to-book ratio, and more excess cash, consistent with these innate fundamental characteristics having direct effects on firms' adoption decisions (two-tailed p values significant at 5 percent or better). These multivariate results are consistent with the univariate results reported in Table 3. In addition, the coefficients on PROFITABILITY and FREE_CFP are positive and significant (two-tailed p values significant at 1 percent or better) when either variable is included in Eq. (1) (i.e., Model 1 and Model 2, respectively). However, the coefficient on FREE_CFP is not statistically different from zero when both variables are included (Model 3), suggesting excess cash can be viewed as a proxy for profitability, rather than a proxy for agency issues. The last column presents the estimations for the reduced sample of 12,622 observations with GROWTH, RISK, EXT_FIN, and CFO_OP included. Only the coefficient on EXT_FIN is positively significant (although there is a small improvement in pseudo-R^2), suggesting the addition of these variables might not improve the explanatory power of models. Therefore, we calculate the predicted probability of ERPS adoption using the coefficients in Model 1.

<Insert Table 4 about here>

Summarizing, our findings suggest that firms establish a new growth option by adopting ERPS in an effort to differentiate themselves, create barriers of entry, and obtain

sustainable competitive advantage (e.g., Benaroch 2002; Sambamurthy et al. 2003). However, some firms may not adopt ERPS due to a lack of ability to fully fund such long-term irreversible investments. Our findings are consistent with industry and professional surveys, which show that the basic drivers motivating adoption of ERPS include cost reduction, improved efficiency, reduced product cycle time, improved customer service and satisfaction, the ability to change and configure business in response to changing market place, as well as the enabling of e-commerce (Attaway, 1999; Glover et al., 1999).

The Decision to Exercise the Enhancement Option

Table 4 presents descriptive statistics on the variables included in Eq. (2), as well as a correlation matrix of the explanatory variables. Panel A of table 4 presents descriptive statistics for 34 instances of system enhancements announced by 30 ERPS adopting firms over the 10-year time period following adoption. For comparison, in Panel B, we present 1,318 firm-years for all adopters (firm-years) that did not report an enhancement choice and have necessary data for analysis. In panel A, we also report differences in means and medians for each of the variables using both two-tailed t-tests and Wilcoxon rank sum tests. As shown earlier in table 2, the total number of observations available for the second stage analysis is 1,415.

As previously discussed, research hypothesis H2 is tested by using the predicted probability of adoption from the estimation of Eq. (1) (based on model 1 in Table 4) to measure the extent to which the initially planned ERPS implementation "matches" the organization's needs. We create an indicator variable (PROB_ADOPT) which takes the value of 1 if the firm's estimated probability of adoption is greater than the mean estimated probability of all firms in the sample. As we argued in research hypothesis H2, we expect this variable to be significantly positively associated with the probability of new enhancement choices among adopters in our second stage analysis (Eq. (2)).

Consistent with H2, the predicted probability of adoption (as captured by PROB_ADOPT) is greater for adopters that exercised an enhancement option during the post-implementation period than for adopters that did not exercise an enhancement option (0.324 versus 0.141; two-tailed $p<.01$). The average initial post-adoption performance (INIT_PERF -- measured by average ROA) for firms with system enhancements is 18.1 percent. The mean of INIT_PERF for the control group is significantly smaller at 14 percent. These univariate results provide some support for the conjecture that system enhancement firms are more likely to enjoy immediate benefits from initial ERPS implementation possibly because their initial adoptions better match these firms' needs and innate characteristics. Moreover, firms with enhancements had a higher mean PIR score than the control sample (61.8 percent versus 2.1 percent; two-tailed $p<.01$). These findings provide some initial support for H3. Further, enhancements tend to occur during the medium term of the ERPS implementation period (47.1 percent), rather than during the early term (17.6 percent), which is slightly different from the more even distribution of the control sample over time (32.3 versus 25.3 percent), providing partial support for H4.

However, differences between the means and medians of ΔHERFINDAHL and ΔMKT_SHR are not statistically significantly different from zero, providing no evidence to support H1b. Turning to other fundamental characteristics, the average SALES is significantly higher for system enhancement firms, and their average MB ratio is also higher, but is only marginally significant, suggesting that differential operation scale and investment opportunities are likely to exist between enhancement adopters and non-enhancement adopters.

Turning to Panel C, which presents the Pearson and Spearman correlation matrix among the variables in Eq. (2), enhancements are positively related to higher probability of initial adoption, more high-quality PIR activities, higher medium-term occurrence, larger

operation scale, and more investment opportunities. We also note that several correlation coefficients among the independent variables tend to be high. PROB_ADOPT and INIT_PERF are significantly correlated, suggesting that adopters realize expected benefits due to a good match between organizational need and initial ERPS use; both variables are also significantly correlated with firm fundamental characteristics (two-tailed p values significant at 5 percent or better). Further, variable inflation factors (based on OLS) for the control variables used in the multivariate regression are generally small mitigating the concern for multicollinearity.

<Insert Table 5 about here>

Table 6 shows the logistic regression models which provide tests for the research model specified in Eq. (2). The first column of Table 6 (Model 1), presents a logistic regression of adopters' enhancement decisions based on Eq. (2) with standard errors clustering by each ERP adopting firm. The model is statistically significant (p<0.01), with a pseudo R^2 of 0.419. The results regarding system related factors are consistent with the univariate results in Table 5. In particular, we find that the coefficient on INIT_PERF is significantly positive after controlling for fundamental factors that affect system enhancements (two-tailed p<.01), providing strong support for H2. After controlling for INIT_PERF and firm fundamental characteristics (the exogenous determinants of the adoption choice), the coefficient on PROB_ADOPT is not significantly different from zero. These findings suggest that the immediate after-effect of ERP adoption significantly affects a firm's ability to optimally reconfigure an ERP investment using a follow-up enhancement option.

Furthermore, the coefficient on PIR is also significantly positive (two-tailed p<.01), consistent with expectation and in support of H3. This suggests that an organization that follows a well-planned, high-quality PIR process has greater ability to optimally reconfigure

an ERP investment using a follow-up enhancement option. This finding is consistent with Nicolaou (2004a) and Nicolaou and Bhattacharya (2006, 2008), which suggest that PIR activities develop the necessary contextual conditions for an enhancement option to be present by facilitating system implementation planning and business process effectiveness. In particular, high-quality PIRs were demonstrated in past research to enable flexibility as exemplified by their positive impact on financial performance (Nicolaou and Bhattacharya, 2008). Furthermore, these results provide support for Benaroch (2002), who argued that since flexibility is not inherent in any investment, proactively embedding flexibility in risky IT investments can add value.

In contrast, the explanatory power of fundamental factors tends to be weak compared to system related factors. The coefficients on ΔHERFINDAHL and ΔMKT_SHR are not significantly different from zero.[11] The coefficients on EARLY and MEDIUM are also not significantly different from zero (possibly due to model misspecification as discussed next), providing little support for H4. Regarding firm-level characteristics, only SALES is significantly (albeit marginally) positively associated with the probability of system enhancement in model 1. Overall, these other variables do not provide substantial incremental power in explaining post-adoption enhancement decisions.

Model 1 includes PIR as an independent variable to explain post-adoption enhancement decisions. However, ERP enhancements and PIR activities could also be endogenous choices which bias our results. Next, we use two approaches to address the possibility that the choice of PIR could be endogenous with ERP enhancement. First, we use a two-stage instrumental variables (IV) estimation. In the first stage, we estimate a model of PIR on all right-hand side variables in Eq. (2) and use the estimated coefficients to obtain predicted PIR. In the second stage, the predicted PIR from the first stage become an

[11] A possible explanation for this (absence of) finding is that some enhancements may be caused by issues and problems uncovered during the initial implementation and therefore are not strictly demand-driven (Nicolaou and Bhattacharya, 2006).

additional independent variable in Eq. (2) modeling the enhancement decision. However, the Hausman's (1978) test for exogeneity failed to reject the null. Therefore, we choose not to report this analysis as the estimation under Model 1 is more efficient than the two-stage IV estimation.

Second, since PIR activities could be a driver motivating system enhancements, we may have two binary response variables that vary jointly. We adopt bivariate probit models to account for the possibility of a joint distribution (Greene, 2002) and report the results in the last two columns of Table 6 (Model 2). The estimate of rho (i.e., the correlation of the residuals from the two models) is 0.868, suggesting that unexplained probability to perform high-quality PIR is actually associated with higher incidences of system enhancements among ERPS adopters ($p < 0.001$), and therefore the bivariate probit approach is justified. While the tenor of the results is unchanged, there are several notable differences between the estimation under Model 2 and the estimation previously reported based on Model 1, suggesting that the simple logit model for enhancement decisions could be misspecified.

Model 2 shows that high-quality PIR activities typically occur over the first few years immediately following the initial ERPS adoption, whereas a relatively longer lag is observed for system enhancements—they are more likely to occur 3 to 5 years after the adoption (but still within the early post-implementation period as defined by Nicolaou and Bhattacharya, 2006, 2008). This finding provides support for H4, suggesting that system enhancements usually follow well-planned high-quality PIR activities.

Although both decisions are significantly positively associated with firm size, the MB-ratio is only significantly associated with PIR activities. This seems to imply that companies can better manage beneficial opportunities by adopting high-quality PIR practices that relate to project planning, strategy, and process integration. In other words, PIR moderates the influence of growth opportunities on system enhancements. In addition, the

immediate after-effect of ERPS is positively associated with the enhancement decision, but not PIR. As Nicolaou and Bhattacharya (2008) argue, PIR is a moderating variable that influences the relationship between ERPS investments and potential productivity gains achieved by implementing firms. As such, while performance is not a driver of PIR, it may motivate the decision of ERPS enhancement, as a positive performance outcome following the initial ERPS adoption event, creates additional flexibility.

Summarizing, the combined evidence of Model 1 and Model 2 in Table 6 suggests two critical factors for an enhancement option to be present in an ERPS project. These are how quickly companies begin to reap the benefits they sought to accomplish from the ERPS adoption and whether well-planned PIR practices are in place to enhance system implementation planning and business process effectiveness. Therefore, by establishing an association between post-implementation system fit, review, and enhancement, our findings support the real options perspective of ERP systems adoption and post-implementation management. This suggests that there could be multiple ways to reconfigure the investment in ERPS using different of series of compound options.

<Insert Table 6 about here>

V. CONCLUSION

This paper examines whether firms' investments in ERPS, including the initial adoption decision, post-implementation reviews, and subsequent changes are consistent with an economic-determinants-and-real options perspective. Using a large-scale panel data, we posit and find that highly concentrated industries and industry leaders are more likely to adopt ERPS due to greater entrance barriers and competitiveness benefits from investments in ERPS. This suggests that uncertainty tends to have a non-negative effect on investments in ERPS among firms. We also find that the likelihood of adoption is positively associated with larger firms, firms that have higher profit levels, higher market-to-book ratio, and more

excess cash, consistent with these innate fundamental characteristics having direct effects on firms' adoption decisions. Combined, we provide two possible explanations for a firm to adopt ERPS: (i) the quest to differentiate itself and mitigate competition from new entrants and existing competitors, and (ii) the need to eliminate inefficiencies and the creation of new growth opportunities.

We find some evidence that the likelihood of system enhancement (i.e., upgrades or add-ones) following initial ERPS implementation varies with the extent to which the initial decision to use ERPS "matches" the firm's fundamental characteristics. More importantly, we find that the exercise of the option to enhance ERPS is positively associated with the extent to which a firm attained the benefits it sought to accomplish with the initial ERPS adoption. Moreover, high-quality post-implementation practices that relate to project planning, strategy, and process integration also increase the odds of system enhancements. These two factors explain a significant portion of the variation in post-implementation enhancement choices. Although the explanatory power of fundamental factors tends to be weak, our findings suggest that the implementation and use of ERPS enhances financial flexibility and organizational capabilities, which, in turn, enables management to optimally reconfigure investment in ERPS and exercise the options for future initiatives that can enhance a firm's strategic agility, competitive flexibility, and innovativeness (Nicolaou 2008).

Our overall results suggest firms efficiently invest in ERPS, and are consistent with real options theory. Our study is different from prior studies on IT investment decisions in the framework of strategic real options (Benaroch et al. 2006) in that we model ERPS adoption decisions and subsequent adaptation choices as two separate but related decisions about exercising real operating options in a continuous implementation process. Our findings provide strong empirical support for the argument that formal adoption of a real options

perspective on IT projects benefits the success rate of such projects (e.g., Benaroch 2002).

Our findings also have important implications for research on ERPS implementation effectiveness and for the use and deployment of ERPS in business organizations.

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TABLE 1
PIR Dimensions and Activities

PIR Dimension	PIR Activities
I. Review of Overall Project Scope and Planning	1. PROJECT PLAN: - Project planning evaluated and changes instituted in subsequent implementation teams. 2. INFRASTRUCTURE: Information infrastructure development considered critical for survival, competitive advantage. 3. STRATEGY: Evaluated system fit with strategic vision for organizational transformation.
II. Review of Driving Principles for Project Development	4. PROCESS INTEGRATION- Formal review of process integration. 5. PROJECT CHANGE: - Initial reactive response to problems due to implementation process inadequacies introduced by system. 6. GLOBAL REACH: Evaluated global reach and support. 7. JUSTIFICATION: - Re-evaluation of initial system justification.
III. Effectiveness of Misfit Resolution Strategies	8. FIT RESOLUTION: evaluated fit of system with needs. 9. MISFIT RESOLUTION: developed workarounds to resolve misfits (by-pass system deficiencies). 10. PROCESS SIMPLICITY: Evaluated process simplicity – adopted simple processes, reengineered processes for simplicity.
IV. Evaluation of Attained Benefits	11. BENEFITS ATTAINED: - Evaluated attainment of benefits. 12. USER COMPLAINTS: lack of benefits as evidenced by user complaints.
V. Evaluation of Learning	13. USER LEARNING: - Reviewed user learning and instituted corrective mechanisms. 14. KNOWLEDGE TRANSFER: - Evaluated knowledge transfer among implementation teams (multi-site implementations).

Source: Nicolaou 2004(b)

TABLE 2
Sample Details
Panel A: Description of Sample Selection

	ERP Firms	Control firms	Total
Observations in the Initial Adoption Test			
Total observations before Compustat data requirements (Control observations are from the same 2-digit SIC industry and year on Compustat)	247	27,457	27,704
Less observations missing necessary financial/market data for analysis	(66)	(7,289)	(7,355)
Total ERP/Control Observations	181	20,168	20,349

Firm-Year Observations in the System Enhancement Options Test	**Firm-Year**	
Total possible ERP observations during the 10-year period following the adoption	1,810	n/a
Less observations missing necessary financial/market data during the 10-year period following the adoption, beyond a minimum of three-year data requirement	(395)	n/a
Total	1,415	

Panel B: Distribution of ERP firms by Two-Digit Standard Industrial Classification (SIC) Code

Industry Sector	SIC Code	# of ERP Firms in the Sample	Percentage of Sample
Agricultural production	1	1	0.55%
Oil & gas	13	3	1.66
Bldg contractors	15	1	0.55
Food and kindred products	20	3	1.66
Textile mill products	22	3	1.66
Lumber & wood products	24	2	1.10
Furniture & fixtures	25	5	2.76
Papers & allied products	26	4	2.21
Printing & publishing	27	5	2.76
Chemicals & allied products	28	17	9.39
Petroleum & coal products	29	3	1.66
Rubber & plastics products	30	3	1.66
Leather & leather products	31	1	0.55
Stone, clay & glass products	32	1	0.55
Primary metal industries	33	7	3.87
Fabricated metal products	34	5	2.76
Industrial machinery & equipment	35	24	13.26
Electronics & electrical equipment	36	20	11.05
Transportation equipment	37	16	8.84

Instruments & related products	38	11	6.08
Miscellaneous manufacturing	39	4	2.21
Trucking, courier, & storage services	42	1	0.55
Air transportation services	45	1	0.55
Tele communications & broadcasting	48	4	2.21
Electric, gas & sanitary services	49	5	2.76
Wholesale—Durable goods	50	3	1.66
Wholesale—Paper & paper products	51	2	1.10
Retail—Building materials, hardware, garden supply	52	1	0.55
Retail—General merchandise stores	53	1	0.55
Retail—Food, grocery, & convenience stores	54	1	0.55
Retail—Eating & drinking	58	3	1.66
Retail—Miscellaneous retail	59	4	2.21
Commercial banks & saving institutions	60	1	0.55
Insurance industries	63	3	1.66
Business services	73	9	4.97
Services—Amusement and recreation	79	1	0.55
Non-operating establishments	99	2	1.10
	Total	181	100.00

TABLE 3
Summary Statistics for ERP Adoption and Its Determinants

Variable	N	Mean	Std Dev	Q1	Median	Q3	t-test [a]	Wilcoxon rank sum test [a]
Panel A: ERP firms (ADOPT = 1)								
HERFINDAHL	181	0.059	0.046	0.037	0.045	0.073	1.350	1.767 *
MKT_SHR	181	0.012	0.019	0.000	0.003	0.012	6.100 ***	11.839 ***
FIRM_SIZE	181	6.203	2.128	4.650	6.250	7.633	10.440 ***	9.861 ***
PROFITABILITY	181	0.140	0.093	0.106	0.150	0.180	15.600 ***	7.025 ***
MB	181	1.840	1.227	1.150	1.432	1.963	4.790 ***	1.238
FREE_CFP	181	0.058	0.075	0.000	0.061	0.102	15.320 ***	6.180 ***
LEVERAGE	181	0.530	0.223	0.399	0.535	0.662	1.120	1.795 *
GROWTH	140	0.239	0.542	0.035	0.126	0.301	2.400 **	0.051
RISK	140	0.027	0.016	0.015	0.022	0.036	10.520 ***	7.959 ***
EXT_FIN	140	0.114	0.379	-0.038	0.011	0.096	0.480	0.629
CFO_OP	140	0.071	0.166	0.034	0.097	0.147	4.740 ***	3.696 ***
Panel B: Control firms (ADOPT = 0)								
HERFINDAHL	20,168	0.055	0.041	0.032	0.043	0.064		
MKT_SHR	20,168	0.003	0.009	0.000	0.000	0.001		
FIRM_SIZE	20,168	4.549	2.123	3.096	4.420	5.908		
PROFITABILITY	20,168	0.029	0.277	0.013	0.099	0.165		
MB	20,168	2.283	2.230	1.075	1.509	2.505		
FREE_CFP	20,168	-0.031	0.243	-0.009	0.002	0.081		
LEVERAGE	20,168	0.511	0.305	0.281	0.493	0.681		
GROWTH	12,482	0.351	0.997	0.007	0.137	0.362		
RISK	12,482	0.041	0.025	0.023	0.036	0.051		
EXT_FIN	12,482	0.129	0.373	-0.032	0.009	0.118		
CFO_OP	12,482	0.003	0.245	-0.049	0.063	0.134		

Panel C: Pearson Correlations (Top) and Spearman Correlations (Bottom) for ERP Adoption

		1	2	3	4	5	6	7	8	9	10	11	12
ADOPT	1		0.010	0.088	0.073	0.038	-0.019	0.035	0.006	-0.012	-0.059	-0.004	0.029
			(0.139)	(0.001)	(0.001)	(0.001)	(0.008)	(0.001)	(0.411)	(0.185)	(0.001)	(0.629)	(0.001)
HERFINDAHL	2	0.012		0.019	-0.132	0.042	-0.024	0.048	-0.018	-0.012	0.064	-0.024	0.031
		(0.077)		(0.008)	(0.001)	(0.001)	(0.001)	(0.001)	(0.010)	(0.177)	(0.001)	(0.007)	(0.001)
MKT_SHR	3	0.083	0.048		0.501	0.130	-0.112	0.123	0.139	-0.077	-0.292	-0.124	0.134
		(0.001)	(0.001)		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
FIRM_SIZE	4	0.069	-0.164	0.708		0.332	0.020	0.263	-0.033	-0.004	-0.677	-0.113	0.262
		(0.001)	(0.001)	(0.001)		(0.001)	(0.004)	(0.001)	(0.001)	(0.653)	(0.001)	(0.001)	(0.001)
PROFITABILITY	5	0.049	0.124	0.511	0.401		-0.435	0.784	-0.118	-0.117	-0.402	-0.398	0.698
		(0.001)	(0.001)	(0.001)	(0.001)		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
MB	6	-0.009	0.056	-0.284	0.142	0.044		-0.461	-0.086	0.213	0.076	0.377	-0.301
		(0.216)	(0.001)	(0.001)	(0.001)	(0.001)		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
FREE_CFP	7	0.043	0.107	0.464	0.378	0.694	-0.036		-0.033	-0.260	-0.324	-0.391	0.665
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
LEVERAGE	8	0.013	-0.107	0.303	0.037	-0.062	-0.304	-0.006		-0.117	0.008	-0.052	0.047
		(0.073)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.371)		(0.001)	(0.399)	(0.001)	(0.001)
GROWTH	9	0.000	0.042	-0.074	0.119	0.175	0.344	-0.004	-0.169		0.053	0.196	-0.186
		(0.960)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.681)	(0.001)		(0.001)	(0.001)	(0.001)
RISK	10	-0.071	0.119	-0.678	-0.725	-0.448	0.088	-0.413	-0.164	0.019		0.159	-0.311
		(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.031)		(0.001)	(0.001)
EXT_FIN	11	-0.006	-0.002	-0.290	-0.109	-0.228	0.276	-0.253	-0.105	0.229	0.221		-0.498
		(0.530)	(0.811)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)		(0.001)
CFO_OP	12	0.033	0.076	0.408	0.301	0.581	-0.068	0.557	0.078	-0.016	-0.355	-0.425	
		(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.075)	(0.001)	(0.001)	

Variable definitions: ADOPT is equal to 1 if the firm is an ERPS-adopting firm, and 0 otherwise. HERFINDAHL (Herfindahl Index) is the sum of the squares of the market shares of the 50 largest firms (or summed over all the firms if there are fewer than 50) within the business sector that the firm participates in. MKT_SHR is the firm's percentage of sales to the business sector that the firm participates in. FIRM_SIZE is the logarithm of the market value of the firm's equity in millions of dollars. PROFITABILITY is measured by ROA, defined as earnings before extraordinary items scaled by total assets. MB (market-to-book-asset ratio) is the ratio of the market value of total assets to the book value of total assets. The market value of total assets is calculated as the market value of equity plus the book value of asset minus the book value of equity; the book value of equity is defined as stockholders' equity or common equity plus preferred stock par value or total asset less total liabilities, plus balance sheet deferred taxes and investment tax credit (if available) and post-retirement benefit liabilities (if available), minus the book value of preferred stocks (estimated in the order of the redemption, liquidation, or par value, depending on availability). FREE_CFP (free-cash-flow problem) is equal to zero if the book-to-market ratio is less than one, and is the three-year average of [(cash flow from operations common and preferred stock dividends)/total assets], otherwise. LEVERAGE is the ratio of total debt to the book value of assets. GROWTH is the annual sales growth in percentage. RISK is the standard deviation of residuals from a regression of its daily excess stock returns (raw returns less the riskless rate) on the market factor (i.e. the value-weighted market return less the riskless rate). One firm-year observation of idiosyncratic risk is computed using firm-specific daily stock returns from the prior year. EXT_FIN (external financing) is the net amount of cash flow from external financing sources calculated as net change in equity plus the net change in debt, scaled by total assets based on Bushman et al. (2008). The change in equity is the net cash received from the sale (and/or purchase) of common and preferred stock less cash dividends

paid and the net change in debt equals net cash received from the issuance (or reduction) of debt. CFO_OP (cash flow from operations) is calculated as calculated as earnings before depreciation minus working capital accruals scaled by average assets based on Bushman et al. (2008). Working capital accruals is measured as change in current assets less change in cash and cash equivalents less change in current liabilities other than change in short-term debt and change in tax payable. All variables are measured as of the beginning of the ERPS adopting year, unless otherwise specified. The continuous variables are winsorized at the top 1% and bottom 99% percentiles.

[a] ***, **, and * indicate significant differences in means or medians between ERP-adopting firms and control firms at the 0.01, 0.05, and 0.1 levels respectively, two-tailed.

Table 4

The Decision to Adopt ERPS

Independent Variables	**Predicted Sign**	***Model 1***	***Model 2***	***Model 3***	***Model 4***
		Coefficient Estimate (p-value)	**Coefficient Estimate (p-value)**	**Coefficient Estimate (p-value)**	**Coefficient Estimate (p-value)**
Intercept	?	-6.994	-6.886	-6.956	-6.439
		(0.001)	(0.001)	(0.001)	(0.001)
HERFINDAHL	+ (H1a)	4.240	4.557	4.284	4.185
		(0.008)	(0.005)	(0.007)	(0.021)
MKT_SHR	+ (H1a)	20.203	19.450	20.464	17.807
		(0.001)	(0.001)	(0.000)	(0.009)
FIRM_SIZE	+	0.214	0.224	0.207	0.217
		(0.001)	(0.001)	(0.001)	(0.003)
PROFITABILITY	+	2.748		2.155	2.330
		(0.001)		(0.007)	(0.011)
MB	+	-0.157	-0.123	-0.147	-0.247
		(0.020)	(0.049)	(0.031)	(0.002)
FREE_CFP	+		2.670	1.056	
			(0.000)	(0.222)	
LEVERAGE	?	-0.251	-0.290	-0.234	-0.202
		(0.470)	(0.405)	(0.505)	(0.610)
GROWTH	+				-0.041
					(0.742)
RISK	-				-10.571
					(0.195)
EXT_FIN	+				0.756
					(0.002)
CFO_OP	+				-0.217
					(0.762)
Industry Dummies		Yes	Yes	Yes	Yes
Year Dummies		Yes	Yes	Yes	Yes
N		20,349	20,349	20,349	12,622
Pseudo R^2		0.094	0.092	0.095	0.108
(p-value)		(0.001)	(0.001)	(0.001)	(0.001)

***, **, * denote significance at the 0.01, 0.05, 0.10 levels (two-tailed), respectively.
See Table 3 for variable definitions. We cluster standard errors by firm and include year and industry indicators.

TABLE 5

Summary Statistics for ERP Enhancement Decisions and Their Determinants

Variable	N	Mean	Std Dev	Q1	Median	Q3	t-test [a]	Wilcoxon rank sum test [a]
Panel A: Enhancement Adopters (ENHANCE = 1)								
PROB_ADOPT	34	0.324	0.475	0.000	0.000	1.000	2.220***	2.977***
INIT_PERF	34	0.181	0.082	0.130	0.158	0.223	2.670***	2.293***
PIR	34	0.618	0.493	0.000	1.000	1.000	21.410***	18.609***
EARLY	34	0.176	0.387	0.000	0.000	0.000	1.020	1.021
MEDIUM	34	0.471	0.507	0.000	0.000	1.000	1.810*	1.813*
ΔHERFINDAHL	34	-0.004	0.026	-0.013	-0.004	0.000	0.380	1.436
ΔMKT_SHR	34	0.017	0.051	-0.001	0.001	0.008	-0.850	1.230
SALES	34	8.296	1.683	7.206	8.348	9.319	3.830***	3.785***
MB	34	2.395	1.876	1.202	1.487	2.805	1.750*	1.923*
LOSS	34	0.382	0.493	0.000	0.000	1.000	0.140	0.145
CFO_SHORT	34	-0.176	0.152	-0.259	-0.170	-0.102	1.260	1.514
Panel B: Non-enhancement Adopters (ENHANCE = 0)								
PROB_ADOPT	1,381	0.141	0.348	0.000	0.000	0.000		
INIT_PERF	1,381	0.140	0.088	0.110	0.143	0.186		
PIR	1,381	0.021	0.143	0.000	0.000	0.000		
EARLY	1,381	0.253	0.435	0.000	0.000	1.000		
MEDIUM	1,381	0.323	0.468	0.000	0.000	1.000		
ΔHERFINDAHL	1,381	-0.002	0.026	-0.011	-0.003	0.002		
ΔMKT_SHR	1,381	0.009	0.037	0.000	0.000	0.002		
SALES	1,381	6.978	1.989	5.379	7.008	8.495		
MB	1,381	1.828	1.306	1.105	1.402	1.971		
LOSS	1,381	0.395	0.489	0.000	0.000	1.000		
CFO_SHORT	1,381	-0.147	0.130	-0.214	-0.153	-0.088		

Panel C: Pearson Correlations (Top) and Spearman Correlations (Bottom) for ERP Enhancement

		1	2	3	4	5	6	7	8	9	10	11	12
ENHANCE	1		0.079	0.071	0.495	-0.027	0.048	-0.010	0.030	0.101	0.066	-0.004	-0.034
			(0.003)	(0.008)	(0.001)	(0.307)	(0.070)	(0.707)	(0.252)	(0.000)	(0.014)	(0.885)	(0.208)
PROB_ADOPT	2	0.079		0.171	0.062	-0.032	-0.005	0.111	0.357	0.514	0.069	-0.058	-0.059
		(0.003)		(0.001)	(0.020)	(0.236)	(0.840)	(0.001)	(0.001)	(0.001)	(0.010)	(0.028)	(0.027)
INIT_PERF	3	0.061	0.202		0.026	-0.032	-0.013	0.078	0.066	0.277	0.271	-0.144	-0.314
		(0.022)	(0.001)		(0.321)	(0.232)	(0.623)	(0.003)	(0.014)	(0.001)	(0.001)	(0.001)	(0.001)
PIR	4	0.495	0.062	0.031		0.030	0.030	-0.030	0.012	0.082	0.084	-0.029	-0.043
		(0.001)	(0.020)	(0.249)		(0.257)	(0.260)	(0.267)	(0.643)	(0.002)	(0.002)	(0.274)	(0.105)
EARLY	5	-0.027	-0.032	-0.039	0.030		-0.404	-0.028	-0.025	-0.100	0.009	-0.118	-0.090
		(0.307)	(0.236)	(0.140)	(0.257)		(0.001)	(0.294)	(0.344)	(0.000)	(0.739)	(0.001)	(0.001)
MEDIUM	6	0.048	-0.005	-0.018	0.030	-0.404		-0.054	-0.015	-0.030	-0.021	-0.059	-0.025
		(0.070)	(0.840)	(0.501)	(0.260)	(0.001)		(0.044)	(0.581)	(0.259)	(0.433)	(0.026)	(0.356)
ΔHERFINDAHL	7	-0.038	0.038	0.108	-0.037	0.014	-0.066		0.197	0.051	-0.018	0.010	-0.032
		(0.151)	(0.150)	(0.001)	(0.165)	(0.606)	(0.013)		(0.001)	(0.054)	(0.502)	(0.700)	(0.231)
ΔMKT_SHR	8	0.033	0.238	0.157	0.020	-0.048	-0.013	-0.008		0.328	0.051	-0.017	-0.060
		(0.219)	(0.001)	(0.001)	(0.460)	(0.069)	(0.622)	(0.752)		(0.001)	(0.057)	(0.533)	(0.024)
SALES	9	0.101	0.501	0.288	0.084	-0.103	-0.031	0.015	0.320		0.081	-0.104	-0.240
		(0.000)	(0.001)	(0.001)	(0.002)	(0.000)	(0.249)	(0.575)	(0.001)		(0.002)	(0.001)	(0.001)
MB	10	0.051	0.128	0.387	0.053	0.056	-0.087	-0.080	0.126	0.167		-0.093	-0.254
		(0.055)	(0.001)	(0.001)	(0.045)	(0.035)	(0.001)	(0.003)	(0.001)	(0.001)		(0.001)	(0.001)
LOSS	11	-0.004	-0.058	-0.176	-0.029	-0.118	-0.059	0.021	-0.046	-0.088	-0.054		0.165
		(0.885)	(0.028)	(0.001)	(0.274)	(0.001)	(0.026)	(0.424)	(0.085)	(0.001)	(0.042)		(0.001)
CFO_SHORT	12	-0.040	-0.062	-0.402	-0.026	-0.098	0.003	0.003	-0.244	-0.212	-0.318	0.174	
		(0.130)	(0.020)	(0.001)	(0.335)	(0.000)	(0.906)	(0.901)	(0.001)	(0.001)	(0.001)	(0.001)	

Variable definitions: ENHANCE is equal to 1 if the firm have an ERP enhancement (add-on or upgrade) during the year, and 0 otherwise. PROB_ADOPT is equal to 1 if the estimated probability from the regression of initial ERP adoption is greater than the mean estimated probability of adoption. INIT_PERF (initial performance) is the average ROA of the year of and the year immediately after the initial ERPS adoption. PIR is equal to 1 if the firm implemented PIR activities relating to project planning, strategy, and process integration prior to the enhancement, and 0 otherwise. EARLY is equal to 1 for the early ERPS implementation period (Year 1 and Year 2), and 0 otherwise. MEDIUM is equal to 1 for the medium ERPS implementation period (Year 3, 4 and 5), and 0 otherwise. ΔHERFINDAHL is the change in the Herfindahl Index from the beginning of the initial ERPS adopting year to the beginning of the new options adopting year. ΔMKT_SHR is the change in the market share from the beginning of the initial ERPS adopting year to the beginning of the options adopting year. SALES is the logarithm of annual sales, measured as of the beginning of the options adopting year. LOSS is an indicator variable equal to one if the firm has loss (income) before extraordinary items and discontinued operations in any of the three years prior to the options adopting year. CFO_SHORT (cash flow shortfall) is the average of [(common and preferred dividends + cash flow from investing - cash flow from operations)/total assets] for the three years prior to the options adopting year. HERFINDAHL, MKT_SHR, and MB are defined in Table 3. The continuous variables are winsorized at the top 1% and bottom 99% percentiles.

[a] ***, **, and * indicate significant differences in means or medians between options firms and non-options firms at the 0.01, 0.05, and 0.1 levels respectively, two-tailed.

Table 6

The Decision to Enhance ERP

		Model 1	*Model 2*	
Independent Variables	**Predicted Sign**	**Dependent Variable: ENHANCE**	**(2.1) Dependent Variable: PIR**	**(2.2) Dependent Variable: ENHANCE**
		Coefficient Estimate	**Coefficient Estimate**	**Coefficient Estimate**
		p-value	**p-value**	**p-value**
Intercept	?	-8.256	-3.199	-3.927
		(0.001)	(0.001)	(0.001)
PROB_ADOPT	+ (H2)	0.172	0.105	0.170
		(0.730)	(0.597)	(0.422)
INIT_PERF	+ (H2)	8.578	-0.439	2.483
		(0.003)	(0.599)	(0.047)
PIR	+ (H3)	4.361		
		(0.001)		
EARLY	+ (H4)	-0.330	0.441	0.136
		(0.645)	(0.012)	(0.534)
MEDIUM	+ (H4)	0.603	0.342	0.399
		(0.281)	(0.035)	(0.023)
ΔHERFINDAHL	+ (H1b)	1.065	-4.185	-1.920
		(0.805)	(0.179)	(0.565)
ΔMKT_SHR	+ (H1b)	0.777	-0.533	-0.476
		(0.826)	(0.790)	(0.824)
SALES	+	0.234	0.111	0.140
		(0.074)	(0.014)	(0.012)
MB	+	-0.001	0.098	0.062
		(0.996)	(0.029)	(0.268)
LOSS	-	0.549	-0.022	0.185
		(0.180)	(0.882)	(0.258)
CFO_SHORT	-	1.639	-0.081	0.520
		(0.462)	(0.892)	(0.439)
Industry Dummies		Yes	Yes	Yes
Year Dummies		Yes	Yes	Yes
N		1,415	1,415	1,415
Pseudo R^2 / rho		0.419		0.868
(p-value)		(0.001)		(0.001)

***, **, * denote significance at the 0.01, 0.05, 0.10 levels (two-tailed), respectively.
See Table 5 for variable definitions. We cluster standard errors by each adopting firm and include industry indicators.