ENTERPRISE RESOURCE PLANNING PRODUCTIVITY FUNCTION: THE IMPACT OF CEO HOLDINGS AND HORIZON AND IMPLEMENTATION CHARACTERISTICS

by

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To my parents

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All praise be to Allah, the lord of the worlds; with genuine humility, I acknowledge your aid, O God, I appreciate your grace, O God; with all my heart, I thank you, O God

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ABSTRACT

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The productivity of Enterprise Resource Planning (ERP) systems has been discussed in several other studies in the past decade. Those studies utilized several research methodologies, including case studies, surveys and archival data. The results were largely consistent with the theoretical predictions that ERP implementation enhances firm productivity. The only exceptions were the results of studies that were conducted using financial archival data as a measure of productivity.

This study predicts that the exceptional findings of the previous studies in the ERP-productivity relationship are due to the failure to consider several important factors: CEO equity holdings and horizon, timing of the implementation, type of modules implemented, and the scope of the implementation.

The results were consistent with the study prediction, particularly for CEO holdings with significance in five out of six productivity measures. Moreover, the results of the CEO holdings indicate that within ERP-productivity context, the amount of control (i.e., percentage held by a CEO in a firm) is more important than the dollar value of her/his wealth. Finally, the results also indicate that the influence of an individual CEO on the organization outcome within the context of ERP-productivity is greater than the influence of the other top five executives as a group, after excluding the CEO effect.

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CHAPTER I

INTRODUCTION

Enterprise Resource Planning (ERP) systems are being implemented in firms to replace legacy systems used by various organizational units with a single system to integrate information that flows through the entire firm. The integration of financial and accounting information, customer information, human resource information, and supply chain data into a single system enables managers to assess and evaluate all available information more easily and quickly, thus facilitating the decision-making process (Davenport, 1998; Mabert et al., 2003a). However, investing in ERP systems does not always result in the desired benefit sought by the implementing firms. One factor that contributes to the discrepancies between ERP investment and the benefits sought by the implementing firm is the difference between a firm strategy and the ERP package strategy (Turban et al., 2002).

Early research identifies factors that influence the success of information technology (IT) implementation. Such factors include the characteristics of the implementing team (Adam & O'Doherty, 2000; Abdinnour-Helm et al., 2003; Haines & Goodhue, 2003), including consultant characteristics (Thong & Yap, 1994) and the degree of top management involvement (Adam & O'Doherty, 2000; Fui-Hoon Nah et al., 2003). Also, among the contextual factors found to be of significant contribution to the implementation success is the size of the firm (Mabert et al., 2003b). Finally, the cultural aspect of the firm (Kyung-Kwon & Young-Gul, 2002; Duplaga & Astani, 2003) and software characteristics (Bradford &

Florin, 2003) are found to be important factors that contribute to a successful implementation.

The studies mentioned above emphasize the need to identify the various contextual factors surrounding the implementation. Identifying these factors becomes critical due to its impact on the level of the success of the implementation.

This study contributes to the literature of ERP systems by reexamining the productivity function.[1] Specifically, the study looks at critical factors that can impact the relationship between the event of ERP implementation and the post-implementation financial performance of the firm. Three critical factors are identified as contributors to the productivity function of ERP systems: (1) CEO characteristics, most particularly a CEO's equity holdings and horizon; (2) the timing of the implementation (i.e., early/late adopters); and (3) implementation characteristics in terms of the scope of the implementation and the type of modules that are implemented.

The first two factors have not been considered in any other discernable prior research concerning ERP productivity; while the third factor has been. This study also considers the methodological limitations of the previous studies on the implementation characteristics and suggests ways to overcome those limitations.[2]

This chapter is organized as follows: (1) a brief literature review, (2) statement of the purpose of the study, (3) originality of the study, (4) limitations and possible avenues for further research, and (5) a descript ion of the organization of the remainder of this study.

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[1]Productivity function, within the context of this study, refers to a firm's financial performance. The two terms, namely productivity and performance, will be used interchangeably in this discussion.

[2]This methodological issue will be discussed in Chapter 4.

Current Literature on IT and ERP

The existing literature has attempted to answer the question, "Is there a payoff[3] for IT investments"? This question, according to Dehning and Richardson (2002) has been answered, namely, "Yes, IT does pay off." However, to answer this question in more substantive terms, there is a need to reformulate the question more specifically by asking, "When and why is there a payoff?" (Dehning & Richardson, 2002, p. 8). The question has now evolved to become, "Under what conditions does IT pay off?" In an effort to answer this more precise "when/why" question, several studies have been conducted (Dos Santos et al., 1993; Brynjolfsson & Hitt, 1996; Bharadwaj et al., 1999; Dehning et al., 2003)[4] to identify the contextual factors that can impact the relationship between IT investment and the productivity function of that investment.

Studies of ERP investments have also been conducted in a similar manner to the investigation of the nature and outcome of the IT investment. Hayes et al. (2001) documented the positive market reaction to ERP implementation announcements, a finding that triggered several follow-up studies to investigate the productivity function of ERP systems post-implementation.

Previous literature on the productivity of ERP systems, mainly in the archival methodology arena, generated mixed results and contradicted the expected association between performance measures and the actual event of implementation (Poston & Grabski, 2001; Hunton et al., 2003). The aim of these studies was to answer the same "when/why"

[3] For further discussion of the attempts of the literature to answer this question, see Dehning and Richardson (2002), where the above-referenced revised question was found.

[4] These studies and others that discussed the particular conditions under which IT does pay off, will be discussed in chapter 2.

question within the ERP context, but the results were mixed. Other studies (Hitt et al., 2002; Nicolaou, 2004) had methodological limitations.

Poston and Grabski (2001) examined the expected benefits of implementing an ERP system from a sample of 50 adopting firms. Using a matching sample that did not adopt the ERP systems, the two authors conducted a post and pre-implementation analysis. The results were mixed. The adopting firms outperformed the matching sample on some of the financial performance measures, but not others. The authors recommended additional research that would expand the post-implementation period to more than three years.

Hitt et al. (2002) used several performance metrics[5] and documented that the performance of adopters did, in fact, improve post-implementation. However, their study included the implementation period in the testing period, so the results might have been limited in scope. Since ERP implementers experienced a dip in their performance during the implementation years, including the "dip period" within the testing period limits the usefulness of their results. Another limitation to this study was the lack of external validity because the researchers' limited their sample to a specific vendor, namely SAP.

Hunton et al. (2003) examined the performance of 63 adopting firms relative to a matched sample. Their results indicated that the adopters outperformed the match sample due to a decline in the performance of the control sample firms and not to an improvement in performance by the adopting firms. In addition, these authors found that firm size and its financial health pre-implementation marginally impact the relationship between ERP implementation and a firm's post-implementation financial performance. Specifically, the

[5]Hitt et al. (2002) also used Tobin's Q as performance measure.

authors found for small (large) firms the relationship between financial health and performance was positive (not significant). The authors suggested the short post-implementation testing period was the more likely reason for the inconsistent results.

To overcome the limitation of previous research, mainly the short post-implementation testing period, Nicolaou (2004) expanded the testing period to a four-year post-implementation. Nicolaou used differential performance as the dependent variable (i.e., the difference between the adopting firm's performance measure and the matched firm's performance measure post-implementation). His results indicated that the impact of ERP implementation on differential performance was positively significant.

Nicolaou (2004) added other variables to help identify the condition under which ERP systems were expected to pay off. Those variables were: (1) vendor choice, (2) type of benefit sought, (3) type of module implemented, and (4) length of the implementation period. These variables helped to explain the relationship between ERP implementation and differential performance.

The main limitation of Nicolaou's study lies in the methodology used by the author to test his hypotheses. Nicolaou, did not use a full regression model that included all the factors expected to impact productivity function; instead, the author tested each independent variable in a single regression model. For example, when the author tested for the impact of the type of module implemented, he did not include the other variables, such as vendor choice, type of benefit sought, and length of the implementation period. Thus, the regression results may reflect nonrandom effects of the other omitted independent variables.

Another limitation pertains to the definition of the dummy variable that captured the event of ERP implementation. The author assigned the value "1" to the variable if the adopter

performance was higher than the non-adopter. This definition did not capture the event of an ERP implementation; rather, it captured the difference in performance because the value of the dummy variable depended on the direction of the dependent variable. Such limitations in the methodology reduced the reliability of the results. Finally, his hypotheses were not directional, which suggests that the study was more explanatory in nature than theory driven.

Purpose and Motivation of the Study

Early research on ERP productivity suffered from several problems, one of which is the anomalous findings of the studies that utilized the archival methodology to investigate the productivity function of ERP systems. The productivity of ERP systems has been discussed in several studies in the past decade or so. Those studies utilized several research methodologies, including case studies, surveys and archival data. The results were largely consistent with the theoretical predictions that ERP implementation enhances firm productivity. The only exception was the results of studies that were conducted using financial archival data as a measure of productivity. For example, the results of Poston and Grabski (2001) and Hunton et al. (2003) were contradictory to the expected benefit that was supported by theory as well as by the findings of the other studies that utilized different methodologies. The so-called "productivity paradox" was concluded by Poston and Grabski (2001) based on these contradictory findings.[6] Possible reasons for this paradox could be attributed to the exclusion of important factors that might impact the ERP-productivity association (Poston & Grabski, 2001). Also, Hunton et al. (2003) did not consider the scope of implementation.

[6]In this study, the word "anomaly" will be used instead of "paradox" due to the positive results found in those studies that utilized different methodologies (e.g., case studies and surveys).

The findings of archival studies are not just contradicting the theoretical prediction, it is also contradicting with the existing development in the real world. Most archival studies found no association between ERP implementation and enhancement in firm performance, even though there has been an increased investment in ERP systems worldwide. According to Moller et al. (2004), the annual expenditure of ERP systems is estimated to be over $18 billion worldwide.

Another problem created in early research was the limitation of the statistical tests found in some of early research, namely Nicolaou (2004), whose tests lacked reliability, and Hitt et al. (2002), whose tests lacked external validity.[7]

The aim of this study is to overcome the previously mentioned limitations and problems found in earlier studies. This study posits that the anomalous findings of the previous studies in the ERP-productivity relationship are due to the failure to consider several important factors, including CEO equity holdings and horizon, timing of the implementation, type of modules implemented, and the scope of the implementation. It is the purpose of this study to reinvestigate these inconsistent findings and to explicitly take these additional factors into account.

CEO Characteristics

In this study, the impact of CEO characteristics on the association between ERP-productivity relationships will be examined. CEO characteristics, namely CEO equity holdings and CEO horizon pre-implementation, are critical variables that may help to explain the association between ERP implementation and firm performance. These variables have not

[7]These limitations were discussed previously and will be discussed in details in chapter 2.

been accounted for by early research that utilized financial archival data as a proxy for productivity.[8]

Early research has documented the association between CEO holdings and horizon with long-term investments (Dechow & Sloan, 1991; Barker & Muelle, 2002). Given that ERP systems are long-term strategic investments (Wah, 2000) and considering the influence of CEOs on a firm's strategy and investment decisions (Barker & Mueller, 2002), these two CEO characteristics are hypothesized to impact the association between ERP implementation and post- implementation performance.

The IT literature has identified the important role played by top management in information systems implementation. Aladwani (2002) documented the role of management advocacy—management willingness to provide the resources and the authority for the IT project—for project success. Adam and O'Doherty (2000) highlighted the importance of the role of top management in ERP implementation by management's setting clearer goals and objectives. Lack of top management commitment and support in IT projects is one problem identified in large manufacturing firms (Duplaga & Astani, 2003). Fui-Hoon Nah et al. (2003) examined the perception of chief information officers and the critical factors necessary for successful ERP implementation. The results showed that top management involvement is among the most critical factors for successful ERP implementation.

This study postulates that high CEO holdings will result in high firm productivity post-ERP implementation. Equity holdings capture the wealth of the CEO that is tied to the wealth of the stockholders. Agency theory argues that in principal agent settings,[9] there is a

[8]CEO horizon captures the time left for the CEO to serve in the firm. It is measured as the difference between the retirement age and the age of the CEO in the year of the implementation announcement.

[9]Where the CEO is the agent and stock holders are the principals.

need to tie agent's wealth to principal's wealth. Substantial CEO stock holdings are one important way to tie CEO's wealth to stockholders' wealth, which then tends to ensure the maximization of stockholders' wealth (Jensen & Murphy, 1990b).

Early research documents that CEO equity is positively associated with the intensity of long-term investment (Barker & Mueller, 2002, p. 785). The same study also demonstrates that increased ownership (at risk wealth) motivates top managers to become more long-term oriented. Consequently, CEOs with significant stock holdings will be enticed to undertake more investments that will be rewarded by the capital market. This is consistent with the findings for ERP implementations (Hayes et al., 2001). The stock market typically rewards implementers. Dechow and Sloan (1991) also found that CEO wealth sensitivity to firm productivity is associated with long-term investments.

The following points, derived from previous studies, provide support for an expected strong relationship between CEO holdings and the post ERP implementation performance:

- Long-term nature of investment in ERP systems and the risk associated with such an investment (Poston & Grabski, 2001; Hitt et al., 2002; Hunton et al., 2003; Nicolaou, 2004)
- Influence of a CEO on a firm's strategy and decision outcome (Zahra & Pearce Ii, 1989)
- Early documentation of the relationship between similar long-term investment and CEO characteristics (Dechow & Sloan, 1991)
- The Upper Echelons theory that emphasize the role of top management team in the firm (Hambrick & Mason, 1984)

- Convergence-of-interest hypothesis predicting high ownership should lead to great market valuation; convergence-of-interest hypothesis posits that there is a monotonic positive relationship between management ownership and firm value (Morck et al., 1988)[10]
- Negative association between firm risk taking and the personal wealth of the CEO vested in the firm (May 1995)

ERP systems can be risky, and the association between the wealth of the CEO and risky projects is negative unless such investments show promise of reward by the market or in the long term. The CEO with high holdings probably would not initiate such a project unless it is fully expected to generate benefit to the firm.

Long horizon of a CEO will positively impact post ERP implementation performance.[11] Such a proposition is supported by previous discussion regarding the association between CEO characteristics and long-term investment. The horizon proposition is also supported by the early literature that documents a positive association between long term investment and CEO horizon (Baker et al., 1988; Dechow & Sloan, 1991).

Such a positive association can be attributed to the different priorities among different CEOs. While CEOs with a short horizon are interested in current profitability, CEOs with a longer horizon are more interested in long-term profitability (Barker & Mueller, 2002). Since

[10]Mork et al. (1988) documented nonmonotonic relationship. When the percentage is less than 0.05 there is a positive relationship; this relationship becomes negative when the holdings are greater than 0.05 but less than 0.25. Slow rise in the positive relationship is observed when the holdings exceed 0.25. The purpose of this study is to examine the interaction term of the holdings with the ERP event, not the main effect of holdings. The dependent variables are another difference in this study, accounting performance measures, not market valuation.

[11]The CEO horizon refers to the time left for the CEO to serve the firm and is measured as the difference between retirement age and the current age of the CEO (Baker et al., 1988; Dechow & Sloan, 1991).

ERP systems are long-term investments and are modular in nature, their benefits are realized as continuous maintenance/changes are applied to the system after the implementation (Markus et al., 2000). CEOs with a short horizon will not devote themselves to such effort since its benefits will not be realized during their term.

According to Wright and Wright (2002), adopting ERP systems could lead to changes in the business process and strategy of a firm. Such changes would be resisted by short-horizon CEOs, since CEOs with short horizon have greater difficulty in accepting new ideas and learning new behaviors (Hambrick & Mason 1984). Mabert et al. (2003a) state that one possible form of resistance to the changes imposed by the ERP package could be in the form of customizing the code of the ERP package. This would undermine the ERP package functionality, boost up the time and the cost of the implementation, and complicate the process of upgrading the system in the future. Thus, the firm would not fully benefit from the implementation. Thus the anomalous findings presented by previous studies can be attributed to not identifying the differences in priorities and perceptions of change between CEOs with different horizons. These differences were not accounted for by the previous studies that examined the ERP-productivity relationship.

Timing of Implementation

The timing of the implementation is another factor that is expected to influence the relationship between ERP implementation and post-implementation financial performance. Support for the timing proposition is provided by the "efficiency argument" and the release of multiple versions of ERP packages. The efficiency argument postulates that late adopters of ERP systems are expected to learn from the mistakes of early adopters (Ho et al., 2005). The basis of such an argument was obtained from Mabert et al. (2003), who found that late

adopters were more likely to finish their projects on time and with a cost equal to or less than the designated budget for the project.

Support for the timing proposition is also provided by the availability of multiple versions of ERP systems, where the later versions are more powerful and versatile than the earlier versions. Kremers and Van Dissel (2000) examined the reasons that led firms to migrate from an early Baan version to a later version. Added functionality and keeping the system up-to-date were among the reasons found by the authors that motivated the migration. Such features available in the newer versions impacted the productivity of late adopters more positively. Later adopters not only had the advantage of learning from the early adopters, but also had the advantage provided by being able to implement more capable versions of the ERP systems. Earlier studies yielded inconsistent results, probably due to their failure to consider this timing factor. Thus, the third proposition of this paper is that later adopters will have higher post-implementation productivity relative to early and non-adopters.

Scope of Implementation and Modules Type

Scope of implementation can be an important contributing factor to the productivity function of ERP systems. Implementation scope is defined as the size of implementation in terms of the functional areas covered by that implementation. As for the module type, each module is classified according to its contribution to the value chain of the firm. The value chain consists of primary activities (inbound logistic operations, outbound logistic marketing, sales and services) and support or secondary activities (firm infrastructure, human resources technology, purchasing) (Romney & Steinbart, 2002; Turban et al., 2002). Firms with larger implementation scope (Hitt et al., 2002) or firms that implement primary modules are

expected to outperform firms that implement only secondary modules or non ERP implementers (Nicolaou, 2004).

Thus the differences in the scope of implementation and the differences in the type of module implemented are another factor considered in this study. This study differs from Hitt et al. (2002), who investigated the scope of the implementation of single ERP vendor, by extending the implementation to various ERP vendors to maximize the external validity. This study also differs from Nicolaou (2004), who investigated the impact of module type by adopting a partial regression-model, by adopting a full regression-model when testing for the impact of ERP implementation to enhance the reliability of the findings.

To summarize, previous studies in ERP productivity that utilized the archival data methodology did not identify the role of CEO equity holdings and horizon, the timing and scope of the implementation, nor the type of module implemented. Such variables are expected to impact the ERP productivity function. Both studies that considered the scope of implementation (Hitt et al., 2002) and the type of module implemented (Nicolaou, 2004) had some limitations as discussed in the previous paragraph. This study attempts to overcome these limitations and resolve the productivity anomaly documented in the archival research paradigm that investigates ERP productivity.

Originality of the Study

This study differs from earlier research in four main ways. First, this study investigates the productivity function by considering the impact of two CEO characteristics: CEO equity holdings and the CEO horizon. None of the previous studies of ERP productivity have considered these characteristics. Early research has documented the association between CEO holdings and horizon with long-term investments (Dechow & Sloan, 1991; Barker &

Mueller, 2002). Given that ERP systems are long-term investments, investigating the effect of CEO characteristics is critical. Investigating such issues more fully will contribute not only to the ERP literature, but will also help settle the debate about whether or not individual top executives impact organizational outcomes. Additionally, this study contributes to the literature concerning incentive from equity ownership, wherein contracts are designed according to the nature of the investment carried by the firm. Firms operating in a stable price environment, technology or market share do not encounter high monitoring costs. However, less stability of these factors (i.e., more risk or noise) will increase the monitoring costs of the agent activity. Such costs can be reduced by aligning the wealth of the CEO with the wealth of the shareholders (Demsetz & Lehn, 1985). Considering that ERP projects are risky, increased CEO equity is one way to reduce the monitoring cost.

Second, this study is the first to take into account the efficiency argument within the productivity function of an ERP system. Prior research has considered this argument in terms of completing the project on time, and on or under budget (Mabert et al., 2003a), or in terms of security analyst forecast revision to ERP implementation announcement (Ho et al., 2005). This study considers this argument in terms of ERP implementation impact on firm productivity (accounting financial ratios).

Third, this study considers the scope of implementation (the size of the implementation) and the type of modules implemented (primary or secondary.) Two studies have considered these two variables, namely Hitt et al., (2002), who considered the scope while Nicolaou (2004) considered the module type. However, the former study results lacked external validity due to restricting their sample to one single vendor, while the latter results lacked reliability due to not utilizing a full-regression model.

Fourth, this study will address some methodological issues:

1. A longer post-implementation testing period will be used, analyzing up to four years post-implementation; such issue was not dealt with by the earlier research (Poston & Grabski, 2001; Hitt et al., 2002; Hunton et al., 2003).

2. The findings of this study are more generalizable than those of Hitt et al. (2002) since this study examines all public announcements made to the press and SEC filings. Therefore, the study is not limited to a specific ERP vendor.

3. In contrast to Nicolaou (2004), who used partial regression models to test each variable individually, this study includes all variables of interest in a single model.

4. This study controls for the differences among the firms by using the block design to reduce the error variance and increase the validity of the inferences.[12] Such design was not used by early research.

As a result of the previously mentioned differences, this study implications and contribution are different. In chapter 5, the implications and contribution of this study will be discussed in detail.

Limitations

Although this study attempts to investigate the impact of CEO characteristics and several other factors on the productivity function of ERP systems, this study might still have some limitations. First, the problem of some unknown omitted variables might exist, similar to the limitation of any other archival study. In an effort to overcome this limitation, matching samples will be used to control for economic factors that might impact the market

[12]The block design is explained in greater detail in chapter 3.

or the industry. Despite that effort, only inferences about correlation can be implied; no direct causality between implementation and post-implementation performance can be concluded. Other potential limitations include those related to the expected small sample size collected from the available voluntary press announcements. To overcome such problems, SEC filings will be searched to identify implementing firms. However, there are firms that do implement ERP systems but do not announce to the press or discuss such investments in their SEC fillings (Nicolaou, 2004).[13] Finally, other CEO characteristics, such as functional and educational background, board structure characteristics and corporate governance variables, which might have some impact on the results of the research, are not considered. They should be considered and addressed in future research.

Organization of the Study

Chapter 2 will offer a discussion that links agency theory compensation and contracting literature to defend the research proposition regarding CEO characteristics. Also chapter 2 will discuss the productivity function of ERP systems with regard to the scope of implementation, type of module implemented and the timing proposition.

Chapter 3 deals with hypotheses development and the methodology applied to this study. Chapter 4 presents the obtained results and discusses how these results are different or consistent with the previous literature. Finally, chapter 5 presents the summary, implications, contributions and limitations of this study, and possible avenues for future research.

[13]The assumption would be that if firms did not include implementation in their SEC filings, probably the investment was not significant to the firms.

CHAPTER II

LITERATURE REVIEW

Introduction

This chapter reviews the documented association between investment in IT and firm performance and summarizes the current status of ERP productivity literature. A review of selected studies that highlights the role of top management in IT and ERP systems implementation are included, together with a review of the literature of CEO characteristics and their impact on long-term investment. The motive behind this review is to integrate the literature on CEO characteristics with the literature on IT and ERP productivity to better understand the ERP-productivity relationship. Finally, this chapter also describes the evolution of ERP systems.

IT and Firm Performance

Earlier studies that attempted to answer the "When/Why" question focused on identifying the contextual variables that contribute to the association between IT investment and firm performance. These contextual variables can be classified as either firm specific or technology specific.[27]

[27]Also among the contextual variables are industry specific variables. However, the studies discussed under the subsections that are firm specific and technology specific control for industry specific. Therefore, to avoid redundancy, whenever applicable the industry contextual variables will be pointed out during the discussion.

Firm Characteristics

Three firm specific characteristics have been identified to have association with IT performance; these include: (1) the level of IT expenditures in the firm, (2) top management and firm IT capability and (3) the innovativeness of the firm in terms of investing in IT. Each firm specific is discussed below in the same order mentioned above.

Several studies have investigated the association between IT expenditure and firm performance, and in general, the research demonstrates a positive association between the intensity of IT expenditure and firm performance. One study that investigated the impact of IT expenditure intensity on firm performance, as measured by Tobin's q, was conducted by Bharadwaj et al. (1999).[28] Tobin's q was used as a proxy for performance because of its ability to capture strategic flexibility and intangible value that would enhance firm performance usually not captured by traditional accounting variables. The authors found that the IT expenditure variable contributed to firm growth, when measured by Tobin's q. The coefficients of IT expenditures were significant across a five-year testing period, confirming that IT expenditures did contribute to firm potential performance.

Mitra and Chayam (1996) investigated whether higher IT spenders have better performance when using a different approach for operationalizing the performance variable. This study measured the productivity and the efficiency of a firm. The performance measures included operating expenditures, cost of goods sold and selling, general and administrative expenditure. The authors found that IT spending is negatively (positively) related to operating expenditures and the cost of goods sold (selling, general, and administrative

[28]The authors operationalized IT expenditure as the ratio of IT expenditure on time t divided by sale on time t.

expenditures). The authors concluded that in general, IT expenditure positively contributes to both productivity and efficiency of a firm.

Brynjolfsson and Hitt (1996) investigated the impact of IT stock, as a proxy for IT expenditure, on the return on assets (ROA) and the return on equity (ROE) over a five-year period. The authors operationalized the variable IT stock as the market value of the IT system used by the firm + three times the firm's expenditure on IT labor. The results indicated a positive association between IT stock and ROA for three out of the five years in the testing period. However, there was no association between IT stock and ROE. From the previous discussion a general conclusion can be drawn that the previous literature shows a positive relationship between firm performance and the intensity of IT expenditure.

Top management characteristics are another variable that pertains to firm specific variables, in particular, the appointment of a chief information officer (CIO). Since information systems are considered an important resource of a firm, greater attention is placed on managing these resources. A CIO's responsibilities not only include the supervision of IT architecture, but also the IT database and the IT vision of the firm (Turban et al., 2000). The impact of creating the new position of CIO was investigated by Chatterjee et al. (2001). The authors clearly showed that the increased contribution of IT to firm performance resulted in an increase in the number of companies that actually appointed a CIO. More importantly, the appointment of a CIO reflected a change in top management policy and thinking. The creation of a new CIO position reflected that top management's perception of IT investment was changing and recognized the impact on firm activity and firm performance. The authors found that the market perceived the announcement of a newly created CIO position positively. For firms operating in IT-driven industries, these

announcements gained even higher abnormal return relative to other industries, confirming that the association between firm specific variables (the creation of a CIO position) and performance is indeed moderated by industry specific variables in IT driven industries.

Bharadwaj (2000) examined the performance of high IT capable firms. A firm was classified as high IT capable if it appeared on the InformationWeek 500 list, a directory published annually listing firms based on their use of technology. The author matched firms on the list with non-listed firms and compared several accounting performance measures and expenditures ratios over a period of four years. The study found that "high capable firms" outperformed the match group in terms of ROA, return on sale (ROS), ratio of operating income to sales, ratio of operating income to assets, ratio of operating income to number of employees, ratio of selling general and administrative expenditure to sales, and ratio of operating expenses to sales in all the four years studied. The ratio of cost of goods sold to sales, however, was lower in two out of the four years.

Finally, a study by Dos Santos et al. (1993) examined market reaction toward innovativeness in IT implementations.[29] The authors found that in general the stock market does not reward firms that invest in IT in terms of abnormal return. However, the market does reward innovators in terms of positive abnormal return. The industry moderating effect was also observed in this study. The authors found that announcements of IT investment received significant positive abnormal return only for firms in the financial and service industry. The same reaction was not observed for manufacturing firms.

[29]The authors' definition of innovativeness in IT investment is a new product or service, new IT application within an industry, or a first use of a technology.

In conclusion, a firm's specific characteristics play an important role in explaining the association between IT and firm performance. Similarly, the association between IT and performance is influenced by industry specific characteristics. The following subsection discusses the characteristics of the implemented information technology.

IT Characteristics

One of the technology specific contextual variables identified and investigated by the literature is whether or not the technology used is strategic (Dehining & Richardson, 2002). Turban et al. (2002, 83) described a strategic information system as an information system that is able to "significantly change the manner in which business is done. . . .[and to] change the goals, process, products or environmental relationships to help the organization to gain a competitive advantage." ERP systems are strategic systems since they are capable of changing firm strategy, the firm's business process, firm organization, and even firm culture (Davenport, 1998; Wah, 2000; Francalanci, 2001; Turban et al., 2002; Wright & Wright, 2002).[30] Thus, strategic systems have technology characteristics that differ from those of non strategic systems, and therefore, the impact on firm performance is different.

Hayes et al. (2000) investigated the impact of information system outsourcing announcements as a strategic IT investment on the daily stock return. Hayes et al. (2000) found that the market reacted positively to information systems outsourcing announcements in terms of abnormal return. The reaction was significant for small firms and for firms in the service sector. Such significance was not observed for large firms or firms that operated in sectors other than service sectors. The findings of this study highlight the clear role of

[30] Studies of ERP systems will not be discussed in this section, but rather in chapter 3.

industry specific factors in determining the association between strategic IT investment and firm performance.

Subramani and Walden (2001) investigated stock market reaction to a firm's announcements of investment in e-commerce applications. The results indicated that the market rewards firms that invest in e-commerce applications. The reward (abnormal return) was more significant for firms that announced investment in business-to-consumer (B2C) applications than for firms that announced investment in business-to business (B2B) applications. These findings indicate that even within strategic systems certain applications do contribute to the association between IT and firm performance. These results also highlight the importance of IT characteristics. The authors also found that abnormal return was higher for e-commerce applications that sold tangible goods than for e-commerce applications that sold digital goods. The type of goods sold supported the impact of type of industry on the association between strategic IT investment and firm performance.

Finally, the scope of implementation and the type of modules implemented were among the various IT characteristics identified by the early research. Both factors impacted the association between IT Implementation and firm performance. The scope of implementation corresponded to the size of the implementation within each firm. Larger scopes of implementation (i.e., the number of functional units within the firm that implemented an integrated IT system) resulted in better firm performance (Hitt et al., 2002; Barki & Pinsonneault, 2005).

The functional area in which the system is implemented also influences the association between IT implementation and firm performance, based on contribution of the IT system to the value chain of the firm (the type of modules implemented). Romney and

Steinbart (2002) and Turban et al. (2002) indicated that a firm value chain can be categorized as primary activities (i.e., inbound logistic, operation, outbound logistic marketing, and sales and services) and support or secondary activities (i.e., firm infrastructure, human resources technology, and purchasing). Barki and Pinsonneault (2005) postulated that systems implemented in units that function within a firm's primary activities generate better performance for the firm compared to systems implemented in units that function within secondary activities of the firm.[31] Barki and Pinsonneault (2005) argued that as firm integration extended to include external parties like customers and suppliers, firm performance improved more than for an implementation that limited to internal integration.

This previously discussed research demonstrates how the type of technology implemented (strategic or not strategic) can impact a firm's performance. More interestingly, even differences within the components of the systems (B2C vs. B2B, scope of implementation, type of module implemented and extent of integration), or industry specific do impact the IT-performance relationship.

To summarize, IT-performance association was investigated through examining contextual variables that were either related to the technology implemented (strategic), a firm's characteristics (high IT spender), and specific industry (operating in a service sector or the industrial sectors). Identifying the contextual variables that are present helps explain the type of relationship between IT and firm performance, whether that relationship is negative, positive, or non-existent (Dehning & Richardson, 2002). It also answers the "When/Why" question raised in chapter 1. Based on that, this study examines additional contextual

[31] I could not identify any studies that examined the impact of strategic systems on firm performance utilizing accounting variables, except for the ones related to ERP systems. I will present these studies later in this chapter.

variables to explain the association between ERP system investment and firm performance, specifically, the ERP scope and type of implementation as contextual factors related to the technology implemented. It considers CEO characteristics and the time of implementation as contextual variables that relate to firm characteristics. These contextual variables have not been considered in early research.

ERP and Firm Performance

Previous research of the impact of ERP on firm performance can be divided into two categories: (1) the impact of ERP systems on the value of a firm using market measures and the (2) the impact of ERP on firm performance using accounting measures. The following two subsections review studies that examined both categories.

The Impact of ERP Systems on Firm Value

The first study to test market reaction to an announcement of ERP systems implementation utilizing event study methodology was Hayes et al. (2001). It is also one of the most cited papers in the ERP literature. The authors investigated market reaction to ERP implementation announcements. The results indicated a positive abnormal return for the period of the announcement. The main effect of firm size and firm health, as measured by Altman's Z score alone, has no significant impact; however, the interaction of size and health is significant. For small (large) firms the relationship between financial health and performance was positive (not significant). The authors' findings also indicated that market reaction to large vendor implementation announcements was significantly positive. The market did not react significantly to small vendor announcements. An additional test using

ANOVA[32] confirmed this difference between large and small vendor announcements. The Hayes et al. study complemented the previous literature on the association between IT and the market value of a firm. Hayes et al. (2000) and Dos Santos et al. (1993) presented studies within the IT literature that utilized event study methodology.

An experimental study conducted by Hunton et al. (2002) aimed to understand the reaction of financial analysts to ERP implementation plans. As a triangulation to Hayes et al. (2001), the Hunton et al. (2002) researchers used earning forecasts revisions instead of abnormal returns and found that announcements of ERP implementation had a significant positive effect on earnings forecast revisions. They also found that such announcements for small/healthy and large/unhealthy firms were perceived as more significantly positive than announcements for small/unhealthy firms. The Hunton et al. (2002) study did not account for the impact of ERP vendor size on the forecasts of analysts or whether analyst familiarity with the vendor impacted analyst decisions. In general, the results supported and complemented the findings of Hayes et al. (2001).

As a triangulation to the Hayes et al. study, Ho et al. (2005) used the analysts' forecast revision stored in the IBES database and extended the testing period for the forecast revision to more than one year. The authors documented that the revisions occurred in longer windows of three years and attributed these revisions to the fact that an implementation project can take up to three years. Adopting firms are associated with forecast revision up to a three-years-ahead forecast, especially for early (1993-1997) and late adopters (2000-2002). The association was both positive and significant. Firms that implemented ERP systems

[32] Firm size is included in the model as a control variable and tested; the interaction between firm size and vendor size is also included. Both the main effect and the interaction effect are not statistically significant.

during 1998-1999 did not have a significant impact on analysts' forecast revision.[33] In contrast with the findings of Hunton et al. (2002), this research showed that there is no effect for the size of the firm, health of the firm, or the interaction effect of both these factors. The results suggested an investigation was needed for the "efficiency argument."[34]

Impact of ERP Systems on Productivity of a Firm

Several studies have used archival data to investigate the impact of ERP systems on business process and firm performance. Poston and Grabski (2001) investigated the impact of ERP implementation on a firm with the expectation that ERP systems would reduce internal and external coordination costs, and therefore, the performance of the firm post-implementation would improve. Using a matched sample of firms that did not implement an ERP system, the authors investigated the cost of goods sold (COGS) and selling, general, and administrative costs (SG&A) as proxies to obtain internal coordination costs. For external coordination costs, Poston and Grabski (2001) used SG&A. Both internal and external coordination costs were scaled to revenue.

The authors expected that both coordination costs (internal and external) would be greater pre-implementation for the treatment sample, and the difference in the coordination cost between pre- and post-implementation for the treatment sample would be less than the difference in coordination cost for the control sample. The authors also expected that residual income would be greater post- implementation for the treatment sample and expected that the difference between pre- and post-implementation for the treatment sample would exceed the

[33] The explanation suggested by the authors was that the implementation decision was motivated by Y2K requirements, not by business requirements.

[34] The efficiency argument suggests that late adopters have the advantage of learning from the experience and mistakes of the early adopters.

difference for the control sample. Finally, Poston and Grabski (2001) expected that the ratio of employee to revenue for treatment sample post-implementation would be less than the same pre-implementation ratio. Final results for the study were inconsistent with the predictions. A significant increase was observed for the treatment sample in the cost ratio post-implementation, while the control sample experienced more employee reduction and a significant increase in residual income after the implementation. Although the treatment sample decreased the number of employees, the number of employees in the matching sample decreased more significantly.

Another study by Hunton et al. (2003) compared the performance of adopter firms to the performance of non-adopter firms. The researchers investigated the impact of implementation on ROA, Return on Investment (ROI) and Assets Turn Over (ATO). The research found that for non-adopters, the performance measures were negative and significant. However, Hunton et al. (2003) found that the performance of adopting firms remained steady and did not improve post-implementation. Non-adopter firm performance, on the other hand, declined post-implementation. Further, when Hunton et al. (2003) conducted within group analysis (i.e., examined the impact within adopting firms only), they found that the size and the health of the firm moderated the performance post-implementation. Specifically, healthy small firms exhibited higher ROA, ROI, and ROS post- implementation.

Findings from studies by Poston and Grabski (2001) and Hunton et al. (2003) were inconsistent with the expected benefits of ERP implementation. A possible explanation, according to Poston and Grabski (2000), was that industry experts had predicted that a four-to-five-year window would have been more appropriate for observing improvement in

performance after ERP implementation. However, both studies examined performance on only three years' post implementation. Another possible reason might have been that neither study considered the type of module that was implemented. ERP modules can be classified as primary and secondary modules, according to the module attribution to the value chain of the firm.[35]

A third study was conducted by Hitt et al. (2002). It compared performance measures between adopters and non-adopters of the SAP R/3 system from 1996 to 1998. The authors also investigated the performance measures before, during, and after implementation for the adopters. Their results indicated that ERP adopters had greater performance as measured by profit margins, returns on assets, inventory turnover, and accounts receivable turnover. However, the adopters experienced lower levels of post-implementation return on equity. The authors attributed that result to the possibility of higher equity financing before and during implementation rather than simply to a decline in firm performance.

The Hitt et al. (2002) study differed from the previous two studies discussed here. Hitt et al. (2002) did provide a control for the scope of implementation. They found that the greater the scope of implementation, the greater the enhancement of performance. However, the study lacked external validity and the research findings were difficult to generalize because of the study's focus on only one major ERP vendor implementation, namely SAP. In addition, the study included the implementation period in the testing period, so the results might have been limited in scope. Since ERP implementers experienced a dip in their

[35] The terms primary/secondary module were explained earlier and will be explainedagain in more detail in chapter 3.

performance during the implementation years, including the "dip period" within the testing period limits the usefulness of their results.

Finally, Nicolaou (2004) investigated the productivity of firm post-implementation, using a longer time span of four years after implementation. In this study, the author attempted to resolve earlier inconsistent results and included new variables to explain the impact of ERP implementation on performance. The author also used a match sample methodology. Performance measures included the difference in ROA, Return on Investment (ROI), OIA, ROS, OIS, COGS (make sure that all these abbreviations have their original phrases somewhere before this point) scaled by Sales, SG&A scaled by Sales, and the number of Employees divided by Sales (ES). The results for the impact of ERP without the new variables yielded mixed results for a period of four years post-implementation. However, when Nicolaou added the new variables, the results improved. Nicolaou introduced two new variables, namely Objective of the Implementation (business or system integration objectives), and Length of Implementation, along with other variables identified by earlier research, such as vendor choice (large or small vendor), and type of module implemented (primary or secondary). Although the addition of new variables improved the research results, there are still some shortcomings in the statistical model Nicolaou used.

Nicolaou's study used the difference in financial performance post-implementation between the adopting firm and its match as the dependent variable. If the difference is positive, then the independent variable (i.e., the dummy variable that is capturing the event of ERP implementation) will equal 1, otherwise, the dummy variable will be 0. Such a methodology indicates that the independent variable depends on the dependent variable. Another limitation to the study was that Nicolaou did not run a regression model that

incorporated all the variables under investigation. Rather, he ran several regression models so that each model was designated to examine only one independent variable. Reck (2004) observed Nicolaou's (2004) study and commented on that particular shortcoming..

In summation, research on ERP systems utilizing archival data methodology did not incorporate certain firm specific characteristics or technology specific characteristics that could indeed influence the ERP-performance relationship. One firm specific characteristics not included in the prior models were CEO characteristics. A CEO's influence on firm strategy and investment decisions can obviously have great importance (Zahra & Pearce, 1989). The influence of top management on long term investment, IT, and ERP implementation will be reviewed in sections 4 and 5 respectively.

Another limitation of the prior studies is the lack of consideration regarding time of implementation. The timing effect on the association between ERP and firm performance was suggested by Ho et al. (2005); however, it has not been examined by any other study in firm performance as measured by accounting variables. Another limitation found in the previous studies was the length of the testing period and model misspecification. This study will reexamine the productivity function of ERP systems by taking into accounts all these factors.

Role of Top Management in IT and ERP Implementation

The role of top management in IT implementation is critical. Prior ERP studies that utilized archival methodology failed, however, to consider the role of top management for IT implementation success. This section reviews studies of the role of top management in IT implementation and suggests the importance of top management in ERP implementations.

Jarvenpaa and Ives (1991) investigated the role of CEO as an important factor in IT management success. Three models as independent variables were examined: (1) executive involvement; (2) executive participation; and (3) executive participation, organizational conditions, and executive functional background (all as independent variables and executive involvement as a mediating variable).

In all three models, the dependent variable is the progressive use of IT. Executive involvement refers to the importance assigned by the CEO to IT implementation. Executive participation refers to a CEO's personal intervention in the management of IT. Organizational conditions indicate the potential for a progressive use of IT in the industry. The results of the study indicate that executive involvement, executive participation, executive age, and functional background are associated significantly with progressive use of IT in a firm.

Adam and O'Doherty (2000) investigated the experience of ERP adopters in Ireland over a three-year period. Using semi-structured interviews with key individuals who were involved in the implementation process, the authors used staff adaptation to ERP systems and the degree to which managers had taken ownership of the ERP systems as determinants of successful implementation. The authors reported that the risks associated with ERP implementation might be due to the complexity of the implementing organization and the complexity of the ERP system actually being implemented. The availability of clear managerial objectives and the ability of firms to work with experienced implementers were factors that reduced implementation complexity (Adam & O'Doherty, 2000).

A study conducted by Aladwani (2002) highlighted the importance of the role of top management in information systems (IS) projects. This study wanted to validate an integrated

and theory-driven performance model of IS. Organizational characteristics included management advocacy—the willingness of management to provide the required resources and authority for project success. Six factors that influenced performance were used as independent variables, which included technology, organization, project, task, people, and process. The dependent variables were task outcome, psychological outcome, and organizational outcome. The results of the study indicated that management advocacy does have a significant and direct impact on task outcome and organizational outcome. The setting of clear goals and objectives by management also has a significant impact on the psychological outcome.

Although the role of top management in IT implementation is critical, prior ERP studies utilizing the archival methodology failed to consider this factor. Possible reasons for such exclusion were data availability and the lack of any archival study that examined the impact of top management on the IT-performance relationship.[36] To overcome this limitation, this study considers the impact of CEO power on organizational outcome in terms of financial performance. The research also benefits from the similarities between investment in R&D and investment in IT to highlight the role of top management on the ERP-performance relationship.[37]

CEO Characteristics and Long-Term Investment

The impact of CEO characteristics on long-term investment has been documented. Two CEO characteristics, namely CEO equity holdings and CEO horizon in particular, have been found to be the most significant. CEO holdings can be defined as the equity of the firm

[36] Methodology used in the studies mentioned in this section, include survey and semi structural interviews.
[37] The similarity between investment in R&D and ERP systems will be mentioned in the conclusion.

held by a CEO as a percentage of the total outstanding share of the firm (Jensen & Murphy, 1990a). The CEO horizon refers to the time left for the CEO to serve the firm and is measured as the difference between retirement age and the current age of the CEO (Baker et al., 1988; Dechow & Sloan, 1991).[38] Studies that highlight the role of CEO characteristics on long term investment are reviewed below.

Dechow and Sloan (1991) investigated whether CEOs manage discretionary investment expenditures in their final years in office to improve short-term earning performance. This behavior is mostly found among executives with compensation plans tied to earnings and is referred to in the literature as the "horizon problem." The authors of this study used R&D expenditure as a proxy for long-term investment and developed three hypotheses. The first concerned whether such a problem actually existed and postulated the increasing likelihood of a reduction in R&D in the CEO departure year. The results indicated that R&D expenditures declined more than expected during a CEO's year of departure. The second and third hypotheses investigated two possible factors that mitigated the horizon problem, namely CEO wealth sensitivity to firm value and the relay process[39]. The results were consistent with the authors' predictions; both wealth sensitivity and the relay process mitigated the horizon problem. However, when both factors were included in one model, the relay process was no longer significant. However, the relay process variable did maintain the same predicted sign.

[38] The operationalization of both variables, i.e., holdings and horizon, will be presented in chapter 3.

[39] Wealth sensitivity was measured as CEO holdings of equity at time t, scaled by CEO's cash compensation at time t-1. The relay process refers to where a CEO works with his successor before she/he steps down. In this process the old CEO delegates responsibilities to the new CEO over time. When the new CEO takes the position, the old CEO remains with the firm as Chairman of the Board and continues to work with the new CEO for an average of three to four years before fully retiring.

May (1995) investigated the impact of human capital (years vested in the firm) and CEO wealth on both diversification and firm risk attributes. The Researcher also examined the impact of CEO background and firm past performance on diversification. Diversification in this study refers to a firm acquiring firms that operate in different industries. Risk attributes is defined as debt ratio and equity variance. May postulated that CEOs with high human capital are more likely to pursue diversification strategies, and their firms are more likely to have lower firm risk attributes. As for CEO wealth, the author postulated that CEOs with high wealth would pursue more diversified strategies, and their firms' risk attributes would be low. High equity holding CEOs were presumed to have less diversified wealth.

In terms of CEO background, the author hypothesized that diversification by the CEO would be directed toward areas that she/he was familiar with from prior experience in the firm. As for past performance, the author expected that a firm with poor performance would be more likely to pursue diversified strategies. The results of the research indicated that there was weak evidence to support the association between human capital and diversification, but strong evidence to support the association between high wealth and diversification. As for risk attributes (i.e., debt ratio and equity variance), CEO wealth was not significant. These findings could be attributed to the definition of the equity holding used by the author. May did include in the proxy of the CEO wealth an estimation of CEO cash compensation. Such inclusion might reduce the power of the equity holdings according to Jensen and Murphy (1990a).

Barker and Mueller (2002) investigated the relationship between CEO characteristics and firm R&D spending. They found that CEOs with high stock ownership were more likely

to invest in R&D. Also, they found that expenditure for R&D negatively related to the age of the CEO (i.e., the older the CEO, the less R&D expenditures).

Based on the literature review in this section, the reader can observe the following. First, CEO characteristics do impact R&D investment significantly. Such characteristics have a similar influence on IT investment due to the similarity between investment in R&D and investment in IT. R&D and IT investments are similar and both can be risky projects. They are expected to improve firm performance and generate future benefits to the firm (Dehning & Richardson 2001, p. 24). This is also true with ERP systems. They are risky long-term projects and are also expected to generate future benefits to the firm (Poston & Grabski, 2001; Hunton et al., 2003; Nicolaou, 2004). Given the risky nature of ERP systems, CEOs with higher holdings will not risk their wealth unless the outcome of such investment is expected to impact their own wealth positively.

The second observation is regarding the horizon of a CEO. Younger CEOs are more long-term oriented and more receptive to new technology and strategies[40]. ERP projects require continuous upgrading and maintenance, and their benefits are most often realized in the long term. A younger CEO is expected to be devoted to such projects because he/she will probably be around the firm longer.

Timing of Implementation

The following provides a brief history of the evolution of ERP systems and discusses studies that investigated the timing issues related to ERP systems. The main purpose here is

[40] This argument will be presented with more details in Chapter 3.

to provide support for the proposition that late ERP adopters exhibit better productivity than do early adopters.

The roots of ERP systems trace back to materials requirement planning (MRP) systems. MRP is a computerized planning process that integrates inventory management, production, and purchasing of interrelated products. MRP systems are dedicated only to production scheduling and inventory. MRP systems are also custom-designed, using designer/user requirements and designer/user interaction with the system (Mabert et al, 2003).

However, the manufacturing process is more complex and involves allocation of resources, including financing and human resources. These functionalities are beyond the capabilities of MRP systems. As a result Manufacturing Resource Planning (MRPII) emerged. MRPII is a computerized planning process that integrates financing, purchasing, production, inventory and labor in a firm. MRPII systems incorporate the functionality of MRP systems and add both labor costing and financial planning.

During the MRP and MRPII era, each department in a firm had its own information system, a circumstance that led to a lack of overall integration. Although MRPII systems added the allocation of resources needed for production function, it did not add other functionalities of the manufacturing process (Mabert et al, 2003). ERP systems solutions, therefore, emerged to provide better integration of different departments within the firm.

ERP systems continued to evolve over time and extended its integration to include external integration with such business partners as suppliers and customers. ERP system integration was not limited to manufacturing activities or the primary activities of the value

chain. It was extended to the secondary activities.[41] As time passed, ERP systems became global systems that had the ability to integrate a global supply chain and could be integrated into e-commerce applications. Firms are connected to international parties that include firm branches, customers and suppliers around the world through ERP systems that are capable to convert currencies in financial statements of the branches or transactions held with other parties outside the U.S. in a timely manner[42].

ERP systems differ from MRP systems. ERP systems are packaged systems that often require the implementing firm to change its organization or the way it conducts business (Francalanci, 2000; Mabert et al, 2003). MRP systems, on the other hand, are designed to fit the business processes of the firm. ERP systems are different from MRPII in that ERP systems include functionalities[43] that are beyond the focus of MRPII systems (Yusuf & Little, 1998).

As time passes, newer versions of ERP systems add functionality and update components that will enhance the capability of the system (e.g., SAP R/2 and SAP R/3). According to Kremers and Van Dissel (2000), added functionality to a newer version and keeping the system up to date, are among the reasons firms report as motives to migrate from an older to a newer version of an ERP system.

Another issue related to the timing of the implementation is the efficiency argument (Ho et al., 2005) Ho and colleagues found that the three-year-ahead analyst forecast revision was positive for late ERP implementation announcements made during 2000-2002. The

[41] Value chain activities, including the scope of ERP implementation, will be discussed in chapter 3.

[42] This information was obtained from the collected announcements.

[43] These functionalities include but are not limited to human resource planning, decision support systems, regulatory control, maintenance support, and supply chain management.

authors attributed this positive revision to the fact that late ERP adopters learn from the mistakes of early adopters, a finding that advances the timing proposition (see chapter 1).

Mabert et al. (2003) investigated differences in the approaches used by companies for ERP implementation and how such approaches impacted a firm's ability to manage implementation on time and under budget. The authors found that late implementers had a shorter time of implementation and smaller budgets, indicating that the implementation process became more efficient over time. Thus, late adopters learned from early adopters and benefited from the "learning curve effect."

Support for the timing proposition presented in chapter 1 is found in the evolution of ERP systems; simply put, systems functionalities improve over time. The release of new ERP packages motivates firms to migrate to later versions to benefit from added functionality that was not available earlier. Availability of such new features positively impacts the productivity of the firm. Moreover, this timing proposition is supported by both the "efficiency argument" and the "learning curve effect" views.

Summary and Conclusion

Identifying the contextual variables surrounding the implementation of an ERP system clarifies the ERP-performance relationship. The selected studies reviewed in this chapter demonstrate how critical these contextual variables are in answering this study's main question. However, some critical contextual factors were not considered in these studies. This includes the role of CEO characteristics in IT investment within the archival methodology paradigm. For example, CEO characteristics can be considered contextual factors that relate to the specific variables of a firm. Presently there is no literature that addresses a CEO's Equity and Horizon impact on the ERP-performance association.

Both the scope of implementation and the type of modules implemented are also critical factors in explaining the ERP-performance relationship. Although both variables were considered in earlier research, the methodology used to investigate their impact is questionable. It is desirable to reexamine the impact of these variables to resolve the anomalous findings inform the previous studies that used archival methodology.[44]

Finally, the timing of an ERP implementation is expected to impact firm performance. The timing argument is a contextual factor pertaining to technology characteristics. The evolution of ERP systems packages is expected to enhance firms' performance due to the added functionality available in recent ERP packages. Both the efficiency argument and the learning curve effect support the timing argument. Chapter 3 will discuss the development of the hypotheses and the methodology used for this research.

[44] Anomalous findings of the archival studies on ERP productivity were described in chapter 1: Purpose and Motivation of the Study.

CHAPTER III

HYPOTHESES DEVELOPMENT AND METHODOLOGY

Introduction

This study attempts to answer the "When/Why" question of ERP investments. Specifically, under what conditions or contextual factors investment in ERP systems will positively impact a firm's productivity. In chapter 1 each of the four propositions postulates a condition expected to affect the productivity of the firm post-ERP implementation. This chapter will first, develop the hypotheses based on each proposition, and second, describe the methodology for testing the hypotheses as well as define the operationalization of the variables.

Hypotheses Development

The section is divided into four sub-sections; each subsection is related to one hypothesis. The first and second subsections focus on the two CEO characteristics—equity holdings and horizon. The third sub-section deals with the proposition regarding the timing of implementation and the last subsection discusses the characteristics of the implementation.

CEO Equity Holdings

The level of CEO involvement in IT implementation decision and process is considered a critical success factor for IT implementations (Jarvenpaa & Ives, 1991). Therefore, CEO equity holdings are predicted to be positively associated with the level of her/his involvement IT implementation. This assertion is based on the findings of Hayes et al.

(2000), who established that an implementation of an ERP system has a significant positive impact on the market value of the firm. The stronger the relationship between the market value of the firm and CEO wealth, the stronger the impact that an ERP implementation would have on the CEO wealth.[63]

Since the level of CEO involvement is critical for successful ERP implementation, the level of CEO equity holdings will be positively associated with the level of CEO involvement in ERP implementation. This positive association between level of involvement and equity holdings is due to the established relationship between firm performance impacts on CEO wealth. Equity holdings[64] can be defined as the percentage of the company's outstanding shares held by the CEO (Jensen & Murphy, 1990a, 141). This definition captures the impact of any change in firm value on the personal wealth of the CEO. For example, if the CEO owns 5% of the firm, then she/he will gain (lose) five cents for each dollar the firm gains (loses). Moreover, high ownership leads to better market valuation, which reflects managers' greater incentives to maximize value of the firm as their stakes rise (Morck et al., 1998). This finding justifies the hypothesized positive association between the level of CEO involvement and the ERP implementation process and decision.

Equity holdings of CEOs significantly influence the performance of long-term investments made by firms, as the literature reviewed in chapter 2 suggests. Since ERP systems are long-term investments, CEO holdings should influence the performance of ERP investments. Three attributes of investment in ERP systems are considered in reaching this proposition. First, is the long-term nature of investment in ERP systems. Previous literature

[63] According to Jensen and Murphy (1990a, 141) if senior managers have high equity holdings, they will experience a more powerful and direct "feedback effect" from the changes in the market value of the firm.

[64] The operationalization of the variable holdings will be provided in the methodology section.

on CEO holdings and long-term investment documents that long-term investment and CEO holdings are positively associated (Barker & Mueller, 2002). The same study also demonstrates that increased ownership motivates top managers to become more long-term oriented. CEOs with significant stock holdings will undertake investment that will be rewarded by the capital market. Such behavior is consistent with the agency theory that ties agent wealth to principal wealth as a way to reduce costs of the conflict of interest.[65] Jensen and Murphy (1990a) postulate that substantial CEO stock holdings is one method used to tie the CEO wealth with stockholders' wealth to ensure the maximization of stockholders' wealth. An ERP system implementation is a long-term investment (Poston & Grabski, 2001; Hitt et al., 2002; Hunton et al., 2003; Nicolaou, 2004) that positively influences the capital market perception of the firm (Hayes et al., 2000; Ho et al., 2005). Thus CEOs with high holdings (i.e., their wealth is tied to the shareholder wealth) are expected not to engage in ERP implementation unless it will result in a better performance for the firm.

The second attribute of ERP systems implementation is the risk associated with it. ERP systems are risky projects in nature (Hayes et al., 2000; Hitt et al., 2002; Hunton et al., 2003) and adopting an ERP system "does not guarantee success" (Ho et al., 2005, p. 1). For example, FoxMeyer Drug, a bankrupted firm, claimed that its ERP system contributed to the firm's bankruptcy (Davenport, 1998, p. 122). Investing in the ERP system could expose the implementing firm to serious risk that could in turn impact the firm's performance. However, from shareholders' viewpoint, equity ownership minimizes such risk because it provides a mechanism to monitor employees engaging in risky and unpredictable projects (Clinch,

[65] Where the CEO is the agent and stock holders are the principals.

1991). CEOs with higher level of holdings will not initiate the implementation project unless they have good reason to believe that the project will positively impact firm performance and that any risk associated with implementation will be minimized.

The third attribute relates to the mandatory changes imposed by ERP systems on the firm. ERP implementation can change the way the firm conducts its business (Wright & Wright, 2002), change the culture of the firm (Davenport, 1998) and most importantly, change the firm strategy (Turban et al., 2000; Wah, 2000; Francalanci, 2000). Previous research documented a CEO's influence on firm strategy and investment decisions (May, 1995; Barker & Mueller, 2002) and found the influence on firm strategy increased as the CEO holdings in the firm increased (Hambrick & Mason, 1984; Zahra & Pearce, 1989). Therefore, the influence of CEOs on the implementation decision and process will be positively associated with the level of her/his holdings. This will result in a positive impact on the productivity of the firm, since the CEO's role is critical for IT management success (Jarvenpaa & Ives, 1991). Again, the ERP implementation impact on CEO wealth is associated with her/his holdings in the firm. A CEO with high holdings will not initiate an ERP project unless it will also enhance the performance of the firm.

This discussion leads to the following hypothesis (alternate form):

H1: *CEO holdings impact the relationship between ERP Implementation and performance positively; the higher CEO holdings, the stronger the relationship between ERP adoption and firm performance.*

CEO Horizon

The long horizon of a CEO is expected to be a positive contributor to the ERP-productivity association. The influence of horizon on the long-term investment was identified

in previous research (Dechow & Sloan, 1991) and was discussed in chapter 2. The term horizon[66] refers to the time left for a CEO to serve in the firm. It is measured as the difference between retirement age and the current age of the CEO (Dechow & Sloan, 1991; Barker & Mueller, 2002). In this study, the horizon of CEO starts from the time of the ERP implementation and runs to the time the CEO reaches retirement age. The horizon is expected to be associated positively with post-implementation performance. Support for this proposition is derived from: (1) differences in a CEO's priorities and (2) differences in a CEO's attitude towards changes imposed by the ERP system. These differences are caused by a CEO's horizon and are discussed in details below.

Differences in priorities: A horizon problem exists when CEOs manage discretionary investment expenditures in their final years to improve short-term earnings (Dechow & Sloan, 1991). Short-term horizon CEOs focus more on short-term earnings so they can benefit from them before leaving the firm; CEOs with long horizons are more interested in long-term earnings (Barker & Muller, 2002). Implementing an ERP system could result in a dip in a firm's short-term performance (Koch, 2004; Nicolaou, 2004). This dip hints that a short horizon CEO might engage in an ERP project for reasons other than long-term productivity. For instance, "scrambling for a solution" to the Y2K problem (Ho et al., 2005). Such ad hoc implementation might be initiated to meet the pressure of the business partners or the shareholders and could negatively impact the firm performance in the long run. Such negative impact in the long run would not be of concern for the CEO with short horizon, due to the fact that he would have left the firm, unless her/his wealth was tied to the firm. On the

[66] Usually the retirement age is 65, the operationalization of this variable will be provided in the methodology section.

other hand, CEOs with long horizons will be concerned with long-term implementation benefits. Long horizon CEOs are expected to play a greater role in ERP implementation relative to short horizon CEOs. A positive association is expected between ERP implementation and post implementation performance for firms with long-horizon CEOs.

Differences in attitudes: A CEO's attitude toward changes imposed by an ERP system differs according to the CEO horizon. Wright and Wright (2002) argue that implementing an ERP system can lead to alteration of the business process of a firm. Davenport (1998) adds that an ERP system also changes the organization and the culture of the firm. In other situations, the change extends even to altering the firm strategy (Turban et al., 2000; Wah, 2000; Francalanci, 2000). Older executives (i.e., executives with shorter horizons) sometimes have greater difficulty accepting new ideas and learning new behaviors (Hambrick & Mason, 1984), which will impose a negative impact on the process of the implementation. To minimize the changes imposed by ERP systems on the firm, short horizon CEOs more likely would prefer to customize the code of the ERP package relative to long horizon CEOs. Such customization reduces the ERP package capability (Francalanci, 2000).

This discussion leads to the following hypothesis (alternate form):

H2: *CEO Horizon impacts the relationship between ERP implementation and firm performance positively; the longer the CEOs Horizon, the stronger the relationship between ERP implementation and firm performance.*

Timing of ERP Implementation

IT is a field that is changing rapidly; thus as time passes, the functional capability of the technology increases. ERP systems are not far from such changes, as can be seen from

the discussion about the evolution from MRP to MRPII to ERP (see chapter 2).[67] As time passes, newer versions of ERP systems provide added functionality and updated components that enhance the capability of the system. Added functionality and the capability to keep the system up to date were among the reasons reported by firms as a motive for migrating from old to newer version of the ERP package (Kremers & Van Dissel, 2000). Late adopters are more likely to adopt higher capability ERP systems relative to early adopters, thus the improvement in performance of late adopters is expected to be higher relative to early or non adopters.

The efficiency argument, supported by the findings of Mabert et al. (2003), indicates that late adopters learn from the mistakes of early adopters and are able to finish their projects on time and with costs equal to or less than the designated budget for the project. Also the findings of Ho et al. (2005) indicate that the market differentiate between late and early adopters. These findings suggest that the time of implementation is an important factor in the productivity function of ERP systems due to the "learning curve."

This discussion suggests a contingent positive association between the time of implementation and the capability of the system. The more recent the implementation, the more capable the system will be and thus the more enhancement of firm performance. The following hypothesis is proposed (alternate form):

H3: *Timing of implementation impacts the relationship between ERP implementation and firm performance; the more recent the implementation, the stronger the association between ERP implementation and firm performance.*

[67] Also differences between these systems capability was demonstrated in Chapter 2.

An alternative hypothesis for H3 can be advanced based on the "innovativeness argument" discussed in chapter 2. The innovativeness argument, according to Dos Santos et al. (1993), postulates that early adopters will capture better market position resulting in superior performance. Although the market perception is positive for early announcements (Ho *et al*., 2005; Dos Santos et al., 1993), there is little if any empirical evidence to prove the innovativeness argument on post implementation performance or productivity. Being innovative does not guarantee better market position, especially in the IT domain. The competitors will follow the innovators' steps which will reduce the gap in the market position. What enhances the market position is the continuous improvement and effort to be innovative (Turban et al., 2000). Although the time lag might lead to superior competitive position by early adopters, according to the innovativeness argument, this superiority will not be sustained in the long run if the system is not kept updated and the competitors implement more recent systems that are more capable.

For testing purposes, a control variable will be included to control for the performance of early adopters.

Scope of Implementation and Type of Module

Scope of implementation corresponds to the size of the implementation and the type of module implemented represents the module contribution to firm's value chain. The size of implementation in this study refers to whether the frim had a partial implementation (i.e., secondary or primary modules only) or a full implementation (i.e., secondary and primary modules). As for module type, each module is classified according to its contribution to the value chain of the firm.

According to Romney and Steinbart (2002) and Turban et al. (2002), a firm's value chain can be categorized as primary activities (inbound logistic, operation, outbound logistic marketing, and sales and services) and support or secondary activities (firm infrastructure, human resources technology and purchasing). ERP systems modules can be classified according to their contribution to the value chain.

Both scope of implementation and primary modules implementation are positively associated with firm performance, according to Nicolaou (2004) and Hitt et al. (2002). Moreover implementations with larger scope or implementations of primary modules are positively associated with the implementation effort which positively associated with post implementation performance (Barki & Pinsonneault, 2005; Niclolou, 2004). Based on that finding the following two hypotheses are developed (alternate form):

H4a: *The scope of implementation impacts the relationship between ERP implementation and firm performance; the greater the scope, the stronger the association between ERP implementation and firm performance.*

H4b: *The type of module implemented impacts firm performance; firms implementing primary modules will have better performance relative to firms implementing secondary modules or non- implementing firms.*

Although these two hypotheses were examined in two previous studies, there is a need to reexamine these issues within the context of this study. While Hitt et al. (2000) investigated the effect of implementation scope, their sample was limited to a specific ERP vendor, SAP. This study will use a sample that includes adopters of various vendors. Although Nicolaou (2004) investigated the effect of the type of module implemented, he did not examine that effect in the presence of the other independent variables in a single

regression equation. Therefore the regression results may reflect nonrandom effects of the other omitted independent variables, a methodological limitation that this study attempts to remedy.[68]

Methodology and Sample Selection

In this section the following three issues will be detailed: (1) the definition and the operationalization of the variables; (2) the data collection procedure, including the firm matching procedure; and (3) the univariate and multivariate statistical tests that will be conducted to test the four hypotheses presented in the previous section.

Variables

The dependent variable of interest is the firms' post-implementation performance. Six widely accepted accounting measures of firm performance have been identified as the proxy. Several other studies used similar accounting ratios as a proxy for firm performance in both the IT literature (Hitt & Brynjolfsson, 1996; Mitra & Chaya, 1996; Mukhopadhyay et al., 1995; Kar Yan, 1998; Bharadwaj, 2000; Brynjolfsson & Hitt, 2003) and the ERP literature (Poston & Grabski, 2001; Hitt et al., 2002; Hunton et al., 2003; Nicolaou, 2004).

Since the expectation is that the implementing firms will experience reduction in costs and increase in revenue, accounting variables are more likely to capture that change (Nicolaou 2004, p. 89). The operationalization of these dependent variables is summarized in Table 1.

[68] The limitation of Hitt et al (2002) and Nicolaou (2004) was discussed in details in chapter two.

These performance ratios are used to capture the impact of ERP implementation on a firm's performance. The first two ratios are intended to measure a firm's performance in terms of how efficiently the firm uses its assets. The third and fourth ratios are intended to

Table 1. Performance Measures

Performance Variable	Operationalization
Return on Assets (ROA)	[Income before extraordinary items (237)/Total Assets(6)]*100
Operating Return on Assets (OIA)	[Operating income before depreciation charges(13)/Total Assets (6)]*100
Return on Sales (ROS)	[Income before extraordinary items(237)/Net Sales(12)]*100
Operating Income Over Sales (OIS)	[Operating income before depreciation charges(13)/ Net Sales(12)]*100
Cost of Goods Sold Divided by Sales (CGS)	[All costs directed to production (41)/Net Sales (12)]*100
Selling, General and Administrative Expenses Over Sales (SGA)	[SG&A(189)/ Net Sales(12)]*100

- The Variables Definition is obtained from Nicolaou (2004).
- The Number between brackets is the COMPUSTAT item number.

measure the firm's performance in terms of the profitability of the firm. Finally, the last two ratios are intended to measure the firm's performance in terms of its expenditures. To capture the change in performance, these variables need to reflect the difference between post- and pre- implementation performance as presented in equation 1:

$$\Delta PerformanceRatio = \left(\frac{AVPOST - AVPRE}{AVPRE} \right) \quad (1)$$

AVPOST is the average of four years' post implementation and the AVPRE is the average of three years' pre implementation. The reason for scaling over the three years' pre-average of performance is to account for the possible effect of a firm's past performance that might be reflected in the current performance (Brown & Perry, 1994). If the pre-average of a firm is negative then this firm will be deleted from the sample.

Independent Variables

ERP. This dummy variable reflects ERP implementation. Firms that implemented ERP systems will be assigned the value one, and their match firms that did not implement ERP system will be assigned the value zero. This variable is expected to have a positive association with performance.

Holdings. The equity holdings of the CEO are measured in the year preceding the announcement of ERP system implementation (year t-1). The holdings in the year t-1 of implementation are defined as:

$$Holdings_{t-1} = \frac{NRS_{t-1} + NRSTKH_{t-1}}{TOS_{t-1}} \quad (2)$$

Where, NSR and NRSTKH are the number of outstanding shares held and the number of restricted shares held by a CEO respectively, and TOS is the total outstanding shares for the firm. The holdings variable was defined as a percentage of the company's outstanding shares held by the CEO. Such definition is based on the recommendation by Jensen and Murphy (1990a, p. 141). This definition reflects the portion of CEO wealth associated with the firm's value. The variable is continuous and will represent the holdings in the year t-1. The interaction term of the holding variable with the variable ERP captures the impact of CEO holdings on ERP-performance relationship and is expected to be positive as postulated

in H1. Another operationalization for this variable in term of dollar amount will be presented in the robustness test section of chapter 4 along with the motive behind such operationalization.

Horizon. The Horizon variable reflects the time left for the CEO to serve in the firm. It is measured as the difference between the retirement age and the age of the CEO in the year of the implementation announcement (t=0), and can be defined as:

$$Horizon_{t0} = 65 - CEOAge_{t0} \quad (3)$$

where 65 is the retirement age. This variable is continuous. To test H2, the interaction term of the *holding* variable with the variable *ERP* will be obtained. The interaction term is expected to be positive, since the longer the CEO horizon, the more positive the ERP-performance relationship.

Timing of implementation: The fourth independent variable of interest in this study is the timing of implementation. As hypothesized earlier, recent implementation is expected to be associated with more positive post implementation performance. Two variables are created following the classification of Ho et al. (2005). The first variable, "early," is a dummy variable whose value is 1 for early adopters (implementations during the years 1990-1997) and 0 otherwise. The second variable, "late," also a dummy variable whose value is 1 if the firm implemented the system during the year 2000, and 0 otherwise. These two variables will compare the performance of early and late adopters and the performance of firms that implemented an ERP system during the years 1998-1999 to capture the effect of Y2K as suggested by Ho et al. (2005). Both timing variables will be multiplied by the variable *ERP* to obtain an interaction term to test H3. The interaction term for late adopters is

expected to be positively associated with post implementation performance. If the innovativeness argument is true then the interaction with the variable early adopters will be positive.

Scope of implementation and module type: To test H4a-b, both the scope of the implementation and the type of the module will be operationalized with dummy variables. If the firm is implementing primary modules, then a variable "primary" will receive the value of 1; 0 otherwise. Similarly, if the firm is implementing secondary module, the variable "secondary" will receive the value of 1; 0 otherwise. The interaction term of the variables "secondary-primary" will result in the variable "full." The "primary-secondary" variables are intended to capture the type of the module and the variable "full" is intended to capture the scope of the implementation. Thus to test H4a, the interaction term of the variables ERP and the variable "full" will be obtained and expected to be positively associated with performance. To test H4b, the interaction term of the variable "ERP" and the variable "primary" will be obtained and expected to be positively associated with performance.

Control Variables:

Early research has documented that the relationship between ERP implementation and post-implementation performance is moderated by the following factors: Firm size, firm health as measured by Altman Z score, vendor, and the objective of the implementation. Firm size, vendor size and health variables are considered in this study, while the objective of the implementation is not.

Implementation objectives as operationalized by Nicolaou (2004) can be divided into system-led objectives or business-led objectives. The implementation objectives are set pre-implementation. There is a probability that the implementation objective changes during the

process of the implementation due to the difference between ERP package functionality and firm strategy (Francalanci, 2001; Turban et al., 2002). Data about changes in the implementation objectives are not available. Nicolaou's results indicated that firms implementing ERP systems for system-led objective outperform firms implementing the same systems for business-led objectives in terms of ROA, OIA and CGSS. However, these results still lack reliability due to methodological defects (see chapter 2). It is more reliable to exclude these two variables from the model until clear definition can be identified. The remainder of this section discusses control variables included in this study.

Firm size: In this study, total assets are used as a proxy for the size of the firm in the year of announcement (t=0). In previous studies that examined ERP productivity, firm size was controlled for due to the huge cost to the firm resources (Hunton et al., 2003; Nicolaou, 2004).

Vendor size: Similar to Nicolaou (2004), large vendors are identified based on their representation in the collected sample. 48% and 20% of the sample were represented by SAP and Oracle, respectively. Therefore, a dummy variable, "large vendor" was created to represent large vendors; if the system implemented is SAP or Oracle, then this variable is assigned the value 1; 0 otherwise. The interaction term of the variable "*ERP*" and "large vendor" will be obtained and is expected to be positively associated with a performance similar to the Nicolaou (2004) study.

Firm financial health: The financial health of a firm is operationalized using Altman Z score model that predicts bankruptcy. The Z score is the value resulting from the discriminate analysis equation 3. The formula for Altman's Z-score varies slightly among different studies. For the purposes of the present research, the following version is used, and

firms will be classified as healthy and unhealthy based on the cutting score of 2.99, which is consistent with Hayes et al. (2001) and Ho et al. (2005):

$$Z = 1.2\ (WC/TA) + 1.4\ (RE/TA) + 3.3\ (EBIT/TA) + 0.6\ (MVE/TD) + 1.0\ (Sales/TA) \quad (4)$$

Previous studies that used this variable, within the ERP literature, operationalized it first by calculating Altman Z score, and then used the value of 2.99 as the cutoff point. Firms with Z score over 2.99 will be classified as healthy firms, while others will be classified as low health firms. White et al. (1994, p. 1050) classified all firms having a Z score of greater than 2.99 as non-bankrupt firms; and firms with Z score below 1.81 as bankrupt firms, thus creating a "zone of ignorance," that is the gap between these two scores. Therefore, operationalizing this variable as a dummy might lead to misspecification of the model due to the "zone of ignorance" effect. For robustness the "zone of ignorance" is accounted for, in this study, by operationalizing the Z score as a continuous variable. Also, to be consistent with early research the health variable is operationalized as a dummy variable, to be consistent with early studies. The health of the firm as a dummy variable takes the value of 1 if the firm's Z score is 2.99 or above and 0 otherwise. Table 2 defines the variables used in equation 4.

Table 2. Altman Z Score Variables Definitions

Variable	Definition
WC	Working capital
TA	Total assets
RE	Retained earnings
EBIT	Earnings before interest and taxes
MVE	Market value of equity
TD	Total debt
Sales	Sales

Firm size and financial health: In consistency with Hunton et al. (2003), the impact of the interaction term between size and health of the firm will be included in the model. As argued by Hayes et al. (2001) and Hunton et al. (2003), a small healthy firm is expected to have better performance post- implementation.

Blocks: Each firm and its match are assigned to a block. Since each firm and its match differ from other firms in terms of industry and size (total assets and sales), a conclusion can be made that the sample on hand is not homogeneous. This will inflate the error variance and reduce the validity of the inferences. One way to reduce the error variance and increase the validity of the inferences is by grouping the observations into homogenous blocks (Neter, et al., 1996).

Sample Selection (Data Collection Procedure)

Hayes et al. (2001) searched the Lexis-Nexis Academic Database for ERP announcements for the period 1990 to 1998. They used several key words, such as "implement," "convert," and "contract," each associated with the following ERP vendors: Baan, Epicor, GEAC Smartsstream, Great Plains, Hyperion, Intentia International, JD Edwards, Lawson, Oracle Financials, PeopleSoft, QAD, SAP/3, or SSA. This study uses two different approaches for data collection. The first approach is similar to that of Hayes et al. (2001) but with a different time frame, from January 1, 1990 to December 31, 2000. The second approach is used to increase the sample size. A computer program was developed to automate the search process on the SEC Web site. The program accessed the 10-K and 10-Q filings of firms for the period 1993-2001, searching for any paragraph containing ERP

reference and storing the results in a database that was developed for this purpose[69]. From the first approach, an initial sample of 3,023 announcements was retrieved and 2,815 announcements were excluded because of duplication or of non-relevance. The outcome was 208 usable announcements. The second approach resulted in an initial sample of 2,093 references to ERP implementation. A total of 1,981 announcements were excluded because of duplication, overlapping from the first step, or non-relevance; thus resulting in 112 additional usable observations. Finally, an additional 70 announcements were provided by Ho et al. (2005).

The completion date of the implementation is needed for this study to perform proper tests. A search was conducted on the Lexis-Nexis Academic Database for completion dates announcements. In addition, the management discussion and analysis section of the annual reports to shareholders and SEC filings 10-K and 10-Q forms were searched to retrieve the implementation completion dates or the expected completion dates. Fifty-two firms with unidentified completion or expected completion dates were removed from the sample. Another 20 firms were excluded because their data were not available on the COMPUSTAT database. Finally, three firms were excluded because no match firm could be identified, resulting in a usable sample of 315 announcements. Table 3 summarizes the data collection procedure.

After identifying the implementation and completion date announcements for the firms, the financial performance measures for three consecutive years prior to the implementation date and four consecutive years after the completion date were collected

[69] The SEC website provides the filings from 1993 to 2006; therefore, it is not possible to search the filings prior to year 1993.

from the COMPUSTAT database. The four-year average post implementation was obtained to expand the post implementation period, since ERP productivity needs to be observed for the long run (Poston & Grabski, 2001).

Data for CEO holdings and Horizon were obtained from the COMPUSTAT Executive Compensation database and the proxy statements of the announcing firms. Announcements collected from the Lexis-Nexis Academic database and SEC filings of adopting firms were used to identify the ERP implementers, time and scope of implementation, and type of module implemented.

Table 3. Data Collection Summary

Initial sample from Lexis-Nexis database	3,023	
Less non-relevant and duplicate announcements	(2,815)	
Subtotal	208	
Data provided by Ho et al. (2005)	188	
Less overlapping announcement	(118)	
Subtotal		278
Data retrieved from 10-K and 10-Q	2,093	
Less irrelevant, duplicate & overlapping announcements	(1,981)	
Subtotal from 10-K & 10-Q forms		112
No completion or expected completion date identified	52	
Data not available on COMPUSTAT database	20	
No match firm available	3	
Total deleted firms		(75)
Data usable for this study		315

To test the hypotheses, a sample of match firms that did not adopt ERP system was identified. The matched sample was needed to control for industry and economic effects. The matching is based on the industry (SIC code) first, and then based on size in terms of total

assets and sales at year t-1 of the announcement year. When a match firm could not be identified based on the 4-digit code, a 3-digit and then a 2-digit matching was carried out. Subsequently, the firms were matched in size.[70]

To validate the matching procedure, a statistical comparison was conducted between selected performance variables of the adopting firms sample pre- implementation and that of the control (match) firms sample in accordance with Barber and Lyon (1996) recommendation. The comparison was conducted using a paired t-test on mean differences of three years' average pre-implementation. Table 4 shows the results of the test of mean differences in term of size as captured by both total assets and total sales, and in term of performance using the average of ROA and the average CGSS for the three years preceding the adoption of ERP systems. The results validate the matching procedures since there are no significant mean differences in any of the reported variables. To ensure that the matched firm did not implement an ERP system during the testing period, ERP vendors' Web sites were searched for verification.[71]

Statistical Tests

Figure 1 summarizes the model tested in this study. The main relationship (i.e., the line between the ERP event and performance) has been tested in early research. This study adds to the model the contextual variables pertaining to the CEO characteristics and the implementation characteristics as shown in the two circles on the top of the model. The (+) sign indicate that all relationships are expected to be positive.

[70] Twenty three firms was matched based on three SIC digit codes. While fifty seven firms was matched based on the two digit SIC code.

[71] The vendors' websites were searched for the name of the matched firms to identify whether any of the matched samples have implemented an ERP system during the testing period.

Table 4. Matching Comparison Adopters and Control Group Firms

Matched Variable	Sample	Mean	Standard Deviation	Paired t-test (n)	Mean Difference	t-value	Prob.
Total assets (t-1)	ERP firms	8839.68	22948.88	315	-2724.67	-1.30	0.20
	Control firms	6115.01	28908.12	310			
Total sale (t-1)	ERP firms	7231.53	20078.53	313	-2346.40	-1.59	0.11
	Control firms	4885.13	16485.14	311			
Average 3 yrs. pre-implementation ROA	ERP firms	3.59	11.16	312	-1.17	-1.30	0.19
	Control firms	2.42	10.77				
Average 3 yrs. pre-implementation CGSS	ERP firms	67.69	41.44	312	0.14	0.05	0.96
	Control firms	67.55	31.71	309			

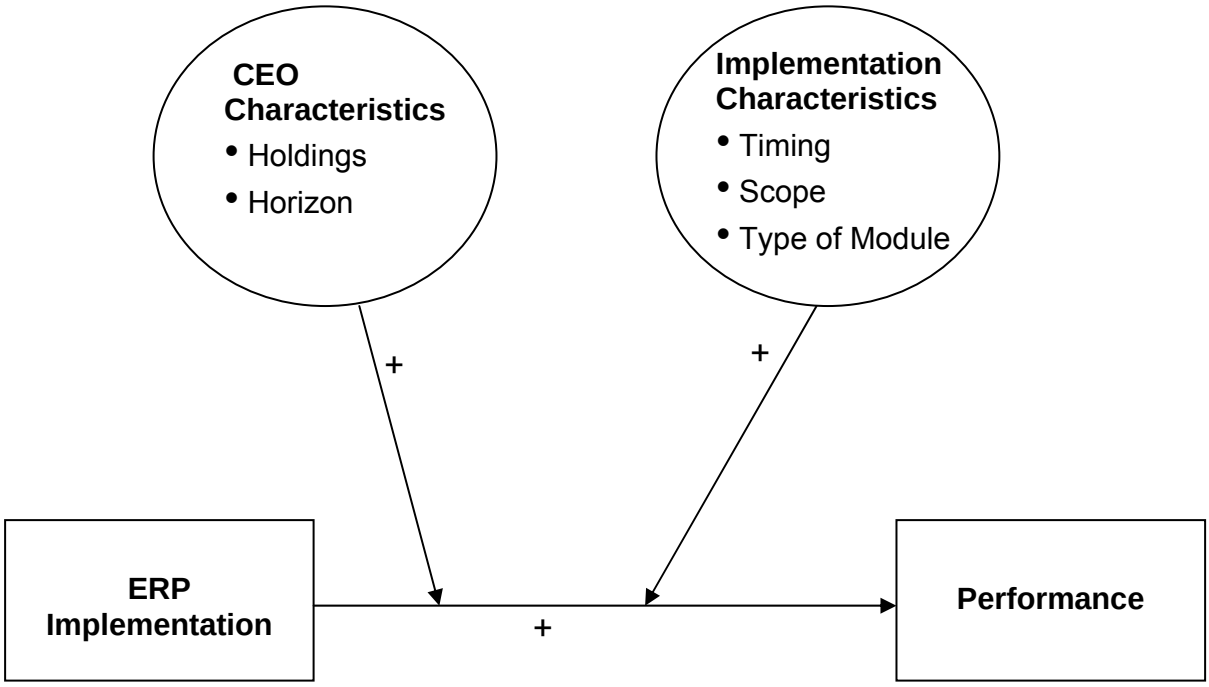

Figure 1. Summary of the model tested.

The first statistical test is a univariate t-test aimed to test H1 for the difference in performance between adopting firms with high equity holdings and adopting firms with low equity holdings[72]. The mean of the holdings for the ERP sample was calculated and used as a cutoff score to classify the firms into two portfolios. ERP adopting firms with holdings equal or greater than the mean were assigned to the high holdings portfolio, while adopting firms with holdings less than the mean were assigned to the low holding portfolio. If the performance for firms assigned to the high holdings portfolio is significantly higher than the other portfolio, then H1 is supported.

[72] Performance variables of concern are the six accounting ratios presented earlier in this section and were summarized in Table (1).

Another univariate t test was carried out to test H2. Similar to the holdings, the ERP firms were classified into two portfolios based on a cutting score equal to the mean of the horizon. ERP firms with horizon that was equal to or greater than the mean were classified as long horizon ERP firms and assigned to the first portfolio. The remainders were assigned to the second portfolio. If the performance for long horizon ERP firms' portfolio is significantly higher than the second portfolio, then H2 is supported.

To test all four hypotheses within one model, the following multivariate regression model was utilized:

$$\Delta Perf_j = \alpha + b_1 Horizon_{it} + b_2 Hodings_{it-1} + b_{13} Health + b_4 LogAssets_{it-1} + b_5 ERP + b_6 ERP \times Holdings + b_7 ERP \times Horizon_{it} + b_8 Prim + b_9 Full + b_{10} Early + b_{11} Late + b_{12} Vendor + b_{13} ERP \times Late + b_{14} ERP \times Full + b_{15} ERP \times Prim + b_{16} ERP \times Early + b_{17} ERP \times Vendor + b_{18} Size \times Health + b_{19} Block_1 \ldots b_n Block_{\frac{n}{2}} + e \quad (5)$$

where;

The dependent variable is the difference between a four-year average post implementation performance and a three-year average pre implementation performance scaled by the average of performance pre implementation (see equation 1). The scaled change is calculated for the following accounting measures:

ROA: Return on Assets

OIA: Operating Income over Assets

ROS: Return on Sale

OIS: Operating Income over Sale

CGS: Cost of Good Sold divided by Sale

Horizon: measures the years between the ERP implementation and the time the CEO reaches retirement age, as operationalized in equation 2.

Holdings: the percentage of the CEO holdings of year t-1 as operationalized in equation 1.

Health: financial health of the firm measured using Altman's Z score and take the value of 1 for healthy firms; 0 otherwise as discussed earlier in this section; also operationalized as metric variable based on the firm Altman's Z score.

LogAssets: Log of total assets to capture the firm size.

ERP: dummy variable = 1 if the firm is ERP implementator, 0 otherwise.

ERP × HOLDINGS: the interaction term of ERP and CEO holdings that represents the CEO holdings that belong to an ERP firm (this variable tests H1 and expected to be positive).

ERP × HORIZON: the interaction term of ERP and Horizon that represents the CEO's Horizon that belongs to an ERP firm (this variable tests H2 and is expected to be positive)

Prim: dummy variable =1 if the firm reported implementing the primary modules, 0 otherwise.

Full: dummy variable =1 if the firm reported implementing primary and secondary modules, 0 otherwise.

Early: dummy variable: value is 1 for early adopters (implementations during the years 1990-1997) and 0 otherwise.

Late: dummy variable whose value is 1 if the firm implemented the system in the year 2000, and 0 otherwise.

Vendor: dummy variable whose value is 1 if the ERP system implemented is SAP or Oracle, 0 otherwise.

ERP × Late: the interaction term for ERP and Late that represents the implementation of an ERP system prior in the year 2000 (this variable tests H3 and is expected to be positive).

ERP × Full: the interaction term for ERP and Full that represents the implementation of primary and secondary modules that belongs to an ERP firm (this variable tests H4a, the scope of implementation and is expected to be positive).

ERP × Primary: the interaction term for ERP and Primary that represents the primary module implementation that belongs to an ERP firm (this variable tests H4b, and expected to be positive).

ERP × Early: the interaction term for ERP and early that represents the implementation of an ERP system prior to 1998 (this variable is to control for the innovativeness argument effect, if any).

ERP × Vendor: the interaction term for ERP and Vendor that represents the implementation of SAP or Oracle ERP system (this is a control variable to be consistent with early research).

Size × Health: the interaction term for size and health, used as control variable to account for the effect of small unhealthy firms as described earlier in this section.

Block: sequences of multiple dummy variables to capture the block in which both the ERP firms and its match belong to. For example, if the firm and its match belong to block1, then both firms assigned the value 1, otherwise 0. The number of the block variables included in the regression model depends on the number of blocks included in the regression.

Robustness Tests

To test for robustness, first the univariate tests are re-estimated by using the median as a cutoff score. Second, regression equation 5 is re-estimated by removing the CEO horizon and holdings variables and including a variable that represents the holdings of the other top four executives. This variable was estimated first by adding the holdings of the top five executives. Then the total holdings of the CEO were subtracted from that total. The top five executive holdings were collected from the COMPUSTAT Executive Compensation database, and from the firms' proxy statement. If the results of the re-estimated regression are similar to the one initially obtained from equation 5 then it is the top management effect as a group that determines the association between ERP implementation and performance, not the CEO. IN this case, the initial conclusion about the impact of CEO holdings on ERP-performance relationship would become invalid.

The final robustness test was conducted to validate the operationaliztion of the holdings variable. Equation 5 was re-estimated by measuring the CEO holdings in terms of dollar value. All holding values were converted to the year 1990 dollar using the consumer price index[73]. According to Barker and Mueller (2002, 790), the amount of "at-risk wealth" in a firm's stock is what drives the long-term focused behavior of the executive, not the degree of ownership control. In other words, it is the dollar value of the ownership not the percentage held by the CEO that drives the long-term investment behavior.

[73] The dollar value for the year 1990 was selected because it was the first year in the testing period.

Summary

The purpose of this chapter is to develop the hypotheses and outline the methodology and the sample selection procedure. This study reexamines the ERP-performance relationship by incorporating into the model several contextual variables that are posited to significantly influence such relationship. Four hypotheses are developed, each corresponding to one contextual variable. Those contextual variables are CEO holdings and horizon, timing of implementation, scope of implementation, and type of modules implemented.

The procedure to collect each type of data is described along with the data sources. The mechanism to validate the collected data, including the match sample of non-adopting firms, also is described. Metrics for all variables are described, as well as the source.

Finally, univariate and multivariate statistical tests that are carried out are described along with the purpose of each test. Additional robustness tests as well as their purposes are also described. Chapter 4 will report the results of this study.

CHAPTER IV

RESULTS AND ANALYSIS

This chapter presents the results of the methodologies described in chapter 3. The first section provides the sample distribution across years and industries as well as the descriptive statistics. The second section provides the results obtained from the univariate tests for H1 and H2. The multivariate tests for all four hypotheses, using the regression equation 5 described in chapter 3, are presented in the third section. The fourth section provides the results of the robustness tests utilized to validate the findings. The final section summarizes and concludes this chapter.

Data Sampling

The data collection procedure is described in chapter 3 and summarized in table 3. Table 5 represents the distribution of the sample across the years. The table reveals that 50% of the sample is concentrated in the years 1998 and 1999. This percentage is comparable to that in the sample of Ho et al. (2005), which was 47%. The year 1998 represents 35% of the total samples in this study, which is comparable to Nicolaou's (2004) sample for the same year (37%). These two years, 1998 and 1999, represent a time when many firms were scrambling for a solution of the Y2K problem (Ho et al., 2005). These percentages validate the need to test the timing proposition.

Table 6 provides the distribution of the sample according to the industry code. The largest sector in the sample is the manufacturing sector (SIC codes 2000 and 3000) which

Table 5. Announcement Distribution by Year

Year	Number of Firms	Percentage
1990	3	0.95
1991	2	0.63
1992	4	1.27
1993	3	0.95
1994	5	1.59
1995	16	5.08
1996	48	15.24
1997	55	17.46
1998	111	35.24
1999	48	15.24
2000	20	6.35
Total	315	100.00

Table 6. Announcements Distribution by Industry Code (SIC)

Industry Code	Number of Firms	Industry	Percentage
700	7	Agricultural Services	2.22
1000	7	Mining Construction	2.22
2000	76	Manufacturing	24.13
3000	140	Manufacturing	44.44
4000	20	Transportation, Communications, Utilities	6.35
5000	23	Wholesale & Retail Trade	7.30
6000	12	Finance, Insurance, Real Estate	3.81
7000	27	Services	8.57
8000	1	Health Services	0.32
9000	2	Public Institutions	0.64
Total	315		100.00

Table 7. Descriptive Statistics for the Variables of Interest, Classified by Sub-sample and as a Total Sample

Sample*		AVROA	AVOIA	AVROS	AVOIS	AVCGSS	AVSGAS	CEO Holdings	CEO Holding	CEO Horizon
		Panel A: Average Three Years Pre Implementation Performance and CEO Characteristics Variables								
								$ Millions	%	
Match	N	310	313	309	315	311	315	303	303	313
	Mean	2.42	10.65	-2.66	8.30	67.69	26.12	347.4228	0.12	9.49
	Median	4.20	13.68	3.60	11.64	69.20	19.57	5212831	0.02	10.00
	Minimum	-76.39	-348.74	-486.58	-498.77	8.10	0.24	0	0.00	-19.00
	Maximum	33.43	52.45	47.51	61.07	515.89	358.00	35760	2.21	29.00
	Std. Deviation	10.77	26.06	41.53	41.65	31.71	30.98	3272.808	0.27	8.23
ERP	N	312	312	315	315	312	311	312	312	300
	Mean	3.59	13.56	2.47	10.99	67.55	24.62	46.54942	0.05	10.46
	Median	4.84	14.5	3.97	12.08	65.38	22.07	5544416	0.01	10.00
	Minimum	-115.78	-112.66	-360.01	-521.10	12.58	1.51	0	0.00	10.00
	Maximum	32.68	54.11	75.74	61.78	599.14	239.86	3585	0.57	32.00
	Std. Deviation	11.16	12.48	23.54	36.76	41.44	19.72	250.21960	0.10	8.37
Total	N	622	625	624	630	623	626	615	615	613
	Mean	3.04	12.17	0.02	9.71	67.62	25.34	197.3028	0.08	9.99
	Median	4.55	14.06	3.81	11.97	67.42	20.59	5.259052	0.01	10.00
	Minimum	-115.78	-348.74	-486.58	-521.10	8.10	0.24	0	0	-26.00
	Maximum	33.43	54.11	75.74	61.78	599.14	358.00	35760	2.21	32.00
	Std. Deviation	10.99	20.17	33.43	39.17	37.09	25.69	2325.831	0.209133	8.31

*AVROA: Average 3 years pre implementation for Return on Assets; AVOIA: Average 3 years pre implementation for Operating Income over Assets; AVROS: Average 3 years pre implementation for Return on Sale; AVOIS: Average 3 years pre implementation for Operating Income over Sale; AVCGS: Average 3 years pre implementation for Cost of Good Sold divided by Sale; AVSGA: Average 3 years pre implementation for Selling General & Administrative Expenditure over Sale; CEO Holdings is the percentage of the CEO holdings on year t-1; CEO Horizons measures the years between the ERP implementation and the time the CEO reaches retirement age.

Table 7—*Continued*.

Panel B: Descriptive Statistics for Scaled Change in Performance Post Implementation

		Δ4ROA	Δ4OIA	Δ4ROS	Δ4OIS	Δ4CGSS	Δ4SGAS
Match	N	306	307	304	305	305	310
	Mean	-0.52	-0.26	0.45	0.64	0.00	0.08
	Median	-0.42	-0.18	-0.37	-0.06	0.004	0.003
	Minimum	-29.51	-10.50	-33.25	-8.65	-0.95	-0.95
	Maximum	33.25	13.84	256.78	178.17	1.38	3.94
	Std. Deviation	5.83	1.72	20.12	13.34	0.23	0.52
ERP Adopter	N	303	302	305	304	305	307
	Mean	0.18	0.19	4.11	0.18	-0.18	0.03
	Median	-0.18	-0.05	-0.10	0.06	-0.02	-0.03
	Minimum	-20.08	-5.12	-12.81	-11.04	-34.47	-3.86
	Maximum	58.10	14.26	796.51	15.33	0.67	2.11
	Std. Deviation	5.34	1.86	55.69	2.32	2.40	0.49
Total	N	609	609	609	609	610	617
	Mean	-0.15	-0.02	2.40	0.39	-0.09	0.05
	Median	-0.30	-0.12	-0.28	-0.02	-0.01	-0.01
	Minimum	-29.51	-10.50	-33.25	-11.08	-34.47	-3.86
	Maximum	58.10	14.26	796.51	178.17	1.38	3.94
	Std. Deviation	5.58	1.81	42.88	9.28	1.76	0.50

Δ is defined as: *The average performance ratio of the 4 years pos t implementation minus the average performance ratio of the 3 years pre implementation;* Δ4ROA: Scaled change for Return on Assets 4 years post implementation; Δ4OIA: Scaled change for Operating Income over Assets 4 years post implementation; Δ4ROS: Scaled change for Return on Sale 4 years post implementation; Δ4OIS: Scaled change for Operating Income over Sale 4 years post implementation; Δ4CGS: Scaled change for Cost of Good Sold divided by Sale 4 years post implementation; Δ4SGA: Scaled change for Selling General and Administrative expenditure over sale 4 years post implementation

constitutes 69% of the total announcements. The smallest sector in the sample is the health services sector, which constitutes 0.32%. A total of nine different sectors are represented in the sample, thus strengthening the generalizability of the results since the sample is not restricted to a certain industry.

Panels A and B of table 7 provide the descriptive statistics for both ERP and match samples. Panel A shows descriptive statistics for the average three years pre implementation performance, horizon at year t=0 and holdings at year t-1 in terms of dollar value and in terms of percentage of holdings. The mean (median) holdings percentage of a CEO in the total sample is 0.08 (0.01), while the mean (median) for the match and the ERP sub samples is 0.12 (0.02) and 0.05 (0.01) respectively. As for the horizon variable, the mean and the median equal to approximately 10 years for the entire sample and also for each sub sample. The table also includes descriptive statistics for the three-year average of the performance variables pre implementation and the scaled difference in performance post implementation. Except for the variables ROS and ΔROS, the distribution of the variables is not skewed based on the difference between the median and the mean of each variable.

Univariate Tests for H1 and H2

The first set of statistical tests is designed to examine hypotheses 1 and 2 using a univariate within group t test.[85] The first hypothesis states that there is a positive association between CEO holdings and post implementation performance. To test the hypothesis, two portfolios were formed based on the cutoff score of holdings equal to 0.05. The first

[85] The procedure of conducting the test was described in chapter three.

portfolio (low CEO holdings) contained firms with holdings less than 0.05. The second portfolio (high CEO holdings) contained firms with holdings equal to or greater than 0.05. A univariate t test was conducted to compare the mean difference in performance between the two portfolios. The comparison was conducted across six performance variables, and the results are reported in table 8.

Table 8. Performance Comparison High Holdings vs. Low Holdings for ERP Implementers (H1)

Matched Variable	Portfolio	Mean	Standard Deviation	n	Mean Difference	t-Value	Prob.
ΔROA	Low	-0.70	3.59	204	4.13***	4.30	0.00
	High	3.43	9.82	62			
ΔOIA	Low	-0.23	1.29	201	1.65***	6.03	0.00
	High	1.41	2.41	79			
ΔROS	Low	-0.57	3.14	201	17.50***	2.20	0.01
	High	16.92	96.34	67			
ΔOIS	Low	-0.33	1.42	204	1.91***	5.33	0.00
	High	1.58	3.55	80			
ΔCGSS	Low	0.02	0.17	226	-0.87**	-2.06	0.02
	High	-0.85	4.96	79			
ΔSSGA	Low	0.11	0.41	219	-0.39***	-4.84	0.00
	High	-0.28	0.58	88			

*p<0.1, ** p<0.05, ** *p<0.001, All p-values reported as one sided.

Δ is defined as: The average performance ratio of the 4 years post implementation minus the average performance ratio of the 3 years pre implementation

Δ4ROA: Scaled change for Return on Assets 4 years post implementation (37 observations deleted due to negative pre-ROA performance)

Δ4OIA: Scaled change for Operating Income over Assets 4 years post implementation (22 observations deleted due to negative pre-ROA performance)

Δ4ROS: Scaled change for Return on Sale 4 years post implementation (37 observations deleted due to negative pre-ROA performance)

Δ4OIS: Scaled change for Operating Income over Sale 4 years post implementation (20 observations deleted due to negative pre-ROA performance)

Δ4CGS: Scaled change for Cost of Goods Sold divided by Sale 4 years post implementation

Δ4SGA: Scaled change for Selling General and Administrative expenditure over sale 4 years post implementation

Table 8 also reports the number of firms assigned to each portfolio in column five. The results in table 8 provide strong support for hypothesis one. The difference is most significant and positive on performance measures for firm efficiency of asset utilization (i.e., ΔROA and ΔOIA, the difference for each is both positive and significant at p-value less than 0.01). As for the variables that reflect firms' profitability, ΔROS and ΔOIS each exhibits significant positive difference. The results, however, are stronger for the ΔOIS where the p-value is less than 0.01 relative to less than 0.05 for ΔROS. Similarly the results for the performance variables that measure firms' performance in terms of expenditures indicate a significant negative difference in support of H1 (i.e., the expenditures ratio for the low holdings portfolio is greater than the expenditure ratios for the high holdings portfolio). ΔCGSS exhibits significant negative difference at p-value less than 0.05, while ΔSGA exhibited stronger results at p-value less than 0.01. The results reported in table 8 support H1, indicating that for ERP firms, as CEO holdings increase, the financial performance improve.

A similar test was conducted to test H2; however, the classification of the portfolios was based on the horizon of the CEO. The cutoff score was 10.46 years. The results are reported in table 9 showing that the results did not provide support for H2. The insignificant results might be attributed to classifying the observations into two portfolios instead of testing the horizon as a metric variable. The main drawback of classifying the firms into two portfolios is the loss of variation within the horizon variable. For example, the maximum value of horizon in the ERP sample is 32 years. Thus, CEO with horizon of 10.46 and CEO

Table 9. Performance Comparison High Horizon vs. Low Horizon for ERP Implementers (H2)

Matched Variable	Portfolio	Mean	Standard Deviation	n	Mean Difference	t-Value	Prob.
ΔROA	Low	0.16	3.36	163	-0.42	-0.04	0.48
	High	0.12	8.05	108			
ΔOIA	Low	0.00	0.91	159	0.30	1.12	0.11
	High	0.31	2.36	131			
ΔROS	Low	6.44	65.16	142	-6.26	-0.92	0.82
	High	0.18	8.13	130			
ΔOIS	Low	0.44	0.72	165	0.23	0.74	0.22
	High	0.27	3.07	131			
ΔCGSS	Low	-0.35	3.43	166	0.32	0.87	0.80
	High	-0.02	0.23	139			
ΔSGA	Low	0.04	0.32	161	-0.05	-0.66	0.26
	High	-0.01	0.64	146			

*p<0.1, ** p<0.05, ** *p<0.001, All p-values reported as one sided

Δ is defined as: The average performance ratio of the 4 years post implementation minus the average performance ratio of the 3 years pre implementation

Δ4ROA: Scaled change for Return on Assets 4 years post implementation (32 observations deleted due to negative pre-ROA performance)

Δ4OIA: Scaled change for Operating Income over Assets 4 years post implementation (12 observations deleted due to negative pre-ROA performance)

Δ4ROS: Scaled change for Return on Sale 4 years post implementation (33 observations deleted due to negative pre-ROA performance)

Δ4OIS: Scaled change for Operating Income over Sale 4 years post implementation (8 observations deleted due to negative pre-ROA performance)

Δ4CGS: Scaled change for Cost of Goods Sold divided by Sale 4 years post implementation

Δ4SGA: Scaled change for Selling General and Administrative expenditure over sale 4 years post implementation

with horizon of 32 would be allocated to the same portfolio. To overcome this limitation, the horizon variable was tested as a continuous variable in the multivariate test.

Multivariate Tests

Regression model 5, discussed in chapter 3, was expected to test simultaneously the four hypotheses developed previously. However, due to multicollinearity problems, five

variables were dropped out of the model. The dropped variables were Primary, Full, Vendor, Early and Late. These variables were highly correlated with their interaction terms, thus the statistical software dropped them from the model automatically. A correlation test was conducted and the results indicated that these variables are highly correlated with their interaction terms as presented in Table 10.

Table 10. Correlation Coefficients for the Correlated Variables

Correlated Variables	Pearson Correlation Coefficient
Primary and ERP x Primary	1.00***
Full and ERP x Full	1.00***
Vendor and ERP x Vendor	1.00***
Early and ERP x Early	0.60***
Late and ERP x Late	0.55***

***p<0.001 (two tail test)

The purpose of those variables was to construct the interaction term of the variables with the ERP variable. Since this study is not testing the effect of these variables, dropping these variables is not impacting the statistical test or the inferences.

The re-estimated regression model is provided below; all variables have the same as definitions are described for regression model 5.

$$\Delta Perf_i = \alpha + b_1 Horizon_{it} + b_2 Hodings_{it-1} + b_{13} Health + b_4 LogAssets_{it-1} + b_5 ERP + b_6 ERP \times Holdings + b_7 ERP \times Horizon_{it} + b_8 ERP \times Late + b_9 ERP \times Full + b_{10} ERP \times \Pr im + b_{11} ERP \times Early + b_{12} ERP \times Vendor + b_{13} Size \times Health + b_{14} Block_1 ..... b_{\frac{n}{2}} Block + e \quad (6)$$

Table 11 reports the results for regression model 6. Panel A provides the results using the percentage held by the CEO as proxy for her/his holdings. To control for the possible effect of the "ignorance zone" that might result from operationalizing the variable "firm

health" as a dummy variable, the actual Altman's Z scores were used. Panel B of the same table reports the results using the dummy operationalization for the variable "firm health." For comparison purposes, panel C reports the results without the blocking variables.

The coefficients of the interaction terms of CEO holdings and ERP suggest that the percentage of CEO holdings is significantly associated with firm performance post implementation in 5 out of 6 performance variables (see table 11, panel A). The results reveal that for ERP implementers with high CEO holdings, the assets of the firms were more efficiently utilized as reflected by both ΔROA and ΔOIA. Both variables exhibited significant results at p-value less than 0.01. However, in terms of firm profitability only OIS was found to be positive and significant with p-value less than 0.01. The results were not significant for the ROS variable, the second variable that measures firm performance in terms of profitability. The insignificant results could be attributed to the skewed distribution of the ROS variable. Finally, the two variables, CGSS and SGA, that measure the performance of the firms in terms of expenditure, were found to be negative and significant at p-value, less than 0.05 and 0.01, respectively.

The overall results reported in table 11, panel A, provide strong evidence supporting H1.

As for H2 that postulates that the CEO horizon will impact the association between ERP implementation and post implementation performance, weaker evidence is provided relative to H1. The results indicate partial and weaker support for the CEO horizon impact on the ERP-performance relationship. Longer horizon has a significant positive impact on ΔOIA

$$\Delta Perf_i = \alpha + b_1 Horizon_{it} + b_2 Hodings_{t-1} + b_{13} Health + b_4 LogAssets_{t-1} + b_5 ERP + b_6 ERP \times Holdings + b_7 ERP \times Horizon_{it}$$
$$+ b_8 ERP \times Late + b_9 ERP \times Full + b_{10} ERP \times \mathrm{Prim} + b_{11} ERP \times Early + b_{12} ERP \times Vendor + b_{13} Size \times Health + b_{14} Block_1 ..... b_{\frac{n}{2}} Block + e$$

Table 11. Regression for Four Years Average

(Panel A)

Perform-ance	Inter-cept	Hori-zon	Hold-ings	Health	Size	ERP	ERPx Horizon	ERPx Holdings (%)	ERPx Primary	ERPx full	ERPx LV	ERPx Early	ERP x Late	Size x Health	Adj R^2
Δ4ROA	1.70	-0.08	-2.58*	0.00	-0.19	0.61	-0.07	10.09**	1.2	0.62	0.82	-0.82	-6.44	0.00	0.12
t-value	0.70	-0.43	-1.79	-0.12	-0.60	0.37	-0.36	2.16	0.80	0.37	0.83	-0.74	-2.30	0.22	
p-value	0.48	0.66	0.08	0.90	0.54	0.35	0.46	0.01	0.21	0.35	0.20	0.77	0.98	0.78	
n=535 number of blocks 266															
Δ4OIA	-0.34	-0.06*	-2.01	0.00	0.11	-1.09	0.04*	5.82***	0.97**	-0.12*	-0.21	0.38*	-1.37	-0.00	0.20
t-value	-0.28	-1.93	-1.51	0.37	0.67	-2.79	1.37	2.99	1.75	-0.33	-0.89	1.47	-2.34	-0.29	
p-value	0.77	0.06	0.13	0.71	0.50	1.00	0.08	0.00	0.05	0.06	0.37	0.07	0.99	0.77	
n=565 number of blocks 260															
Δ4ROS	4.73	0.93	-7.98	-0.00	-1.24	5.58	-1.00	-1.32	1.11	1.94*	1.48	-1.45	-1.80	0.00	0.85
t-value	0.67	1.16	-1.29	-0.88	-0.90	1.07	-1.21	-0.13	0.88	1.32	1.08	-0.94	-0.74	0.91	
p-value	0.50	0.24	0.19	0.37	0.36	0.14	0.98	0.55	0.17	0.08	0.14	0.83	0.77	0.36	
n=535 number of blocks 262															
Δ4OIS	-0.76	-0.03**	-1.00*	0.00	0.12	-0.60	0.03**	4.48***	0.04	0.42*	-0.39	0.08	-1.14	-0.00	0.27
t-value	-1.10	-1.99	-1.58	0.44	1.51	-2.15	1.62	3.92	0.12	1.36	-0.86	0.35	-2.00	-0.18	
p-value	0.27	0.04	0.10	0.66	0.13	0.98	0.05	0.00	0.45	0.08	0.81	0.36	0.97	0.85	
n=569 number of blocks 261															
Δ4CGSS	0.03	-0.01**	-0.02	0.00	0.01	-0.01	0.01	-0.32**	-0.05	-0.04	0.02	-0.02	0.20	0.00	0.58
t-value	0.32	-2.86	-0.58	0.42	0.40	-0.22	1.75	-1.92	-1.08	-0.66	0.44	-0.47	2.23	-0.55	
p-value	0.75	0.01	0.56	0.67	0.69	0.41	0.46	0.03	0.14	0.25	0.17	0.32	0.49	0.59	
n=609 number of blocks 303															
Δ4SGA	0.27*	0.01	-0.02	0.00	-0.04*	0.13	-0.01*	-0.78***	-0.09	-0.14*	0.03	0.01	0.39	0.00	0.73
t-value	1.65	1.02	-0.18	0.06	-1.67	1.18	-1.59	-2.80	-0.88	-1.22	0.31	0.13	2.54	-0.25	
p-value	0.10	0.31	0.86	0.95	0.10	0.38	0.06	0.00	0.19	0.10	0.12	0.45	0.49	0.81	
n=609 number of blocks 304															

Table 11 (Panel A)—*Continued*.

*p<0.1, ** p<0.05, ** *p<0.001, All p-values reported as one sided except for the variable ERP, and its interaction terms with Horizon, Holdings, Primary, Full, LV, Early and Late.
Δ is defined as: *The average performance ratio of the four years post implementation minus the average performance ratio of the three years pre implementation*
CEO Holdings is the percentage of the CEO holdings on year t-1.
CEO Horizon measures the years between the ERP implementation and the time the CEO reaches the retirement age.
Health: is financial health of the firm measured using Altman's Z score operationalized as metric variable..
Sizd: Log of total assets to capture the firm size.
ERP is a dummy variable = 1 if the firm is ERP implementator, 0 otherwise.
ERP X HOLDINGS is the interaction term of ERP and CEO Holdings that represent the CEO holdings that belong to an ERP firm (i.e., this variable tests H1 and expected to be positive).
ERP X HORIZON is the interaction term of ERP and Horizon that represent the CEO's Horizon that belongs to an ERP firm (i.e. this variable tests H2 it is expected to be positive)
ERP X Late: is the interaction term for ERP and Late that represent the implementation of an ERP system prior in the year 2000 (i.e., this variable tests H3 and expected to be positive).
ERP X Full: is the interaction term for ERP and Full that represent the implementation of primary and secondary modules that belongs to an ERP firm (i.e., this variable tests H4a, the scope of implementation and expected to be positive).
ERP X Primary is the interaction term for ERP and Primary that represent the primary module implementation that belongs to an ERP firm (i.e., this variable tests H4b, and expected to be positive).
ERP X Early: is the interaction term for ERP and early that represent the implementation of an ERP system prior to 1998 (i.e., this variable is to control for the innovativeness argument effect if any).
ERP X LV: is the interaction term for ERP and Vendor that represent the implementation of SAP or Oracle ERP system (i.e., this is a control variable to be consistent with early research).
Size X Health is the interaction term for size and health, used as control variable to account for the effect of small unhealthy firms.
Block: are sequences of multiple dummy variables to capture the block in which both the ERP firms and its match belong to.
n is the number of firms in the regression. The number of block is the number of block in the regression. The number of blocks differs from one regression to another because a firm might included in the regression but its match firm is not due to some missing data in the match firm.
74 negative observations for pre-average of ROA, 44 negative observation for pre-average of OIA, 74 negative observation for pre-average ROS and 40 negative observation for pre-average of OIS were deleted before running this regression.

Table 11 (Panel B)—*Continued*.

$$\Delta Perf_i = \alpha + b_1 Horizon_{it} + b_2 Hodings_{it-1} + b_3 Health + b_4 LogAssets_{it-1} + b_5 ERP + b_6 ERP \times Holdings + b_7 ERP \times Horizon_{it}$$
$$+ b_8 ERP \times Late + b_9 ERP \times Full + b_{10} ERP \times \Pr im + b_{11} ERP \times Early + b_{12} ERP \times Vendor + b_{13} Size \times Health + b_{14} Block_1 .....b_{\frac{n}{2}} Block_n + e$$

(Panel B): Regression for Four Years Average (Health as a Dummy Variable)

Perform-ance	Inter-cept	Hori-zon	Hold-ings	Health	Size	ERP	ERPx Horizon	ERPx Holdings	ERPx Primary	ERPx full	ERPx LV	ERPx Early	ERP x Late	Size x Health	Adj R^2
								(%)							
ΔROA	1.91	-0.06	-2.14**	-0.89	-0.12	0.01	0.02	10.94***	0.47	0.16	0.14	-0.18	-6.00	1.01	0.09
t-value	0.79	-0.75	-2.00	-0.62	-0.61	0.02	0.25	3.56	0.52	0.12	0.11	-0.16	-3.90	1.13	
p-value	0.41	0.38	0.05	0.56	0.51	0.30	0.39	0.00	0.16	0.27	0.26	0.35	0.29	0.24	
n=535 number of blocks 266															
ΔOIA	-0.23	-0.15**	-2.08	0.36	-0.01	-0.77	0.11*	9.37***	1.12**	-1.15	-0.73	0.19	-5.19	-0.59	0.15
t-value	-0.21	-2.26	-1.62	0.37	-0.57	-1.30	0.89	2.90	1.65	-1.04	-1.31	0.73	-2.78	-0.42	
p-value	0.80	0.02	0.12	0.67	0.56	0.49	0.10	0.00	0.05	0.22	0.42	0.25	0.78	0.69	
n=565 number of blocks 260															
ΔROS	5.11	0.78	-7.80	-3.42	-1.03	4.01	-1.64	-1.55	1.00	2.75*	1.36	-1.83	-11.83	2.81	0.78
t-value	0.45	1.22	-1.33	-0.35	-1.21	1.00	-1.43	-0.89	0.40	1.30	0.84	-1.34	-1.48	1.20	
p-value	0.57	0.19	0.20	0.68	0.22	0.15	0.35	0.27	0.31	0.10	0.23	0.59	0.41	0.19	
n=535 number of blocks 262															
ΔOIS	-1.44**	-0.11	-0.12	0.62	0.15**	-0.48	0.04	6.76***	0.42	0.50	-0.77	0.01	-3.11	-0.51	0.21
t-value	-2.33	-0.76	-1.34	1.35	1.84	-0.8	0.94	3.38	1.02	0.78	-1.29	0.23	-3.50	-1.17	
p-value	0.03	0.47	0.21	0.18	0.05	0.30	0.15	0.00	0.16	0.29	0.40	0.30	0.56	0.22	
n=569 number of blocks 261															
ΔCGSS	-0.28	0.01	0.11	0.76	0.04	-0.01	0.04	-0.59**	-0.02	-0.57	0.39	-0.21	0.91	-0.52	0.52
t-value	-0.88	-1.55	0.77	1.21	1.00	-0.33	1.31	-1.83	-0.23	-1.24	1.16	-0.96	1.50	-1.26	
p-value	0.38	0.12	0.44	0.19	0.32	0.37	0.41	0.04	0.41	0.11	0.38	0.17	0.43	0.21	
n=609 number of blocks 303															
ΔSGA	0.09	0.01	0.01	0.14	-0.03*	0.11	-0.01*	-1.16***	0.00	-0.14*	0.11	-0.01	0.55	0.75	0.70
t-value	0.60	0.96	0.12	1.10	-1.78	1.01	-1.39	-4.57	-0.03	-1.51	1.28	-0.16	3.98	0.45	
p-value	0.55	0.34	0.90	0.27	0.08	0.35	0.08	0.00	0.49	0.07	0.40	0.44	0.50	0.67	
n=609 number of blocks 303															

Table 11 (Panel B)—*Continued*.

*p<0.1, ** p<0.05, ** *p<0.001, All p-values reported as one sided except for the variable ERP, and its interaction terms with Horizon, Holdings, Primary, Full, LV, Early and Late.

Δ is defined as: *The average performance ratio of the four years post implementation minus the average performance ratio of the three years pre implementation*

CEO Holdings is the percentage of the CEO holdings on year t-1.

CEO Horizon measures the years between the ERP implementation and the time the CEO reaches the retirement age.

Health: is financial health of the firm measured using Altman's Z score operationalized as dummy variable.

Size: Log of total assets to capture the firm size.

ERP is a dummy variable = 1 if the firm is ERP implementator, 0 otherwise.

ERP × HOLDINGS is the interaction term of ERP and CEO Holdings that represent the CEO holdings that belong to an ERP firm (i.e., this variable tests H1 and expected to be positive).

ERP × HORIZON is the interaction term of ERP and Horizon that represent the CEO's Horizon that belongs to an ERP firm (i.e., this variable tests H2 it is expected to be positive)

ERP × Late: is the interaction term for ERP and Late that represent the implementation of an ERP system prior in the year 2000 (i.e. this variable tests H3 and expected to be positive).

ERP × Full: is the interaction term for ERP and Full that represent the implementation of primary and secondary modules that belongs to an ERP firm (i.e. this variable tests H4a, the scope of implementation and expected to be positive).

ERP × Primary is the interaction term for ERP and Primary that represent the primary module implementation that belongs to an ERP firm (i.e., this variable tests H4b, and expected to be positive).

ERP × Early: is the interaction term for ERP and early that represent the implementation of an ERP system prior to 1998 (i.e., this variable is to control for the innovativeness argument effect if any).

ERP × LV: is the interaction term for ERP and Vendor that represent the implementation of SAP or Oracle ERP system (i.e., this is a control variable to be consistent with early research).

Size×Health is the interaction term for size and health, used as control variable to account for the effect of small unhealthy firms.

Block: are sequences of multiple dummy variables to capture the block in which both the ERP firms and its match belong to.

n is the number of firms in the regression. The number of block is the number of block in the regression. The number of blocks differs from one regression to another because a firm might included in the regression but its match firm is not due to some missing data in the match firm.

74 negative observations for pre-average of ROA, 44 negative observations for pre-average of OIA, 74 negative observations for pre-average ROS and 40 negative observations for pre-average of OIS were deleted before running this regression.

Table 11 (Panel C)—*Continued*.

$$\Delta Perf_i = \alpha + b_1 Horizon_{it} + b_2 Hodings_{it-1} + b_3 Health + b_4 LogAssets_{it-1} + b_5 ERP + b_6 ERP \times Holdings + b_7 ERP \times Horizon_{it}$$
$$+ b_8 ERP \times Late + b_9 ERP \times Full + b_{10} ERP \times \Pr im + b_{11} ERP \times Early + b_{12} ERP \times Vendor + b_{13} Size \times Health + e$$

Panel C: Regression for Four Years Average (Without Blocking Variables)

Perform-ance	Inter-cept	Hori-zon	Hold-ings	Health	Size	ERP	ERPx Horizon	ERPx Holdings	ERPx Primary	ERPx full	ERPx LV	ERPx Early	ERP x Late	Size x Health	Adj R^2
								(%)							
ΔROA	0.20	-0.08	-2.36**	0.00	-0.00	0.20	-0.03	11.91***	0.91	0.44	0.63	-0.77	-6.20	-0.00	0.05
t-value	0.12	-0.66	-1.99	0.66	-0.04	0.22	-0.22	3.72	0.87	0.38	0.93	-1.09	-3.47	-0.32	
p-value	0.78	0.43	0.05	0.05	0.70	0.41	0.59	0.00	0.19	0.35	0.18	0.13	0.99	0.74	
ΔOIA	-0.13	-0.05**	-2.08*	-0.00	0.07	0.70	0.04**	5.87***	0.42	0.15	-0.17	0.08	-1.93	0.00	0.14
t-value	0.18	-2.34	-1.87	-0.22	0.72	-2.76	1.60	4.07	1.06	0.59	-1.06	0.62	-4.23	0.46	
p-value	0.86	0.02	0.06	0.82	0.47	0.99	0.05	0.00	0.14	0.27	0.86	0.26	1.00	0.86	
ΔROS	24.57	0.63	-9.00*	-0.00	-4.27	18.35	-2.08	-10.33	0. .86	19.77	-8.71	4.57	-24.45	.00	0.70
t-value	1.10	1.18	-1.86	-0.94	-1.21	1.22	-1.51	-0.46	0.29	1.09	-0.89	0.83	-1.06	0.75	
p-value	0.27	0.24	0.06	0.35	0.22	0.11	0.93	0.68	0.38	0.14	0.83	0.20	0.85	0.45	
ΔOIS	-0.70	-0.03***	-1.05**	-0.00	0.12**	-0.36	0.03**	4.55***	0.00	0.40**	-0.33	-0.20	-1.32	0.00	0.18
t-value	-1.51	-2.69	-1.96	-0.04	2.08	-1.81	1.93	5.10	0.00	1.97	-1.17	-0.14	-3.09	0.37	
p-value	0.13	0.00	0.05	0.96	0.03	0.95	0.02	0.00	0.50	0.02	0.88	0.55	0.99	0.71	
ΔCGSS	-1.31	0.00	0.16	0.00	0.21	-0.72	0.08	0.49	-0.13	-1.02	-0.68	-0.41	1.39	0.00	0.09
t-value	-1.03	0.03	0.80	0.82	1.07	-1.03	1.08	0.41	-0.67	-1.06	1.00	-0.94	1.19	0.18	
p-value	0.31	0.98	0.42	0.42	0.29	0.15	0.36	0.16	0.25	0.15	0.34	0.18	0.38	0.86	
ΔSGA	0.36	0.01	-0.01	0.00	-0.05**	-0.09	-0.01**	-1.72***	0.03	-0.08	-0.01	0.21	0.91	0.00	0.15
t-value	2.12	1.35	-0.11	0.44	-1.99	-0.54	-1.69	-2.94	0.28	-0.78	-0.08	1.18	2.11	-0.66	
p-value	0.04	0.18	0.91	0.66	0.05	0.29	0.05	0.00	0.11	0.22	0.47	0.38	0.48	0.51	

Table 11 (Panel C)—*Continued*.

*p<0.1, ** p<0.05, ** *p<0.001, All p-values reported as one sided except for the variable ERP, and its interaction terms with Horizon, Holdings, Primary, Full, LV, Early and Late.

Δ is defined as: *The average performance ratio of the four years post implementation minus the average performance ratio of the three years pre implementation*

CEO Holdings is the percentage of the CEO holdings on year t-1.

CEO Horizon measures the years between the ERP implementation and the time the CEO reaches the retirement age.

Health: is financial health of the firm measured using Altman's Z score operationalized as metric variable.

Size: Log of total assets to capture the firm size.

ERP is a dummy variable = 1 if the firm is ERP implementator, 0 otherwise.

ERP × HOLDINGS is the interaction term of ERP and CEO Holdings that represent the CEO holdings that belong to an ERP firm (i.e., this variable tests H1 and expected to be positive).

ERP × HORIZON is the interaction term of ERP and Horizon that represent the CEO's Horizon that belongs to an ERP firm (i.e., this variable tests H2 it is expected to be positive)

ERP × Late: is the interaction term for ERP and Late that represent the implementation of an ERP system prior in the year 2000 (i.e., this variable tests H3 and expected to be positive).

ERP × Full: is the interaction term for ERP and Full that represent the implementation of primary and secondary modules that belongs to an ERP firm (i.e. this variable tests H4a, the scope of implementation and expected to be positive).

ERP × Primary is the interaction term for ERP and Primary that represent the primary module implementation that belongs to an ERP firm (i.e., this variable tests H4b, and expected to be positive).

ERP × Early: is the interaction term for ERP and early that represent the implementation of an ERP system prior to 1998 (i.e., this variable is to control for the innovativeness argument effect if any).

ERP × LV: is the interaction term for ERP and Vendor that represent the implementation of SAP or Oracle ERP system (i.e. this is a control variable to be consistent with early research).

Size×Health is the interaction term for size and health, used as control variable to account for the effect of small unhealthy firms.

74 negative observations for pre-average of ROA, 44 negative observation for pre-average of OIA, 74 negative observation for pre-average ROS and 40 negative observation for pre-average of OIS were deleted before running this regression.

and ΔOIS with p-value less than 0.05 and 0.10 respectively. Also it has significant negative impact on ΔSGA with p-value less than 0.10. Thus indicating that among the two CEO characteristics investigated in this study, CEO holdings are more important contributors to the ERP-performance relationship.

The results for the timing hypothesis, H3, are not significant in any of the performance variables. H3 postulates that the more recent the implementation, the more positive the impact on an ERP implementation of firm performance. A possible reason for the insignificance results is the small number of firms that implemented ERP systems during the year 2000. In the sample of this study, only 20 firms implemented an ERP system during that year, while there were 295 firms implemented in earlier periods. The alternative hypothesis for H3, the innovativeness argument, captured by the control variable ERP×Early, exhibited limited support. The only performance variable found to be significant and positive was ΔOIA at level of significance of p-value less than 0.10.

The test of hypothesis 4a, which postulates that the larger the scope of the implementation, the stronger the ERP-performance relationship, shows mixed results. In contradiction to H4, a ΔOIA is negative and significant at p-value less than 0.10. The conflicting results might be due to the huge cost of implementing a larger scope of ERP systems. In other words, firms that implement large scope (i.e., full) ERP systems encounter greater capital expenditures for these systems.[86] The larger asset base can hold the ex-post OIA (operating income over total assets) low. However, these firms also exhibit a better ΔROS ΔOIS and ΔSGA, at level of significance of p-value that is less than 0.10 in comparison to non-implementers and firms with partial ERP systems implementation. These

results indeed indicate that there is a positive association between large scope of implementation and improvement on performance in terms of sales.

Firms that implemented a primary module experienced a better performance in terms of ΔOIA in consistency with H4b (p-value less than 0.05). The results of the other performance variables were not statistically significant; however, all of the coefficients were consistent with the predicted sign.

The vendor choice has no impact on the ERP productivity. This is inconsistent with early research findings, but can be explained by the following reasons. First, the positive impact of vendor on market reaction could be attributed to brand familiarity (i.e., the market is more familiar with larger vendors) and not because those vendors can provide ERP systems that are more productive for the firm. The argument for brand familiarity can be found in Odom and colleagues (2002), who investigated the impact of Web seal brand familiarity. Such an argument is found to be valid in the marketing behavior literature, but is beyond the scope of this study. Second, according to Mabert et al. (2003) the type of vendor implementation does not impact the implementation outcome, time lines, and success rates. Therefore, these results are consistent with the findings of Mabert et al. (2003).

Table 11, panel B, details the results of the same regression model 6 after operationalizing the firm health variable as a dummy variable. Except for the variable "full," the difference in the results between panel A and B is not significant. Although the results are similar among the other variables in term of statistical power, the ones reported in panel A have a greater explanatory power in term of the adjusted R-square relative to the one reported in panel B.

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[86] Similarly, Nicolaou (2004) found negative significant results for the OIA variable in his study.

Table 11, panel C, contains the results after the blocking variables were removed from regression model 6. The results differed significantly; moreover, the explanatory power in term of adjusted R-square declined significantly. Thus, including blocking variables and grouping the observations into homogenous blocks helps to reduce the error variance and increase the validity of the inferences as expected and described earlier in chapter 3. Based on these results, the remaining regressions will utilize a metric operationalization for the "firm health" variable and will include blocking variables. The results reported in panel A will also be emphasized.

The overall results from table 10 in panels A and B indicate that CEO holdings as a percentage of the total outstanding shares is an important contributor to the association between ERP implementation and firm performance. The strong results for the simultaneous test utilized by the multivariate regression model 6 and reported in table 11, panel A, are consistent with the results obtained from the univariate test. Both the multivariate and univariate tests provide the strongest support for H1, that CEO holdings are impacting the ERP-performance relationship. As for the rest of the contextual variables considered in this study, all of them received partial support. The only hypothesis that did not have significant results is the H3 that postulates that the more recent the implementation the stronger the association between ERP and firm performance. A possible explanation for these insignificant results may lie in the small number of firms that implemented ERP system during the year 2000 that represents the recent implementations.

Robustness Tests

A few additional tests have been performed to assess the robustness and reliability of the findings presented above. First, the univariate tests are re-estimated using the median as cutoff score. The cutoff score was 0.01 for the holdings and 10 for the horizon. Tables 12 and 13 report the results of the univariate tests for H1 and H2 respectively. As it can be observed the results did not differ from the one reported earlier by tables 8 and 9. The results indicate that the holdings of a CEO are an important contributor the relationship between ERP implementation and firm performance. As for the horizon there are no significant results found.

As for the second robustness test, regression model (6) is re-estimated by replacing the CEO holdings and horizon with the holdings for the top five executives. The horizon and holding data pertaining to the top five executives are obtained from the COMPUSTAT Executive Compensation database and from the proxy statement of the firms. If the results are similar to the one obtained in table 11, panel A, then the findings are not valid, because this study built its H1 and H2 based on the influence of the CEO, not the top five executives on a firm's outcome.

The results on the interaction term of holdings (i.e., the aggregated holdings of the top five executive except the CEO holdings) and ERP are reported in table 14. The results are different from the results reported in table 11, panel A. The holdings of the top five executives, excluding CEOs' holdings, is found to be significant only for the OIA (p-value less than 0.01). The conclusion that can be drawn, therefore, is that CEO holdings are more important than the aggregate holdings of the top five executives in determining the financial

performance post ERP implementation. Also, the results confirm the argument that individual executives can influence the outcome of an ERP investment as suggested in all previous chapters of this study.

The final robustness test is conducted to examine the argument presented by Barker and Mueller (2002, p. 790), that it is not the percentage held by the CEO that drives the long

Table 12. Performance Comparison High Median Holdings vs. Low Median Holdings for ERP Implementers (H1)

Matched Variable	Portfolio	Mean	Standard Deviation	Paired t-test	Mean Difference	t-Value	Prob.
ΔROA	Low	-0.44	2.35	214	1.61**	1.67	0.03
	High	1.17	8.34	52			
ΔOIA	Low	-0.20	1.44	211	0.79***	3.15	0.00
	High	0.58	2.03	69			
ΔROS	Low	-0.48	2.00	207	8.93*	1.29	0.09
	High	8.45	69.89	61			
ΔOIS	Low	-0.31	1.37	190	1.59***	2.91	0.00
	High	0.64	2.93	94			
ΔCGSS	Low	0.04	0.17	225	- 0.51*	- 1.37	0.08
	High	-0.47	3.67	80			
ΔSSGA	Low	0.12	0.4617238	218	-0.24***	-3.30	0.00
	High	-0.12	0.5001771	89			

*p<0.1, ** p<0.05, ** *p<0.001, All p-values reported as one sided.

Δ is defined as: The average performance ratio of the 4 years post implementation minus the average performance ratio of the 3 years pre implementation

Δ4ROA: Scaled change for Return on Assets 4 years post implementation (37 observations deleted due to negative pre-ROA performance)

Δ4OIA: Scaled change for Operating Income over Assets 4 years post implementation (22 observations deleted due to negative pre-ROA performance)

Δ4ROS: Scaled change for Return on Sale 4 years post implementation (37 observations deleted due to negative pre-ROA performance)

Δ4OIS: Scaled change for Operating Income over Sale 4 years post implementation (20 observations deleted due to negative pre-ROA performance)

Δ4CGS: Scaled change for Cost of Goods Sold divided by Sale 4 years post implementation

Δ4SGA: Scaled change for Selling General and Administrative expenditure over sale 4 years post implementation

Table 13. Performance Comparison High Median Horizon vs. Low Median Horizon for ERP Implementers (H2)

Matched Variable	Portfolio	Mean	Standard Deviation	Paired t-test	Mean Difference	t-Value	Prob.
ΔROA	Low	0.15	3.49	168	-0.02	-0.02	0.48
	High	0.13	7.72	103			
ΔOIA	Low	-0.01	0.92	160	0.31	1.26	0.12
	High	0.30	2.27	130			
ΔROS	Low	6.95	67.79	132	-6.76	-0.99	0.83
	High	0.19	7.80	140			
ΔOIS	Low	0.02	0.71	164	0.25	0.82	0.20
	High	0.27	2.95	132			
ΔCGSS	Low	-0.38	3.58	151	0.37	0.98	0.84
	High	-0.01	0.22	152			
ΔSGA	Low	0.05	0.32	148	-0.06	0.91	0.18
	High	-0.01	0.62	159			

*p<0.1, ** p<0.05, ** *p<0.001, All p-values reported as one sided.
Δ is defined as: The average performance ratio of the 4 years post implementation minus the average performance ratio of the 3 years pre implementation
Δ4ROA: Scaled change for Return on Assets 4 years post implementation (32 observations deleted due to negative pre-ROA performance)
Δ4OIA: Scaled change for Operating Income over Assets 4 years post implementation (12 observations deleted due to negative pre-ROA performance)
Δ4ROS: Scaled change for Return on Sale 4 years post implementation (33 observations deleted due to negative pre-ROA performance)
Δ4OIS: Scaled change for Operating Income over Sale 4 years post implementation (8 observations deleted due to negative pre-ROA performance)
Δ4CGS: Scaled change for Cost of Goods Sold divided by Sale 4 years post implementation
Δ4SGA: Scaled change for Selling General and Administrative expenditure over sale 4 years post implementation

term investment behavior, rather it is the dollar value of the ownership. This study adheres to the argument provided by Jensen and Murphy (1990b) that substantial CEO stock holding motivates CEOs to maximize the wealth of the stockholders.

$$\Delta Perf_i = \alpha + b_1 Hodings_{it-1} + b_2 Health + b_3 LogAssets_{it-1} + b_4 ERP + b_5 ERP \times Holdings + b_6 ERP \times Late$$
$$+ b_7 ERP \times Full + b_8 ERP \times \Pr im + b_9 ERP \times Early + b_{10} ERP \times Vendor + b_{11} Size \times Health + b_{12} Block_1 .... b_{\frac{n}{2}} Block_n$$

Table 14. Regression for Four Years Average (Top Five Executive Holdings Excluding CEO Holdings)

Perform-ance	Inter-cept	Holdings	Health	Size	ERP	ERPx Holdings	ERPx Primary	ERPx Full	ERPx LV	ERPx Early	ERPx Late	Sizex Health	Adj R^2
ΔROA	1.45	0.00	-0.00	-0.27	-0.15	-0.00	1.25	1.14	0.88	-0.7	-2.42	1.45	0.08
t-value	0.64	-0.24	-0.66	-1.09	-0.14	-1.20	0.83	0.76	1.06	-0.80	-1.89	0.80	
p-value	0.80	0.51	0.27	0.89	0.43	0.88	0.20	0.22	0.15	0.79	0.98	0.52	
n=533 number of blocks 256													
ΔOIA	0.00	0.00***	-0.00	0.08	-0.39	-0.00	0.14	0.44	-0.06	0.17	0.09	0.00	0.19
t-value	-0.59	-28.82	-0.41	0.66	-1.17	-0.96	0.30	0.93	-0.29	0.84	0.18	0.49	
p-value	0.55	0.00	0.68	0.51	0.88	0.83	0.38	0.17	0.61	0.20	0.42	0.55	
n=540 number of blocks 225													
ΔROS	8.89	-0.00	-0.00	-0.98	-1.87	-0.00	0.31	2.07**	1.26	-0.97	-4.60	0.00	0.53
t-value	0.90	-1.04	-0.83	-0.93	-0.90	-0.31	0.35	1.77	1.25	-1.00	-1.13	0.87	
p-value	0.36	0.30	0.40	0.35	0.82	0.62	0.18	0.03	0.11	0.84	0.87	0.38	
n=533 number of blocks 250													
ΔOIS	2.83	0.00**	-0.00	-0.17	-1.76	0.00	-0.24	1.08*	-0.13	-0.13	-0.74	0.00	0.04
t-value	0.63	-2.44	-0.78	-0.50	-1.00	0.83	-0.33	1.54	-0.30	-0.32	-0.48	0.80	
p-value	0.53	0.01	0.43	0.61	0.84	0.21	0.63	0.06	0.26	0.625	0.68	0.42	
n=547 number of blocks 255													
ΔCGSS	-0.05	0.00***	0.00	0.01	0.02	0.00	-0.08**	-0.05	0.02	-0.02	0.07	0.00	0.34
t-value	-0.57	-7.25	0.27	1.13	0.52	1.83	-1.62	-0.79	0.56	-0.55	1.05	-0.38	
p-value	0.57	0.00	0.79	0.26	0.20	0.47	0.05	0.21	0.21	0.29	0.35	0.71	
n=607 number of blocks 298													
ΔSGA	0.29**	0.00***	0.00	-0.02	-0.21*	0.00	-0.04	-0.18*	0.00***	0.15	0.17	0.00	065
t-value	2.16	-8.90	-0.16	-1.37	-1.57	-1.06	-0.29	-1.45	0.01	1.25	1.12	-0.02	
p-value	0.03	0.00	0.87	0.17	0.06	0.15	0.39	0.08	0.00	0.39	0.37	0.98	
N=607 number of blocks 298													

Table 14—*Continued*.

*p<0.1, ** p<0.05, ** *p<0.001, All p-values reported as one sided except for the variable ERP, and its interaction terms with Holdings, Primary, Full, LV, Early and Late.

Δ is defined as: *The average performance ratio of the four years post implementation minus the average performance ratio of the three years pre implementation*

Holdings is the percentage of the top five executive holdings minus CEO holdings on year t-1.

Health: is financial health of the firm measured using Altman's Z score operationalized as metric variable.

Size: Log of total assets to capture the firm size.

ERP is a dummy variable = 1 if the firm is ERP implementator, 0 otherwise.

ERP × HOLDINGS is the interaction term of ERP and top five executive Holdings minus CEO holdings that belong to an ERP firm.

ERP × Late: is the interaction term for ERP and Late that represent the implementation of an ERP system prior in the year 2000.

ERP × Full: is the interaction term for ERP and Full that represent the implementation of primary and secondary modules that belongs to an ERP firm.

ERP × Primary is the interaction term for ERP and Primary that represent the primary module implementation that belongs to an ERP firm.

ERP × Early: is the interaction term for ERP and early that represent the implementation of an ERP system prior to 1998.

ERP × LV: is the interaction term for ERP and Vendor that represent the implementation of SAP or Oracle ERP system.

Size×Health is the interaction term for size and health, used as control variable to account for the effect of small unhealthy firms.

All firms with negative pre-average of ROA, OIA, ROS and OIS were excluded from this regression

To test the results obtained from table 11 against the argument of Barker and Mueller (2002), the holdings variable is operationalized in terms of absolute dollar value. Table 15 presents the results for regression model 5. The only significance is observed for the variable SGA with p-value less than 0.10. The results of table 15 are weaker compared to the results reported in table 11, panel A, which used the percentage owned by the CEO as proxy for the variable holdings. The weak results reported by table 15 are important for two reasons. First, it validates the approach used in this study for operationalizing the holdings variable as a percentage of the total outstanding shares. Second, and more important, it supports the argument presented by Jensen and Murphy (1990b) that increased percentage of outstanding stocks, not the dollar value, held by a CEO motivates the CEO to maximize the wealth of the stockholders. Tying the wealth of CEO with stock holders' wealth, within the content of ERP implementations, is the more effective approach to ensure maximizing the wealth of the stockholders.

Summary

This chapter presents the results of the statistical tests on the hypotheses presented in chapter 3. Univariate and multivariate statistical tests are used followed by several robustness tests to validate the results.

The first univariate test is designed to examine the difference of mean performance between low holdings portfolio and high holdings portfolio (H1). The results indicate that there is a difference in the performance between the two types of firms that is statistically significant. The results are consistent across all six performance variables in favor of firms in the high holdings portfolio.

$$\Delta Perf_i = \alpha + b_1 Horizon_{it} + b_2 Hodings_{it-1} + b_{13} Health + b_4 LogAssets_{it-1} + b_5 ERP + b_6 ERP \times Holdings + b_7 ERP \times Horizon_{it}$$
$$+ b_8 ERP \times Late + b_9 ERP \times Full + b_{10} ERP \times \Pr im + b_{11} ERP \times Early + b_{12} ERP \times Vendor + b_{13} Size \times Health + b_{14} Block_1 \ldots\ldots b_{\frac{n}{2}} Block + e$$

Table 15. Regression for Four Years Average (CEO Holdings in Dollar Value)

Perform -ance	Inter -cept	Hori- zon	Hold- ings	Health	Size	ERP	ERPx Horizon	ERPx Holding	ERPx Primary	ERPx full	ERPx LV	ERPx Early	ERP x Late	Size x Health	Adj R^2
ΔROA	1.81	-0.09	0.00	0.00	-0.26	0.91	-0.81	0.00**	1.54	0.06	0.89	-0.33	-2.05	0.00	0.11
t-value	0.83	-0.51	0.32	-0.13	-0.93	0.55	-0.38	2.14	0.93	0.04	0.92	-0.35	-1.38	0.25	
p-value	0.40	0.61	0.74	0.90	0.35	0.29	0. 65	0.02	0.17	0.47	0.18	0.64	0.91	0.80	
n=535 number of blocks 266															
ΔOIA	-0.05	-0.07*	0.00	0.00	0.09	-0.84	0.06	0.00	0.48	-0.10	-0.24	0.53**	0.65	-0.00	0.13
t-value	-0.49	-1.73	0.41	0.24	0.64	-2.16	1.16	1.19	1.12	-0.22	-0.92	1.77	0.95	-0.17	
p-value	0.62	0.08	0.68	0.80	0.52	0.98	0.15	0.18	0.13	0.59	0.82	0.04	0.17	0.86	
n=565 number of blocks 260															
ΔROS	2.21	0.89	-0.00	-0.00	-1.00	6.10	-0.96	0.00	0.73	1.79*	1.46	-1.41	-5.48	0.00	0.65
t-value	0.44	1.15	-0.30	-0.91	-0.89	1.13	-1.19	0.03	0.80	1.26	1.08	-0.88	-0.99	0.94	
p-value	0.66	0.25	0.76	0.36	0.37	0.13	0.88	0.48	0.21	0.10	0.14	0.81	0.84	0.34	
n=535 number of blocks 262															
ΔOIS	-0.75	-0.03	0.00*	0.00	0.10	-0.41	0.41**	0.00	0.46**	0.40	-0.41	0.20	0.16	0.00	0.20
t-value	-1.20	-1.73	1.25	0.36	1.32	-1.58	1.61	1.11	1.75	1.18	-0.87	0.80	0.41	-0.13	
p-value	0.23	0.08	0.21	0.72	0.18	0.94	0.06	0.14	0.04	0.12	0.81	0.21	0.33	0.89	
n=569 number of blocks 261															
ΔCGSS	0.00	-0.01***	0.00	0.00	0.01	-0.01	0.01	0.00	-0.07*	-0.03	0.02	-0.03	0.03	0.00	0.55
t-value	0.04	-2.68	-1.26	0.39	0.83	-0.33	1.70	-0.95	-1.40	-0.47	0.43	-0.73	0.44	-0.50	
p-value	0.97	0.01	0.21	0.70	0.41	0.37	0.45	0.17	0.08	0.32	0.17	0.23	0.17	0.62	
n=609 number of blocks 303															
Δ4SGA	0.20	0.01	0.00**	0.00	-0.20	0.11	-0.01*	0.00*	-0.13	-0.11	0.03	-0.01	0.00	0.00	0.73
t-value	1.33	0.96	-2.21	0.05	-1.16	1.02	-1.48	-1.32	-1.21	-0.93	0.27	-0.15	1.83	-0.19	
p-value	0.19	0.34	0.03	0.96	0.25	0.35	0.07	0.10	0.11	0.18	0.11	0.44	0.47	0.85	
n=609 number of blocks 303															

Table 15—*Continued*.

*p<0.1, ** p<0.05, ** *p<0.001, All p-values reported as one sided except for the variable ERP, and its interaction terms with Horizon, Holdings, Primary, Full, LV, Early and Late.

Δ is defined as: *The average performance ratio of the four years post implementation minus the average performance ratio of the three years pre implementation*

CEO Holdings is in 1991 Dollar value adjusted based on CPI.

CEO Horizon measures the years between the ERP implementation and the time the CEO reaches the retirement age.

Health: is financial health of the firm measured using Altman's Z score operationalized as dummy variable.

Size: Log of total assets to capture the firm size.

ERP is a dummy variable = 1 if the firm is ERP implementator, 0 otherwise.

ERP × HOLDINGS is the interaction term of ERP and CEO Holdings that represent the CEO holdings that belong to an ERP firm (i.e., this variable tests H1 and expected to be positive).

ERP × HORIZON is the interaction term of ERP and Horizon that represent the CEO's Horizon that belongs to an ERP firm (i.e., this variable tests H2 it is expected to be positive)

ERP × Late: is the interaction term for ERP and Late that represent the implementation of an ERP system prior in the year 2000 (i.e., this variable tests H3 and expected to be positive).

ERP × Full: is the interaction term for ERP and Full that represent the implementation of primary and secondary modules that belongs to an ERP firm (i.e. this variable tests H4a, the scope of implementation and expected to be positive).

ERP × Primary is the interaction term for ERP and Primary that represent the primary module implementation that belongs to an ERP firm (i.e., this variable tests H4b, and expected to be positive).

ERP × Early: is the interaction term for ERP and early that represent the implementation of an ERP system prior to 1998 (i.e., this variable is to control for the innovativeness argument effect if any).

ERP × LV: is the interaction term for ERP and Vendor that represent the implementation of SAP or Oracle ERP system (i.e., this is a control variable to be consistent with early research).

Size×Health is the interaction term for size and health, used as control variable to account for the effect of small unhealthy firms.

Block: are sequences of multiple dummy variables to capture the block in which both the ERP firms and its match belong to.

All firms with negative pre-average of ROA, OIA, ROS and OIS were excluded from this regression

The second univariate test is designed to examine the difference of mean performance between short horizon portfolio and long horizon portfolio (H2). The results indicate that there is no difference that is statistically significant.

To test all four hypotheses simultaneously in one regression model, several forms of regression model 5 were utilized. The results revealed that the main contributor for the ERP-performance relationship are the CEO holdings (H1) in terms of her/his percentage of equity holdings. The results were statistically significant across all performance variables except ΔROS. This study is the only study to find such strong results across multiple performance variables for ERP implementation.

As for the horizon of a CEO (H2) the results are partially supported. The horizon found to be significant only for OIA and SGA. There was no support for H3 (i.e., the more recent the implementation the stronger the ERP-performance association). However, there is partial support for the alternative hypothesis (the innovativeness argument) on the OIS. The results are stronger when block variables are included to control for each adopting firm and its match. Also, when the health variable is operationalized as a metric variable to reduce the effect of "the zone of ignorance," the results are stronger.

Two major robustness tests were conducted. The first examined whether the CEO holdings or the top five executive holdings as a group determined the association between ERP and post implementation performance. The results indicate that CEO characteristics are more powerful than the other top five executives. Such results are consistent with Hambrick and Mason's (1984) Upper Echelons model and sheds additional light on the debate about whether an individual top executive matters or not in determining organizational outcomes.

The second test helps to identify within the context of ERP implementation, what operationalization of the variable holdings helps to reduce the agency cost. The results indicate that operationalizing the holdings as a percentage of the total outstanding is more appropriate than operationalizing the variable in terms of dollar value. The results are consistent with the argument provided by Jensen and Murphy (1990b) that it is the percentage held by a CEO that ties her/his wealth to the stockholders wealth, which in turn motivates her/him to maximize the wealth of the shareholders.

CHAPTER V

DISCUSSION

This study reviewed the literature of ERP productivity function and identified anomalous findings for the ERP productivity function. This review indicated the need to identify the contextual factors surrounding ERP implementation. Four contextual variables were identified and hypothesized as potential contributors for the ERP-performance relationship. Also as an effort to overcome the anomalous findings of early research, this study integrated the literature of agency theory with the literature of ERP productivity. The tests were described in chapter 3 and the results were reported in chapter 4. This chapter will provide a summary and interpretation of the results, a discussion of the contribution and the limitation of this study, and suggestions for possible future research avenues.

Summary and Implication of the Results

This study adds to the prior ERP-productivity research by attempting to overcome the anomalous findings of the archival studies by integrating the agency theory into the ERP literature. This study also refines the statistical methodology used by previous research. This section summarizes the results of hypotheses tests, methodology, and the implications of the findings.

Hypotheses Summary

Four contextual variables were identified as possible contributors to the ERP-productivity relationship. Based on these contextual variables four hypotheses were

developed. The four hypotheses, along with their results, are summarized in table 14. The main contributor to the ERP-productivity relationship is the CEO holdings. The results on the holdings indicate that as a CEO's wealth increases in the firm, the more the performance of the firm improve post implementation.

Table 14. Summary for H1-H4b

Hypotheses	Results
H1: CEO holding impacts the relationship between ERP and performance positively	Univariate test: Supported for all performance ratios. Multivariate test: Supported for all performance ratio except ROS
H2: CEO horizon impacts the relationship between ERP and performance positively	Univariate test: Not supported. Multivariate test: Limited, partial support, significant only for OIA and SGA
H3: The recent the implementation the stronger the ERP-Performance relationship	Not supported.
H4a: The greater the scope of the implementation, the stronger the ERP-Performance relationship	Partial support: Only significant for ROS and SGA.
H4b: Firm implementing primary module, will have better performance.	Limited, partial support: Only significant for OIA.

Results were not as significant for the CEO horizon as they were for the CEO holdings. Partial support, however, was found for the CEO horizon with the results confirmed for OIA and SGA. These findings are actually consistent with the ones from prior research in long term projects (i.e., CEOs with short horizon were less motivated to engage in long term projects) (Barker & Mueller, 2002; Dechow & Sloan, 1991).

The results of the timing proposition are not significant in any of the performance variables. The timing proposition is based on the "efficiency argument" and on the potential productivity enhancement provided by the more recent version of ERP systems, both discussed in chapter 3. A possible reason for the insignificant results is the small number of firms that implemented ERP systems in the year 2000. However, the results indicate that there is a limited, partial support for the alternative hypothesis, the "innovativeness argument." Early ERP implementers experienced a positive change in OIS.

Similar to the horizon and timing propositions, the scope of the implementation and the type of module implemented received partial support. Firms that implemented modules in both primary and support value chain activities experienced greater return on assets and reduced their selling general and administrative expenditures. Also, firms that implemented modules in the primary section of the value chain exhibited greater operating income over assets.

Methodology

In addition to the four contextual variables, this study considered some methodological limitations found in earlier studies. Two limitations were considered: (1) not utilizing a full regression model to test the contextual variables simultaneously and (2) reducing the error variance to enhance the validity of the inferences by considering the blocking design.

Testing the variables simultaneously resulted in different results from the one obtained by Nicolaou (2004), who tested each independent variable with a separate regressional model. For example, Nicolaou, while testing vendor choice, found that SAP and Oracle implementers exhibited better performance relative to implementers of other ERP

systems. In this study, when vendor choice was included in the model along with other contextual variables, the type of module did not have any impact on the firms' performance. Thus, the results for the vendor choice found in Nicolaou's study could be attributed to the missing variables that are not included in his model[89]. Moreover the results on the vendor choice are consistent with the findings of Mabert et al. (2003)[90].

Including blocking variables to ensure a homogenous sample is the second improvement in the methodology in this study. When these blocking variables are included the results are stronger in terms of explanatory power. Such refinements have not been considered by early archival studies.

Interpretation of the Results and Implications:

The holdings of a CEO are the most important contextual variable that links the implementation of an ERP system to a firm's post implementation productivity. Within the context of ERP systems implementation the percentage of CEOs holdings is able to explain more of the post-implementation performance than the magnitude of CEO holdings. This is worth noting because in the literature of agency theory there are two different arguments. First, is that the amount of "at-risk wealth" (i.e. in terms of dollar value) in a firm's stock is what drives the long-term focused behavior of the executive to maximize the wealth of the stockholders on the long run, not the amount of ownership control (Barker & Mueller 2002). Second, the increased percentage of outstanding stocks, not the dollar value, held by a CEO motivates the CEO to maximize the wealth of the stockholders according to Jensen and

[89] The limitation of testing the contextual variables in different models is described in details in chapter
[90] The type of vendor implementation does not impact the implementation outcome, time lines, and success rates.

Murphy (1990b). The results of this study indicate that within the context of ERP systems implementations, the percentage of outstanding stocks held by a CEO is more important than the dollar value.

Moreover, the results of the CEO holdings help to shed additional light to the debate about whether an individual top executive matters or not in determining organizational outcomes. One of the robustness tests indicates that within the context of ERP implementations, the CEO holdings are more important than the holdings of the other executives as a group. Thus, an individual top executive, that is CEO, matters in determining organizational outcomes.

The results are partially significant for the horizons of a CEO, but not as strong as the results of holdings. This indicates that the most important characteristics of a CEO that influence the ERP-performance relationship are her/his holdings. The results of the horizon are consistent with early research on similar long term investment like R&D (Baker et al., 1988; Dechow & Sloan, 1991). CEOs with different horizon have different priorities (e.g., short term CEOs focus on short term investment relative to CEOs with longer horizon [see chapters 2 and 3]). CEOs with different horizon perceive change differently (i.e., older CEOs sometimes have difficulty accepting new ideas and learning new behaviors)

As for the timing, although there are no significant results for H3, the efficiency argument needs to be tested again when more ERP implementations are available. Since the testing period in this study is extended to four years post implementations, observation after 2000 have not been used.

Both scope of implementation (the size of the implementation within each firm) and type of modules (primary or secondary) implemented received partial support. Firms

implementing full ERP systems show improvement in their ROS while firms implementing modules for the primary activity of the value chain show improvement in their OIA. Future studies could consider tests for extended five-year post implementation to observe similar improvement in the other performance variables that did not improve significantly. Findings of scope of implantation and type of modules implemented differ from the findings of Nicolaou (2004), who found no significant impact for firms implementing primary modules. The only significance he found was negative for firms implementing primary modules on CGS. This study, however, found positive significant results for OIA as hypothesized. The difference in the results could be attributed to the methodological differences between both studies as described earlier in chapter 2.

The results of this study are similar to the results of Nicolaou in terms of OIA. When firms implement both primary and secondary modules the performance will decline significantly. However, in this study there was a significant impact on both the scaled change of ROS and SGA in the same direction of the predicted sign. Such findings were not observed in Nicolaou's study. It is possible that the results differed because of methodological differences between the two studies. This study tested the partial contribution of the scope of the implementation and the module implemented simultaneously with the other variables of interest, while Nicolaou did not. Another possible explanation is the definition of the dependent variables that captures the performance of the firm. While Nicolaou tests the difference between the implementing firm and its match, this study examines the difference in performance between the firm's pre- and post implementation performance while controlling for the same difference of the match firm.

The results of this study differ from the ones of Nicolaou (2004) on the variable ERP that captures the event of ERP implementation. This study finds that there is no partial contribution for the variable ERP (main effect of the variable), rather its contribution is observed in its interaction terms with other contextual variables, such as holdings horizon, primary and full. In contrast, Nicolaou's study finds that the variable ERP (main effect) impacts the association positively. The difference in the results is most likely due to the misspecification of the models utilized by Nicolaou that omitted important variables (see chapters 2 and 3).

Hunton et al. (2003) indicated that ERP implementers outperformed non-implementers. The authors attributed this finding to the declining performance of the non-implementers while performance of the implementers remained steady. However, this study found that the implementers' performance improved and did not remain steady. The difference in the results of this study and the ones of Hunton and his colleagues may be attributed to the additional contextual variables included in this study. The differences also possibly can be attributed to the statistical and methodological refinement that will be discussed in the next paragraph.

Finally, this study utilized a new enhancement for the methodology used within the archival study. It introduces the technique of "block design" that is well accepted by studies in experimental design. This study appears to be the first to utilize such a design within the archival studies that examine ERP productivity. The difference between the results reported in panels A and C of table 11 is significant. Among the advantages of block design is that it reduces the error variance and increases the validity of the inferences (Neter et al., 1996).

Contribution of the Current Study

The contribution of this study to academia can be found in its attempt to shed additional light on the anomalous findings of the archival research (i.e., findings that contradict the underlying theories of the benefit of investment in ERP and contradict the findings of the studies already conducted using different methodologies). This study complements the existing studies by addressing and remedying their limitations. This study contributes not only to the literature on ERP system productivity, but also to the literature on contracting and compensation by identifying the difference between operationalizing the CEO holdings as a percentage of outstanding shares or as dollar value and when each operationalization is more desired.

The findings of this study can be important to practitioners, especially for firms now planning to engage in ERP implementation or any similar long-term investment. Such firms might consider aligning the wealth of their CEOs with the wealth of the shareholders of the firm, consistent with the agency theory. This alignment between the shareholders wealth and the CEO wealth can be established through equity compensation (holdings). The findings of the literature on employee equity compensation and the type of investment made by the firm, reveal that equity compensation plays a major role in monitoring executives of firms that are engaging in risky and unpredictable projects (Clinch, 1991). Moreover, according to Jensen and Murphy (1990a, 141), if senior managers have high equity holdings, they will experience a more powerful and direct "feedback effect" from the changes in the market value of the firm. Given the risky nature of ERP systems investments and the impact of market value of a firm on CEO personal wealth, CEOs with high holdings are not expected to initiate such projects unless those projects will have a positive impact on the market value of the firm. As

for the horizon, since ERP projects are considered to be long-term investments and since there are negative associations between CEO horizon and long-term investments, firms considering such projects should consider CEOs' horizon before initiating such a project. Also, the horizon factor could help explain why some firms do not realize the expected benefits from their investment in ERP. Although the results on the horizon were not as significant as the one on the holdings, yet they can provide some explanation for the ERP-productivity association.

Limitations of the Current Study

This study examined the possible impact of CEO holdings and horizon, the timing and size of implementation, and the type of module implemented on the productivity function of ERP systems. Similar to other archival studies, some unknown omitted variables could exist. As an effort to overcome this limitation, matching sample is used to control for economic factors that influence the market or the industry. Despite that effort, only inferences about correlation can be implied; no direct causality between implementation and post implementation performance can be concluded. Another limitation includes the small sample size collected from the available voluntary press announcements. To overcome such problems, SEC filings were searched to identify additional implementing firms. However, there are firms that do implement ERP systems but do not announce to the press or include discussion on such investments in their SEC filings (Nicolaou 2004).[91] Also, due to data availability, in this study the efficiency argument is not examined for implementations occurring beyond the year 2000. Other CEO characteristics, such as functional and

[91] The assumption would be that if firms did not include implementation in their SEC filings, probably the investment was not significant to the firms.

educational background, board structure characteristics, or corporate governance variables, which might have some effect on the results of the research, have not been considered.

Suggestions for Future Research

There is a need for future research on the association between ERP implementations and performance because of the increasing investment in ERP systems (Moller et al., 2004) and the continuous improvement and updates of ERP systems. Continuous changes to the systems need continuous improvement and updated research.

Although the timing proposition addressed in this study appears to be strong in theory, the results obtained are not significant. A reinvestigation of this issue appears desirable. Future research also needs to examine the "innovativeness arguments" since there is partial support for it found in this study.

Extending the post implementation period is needed to better examine the scope of the implementation and the type of module implemented. The partial support found in this study should encourage the researchers to extend the post implementation period since according to prior research the benefits of ERP implementation might be observed within four to five years post implementation.

Finally and most importantly, CEO characteristics, especially CEO holdings, are found to be the most important contributors to the ERP-performance relationship. This suggests the need to investigate other CEO characteristics found to be significant in earlier research in areas such as human capital and functional background (May, 1995). Educational background is noteworthy (i.e., whether or not he/she holds a graduate degree, and if so, if the degree is held in technical areas [Barker & Mueller 2002]). Also there is a need to consider board structure characteristics and corporate governance variables since these

variables impose some reduction of the agency cost and impact firms' performance. The presence of a good governance mechanism will impose some restrictions on the CEO's actions that better serve the interest of the shareholders wealth.

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BIOGRAPHICAL STATEMENT

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