VALUE CREATION IN THE KNOWLEDGE-BASED ECONOMY

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ABSTRACT

Effective investment strategies help companies form dynamic core organizational capabilities allowing them to adapt and survive in today's rapidly changing knowledge-based economy. This dissertation investigates three valuation issues that challenge managers with respect to developing business-critical investment strategies that can have significant impacts on firm performance and growth in the competitive, information-orientated business environment. Using firm-level data collected from Taiwan, this dissertation examines specific valuation issues that are vital in shaping not only firm performance but also competitive advantages in current knowledge-based economy: (1) investments in information technology (IT), (2) human capital, and (3) corporate governance. To address these three major managerial challenges relating to firm investment strategies, this dissertation focuses on investigating the impact of three sources of business value creation, including IT investment, workforce education, and Chief Audit Executive (CAE) turnover.

The results of investigating service infrastructure in the banking industry support the idea that in today's complex, fast moving multichannel business environment, evaluation of the strategic value of IT must consider both the direct impact of individual channels and the complementary relationships between IT-based channels and the traditional branch channel while constructing an effective business strategy to align IT use with firm strategic objectives. The interdependence between channels found in this study has a significant effect on firms' short term profitability and long term market competition capability, suggesting that the true value of IT will be fully realized only when coupled with complementary investments in organizational resources.

Second, results of examining investments in workforce and research and development (R&D) activities in IT industries indicate that firms with more highly educated workforces have, on average, better performance. Investment in R&D for improving innovation capability is positively associated with firm performance. More importantly, higher levels of workforce education moderate the impact of R&D investment on firm performance, confirming the hypothesized interdependency between workforce education and firm innovation capabilities. In other words, firms benefit more from investment in R&D activities when they have a higher level of educated workforce. An important strategic implication from the DuPont Analysis is that the complementarity between workforce education and R&D capital reinforces a firm's differentiation strategy.

Finally, the results of analyzing CAE turnover in Taiwan public companies show that CAE turnover is positively correlated with executive turnover (Chief Executive Officer [CEO] and Chief Financial Officer [CFO]) and financial restatements, which are commonly viewed as a signal of a troubled business or failure. The study also shows that CAE turnover has a negative impact on contemporaneous and future firm performance, suggesting that, to some extent, changing the head of the internal audit function conveys a negative signal to the market regarding a firm's performance. Given that the CAE monitors and assesses enterprise risk practices, the findings of this study suggest that CAE turnover could be used as an indicator of business volatility and potential business risk. The passage of the governance law which improves the quality of a firm's internal control system is found to reinforce the signaling role of CAE turnover and improve firm performance.

The results of this dissertation provide important strategic insights regarding the factors managers should consider when making investment choices that are expected to align with a firm's long term development and performance. This dissertation complements literature in managerial accounting and information systems, particularly contributing to business value of IT investment, human capital, and internal audit research streams. It also addresses regulatory implications for policy makers such as regulating relevant disclosures of company information for interested parties and developing a regulatory environment that minimizes regulatory barriers which can suppress businesses and economy growth.

DEDICATION

This dissertation is dedicated to my family,

Ning-Pan Liu, Ho-Kuei, Lee, Yu-Chen Liu, and Chia-Ju Liu.

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CHAPTER 1

INTRODUCTION

1.1 Motivation

Given the nature of the competition in today's fast growing, knowledge-based economy, it is vital for companies to develop appropriate corporate performance measurement systems and investment strategies that align with their strategic objectives and cultivate firm core capabilities to help grow business value (Aguilar 2003; Ashton 2005; Birkett 1995; Frigo 2003; Skinner 1998).[1] Managers face the challenge of understanding and gauging the ways certain high impact firm investments including information technology (IT), human capital, and governance can drive business and account for a large proportion of a firm's value (Ashton 2005; Barsky and Marchant 2000; Beasley et al. 2007; Busco et al. 2005; Epstein and Rejc 2005; Shortridge and Yu 2011). Inadequate investments in these important value creation assets can potentially compromise a firm's competitive advantage and business growth. Managers are, therefore, under pressure to be more proactive in effective development and management of investment strategies for building company's sustainable competitive advantages (Litman 2000). They must understand the value of key capital investments in order to not only cut costs for short term survival but also provide a competitive edge for long term business growth. The purpose of this dissertation is to address the valuation issues related to three key business-critical investments with which managers are currently grappling.

[1] Powell and Snellman (2004) defines the knowledge economy as "production and services based on knowledge-intensive activities that contribute to an accelerated pace of technological and scientific advance as well as equally rapid obsolescence" (Powell and Snellman 2004, p201). OECD (1996) acknowledges knowledge and information are at the center of economy growth and development.

The first valuation challenge issue is to evaluate the value of the firm's IT investment strategy. IT is viewed as one of the principal drivers of competition and plays a critical role in helping firms plan and coordinate activities to sustain their competitive advantages.[2] IT is often ranked as one of the top investment priorities for creating value in a competitive business environment (Gartner 2013). IT has changed the way firms operate and the rules of competition (Porter and Millar 1985). Managers believe that IT enhances a firm's ability to collect large amounts of data, improves the effectiveness and efficiency of the production process, and helps generate and retain competitive advantages (McKinsey & Company 2011a, 2011b). The phenomenon of "big data" resulting from the rapid development of IT in recent years has received much attention from both academia and practitioners (McKinsey & Company 2011b). The resulting advanced analytic opportunities driven by advancement of IT are expected to be a major contributor in redefining business models and helping firms gain a competitive edge in the cutthroat business environment.

Banks, for example, are aggressively using IT to not only improve operational efficiency but also to sharpen risk assessment and drive revenue (McKinsey & Company 2013a). IT investments between the 1980s and early 2000s have fundamentally transformed the banking industry's business model (McKinsey & Company 2013a). Today, accompanied with investment in more complex IT architecture, banks continue to transform to a customer-orientated operating model (KPMG 2012). The major changes that drive bank value are infused with sophisticated insights and predictive analyses from IT investments. For example, banks that use IT data collected through automated teller

[2] A recent study shows that IT is at top of investment priorities as corporate boards agree that IT can change the rules of competition in their industries, and are recognizing IT's increased strategic contribution to company operations (Gartner 2012b)

machines (ATMs) or Internet banking create a competitive advantage and differentiate themselves from their competitors. These banks are better able to understand their customers, have more information for risk decision-making, and develop products and services tailored to the need of their customers (McKinsey & Company 2013a).

On the other hand, managers need to think carefully about their IT strategies because of the large resource commitments required by IT investments. Given that investments in IT are often costly, managers are under pressure to meet growth targets while keeping a tight rein on costs (PwC 2013a). Disruptions caused by technological changes top the list of market threats to growth. To achieve significant productivity improvement, investment in IT should be coupled with complementary organizational investments (Powell and Snellman 2004). It is crucial for managers to develop ways of evaluating the value of IT and learn how to align their IT investment with business strategies. The operating model can be further complicated by rapid changes in IT and the introduction of new channels and technologies such as mobile technology and social media (KPMG 2012). Managers face the challenge of generating revenue through strategic employment of IT in a business environment where customers have become more demanding and less forgiving.

The second valuation issue in today's fast-changing knowledge economy, in particular considering the impact of technological disruption on firms' business strategies, is the growing importance of human capital (Bapna et al. 2013). The value of human capital depends on the extent that it contributes to the sustainability of a company's competitive advantage or core competence by improving operational efficiency and effectiveness and the ability to seize opportunities, and neutralize threats from competitors (Barney 1991; Porter 1985). Increased knowledge work in a knowledge-driven economy places higher demands on employee competencies (Ployhart 2006). Firm managers view employee capital is as essential for gaining a lasting competitive advantage in today's knowledge economy (Bapna et al. 2013). This is especially true for IT industries where employee capital is one of the main forces that drive innovation.

Since innovation is crucial in today's competitive business environment, having talented workers capable of supporting innovation is viewed as a key factor driving business success. In a recent survey, executives, in particular technology executives, viewed new products and services as the primary drivers of growth in their businesses (PwC 2013a). The survey found that research and development (R&D) and innovation and filling the talent gap rank among managers' top investment priorities when pursuing new products and services. Workforce talent is a critical investment directly linked to business value and growth opportunities, therefore managers today invest more in human capital in order to cultivate intellectual resources through retaining qualified, innovative staff that are capable of creating value by utilizing a company's scarce resources.

In a knowledge-based economy, knowledge creation and innovation often occur at the interface of disciplines. The ability to analyze and solve problems as well as the ability to develop new products and services is essential and in high demand in this increasingly complex, fast changing, and competitive, knowledge-based economy. Employees need a certain degree of maturity as well as higher education in order to cope with the high degree of complexities and changes (Córdova 2006; Wladawsky-Berger 2007).

It is clear that education is the primary impetus for employee generating knowledge and innovative ideas (Smith et al. 2005). Given this expectation, how can employee capital derived from level of education contribute to firm innovation and future growth? Studying the ways in which human capital, in particular the education levels of workforce, has both direct and indirect impacts on firm performance would provide valuable insights for companies making business critical investment decisions. Although employee capital has been widely examined in the management and economics literature, the extent to which employee capital directly and indirectly interacts with other firm invested resources that generate knowledge and innovation (e.g., R&D capital) is still unclear. The question of how to cultivate talent to boost innovation through education has become a key issue for business leaders and regulators who want to pursue a competitive advantage strategy.

The third valuation challenge for managers is to evaluate the effect of corporate governance mechanisms, particularly the increased concern of maintaining the quality of the internal audit function. Managers' increased responsibility for internal control over financial reporting (ICFR) under Section 404 of the Sarbanes-Qxley Act (SOX) has promoted the role of internal auditors as they provide guidance for SOX compliance (Gramling et al. 2004; Lin et al. 2011; U. S. House of Representatives 2002). Specializing in the assessment of internal controls, internal auditors have extensive insights into the operation of internal controls and resource constraints on managing these controls (IIA 2008). Internal auditors can be an invaluable resource to the company because they are in a unique position not only to evaluate and test internal controls but also to provide guidelines and suggestions concerning the adequacy of internal control and governance structures that influencing firm performance (IIA 2008, 2013). It is expected that internal auditors help executive management as well as board of directors effectively assess and maintain well-structured controls over financial reporting (IIA 2008, 2013).

In addition, risk assessment and quality control have become much more important to both academia and practitioners because of the increased awareness of operational and control failures. The task of risk management today is much more complex for firms that invest intensively in IT and compete in a hyper-competitive business environment. Control failures resulting from inadequate governance quality control are much more costly than in the past, damaging firms' established reputations and losing the trust of core clients. Since risk taking is a necessary part of being in business, good risk management not only helps mitigate the impact of negative outcomes but also results in better financial outcomes (Ernst & Young 2011).

Today's board directors and top management teams are well aware of the importance of risk management and governance while facing increased risk levels coming from the fast changing business environment (PwC 2013b). Given the increased expectation of risk and governance control from regulators and the market, discussions and examinations of ways that internal audit functions can help gauge a firm's health and fuel future performance are prominent in today's business agendas (Harrington 2004). There has been a significant change in the role of the internal auditor as the impact of effective risk management on firm performance becomes the focus of board directors and top executives (Ernst & Young 2012; Hoffelder 2013; McKinsey & Company 2011d; Narvaez and Bugalla 2012).

The internal auditor is expected to evaluate internal controls, foster enterprise risk management, and facilitate effective corporate governance (IIA 2004). A more competent internal auditor is more likely to detect management biases when monitoring financial reporting (Prawitt et al. 2009). The role of the internal audit with respect to its direct impact on corporate governance and indirect impact on firm performance has been a focus of the accounting literature for many years (Gramling et al. 2004). Despite the attention internal auditing has received from academia and practitioners, the results of research on the value of internal audit and its association with firm performance are still unclear.

A better understanding of the role of governance and effective risk assessment has promoted the importance of the Chief Audit Executive (CAE), the head of the internal audit department, in recent years (Deloitte 2007). The CAE takes a prominent role in assessing and monitoring a firm’s operational risks through constructing a well aligned internal audit function. Rapid technological progress compounds the complexity of risk management. Internal audit could potentially contribute more to aligning enterprise risk with future growth. Anecdotal evidence shows that CAEs are currently in a better position to increase firm value by helping firms manage strategic risks and delivering business insights (Grant Thornton 2013).

To date, however, the role of the CAE and its impact on firm valuation has not been investigated in corporate governance literature. The research has focused on the impact of Chief Executive Officer (CEO) and/or Chief Financial Officer (CFO) turnover on firm performance. The importance of CAE turnover has been underappreciated in current governance literature despite the rise of internal control issues within governance mechanisms. Given SOX's promotion of risk management and governance mechanisms within firms, internal auditors are in a position to support management through consulting and assurance (IIA 2004). The increased emphasis on internal control and governance mechanism accompanied by the impact of government regulation calls for an empirical exploration of the CAE's role and its impact on firm valuation.

Companies must possess the ability to identify key resources that drive future firm value and adaptability to align their strategic plans to a dynamic and competitive knowledge-driven economy. Managers must make smart, targeted investments in identified key resources that simultaneously drive growth, reduce unnecessary costs and manage business risks at tolerable levels. This dissertation aims to provide a comprehensive view of these issues by investigating the significance and impact of these important value creation firm resources on firm value.

1.2 Outline

This dissertation is divided into three parts. The first part, presented in Chapter 2, investigates the association between IT investment and firm performance by examining the impact of service infrastructure in banking industries. Rapid development of IT has changed the business model of many organizations, in particular the banking industry (McKinsey & Company 2013a). One significant change is the implementation of a multichannel strategy which managers believe helps sustain a firm's competitive advantages. However, the key challenge to optimizing the benefits of the multichannel strategy is designing a service infrastructure to direct customers to the appropriate channels (Myers et al. 2004).

This study collects operational data and surveys bank managers from banks in Taiwan to examine (1) the role of IT in the bank service infrastructure, and (2) in what way IT can help sustain a bank's competitive advantage in a hyper-competitive business environment. Significant complementarities between alternate channels are found to have a positive impact on both short term and long term performance. The findings provide support to the notion that IT investment should be considered along with complementary firm resources to maximize IT's strategic contributions. The findings of this study also provide empirical evidence that complement anecdotal evidence on the observed multichannel strategy being used around the world.

Chapter 3, the second part of the dissertation, looks at the ways human capital, in particular level of employee education, affects firm performance. Human capital is expected to be positively associated with firm value through contributing to innovation capability. As a result, investment in human capital is often emphasized by both academia and practitioners. However, the association between these two assets has not been fully examined in the literature. Level of employee and operational data are collected from IT industries in Taiwan in order to provide a holistic view of the value of employee education and its impact on another crucial capital investment in IT industries, innovation capability measured by investment in R&D.

The results show that firms with better educated workforce have better performance. More importantly, the interdependency between workforce education and R&D investment suggests that education indeed contributes to a firm's innovation capability which, in turn, improves firm performance. Firms pursuing a differentiation strategy with greater emphasis on innovation benefit more by having a more highly educated workforce.

The third part of this dissertation, contained in Chapter 4, explores the value of the CAE by investigating the impact of CAE turnover on firm valuation. Valuation of the internal audit function has drawn much attention over the years due to the increased demand for internal control. Governance literature documents the fact that internal auditors contribute to firm value by performing internal monitoring of the quality of internal control and the assessment of risk management practices. There has, however, been little research on the role of the CAE and its implications on firm performance.

This study looks at the information content of CAE turnover in order to explore the impact that CAE turnover has on firm performance. Turnover data on CEO, CFO, and CAE as well as operating and governance data are collected from Taiwanese public companies. The results show that CAE turnover is positively correlated with executive turnover (CEO and CFO), as well as financial restatements, suggesting that CAE turnover can be used as a signal of legitimacy crisis. The negative impact of CAE turnover on firm performance implies that changing the head of internal audit can be used as an indicator of a serious internal control or operational crisis which could in turn lead to poor firm performance in the future. The passage of the governance law, following the spirit of the SOX, reinforces the interdependences between CAE turnover, CEO/CFO turnover, and restatements. It also moderates the negative impact of CAE on firm performance.

To summarize, this dissertation is structured as follows: in Chapter 2, it examines the first valuation issue regarding IT investment by collecting data from Taiwan's banking industry to explore how firms can benefit from investments in IT. Chapter 3 investigates the second valuation issue relating to human capital investment by focusing on the impact of workforce education on firm performance. Chapter 4 explores the value of governance issues by investigating the information content of the change of the CAE and its impact on firm valuation. Finally, the research findings, conclusions, and implications are provided in Chapter 5.

1.3 Contribution

A firm's competitiveness is derived from its ability to build core competencies that generate innovative products and services and provide a competitive edge (Prahalad and Hamel 1990). In a knowledge economy with rapid technological progress and information intensive production, managers face greater valuation challenges when trying to form effective investment strategies that help create firms' competitive advantages and differentiate firms from their competitors. This study investigates and evaluates three main value creation investments that help firms adapt quickly to changing opportunities in the knowledge based economy.

The hypotheses are based on current literature in accounting and information systems. The study uses collected archival and survey data from Taiwan public companies to examine the hypothesized relationships with respect to each valuation issue. The findings provide important strategic insights into the value of firms' IT, human capital, and internal governance investments. The findings also contribute to the accounting and information systems literature by showing (1) how strategic use of IT helps firms compete successfully in a dynamic, competitive environment; (2) how workforce capital driven by employee education directly and in combination with other investments, such as R&D, affects firm value; and (3) the information content of the internal audit function, in the case of CAE turnover, and its associations with firm value.

Viewed in combination, this work seeks to bridge the gap in the current accounting and information systems literature regarding the valuation of vital firm investments in IT, human capital, and governance. The findings of this work also convey important strategic insights to industry leaders who seek to improve vital firm core capabilities in order to survive in a competitive business environment. The findings of this work also provide regulatory implications for policy makers who seek to not only require companies to provide relevant, high quality information to interested parties but also shed lights on how to develop appropriate policies that help grow the economy.

CHAPTER 2

EVALUATING VALUE OF INFORMATION TECHNOLOGY INVESTMENTS IN BANKING INDUSTRY

2.1 Introduction

Evaluating the performance of information technology (IT) investments that create strategic value has long been a challenge for business (Epstein and Rejc 2005; Frigo 2002; Holland and Skarke 2001; Williams 2004). The problem is further compounded when there are strong complementarities or substitution effects between related investment decisions. The value of IT investments often depends on and influences investments in other related assets. In the past decade, firms and organizations of all kinds have invested heavily in IT-based channels and adopted a mixed channel service infrastructure strategy to better serve their customers. For example, in the banking industry, in addition to the traditional branch service channel, banks deploy different IT to offer multiple service channels (e.g. automated teller machines [ATMs] and Internet banking) to satisfy the needs of their customers, improve user experiences, and further lock in customer loyalty. This multichannel environment can be observed around the world (Lam and Pant 2011; McKinsey & Company 2010, 2011c).

While prior research has examined the adoption and impact of an IT-based channel, most of these studies focus on IT as an independent channel, ignoring the fact that it is part of an infrastructure strategy that may involve multiple channels. There is little empirical research on the value and underlying rationale for constructing a service infrastructure that uses a mix of alternate service channels. This study looks at the banking industry in order to gain a more comprehensive understanding of the strategic value of using a mixed channel service infrastructure strategy. Using the banking industry as a context, this study investigates the impact of such a strategy emphasizing how each channel interacts with other channels to impact bank performance.

Initially the introduction of IT-based self-service channels in banking was motivated by the need to cut costs. IT-based channels allowed banks to significantly lower operating costs by reducing the number of staff needed to perform bank transactions. Internet banking, for example, allows customers to perform many simple banking functions anytime and anywhere. ATMs provide services not possible with Internet banking, such as depositing checks and withdrawing money around the clock. Although banks wish that their customers would move most of their transactions to the lower-cost IT-based channels whenever possible, customers often use multiple channels in a way not necessarily in line with what is most cost effective for the banks. Customers do not view each service channel independently. Instead, depending on what is offered by the bank, they mix their use of the different channels to maximize the value they receive from banking (The Economist 2000). This suggests that a customer's choice of which bank and channels to use is influenced by a bank's overall service infrastructure strategy.

Consultants state that a service company's best strategy is to enable customers to interact with it via multiple channels instead of only through physical channels (Hughes and Kaplan 2009; McKinsey & Company 2010). Several previous studies show that the availability of new service channels or different service infrastructures changes consumers' banking behaviors. Xue et al. (2011), for example, found that consumers' adoption of Internet banking motivates them to open more accounts and increase their overall demand for banking services across different channels. These findings are in line with the anecdotal evidence which suggests that the traditional branch channel still plays an important role in delivering banking services and is, in fact, growing along with IT-based channels (Block 2011). These findings also suggest that there exists some strategic synergy among different channels that banks can explore further to obtain a competitive advantage.

The goal of this study is therefore to gain a deeper understanding of how the use of a multichannel strategy impacts bank performance, in particular the strategic value of adopting IT-based channels. This study considers two dimensions of bank performance: bank productivity as an indicator of short term performance and market share competition capability as an important indicator of long term value. A framework is proposed for studying how each channel interacts with the others to affect bank performance, taking into account competitors' investment strategies. This study argues that it is important to consider all major channels together to understand both the individual and joint impact of these channels since the channels might be used in ways that either substitute for or complement each other's functions. Therefore, evaluating a single channel without considering the role of other channels can lead to erroneous conclusions. This research provides strategic insights on the design of an optimal service infrastructure strategy which utilizes unique characteristics of alternate service channels.

This study contributes to the information systems strategy literature by providing a holistic view of the mixed channel strategy involving IT and developing a framework and method to evaluate a mixed-channel strategy. Much research in the banking industry has focused on examining the determinants of IT adoption from the customer perspective (e.g., Curran and Meuter 2005; Lee 2002; Meuter et al. 2005). Some research has explored IT value in the banking industry using case study or survey methods (e.g., Banker and Kauffman 1988; Dos Santos and Peffers 1995; Litchtenstein and Williamson 2006; Tan and Teo 2000). Although prior studies provide empirical evidence on the impact of individual IT-based channels on bank performance, the question of how different service channels interact and affect bank performance jointly has not been examined.

The results of this study provide empirical evidence about the direct impact of alternate service channels on short and long term bank performance. Most importantly, the results show significant complementarities across alternate service channels in driving both bank productivity and market share competition. Instead of diminishing the importance of alternate service channels by substituting for them, the results show that the use of IT actually increases both the demand for alternate service channels and their value. This finding provides empirical support to the argument that IT can serve as a magnifier or accelerator of desired business capabilities even when those capabilities do not directly involve IT (Kohli and Grover 2008). Moreover, while Internet banking, when evaluated on its own, shows a negative impact on short term performance, it has a positive impact on long term market share capability, and most importantly, it increases the positive impact of other channels on both short term and long term performance. This again reinforces the notion that, instead of using internet banking as a substitute for physical channels, internet banking can be used as to retain and attract market share, enhance demand for banking services, and free up activity resources (e.g., bank tellers), which can then be deployed to provide premium services and serve more profitable customers. Overall, the results of this study suggest that those banks that recognize the strategic interaction of different channels, instead of treating and managing each channel independently, and understand how to optimize the use of the multichannel strategy to serve different customer needs and differentiate their services accordingly would benefit the most from IT.

The remainder of this chapter is organized as follows. Section 2.2 describes the current service infrastructure strategy in the banking industry, reviews the relevant literature and develops the hypotheses. Section 2.3 contains a discussion of the research model, estimation methods, and sample data. Section 2.4 presents the empirical tests and results and further explores the relationships among alternative service channels to check the robustness of the results. The conclusion is presented in Section 2.5 with a summary of the findings and a discussion of managerial implications based on the findings.

2.2 Literature Review and Hypotheses Development

2.2.1 Service Infrastructure Investment in the Banking Industry

Banks have long relied on physical branches to serve customers' banking needs. With the arrival of IT-based channels, such as ATMs and Internet banking, banks now rely on different channels to serve their customers. The speed of change in technology allows many simple services traditionally performed by branch tellers to be processed electronically and inexpensively through these IT-based self-service channels. One may expect that with the popularity of ATMs and Internet banking resulting in fewer transactions conducted at the counter, banks can cut or reduce investments in traditional branch channels. On the contrary, bank executives today still value the traditional branch channel because its products and services cannot be completely replaced with IT-based channels. In fact, the investment in branch channel has continued to grow steadily (Hirtle 2007). Banks invest in technology to free staff from processing routine and lower value-added activities allowing them to concentrate more on selling lucrative services to customers. Thus, it may be incorrect to assume that an innovative service channel will compromise the importance of and investment in other, established, alternate channels. For example, it would be incorrect to assume that Internet banking substitutes for other channels or that a bank can make investments in different service channels independently. Since IT plays a pervasive role in banking business operations, it not only transforms operation processes but also substantially changes customer behavior. Anecdotal evidence indicates that bank executives adopt a cross-channel strategy because of the synergy generated (McKinsey & Company 2010; 2011c). The value-generating and transformative roles of IT are widely appreciated, however, it has been difficult to quantity the value firms gained from these roles as traditional accounting and evaluation methods still rely on evaluating each channel individually.

The main challenge for banks as well as researchers is how to evaluate a mixed channel strategy, in particular, how investment in one channel might affect the marginal benefits of another channel on short term and long term value. This requires a comprehensive understanding of how each channel individually and jointly impacts bank performance while taking into account competitors' channel strategies. Appropriate evaluation of a mixed channel strategy is critical to answer the strategic question of how to choose the right mix of service channels to maximize their short term and long term value. To fully understand the impact of a service infrastructure strategy, the effects of strategies implemented by competing banks must also be considered. This study evaluates two dimensions of bank performance. First, it considers the bank's level of productivity, in other words the bank's ability to transform inputs into outputs relative to its competitors. Given a fixed level of inputs, such as the number of employees and fixed assets, banks seek to generate the highest level of outputs (such as deposits and loans in the context of bank operations). Second, it considers the market competition capability of a bank. Market share is critical for banks for two main reasons: (1) a larger market share allows banks to amortize the predominantly high fixed costs in the industry over a larger base, and (2) because market share is associated with a bank's long term value and competitive advantage that generate additional revenue and future profits. To summarize, this study investigates how a channel mix strategy allows a bank to retain and attract customers after incorporating the impact of channel mix strategies pursued by other banks.

In the following sub-sections, this study discusses how each service channel contributes to firm performance in the presence of other service channels and then considers additional interaction effects on firm performance.

2.2.2 Impact of Traditional Branch Channel on Bank Performance

Branch banking is the traditional service channel in the banking industry. Customers' enjoyment of face-to-face interaction and their concerns about online security make it difficult to replace branches with IT-based channels (Cox and Currie 2009). The branch channel is positioned to offer premium services and attract customers who are more profitable and who can be charged premium prices. Branches continue to thrive, despite heavy costs associated with their maintenance, because bank managers believe that more lucrative business, such as personalized financial consulting, which command premium price are better delivered through branches (The Economist 2012). Therefore, the more branches a bank has, the more capable it is of delivering premium services and therefore the higher the potential to increase revenues for the bank. When revenue generated from serving profitable customers outweighs the costs of maintaining branches, bank productivity increases. Continued growth of the branch network seems to be consistent with the belief that branch banking will continue to be an effective channel for generating revenues despite the increased use of alternate IT-based channels (Hirtle 2007).

Higher branch intensity also increases service coverage and convenience for customers and would, therefore, contribute to increased bank market share and customer loyalty as location convenience is one of the most important determinants for convenience-seeking consumers (Bricker et al. 2012; The Economist 2012).This study examines the belief that higher branch intensity leads to higher adoption and use of bank services. The hypotheses on the relationship between the level of branch intensity and bank performance are as follows:

H2.1a: The level of branch investment is positively associated with productivity

H2.1b: The level of branch investment is positively associated with market share

2.2.3 Impact of IT-Based Service Channels on Firm Performance

Prior research indicates that IT spending accounts for approximately 6% of annual revenue for the financial industry (American Banker 2011; Kauffman and Weber 2002).

The banking industry is particularly well known for its aggressive and extensive use of IT (Gopalakrishnan et al. 2003; The Economist 2003)[3]. IT-based services enable banks to react quickly, providing customers with timely, off-site support and convenient service delivery without time or location constraints.[4] Advances in IT also allow banks to offer more diversified functionalities through different channels to satisfy customers' growing demands for various ways of using banking services and to compete for market share. For example, banks keep expanding ATM functionalities to provide more diversified services through this channel. Banks utilize IT-based channels not only to improve customers' banking experiences, but also to collect data for analyzing and predicting consumer behavior which indirectly helps sustain a competitive advantage. That is, IT increases a bank's ability to differentiate its customers and determine which customers might utilize more profitable services. Therefore, the use of IT-based channels is expected to increase bank performance by providing lucrative services to right customer segments. Investment in IT also has the potential to increase productivity by reducing operating costs: the cost for a banking transaction conducted at an ATM is 25% of the cost for the same transaction conducted over a counter in a traditional branch. This transaction costs a mere 1% of an over-the-counter transaction if conducted over the internet (The Economist 2009).

However, the research has shown contradictory results for evaluating the value derived from IT investment. The lack of significant impact of IT investments on firm performance has been attributed to inadequacies of performance measurement, IT

[3] A research of worldwide enterprise IT spending shows that banking is one of IT-intensive industries with IT spending as a percentage of revenue approximately three times as much as on the average of all industries (Gartner 2012a).
[4] As stated in Wells Fargo's strategy, IT-based channels enable their customers to control when, where, and how they want to interact with banks (Wells Fargo 2011).

learning effect, or lagged complementary business processes reengineering (Im et al. 2001; Mittal and Nault 2009; Tambe and Hitt 2012). In addition to these factors that previous research used to explain the lack of significant impact of IT investments, this study attempts to address the problem by providing an evaluation framework that takes into account not only each investment decision but the interdependency of various investment decisions and provide a holistic view of a firm's overall investment strategies on performance.

This study begins by looking at investments in ATMs, an important IT-based self-service channel employed that has been used for the past decades in the banking industry. In addition to improving cost efficiency by performing frequent, routine tasks that are traditionally processed though tellers, ATMs can also generate revenues through transaction fees. One of the main advantages of ATMs is that they expand physical services and provide less expensive access to multifunctional products and services (Saloner and Shepard 1995). ATM networks also serve the needs of bank customers over a wider geographical area (Kauffman and Kumar 2008). The benefits of an ATM network to its customers increase in the number of locations it serves (Saloner and Shepard 1995; Kauffman et al. 2000). Banks adopt ATMs in order to attract customers from competing banks (Hannan and McDowell 1990). ATMs not only contribute to cost savings but also extend a bank's brand beyond is the service coverage area possible with the more expensive bank branch system. This study, therefore, hypothesizes that ATM investment is positively associated with both bank productivity and market share:

H2.2a: The level of ATM investment is positively associated with productivity

H2.2b: The level of ATM investment is positively associated with market share

Internet banking was introduced to the banking industry almost three decades ago. Several studies have examined the determinants of Internet banking adoption from the customer's perspective (Gopalakrishnan et al. 2003; Litchtenstein and Williamson 2006; Suh and Han 2002; Tan and Teo 2000). From a cost perspective, Internet banking provides greater economies of scale to process transactions than branches or ATMs since Internet banking is mostly a fixed-cost technology. Internet banking does not require expensive physical staff as it is mainly customer oriented self-service technology. Therefore, the marginal transaction cost is much lower than that of a branch (Cheng et al. 2006; Yakhlef 2001). Consistent with the objective of improving cost efficiency, Internet banking is considered by some to be a substitute for physical channels such as traditional brick-and-mortar branches and ATMs (Hernando and Nieto 2007).

Although transaction costs incurred through Internet banking are much lower than through alternate channels, the literature shows conflicting opinions about the impact of Internet banking on bank profitability (Hernando and Nieto 2007). Transactions currently processed through Internet banking are low value-added services for which banks cannot command premium prices. Therefore, Internet banking does not lead to higher revenue and is mostly a cost-driven investment. Unlike value-added advisory services where the branch staff interacts with customers, Internet banking is found to have little influence on customer buying decisions, reducing the chance of selling new products to customers (Calisir and Gumussory 2008; Yakhlef 2001). Xue et al. (2011) also found that Internet banking is negatively associated with a short-term drop in customer profitability. These findings suggest that Internet banking, by itself, does not contribute to bank productivity since it does not directly generate or enhance bank revenue.

Regarding its impact on market share competition, Internet banking is becoming more popular because it provides a more convenient way to deliver banking services and imposes few access, location or time constraints on customers (Calisir and Gumussory 2008). The convenience feature of internet banking is found to be a powerful tool for banks to retain customers because the costs of switching banks are relatively high (Schwartz 2011). The service characteristics of internet banking also help attract and retain tech-savvy customer groups who are generally younger and value convenience and timely services (Xue et al. 2011). However, young customers who are attracted by Internet banking, on average, have lower account balances and are less likely to consume higher-premium services offered by the bank. They may have higher transaction volume but are, on average, less profitable to banks in the short run. This is consistent with the previous argument that Internet banking by itself is not a profitable investment for banks.

This study argues that competitive pressure is one of the main driving forces behind a bank's investment in Internet banking, ranking ahead of cost reduction and revenue enhancement. Banks promote the use of the Internet banking channel in order to increase customer loyalty (Xue et al. 2011) and prevent customer switching by offering more flexible and readily available of channel choices. Considering the characteristics of customers attracted by Internet banking and transactions processed through this channel, it is expected that Internet banking is negatively associated with productivity but positively associated with market share. The hypothesized relationship between Internet banking and firm performance are as follows:

H2.3a: Internet banking investment is negatively associated with productivity

H2.3b: Internet banking investment is positively associated with market share

2.2.4 Complementarities between Alternate Service Channels

While bank revenues are largely enabled by branches, the establishment of a branch significantly increases bank operating costs through facility and equipment costs, personnel expenditures, and other support expenses. In addition, coordination costs tend to be higher for banks with more branch offices (Lin et al. 2005). Branches, as a result, are commonly viewed as banks' most resource draining channel. As IT-based channels become more robust and widespread, banks are beginning to view them as an opportunity to lock in their customers by creating deeper relationships through more frequent, less expensive interactions. From the perspective of cost consideration, the cost for a banking transaction conducted at an ATM is 25% of the cost for the same transaction conducted over a counter in a traditional branch. This transaction costs a mere 1% of an over-the-counter transaction if conducted over the internet (The Economist 2009).

By moving routine activities to an IT-based platform, it relieves the pressure on branches, allowing branch channels to focus on delivering high value-added services to customers by improving their branch banking experience and selling new products (Calisir and Gumussory 2008). Without migrating less complex, low value transactions to IT-based channels, incremental costs associated with processing less profitable transactions are more than marginal profits generated from this type of business. For example, low profitable, less sophistic transactions such as cash withdraw and check deposit processed through branch channel cost bank labor, equipment and facility usages but generate low or even zero revenue. Therefore, higher reliance on branches without optimizing channel strategy and relocating resources will potentially lower productivity.

In addition, the adoption of IT-based channels along with strong branch channels enables banks to expand their market share in a more productive way and protect their market share against competitors that offer the same IT channel options (Hannan and McDowell 1990; Kauffman and Kumar 2008). Strong IT-based channels with weak branch channels make it less likely that consumers will engage in premium services, while strong branch channels with weak IT-based channels suggests that branches would have to conduct more low-value transactions such as deposits or cash withdrawn, which are really not cost-efficient. IT-based self-service channels, in particular Internet banking, reduce transaction costs (e.g., traveling to branches and waiting in line during office hours) and increase resource slack, allowing customers to engage in high value-added banking services, which in turn, increases customers' need of branch services. As a result, the need for traditional branch services and the marginal return on investment for branches may be increased by focusing on high value-added services.

Previous IT investment studies examined the value impact of one type of IT-based channel on bank performance (e.g. Banker and Kauffman 1988; DeYoung et al. 2007; Hannan and McDowell 1990; Hernando and Nieto 2007). These studies found that IT-based channels in general have a positive association with market share competition. The benefits are larger for early movers, but diminish over time as competitors mimic the strategy. Considering the effect of one channel on bank performance, however, constrains the examination of IT value and its strategic use. By extending service coverage, a higher level of ATM investment increases customer need for branch resources because certain bank transactions and services can only be provided through the branch channel. Internet banking has also been found to be associated with increased use of branch services, suggesting a positive correlation between investments in branches and Internet banking (DeYoung et al. 2007; Xue et al. 2011). It is hypothesized that the lower costs and higher convenience of IT-based channels increases customer demand for branch channel services. This suggests that even though Internet banking by itself does not necessarily generate revenues, it increases the branch channel's revenue generating capabilities. Leading banks adopting multichannel strategy are observed to capture the benefits of cross-selling from existing customers (McKinsey & Company 2010). This study tests the idea that the synergy created by combining multiple channels to serve targeted customers contributes to higher profitability, greater competitive advantage, and more importantly, building up brand loyalty to mitigate threats from followers to imitate similar strategy. As a result, this study hypothesizes that there exists interdependency between each pair of alternate service channels and that these interdependencies are positively associated with bank performance. The findings have important strategic implications as to how banks should evaluate and manage a mixed-channel strategy. In particular, strong interdependency of channels would suggest that banks have to take a holistic view and have an evaluation framework that takes into account all channels at the same time to understand the benefits *each* channel generates.

H2.4a: There exists significant complementarity effect between Internet banking and branch investments on productivity

H2.4b: There exists significant complementarity effect between Internet banking and ATM investments on productivity

H2.4c: There exists significant complementarity effect between ATM and branch investments on productivity

H2.5a: There exists significant complementarity effect between Internet banking and branch investments on market share

H2.5b: There exists significant complementarity effect between Internet banking and ATM investments on market share

H2.5c: There exists significant complementarity effect between ATM and branch investments on market share

2.3 Research Design and Data

2.3.1 Empirical Model

The empirical model used is shown in Figure 1. Given each alternate service channel has unique functionalities that match with different customers' needs, the study examines the direct impact of alternate service channels on bank performance. More importantly, it is expected that use of alternate service channels create additional complementary effects on bank performance. These indirect impacts of alternative service channels should be considered in evaluating channel strategy as well. Effective and efficient employment of service infrastructure contributes to increased operating productivity and increased market share. To test this, the effect of service infrastructure strategy on both bank productivity and market share, indicating a bank's competitive capability, is addressed and examined in this study.

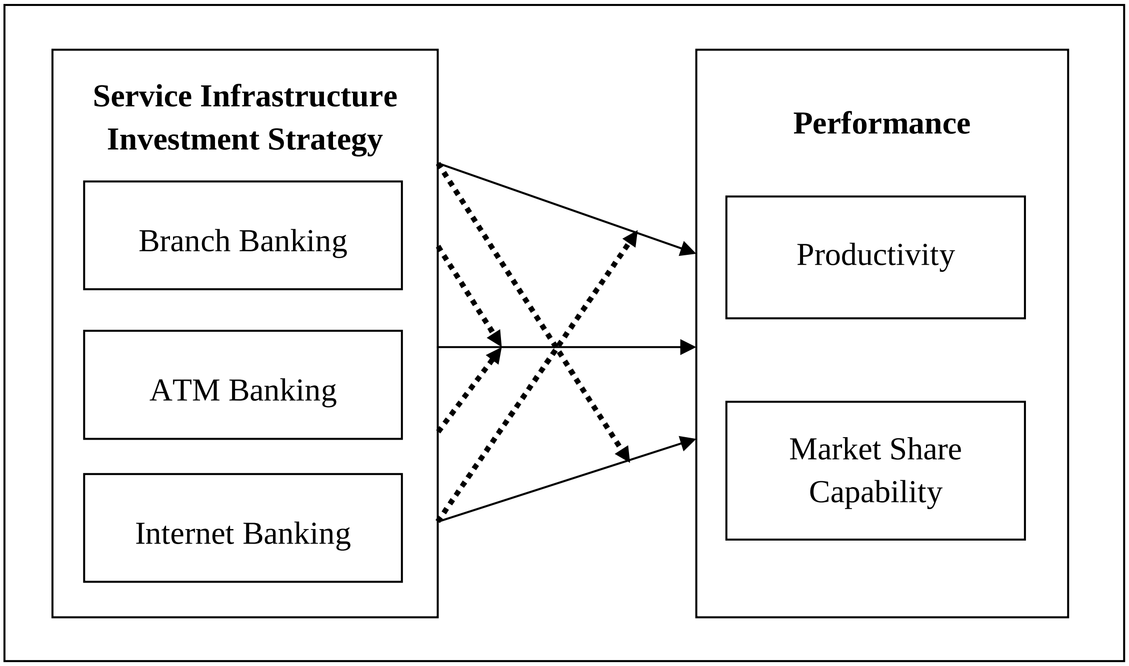

Figure 1. Impact of Service Infrastructure Investments Strategy on Performance

2.3.2 Estimation Methods

A review of prior research indicates that there are a number of methods available to measure bank productivity (e.g., Berger and Humphrey 1992, 1997; Berger and Mester 1997). Traditional parametric functions (e.g., Cobb-Douglas production function) that evaluate firm productivity are restrictive in specifying the structure of production functions. Data Envelopment Analysis (DEA), on the other hand, does not impose an explicit specification of the form of the underlying production relationship (Berger and Humphrey 1997). As a non-parametric linear programming method, DEA requires no specific input or output prices to identify a best practice production frontier (Sturm and Williams 2004). The stochastic DEA model incorporates not only a one-sided inefficiency deviation but also a two-sided random noise deviation which may be caused by measurement errors (Banker and Natarajan 2008). The output-oriented DEA model developed by Banker, Charnes and Cooper (BCC) (1984) is employed to estimate the productivity scores of the different firm-year observations.

Banker and Natarajan (2008) provide theoretical and simulation-based justification for the two-stage DEA method, using DEA in the first stage and OLS regression in the second stage, to evaluate the impact of contextual variables on efficiency. Two-stage DEA-based procedure performed significantly better than parametric methods that rely on commonly used parametric functional forms such as Cobb-Douglas and translog to specify the production correspondence. The two-stage DEA method is used to examine how the use of service infrastructure strategy individually and jointly affects bank productivity. After calculating productivity scores for all sample banks, the logarithm of productivity scores are regressed on the variables of interest and other control variables as expressed in equation 1.

$$\begin{aligned} PRODUCTIVITY_{it} = {} & \beta_0 + \beta_1\, NBRANCH_{it} + \beta_2\, ATMINT_{it} + \beta_3\, ATMUSE_{it} + \beta_4\, EBANK_{it} \\ & + \beta_5\, EBANK_{it}{*}NBRANCH_{it} + \beta_6\, EBANK_{it}{*}ATMINT_{it} \\ & + \beta_7\, EBANK_{it}{*}ATMUSE_{it} + \beta_8\, ATMINT_{it}{*}NBRANCH_{it} \\ & + \beta_9\, ATMUSE_{it}{*}NBRANCH_{it} + \beta_{10}\, INVASSET_{it} \\ & + \beta_{11}\, ACCOUNTSIZE_{it} + \beta_{12}\, DEPOSITDIV_{it} + \beta_{13}\, LOANDIV_{it} + \varepsilon_{it.} \end{aligned} \quad (1)$$

In addition to examining the impact of service infrastructure strategy on bank productivity, the study examines how banks use multiple service channels to compete for market share. The Multiplicative Competitive Interaction (MCI) models approach is utilized to capture the impact of competitive choices (Hanssens et al. 2001). The MCI model is used in many marketing studies to examine a firm's market attraction ability (Banker and Kauffman 1988; Gauri et al. 2009; Karnani 1985; Nakanishi and Cooper 1974, 1982). This approach represents the relative strengths of competitor marketing mix choices in fighting for market share. It also allows for possible cross-competitive effects between reputation (e.g., bank brands) and marketing instruments (e.g., service channels of banks) (Cooper et al. 1996). The market share regression analysis is expressed as follows:

$$\begin{aligned} MKT\_SH_{it} = {} & \beta_0 + \beta_1\, NBRANCH_{it} + \beta_2\, ATMINT_{it} + \beta_3\, ATMUSE_{it} + \beta_4\, EBANK_{it} \\ & + \beta_5\, EBANK_{it}*NBRANCH_{it} + \beta_6\, EBANK_{it}*ATMINT_{it} \\ & + \beta_7\, EBANK_{it}*ATMUSE_{it} + \beta_8\, ATMINT_{it}*NBRANCH_{it} \\ & + \beta_9\, ATMUSE_{it}*NBRANCH_{it} + \beta_{10}\, INVASSET_{it} + \beta_{11}\, ACCOUNTSIZE_{it} \\ & + \beta_{12}\, DEPOSITDIV_{it} + \beta_{13}\, LOANDIV_{it} + \varepsilon_{it} \end{aligned} \tag{2}$$

2.3.3 Measurement of Variables

To examine the impact of service infrastructure strategy on bank productivity, firm performance is measured in terms of bank productivity score by using the value-added approach (Berger and Humphrey 1992). This approach identifies both assets and liabilities as outputs that contribute to bank value added, and recognizes costs associated with the consumption of firm resources to support bank operating activities as inputs (Berger and Humphrey 1992; Park and Weber 2006a, 2006b). Four outputs (total deposits, total loans, total investments, and other operating revenue) and two inputs (number of employees and net value of property, plant, and equipment) are employed to calculate a bank's productivity score, PRODUCTIVITY. Banks with higher productivity scores are better at transforming inputs into outputs. The MCI model is employed to measure long-term market share competition, a bank's ability to use alternate service channels to compete for market share. Three measures of market share are analyzed in this study: deposit market share (DEPOSIT_MKT_SH), loan market share (LOAN_MKT_SH), and number of customers (CUSTOMER_MKT_SH).

In this study, the principal explanatory variables for measuring bank service infrastructure strategy are the three service channels commonly utilized in the banking industry. NBRANCH, measured as the number of branches relative to total assets, reflects branch service intensity. Two variables are used to capture the level of ATM investment: ATMINT measures ATM intensity as the number of ATMs per branch, and ATMUSE measures the level of ATM utilization as the number of ATM transactions per ATM. ATMINT evaluates the extent of ATM investment from the bank's point of view, while ATMUSE captures the extent of ATM utilization incorporating bank customer channel use behaviors. EBANK is the number of years after that a bank has adopted Internet banking[5]. Banks that have used Internet banking for longer time are more likely to use it proactively to satisfy customer preference for convenient services and realize opportunities for cost reduction. Internet banking also allows a bank to collect more data on customer consumption behavior that improves a bank's ability over time to make segregate different market segments and explore potential products.

Following the previous literature, two sets of control variables that are commonly employed while examining performance in the banking industry are considered in this study. First, two measures of economies of scale are employed: bank size measured as the

[5] I conduct a survey to the heads of IT department of banks regarding adoption of internet banking. The results confirm that all banks in the sample used all of the same features and functionalities of Internet banking. The only difference was the extent of experience in using this channel.

reciprocal of total assets (INVASSET) and customer size measured as total deposits divided by the number of customers (ACCOUNTSIZE). Second, economies of scope are taken into account, employing the commonly used Herfindahl index to calculate two measures that indicate a bank's product line diversity: deposit diversity (DEPOSITDIV) and loan diversity (LOANDIV). Table 1 summarizes the definitions of variables and Table 2 provides descriptive statistics on all the variables employed in the study.

Table 1. Variable Definitions for Chapter 2

Dependent Variable	
PRODUCTIVITY	= The logarithm of productivity measure for bank i in year t by using Data Envelopment Analysis method [2 inputs (number of employees, net value of property, plant, and equipments), 4 outputs (total deposits, total loans, total investments, other operating revenue)]
DEPOSIT_MKT_SH	= Total deposits of bank i at year t/Total deposits for all banks at year t
LOAN_MKT_SH	= Total loans of bank i at year t/Total loans for all banks at year t
CUSTOMER_MKT_SH	= Total customer accounts of bank i at year t/Total customer accounts for all banks at year t
Principal Explanatory Variables	
NBRANCH	= (Number of branches/Total assets)*1,000
ATMINT	= (Number of ATMs/Number of branches)/1,000
ATMUSE	= (Number of ATM transactions/Number of ATMs)/1,000,000
EBANK	= Years after Internet banking adoption
Control Variables	
INVASSET	= (1/Total assets)*1,000
ACCOUNTSIZE	= Number of customer accounts/Total assets

DEPOSITDIV	= {1/[(Checking account deposits/Total deposits)^2+(Savings account deposits/Total deposits)^2+(CD/Total deposits)^2]}/1000
LOANDIV	= {1/[(Short term secured loans/Total loans)^2+(Short term unsecured loans/Total loans)^2+(Medium term secured loans/Total loans)^2+(Medium term unsecured loans/Total loans)^2+(Long term secured loans/Total loans)^2+(Long term unsecured loans/Total loans)^2]}/1,000

Table 2. Descriptive Statistics of Variables for Chapter 2

VARIABLES	Mean	Standard Deviation	Minimal	Maximum
PRODUCTIVITY	0.7253	0.2202	0.0934	1.0000
DEPOSIT_MKT_SH	0.0177	0.0245	0.0001	0.1155
LOAN_MKT_SH	0.0176	0.0247	0.0000	0.1065
CUSTOMER_MKT_SH	0.0177	0.0217	0.0000	0.1043
NBRANCH	0.0001	0.0001	0.0001	0.0010
ATMINT	0.0041	0.0041	0.0000	0.0333
ATMUSE	0.0034	0.0017	0.0001	0.0168
EBANK	3.3184	3.4057	0.0000	13.0000
INVASSET	0.0004	0.0004	0.0001	0.0023
ACCOUNTSIZE	0.0021	0.0014	0.0000	0.0173
DEPOSITDIV	0.0021	0.0003	0.0011	0.0029
LOANDIV	0.0041	0.0007	0.0018	0.0057

Note: See Table 1 for variable definitions.

2.3.4 Sample Data

The data collected for this study is from the banking industry in Taiwan during the period from 1995 to 2007.[6] This is an ideal context for two reasons: (1) Taiwan's banks all compete nationwide against one another without apparent market segmentation, and (2) there is little or no differentiation among banks in the services they provide. This allows for a cleaner measure of the impact of service infrastructure strategy without confounding effects from market segmentation or product differentiation. Due to high level of competition, Taiwanese banks have been actively investing in IT in order to be competitive in the market. Examining the dynamic, highly competitive banking industry in Taiwan provides insights into how banks can employ the service infrastructure strategy to compete successfully.

The data source for this study is collected from the Taiwan Economic Journal database which includes financial statements data and ATM investment data. In addition, Internet banking data is obtained by surveying the heads of IT departments of all banks in the data set. Banks undergoing merger and acquisition activities during the studied years are consolidated and considered as a single bank. For instance, if Bank A merged with or acquired Bank B in 1998, the corresponding data values for these two banks in years 1995-1998 are aggregated and considered as a single entity for the entire sample period. The observations for all variables employed in the study are matched and those with

[6] Between 1991 and 2002, the number of banks in Taiwan grew from 25 to 53 due to deregulation. This rapid increase in numbers has led to increased competition. Hyper-competition drives banks that are unable to sustain a competitive position out of the market. It also drives the increase of merger and acquisition activities significantly. This resulted in a decrease in the number of banks from 53 in 2002 to 38 in 2012.

missing values are deleted.[7] After eliminating the missing values in the data set, 260 firm-year observations are obtained.

In the sample, banks spend between $3.00 and $4.06 annually in operating costs to manage $1,000 in assets, and between $4.40 and $13.92 to acquire $1,000 in funds. Banks also generate between $16.30 and $100.66 of revenues from $1,000 of assets.[8] Figure 2 documents the change of the service infrastructure strategy during the sample period. The figure shows the adoption trend of alternate service channels over time. Despite increased use of IT-based channels, the traditional branch channel still maintains its importance in a bank's service infrastructure and grows steadily over time. This is consistent with what has been observed in other areas, such as the United States (FDIC 2013). The ratio of employees to ATMs decreased from 15.56% in 1995 to 5.88% in 2007. This suggests that the ATM-based channel has become a more mature channel utilized by banks, in part to reduce labor costs.

[7] My initial sample banks collected from Taiwan Economic Journal database was 35 domestic commercial banks. After I aggregated bank data due to merger and acquisition activities, I got a total of 24 banks in the sample. I surveyed the heads of IT departments of sample banks in 2008 regarding the year they start providing their Internet banking, and functionalities available for customer use. In 2008, 4 banks were acquired by foreign banks, which I excluded from my sample. As a result, my sample banks reduced from 24 to 20.

[8] U.S. banks generate on average between $5 and $13 from $1,000 of assets in my sample period (in US dollars; US$: NT$=1:30).

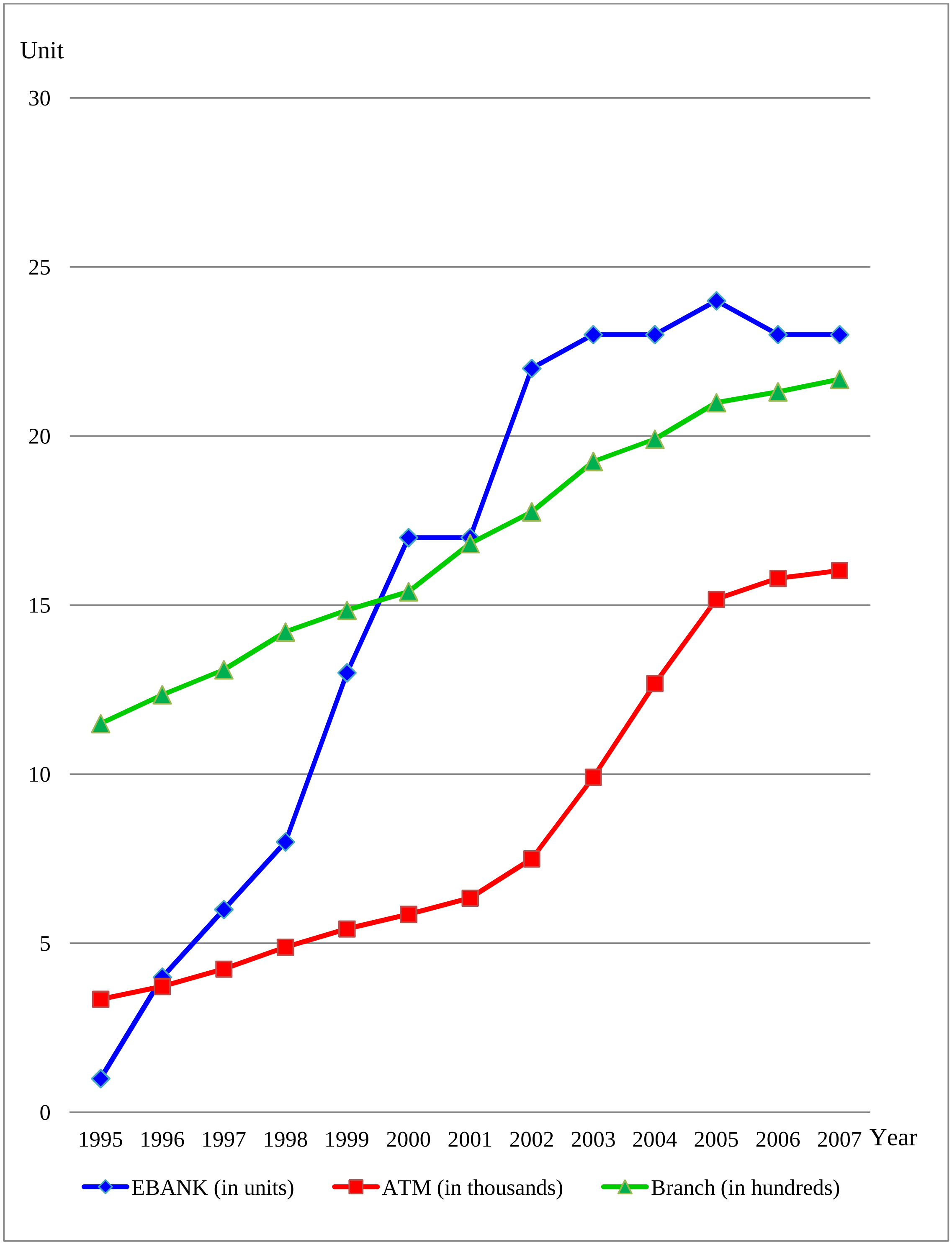

Figure 2. Service Infrastructure Strategy in Taiwanese Banking Industry

2.4 Empirical Results and Discussions

Following Banker and Natarajin (2008), a two-stage DEA procedure is employed to examine the impact of service infrastructure on bank productivity[9]. The first stage of the analysis calculates estimates of the productivity score by utilizing a value-added approach.[10] The logarithm of productivity score (PRODUCTIVITY) on the contextual variables (NBRANCH, ATMINT, ATMUSE, EBANK) is regressed in the second stage of the analysis. Because pooled, cross-sectional, and time-series data is used to estimate the impact of contextual variables on bank productivity, potential serial correlation among sample data may result in biased standard errors of the estimates. This study addresses this problem by using a variant of the Prais and Winsten (1954) estimator proposed by Park and Mitchell (1980) to make first-order autocorrelation adjustments to the variables. The generated estimator is consistent and performs especially well for time series and trended data in relation to several other estimates (Doran and Griffiths 1983). It also reduces the extent to which the serial correlation coefficient tends to be underestimated by simpler methods (Kmenta and Gilbert 1970). The top and bottom 1% of the continuous variables are winsorized to mitigate the influence of outliers. Collinearity is also checked by calculating the Variance Inflation Factors (VIF). The

[9] Correlation between the inputs and the contextual variables is relatively low (on average 30%) in the sample, satisfying the key condition specified by Banker and Natarajan (2008) for the validity of the two stage approach.

[10] As a further robustness check, the study tests the robustness of the results in Table 3 by using the income-based approach (Leightner and Lovell 1998). The income-based approach specifies net interest income and non-interest income as the two outputs of banks' business units to reflect the final objective of generating revenue from the total cost incurred for banks to run the business (Leightner and Lovell 1998). Accordingly, the study measures two banking outputs (interest revenue and other operating revenue) and five inputs (interest expense, facility costs, support costs, labor costs, and other operating costs) to calculate the alternate bank productivity score. The untabulated results are qualitatively similar to the ones using the value-added approach.

results show that all VIF values are less than 5. Overall, there is no issue of collinearity in the study.

The individual and joint effects of service channels on productivity are examined to determine how service infrastructure strategies affect bank productivity, shown in Table 3. NBRANCH is significantly positive for productivity, providing support for hypothesis H2.1a. That is, higher level of investment in branches is associated with higher bank productivity. Also, both ATMINT and ATMUSE have a significant and positive impact on productivity, suggesting that a higher level of ATM investment and more mature utilization of ATM channels contribute to higher productivity which supports hypothesis H2.2a.

EBANK, on the other hand, is negatively related to productivity which provides support for hypothesis H2.3a.[11] This finding suggests that Internet banking, by itself, does not directly contribute to bank productivity. This is consistent with the expectation that, while Internet banking may reduce operating costs for processing simple transactions, banks do not command premium prices for such transactions. In fact, banks increase their inputs, such as employees, plants, equipments, etc., as a result of Internet banking investments. On the other hand, Internet banking investment is found to be associated with a bank's market share capability. Internet banking is used to attract customers who appreciate its unique characteristics such as convenience, real-time processing, and self-management of account activities. By offering such convenience, banks seek to expand

[11] As a sensitivity test, the study re-estimates the models by employing an Internet banking adoption dummy variable, EBANKYD, to examine the impact of the availability of an Internet banking channel on bank performance. Consistent with the findings shown in Tables 3 and 4, the results are qualitatively the same.

market share by attracting new customers to start banking with them and lock in customers at an early stage to cultivate brand loyalty.

One thing that must to be remembered in this kind of strategy is that not all new customers attracted by the Internet banking channel are profitable. The majority of internet banking users tends to be relatively young and tech-savvy (e.g., students or young professionals). Banking activities held by this type of customers on average are routine, with large transaction volume, but relatively small amounts per transaction. This also provides some justification as to why Internet banking is not associated with increased bank productivity. However, even though these customers generate little revenue in the beginning of the establishing bank relationship, bank expects some of these customers will become profitable in the future. It has also been found that adopters of Internet banking tend to be more loyal to the bank (Xue et al. 2011). Banks can use IT-based channels such as Internet banking to distinguish between profitable and unprofitable customers and to help select "right" customers that potentially will become profitable in the future. Internet banking, for example, provides bank more opportunity to collect real time, large scale customer behavior data to determine which customers should be targeted for premium services and personal relationships. Such market share benefits from Internet banking may offset the negative direct impact of Internet banking on productivity.

The complementarities of the effects of alternate service channels on productivity are further examined to gain a comprehensively understanding with respect to the relationship between service infrastructure strategy and bank performance, as shown in the last column of Table 3. Overall, significant and positive complementarities are found across all channels. The interactions between the branch channel and the two IT-based channels are all positive and significant, supporting hypotheses H2.4a and H2.4c. These complementarities are, primarily, from two sources. First, since IT-based self-service channels allow customers to perform certain bank transactions more efficiently without time or location constraint, customers go to branches only when their requirements cannot be met effectively with the self-service channels, thus optimizing channel usage. For example, customers use Internet banking to pay bills, use ATMs to withdraw cash, and go to branches to buy foreign currencies or seek investment advice. Moreover, the ease and accessibility of using IT-based self-service channels also create new demand for new banking services that often require usage of other physical channels (Xue et al. 2011). Second, migration of simple transactions to IT-based channels suggests that branches now have more resource slack that can be used to provide higher value-added services and generate higher revenue, especially those serving profitable customers. Overall, the findings support the notion that IT-based channels are complements to the traditional channels.

The results also indicate that there exists a strong and positive interdependency between the two IT-based channels, supporting hypothesis H2.4b that ATMs and Internet banking complement each other. This again provides rationale for a multichannel strategy. Even customers who use Internet banking a lot do not use just one channel because each channel still keeps its unique functionalities that cannot be replaced by other channels. If a customer has established a relationship with a specific bank, the likelihood that the customer will use multiple channels of the bank increases.

Table 3. Impact of Service Infrastructure on Productivity

VARIABLES	$PRODUCTIVITY_{it}$	
Intercept	0.390(2.00)**	0.695(3.71)***
$NBRANCH_{it}$	4.741(11.49)***	1.936(3.38)***
$ATMINT_{it}$	0.213(1.50)*	0.045(2.99)***
$ATMUSE_{it}$	1.220(1.93)**	1.333(0.41)
$EBANK_{it}$	-0.079(-1.89)**	-0.045(-2.53)***
$EBANK_{it}$*$NBRANCH_{it}$		0.282(3.46)***
$EBANK_{it}$*$ATMINT_{it}$		0.502(2.47)***
$EBANK_{it}$*$ATMUSE_{it}$		0.546(1.62)**
$ATMINT_{it}$*$NBRANCH_{it}$		0.489(4.71)***
$ATMUSE_{it}$*$NBRANCH_{it}$		0.132(0.93)
$INVASSET_{it}$	0.450(3.62)***	0.237(3.00)***
$ACCOUNTSIZE_{it}$	1.795(1.92)**	2.911(0.44)
$DEPOSITDIV_{it}$	0.723(1.79)**	0.560(2.09)**
$LOANDIV_{it}$	0.080(2.02)**	0.024(1.13)
Adjusted R^2	0.428	0.430

Note: See Table 1 for variable definitions. t-values are in parentheses. *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels respectively (one-tailed).

Next, the study examines how service infrastructure strategy affects the bank's market share competitive capability. In Table 4, NBRANCH is positive and significant in all three market share equations, suggesting that higher branch intensity is associated with higher market share, supporting hypothesis H2.1b. Both ATMINT and ATMUSE are also positive and significant in all market share equations, supporting hypothesis H2.2b. The positive and significant impact of EBANK on all three measures of market share provides support for hypothesis H2.3b, confirming the expectation that Internet banking helps retain current customers and attract new customers. This finding indicates that even when banks cannot command premium prices on transactions processed through Internet banking, they promote its use by offering the same channels as competing banks do.

Overall, the positive impact of all three channels on market share competition suggests that all three channels are utilized to attract and meet customers' demands for bank services. Table 4 also shows there are positive complementarities across all three channels for market share competitive capability, providing evidence to support hypotheses H2.5a to H2.5c. All three channels should be considered simultaneously when banks change the investment level of a particular channel. For example, banks that increase their investment in Internet banking should simultaneously consider investments and redeployment of resources in other channels to derive the most benefit from the investment in Internet banking. Considering customer types, deposit customers are more likely to be individuals while loan customers are more likely to be businesses. There is little difference in the direct effect of Internet banking on deposit customers and loan customers. The coefficient of ATM variables on deposit customers is relatively larger than that on loan customers. The coefficient of branch variable on loan customers, however, is significantly larger than that on deposit customers. The results suggest that ATMs attract individual customers who have less use for value-added services. Branches, on the other hand, attract business customers because branches provide more complex products and value-added services that meet the service needs of these customers.

Table 4. Impact of Service Infrastructure on Market Share Competition

VARIABLES	$DEPOSIT\_MKT\_SH_{it}$		$LOAN\_MKT\_SH_{it}$		$CUSTOMER\_MKT\_SH_{it}$	
Intercept	0.111(3.44)***	0.016(2.67)***	0.038(1.44)*	0.019(1.37)*	1.239(4.62)***	1.050(1.82)**
$NBRANCH_{it}$	0.214(2.38)***	0.152(1.25)	0.356(3.36)***	0.251(2.07)**	0.170(1.95)**	0.066(0.21)
$ATMINT_{it}$	0.151(1.72)**	0.129(0.27)	0.026(1.46)*	0.015(0.87)	0.515(3.58)***	0.367(1.53)*
$ATMUSE_{it}$	0.149(2.54)***	0.125(3.05)***	0.077(1.54)*	0.010(1.21)	0.359(4.20)***	0.183(1.58)*
$EBANK_{it}$	0.165(2.67)***	0.114(1.93)**	0.154(1.87)**	0.070(1.67)**	0.308(2.01)**	0.277(2.73)***
$EBANK_{it}$*$NBRANCH_{it}$		0.064(3.04)***		0.055(3.28)***		0.416(1.87)**
$EBANK_{it}$*$ATMINT_{it}$		0.022(1.06)		0.056(1.34)*		0.466(1.34)**
$EBANK_{it}$*$ATMUSE_{it}$		0.039(1.39)*		0.016(0.19)		0.274(2.49)***
$ATMINT_{it}$*$NBRANCH_{it}$		0.038(1.19)		0.013(0.72)		0.266(1.11)
$ATMUSE_{it}$*$NBRANCH_{it}$		0.030(1.37)*		0.090(0.63)		0.063(0.24)
$DEPOSITDIV_{it}$	0.447(2.13)**	0.324(1.50)*	0.104(0.58)	0.093(0.56)	0.302(0.99)	0.093(0.56)
$LOANDIV_{it}$	-0.081(-0.50)	-0.049(-0.26)	-0.106(-0.76)	0.040(0.24)	0.104(0.45)	0.039(0.24)
Adjusted R^2	0.208	0.227	0.137	0.169	0.156	0.184

Note: See Table 1 for variable definitions. t-values are in parentheses. *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels respectively (one tailed).

The study also reruns the specified regressions by replacing productivity with return on assets (ROA), a traditional accounting measure employed in prior research, to examine the impact of alternate services channels on firm profitability. Both individual and joint effects of alternate service channels in Table 3 still survive.[12] A potential selection bias may be a concern if banks that choose to invest in IT-based channels have certain firm characteristics, such as firm size and product diversity, which are highly correlated with the choice of innovative IT-based channels. That is, the adoption of innovative IT-based channels might be an endogenous choice which depends upon bank characteristics that influence firm attitude in investing IT. For example, larger banks or banks offering diversified products and services are the ones who, on average, have greater incentives to be the first to adopt innovative IT-based channels, such as internet banking, in order to better serve their customers. A two-step Heckman selection model is constructed check for simultaneity and test the robustness of the results. The relationship between each pair of alternate service channels and bank productivity continues to hold while considering the issue of sample selection bias.

Partial derivation of equations 1 and 2, with respect to the internet banking variable, is taken individually to further investigate the economic interpretations of independent variables in a regression with interaction effects. An examination of the marginal effect of internet banking on bank performance shows the following results:

[12] To further investigate the impact of bank characteristics, I take the partial derivative with respect to EBANK and find that the fast growing and more customer-oriented banks invest in Internet banking more aggressively and show a higher ROA on average than the more established, government owned banks that have less of a customer focus.

$$\frac{\partial PRODUCTIVITY}{\partial EBANK} = -0.045 + 0.282 * NBRANCH + 0.502 * ATMINT + 0.546 * ATMUSE \tag{3}$$

$$\frac{\partial DEPOSIT\_MKT\_SH}{\partial EBANK} = 0.114 + 0.064 * NBRANCH + 0.022 * ATMINT + 0.039 * ATMUSE \tag{4a}$$

$$\frac{\partial LOAN\_MKT\_SH}{\partial EBANK} = 0.070 + 0.055 * NBRANCH + 0.056 * ATMINT + 0.016 * ATMUSE \tag{4b}$$

$$\frac{\partial CUSTOMER\_MKT\_SH}{\partial EBANK} = 0.277 + 0.416 * NBRANCH + 0.466 * ATMINT + 0.274 * ATMUSE \tag{4c}$$

In equation 3, the negative intercept implies that banks need to invest in other alternate channels before investment in internet banking contributes to a positive return on productivity. This can explain why exclusively online banks opened up physical branches in the past few years (e.g., Etrade banking, ING Direct, etc.) (Lieber 2010; The Economist 2012). In other words, the negative impact of Internet banking on productivity will be balanced out as branch intensity and/or ATM investment increases. Since internet banking is viewed as an effective tool to increase customers' brand loyalty and also contributes to demand increase of other complement channels, bank can benefit more by providing profitable services through other channels to process these increased demands. The marginal impact of internet banking on productivity becomes stronger as the investment intensity of alternate channels increases. Regarding the marginal impact of Internet banking on bank market share, the intercepts in equations 4a to 4c are all positive, indicating that investing in internet banking helps banks increase their market share and banks benefit more by offering alternate channels to serve different customer needs, and as a result, contribute to overall market share.

Table 5 provides further empirical evidence to reinforce the prediction that the two IT-based channels are complements, not substitutes. The last column of Table 5 shows that there exists significant complementarity between Internet banking and ATMs (the coefficient of the interaction term, EBANK*ATMINT, equals 0.105 and is significant at 0.01 level). This supports the notion that the use of one IT-based channel does not diminish the importance of the other but helps create service demands for other IT-based channels. Finally, Table 6 provides empirical evidence to support the assertion with respect to market segment strategy implemented by banks. The larger and positive coefficients of the branch channel, when compared to the two IT-based channels, suggest that branch channel is better able to attract both individual and business customers and more profitable customers. The results also show that ATMs have greater impact on individual segment than on business segment, suggesting that ATM channel is more commonly used to serve individuals. Internet banking, on the other hand, will attract smaller and less profitable customers. [13]

[13] The study conducts sensitivity tests using the two-way fixed effects method (by firm, by year).The results in Tables 3 to 6 remain robust.

Table 5. Impact of Service Infrastructure on Attracting and Expanding Customer Base

VARIABLES	CUSTOMER / $BRANCH_{it}$	
Intercept	1.860(12.67)***	2.071 (12.11)***
$ATMINT_{it}$	0.103 (5.16)***	0.080 (4.95)***
$EBANK_{it}$	0.027 (1.62)**	0.019 (2.88)***
$EBANK_{it}$*$ATMINT_{it}$		0.105 (3.67)***
$INVASSET_{it}$	1.265 (4.23)***	0.924 (3.42)***
$ACCOUNTSIZE_{it}$	0.217 (9.88)***	0.228 (9.55)***
$DEPOSITDIV_{it}$	1.121 (7.79)***	0.919 (6.25)***
$LOANDIV_{it}$	0.290 (5.10)***	0.247 (4.68)***
Adjusted R^2	0.666	0.672

Note: See Table 1 for variable definitions. t-values are in parentheses. *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels respectively (one tailed).

Table 6. Impact of Service Infrastructure on Attracting Different Customer Segments

VARIABLES	DEPOSITS / CUSTOMER$_{it}$		LOANS / CUSTOMER$_{it}$		PROFITS / CUSTOMER$_{it}$	
Intercept	1.276(9.21)***	1.060(7.81)***	1.056(8.20)***	0.942(7.11)***	0.199 (2.27)**	0.098(1.10)
NBRANCH$_{it}$	2.288(2.10)***	4.299(4.04)***	2.239(2.86)***	3.678(3.36)***	1.441 (1.49)*	2.730(2.00)**
ATMINT$_{it}$	0.428(2.60)***	0.216(4.48)***	0.353(2.13)**	0.171(3.52)***	0.425 (2.43)***	0.197(4.09)***
EBANK$_{it}$	-0.021(-1.55)*	0.113(2.38)***	-0.023(-1.64)**	0.095(1.97)**	-0.085 (-4.93)***	0.023(0.12)
EBANK$_{it}$*NBRANCH$_{it}$		-0.026(-1.22)		-0.020(-1.08)		-0.119(-0.57)
EBANK$_{it}$*ATMINT$_{it}$		-0.024(-4.11)***		-0.022(-3.57)***		-0.002(-2.87)***
NBRANCH$_{it}$*ATMINT$_{it}$		0.246(1.51)*		0.204(0.79)		0.431(1.93)**
INVASSET$_{it}$	0.893(3.80)***	0.768(3.23)***	0.987(4.04)***	0.839(3.44)***	0.546(1.88)**	0.352(1.20)
ACCOUNTSIZE$_{it}$	0.222(11.71)***	0.219(11.08)***	0.225(12.13)***	0.229(11.64)***	0.194(11.69)***	0.188(11.20)***
DEPOSITDIV$_{it}$	0.900(7.43)***	0.787(6.32)***	0.934(7.74)***	0.832(6.63)***	0.703(5.89)***	0.615(4.98)***
LOANDIV$_{it}$	0.175(3.74)***	0.170(3.74)***	0.197(4.18)***	0.188(4.08)***	0.196(3.93)***	0.188(4.98)***
Adjusted R^2	0.653	0.681	0.676	0.692	0.609	0.625

Note: See Table 1 for variable definitions. t-values are in parentheses. *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels respectively (one tailed).

2.5 Conclusion

As IT becomes more ubiquitous in the banking industry, banks must adjust their service infrastructure strategies by adopting alternate IT-based channels. These channels not only improve productivity, but also enhance a bank's competitive advantage by collecting more customer data, analyzing consumption behaviors, and predicting future market trends. The intensive use of IT-based channels has fundamentally changed banking business models by changing the cost structure to serve different customer segments, reallocating firm resources to higher value-added activities, and reengineering business operations to maximize profitability. While prior research looks at the relationship between the business value of IT and firm performance, very few studies examine how traditional and IT-based service channels simultaneously impact performance or identify the complementarities across service channels.

This study investigates the impact of banking service infrastructure strategy investments on two dimensions of bank performance, productivity and market share competitive capability. The data is collected from the Taiwanese banking industry using data from the period 1995-2007. The results document the existence of strong interdependence between each pair of alternate service channels. The findings support the argument that IT can serve as a magnifier or accelerator of desired business capabilities even when those capabilities do not directly involve IT. Branch and ATM investments also reinforce the benefits of Internet banking investment. The positive complementarities between alternate service channels indicate the need to analyze interactions between alternate investments in their impacts on both productivity and market share to obtain accurate insights about the strategic value of such investments.

This study reveals contrasting strategic rationales supporting investment in ATMs and Internet banking. While ATMs have a positive direct impact on bank productivity, Internet banking has a negative direct impact. Bank managers need to clearly understand the value proposition of a multichannel strategy. The examination of alternate service channels also complements prior research in the banking industry that examines the impact of IT investment in ATMs and Internet banking on user acceptance, which mainly investigated from the customer's perspective. This study thus contributes to the research stream examining the business value of IT investment by providing an analysis from the firm's perspective, taking into account the firm's alternate service channels. The results also indicate that while Internet banking does not lead to increased productivity it significantly helps with acquiring or securing market share.

As technology advances and people become more comfortable with internet-based channel, banks should also start transforming Internet banking into a more revenue driven channel by integrating more complex, online functions for customers to manage their banking activities. It is expected that the negative impact of Internet banking on productivity will likely decrease or disappear as technologies advance. The proposed framework examined in this study for evaluating the strategic value of IT investments enables bank managers to measure and monitor the association between the invested IT resources and performance (in terms of productivity and market share) over time as technologies progress toward the adoption of more diversified, innovative channels such as mobile banking and social media for the seamless multichannel integration challenge ahead.

CHAPTER 3

EVALUATING VALUE OF WORKFORCE CAPITAL IN INFORMATION TECHNOLOGY INDUSTRIES

3.1 Introduction

"*The most valuable of all capital is that invested in human beings*" **–**Marshal (1920). Alfred Marshal's quote from 1920 is particularly pertinent to information technology (IT) industries which are knowledge-intensive industries that create products or deliver services primarily using the intellectual capital of their employees, who are mainly knowledge workers. The production and assimilation of knowledge, which is embodied in human capital and technology investments, drive the growth of today's knowledge economy (OECD 1996). The leading technology executives are aware that skilled talent is a crucial resource in a knowledge based economy (Gates 2007; McKinsey & Company 2013b; Zuckerberg 2013). In a fast paced industry such as IT, where innovation is key to firm survival, skilled employees are integral to the development and production of new products. Competition for innovative ideas and products drives the development of technology industries making competition for skilled workers more intense. Technology companies currently are fighting a fierce talent war in order to compete successfully in today's knowledge driven economy (Forbes 2011; Miller and Wortham 2011).

Anecdotal evidence points to a growing shortage of skilled workers in technology firms in the US. For example, in 2012 leading technology firms including Apple suggested that the United States does not have enough skilled employees to run a hi-tech manufacturing unit (Duhigg and Bradsher 2012). Similarly, Casselman (2011) states that in 2011, even with record high unemployment among manufacturing workers, companies still had a hard time finding skilled workers to fill their positions.[14] Recent studies show that the U.S. talent pool is not growing fast enough to meet future demand (McKinsey & Company 2011a; Rampell 2012; The Times of India 2010). Scholars are also questioning the wisdom of strategic decisions by firms such as Microsoft and Texas Instruments to outsource not only production, but also research and development (R&D) to developing countries such as India, China, and Taiwan where the quality of the workforce graduating from schools and universities is highly variable (Wadhwa et al. 2008).

These anecdotal examples raise questions about the role of human capital in IT firms' innovation capabilities. They also demonstrate the need for rigorous empirical investigation of the topic. While the role of human capital (especially education) in IT industries has recently received attention in the information systems literature (e.g. Ang et al. 2002; Bapna et al. 2012; Levina and Xin 2007; Mithas and Krishnan 2008; Slaughter et al. 2007), very little research has examined the impact of level of employees education on a firm's ability to leverage its investments in research and development (R&D). It is well established that employing individuals with higher levels of human capital leads to increased firm productivity (Black and Lynch 2001). Prior theoretical work (Nelson and Phelps 1996) also suggests that IT firms value skilled employees for their innovative potential, though little empirical research has formally validated this claim. While innovation can enable a firm to offer differentiated products or cut costs by improving its operational efficiency (Porter 1985), it would be interesting to examine whether innovation led by highly educated workers enables IT firms to pursue a

[14] Similar shortage of skilled talent is also observable in 2012 (The Economist 2011).

“differentiation” or a “cost leadership” strategy. Therefore, the main research questions in this study are as follows: Is human capital, in particular level of employee education, complementary with R&D investments in IT firms? Does this complementarity create value for firms by reinforcing the “differentiation” or the “cost leadership” strategy?

The fast pace of technological change and the competitive global business environment have led many IT firms to pursue a differentiation strategy based on sustained innovation. For example, large multinational firms (e.g. Apple, Microsoft, Intel, Motorola, and Google) spend billions of dollars every year on developing new products and services. Academic research (e.g. Negassi 2004; Oriani and Sobrero 2008) documents that R&D is an important driver of firms’ innovative ability. At the same time, successful innovation also depends on firms’ hiring and retaining highly skilled employees (Nelson and Phelps 1996). For example, Google’s innovation strategy is built around its unorthodox portfolio of human capital and its Ph.D.-centered culture (Stross 2004). Anecdotal evidence also suggests that human capital plays an important role in innovation in the IT industry. In the United States, skilled workers that graduate from the education system contribute to the innovation in IT industries. For example, the software industry was created by the establishment of computer science departments in US universities (Mowery 1999). The close relation between academia and industry is also evident from the technology industries clustered around and partnered with leading universities such as Stanford University near the Silicon Valley and MIT near Boston. Ballot et al. (2001) used training as a proxy for human capital to explore the complementarities between human capital and R&D, but their results were inconclusive. They speculate that education or experience and not training is likely to be the dominant variable that interacts with R&D, and recommend further studies in this area using education or experience as a proxy for human capital.

There is also little research on the incremental impact of graduate degrees, compared to undergraduate degrees, on the innovativeness of IT firms. In recent years, several countries have emphasized science and technology education as drivers of innovations in the IT industry leading to an increase in the number of people with advanced degrees in these fields. For example in Taiwan the number of people with masters' degrees in engineering increased four times from 1995 to 200, and the number of people with PhDs tripled in the same period. However, an oversupply of people with higher education levels in the absence of jobs that value those skills can lead to the problem of over-education, where firms hire people whose education qualifications exceed those required for the job (Tsang 1987). For example, it is not uncommon to find computer science masters and PhDs working as programmers in Russia and India, a job that is commonly held by employees with a college degree or less. While prior research mainly measures education by a single variable (Bassanin and Scarpetta 2002), this is not sufficient to capture the incremental impact of higher levels of education.

To address the research questions, data is collected on firm performance, employee education, R&D investment and other financial information from IT public companies in Taiwan. The results show interesting relationships between employee education and firm performance. First, the employee education levels moderate the relationship between R&D and firm profitability. Second, the results show that education is positively associated with firm performance, suggesting that firms with more highly educated employees are more profitable. The returns on higher levels of employee education (i.e., master's and Ph.D. degree) are significantly greater than those on undergraduate degrees for the average firm. The results further indicate that firms with high R&D intensity and employees with higher levels of education show a significant improvement in profits. Third, the impact of employee education and R&D on firm performance comes from profit margin instead of asset turnover, suggesting that the complementarities between level of employee education and R&D intensity reinforces the differentiation strategy of a firm. Lastly, the results suggest that the stock market is less efficient in recognizing the complementary relationship between employee education and R&D investment.

The main contribution of this study is its addition to the literature on human capital, focusing on IT industries, by exploring the complementarities between employee's level of education and R&D investments in firms' innovativeness. This study contributes to literature on firm investment and human resource strategies by suggesting that level of employee education enhances the value of R&D investments by reinforcing a firm's differentiation strategy. This study provides empirical evidence allowing estimation of the moderating impact of level of employee education on the relationship between R&D and different levels of firm performance. It also measures education at multiple levels showing that higher levels of education are associated with higher returns on R&D investment.

The remainder of this chapter is organized into four sections. Section 3.2 reviews prior literature in education and R&D and develops the hypotheses. The research model, method, and data are described in Section 3.3. Section 3.4 discusses the findings of the hypothesized relationships. A summary of findings and conclusion are provided in Section 3.5.

3.2 Literature Review and Hypotheses Development

3.2.1 R&D Investment and Firm Performance

With rapid technological development and the growth of knowledge-intensive industries, many firms find that the majority of firm value is driven by intangible capitals, such as R&D (Barsky and Marchant 2000). Of these, returns on R&D capital have been the subject of much attention over the past decades (Chan et al. 2001). The role of R&D as an important factor of productivity is well documented in prior research (Griliches 2000; Oriani and Sobrero 2008). The learning literature suggests that an important benefit of R&D is that it helps firms develop absorptive capacity, the ability for a firm to recognize the value of new information, assimilate knowledge and apply it to commercial ends (Cohen and Levinthal 1990). Absorptive capacity not only increases a firm's innovation ability but is also positively associated with business performance (Tsai 2001). A firm's absorptive capacity for learning, however, depends on its supply of relevant technology-based capabilities (Mowery et al. 1996). R&D investment is necessary for the creation of absorptive capacity (Tsai 2001). The knowledge management literature suggests that innovation occurs when a firm identifies potential opportunities to fill the gaps in the industry positioning map, such as new customer segments, new customer needs, or new production methods (Markides 1997). In order to foster innovation, a firm must search for new opportunities by exchanging information and knowledge, building on current knowledge, synthesizing external knowledge with internal knowledge, and becoming a learning organization. Therefore, efficient knowledge exchange among internal and external functions is critical for success (Moenaert et al. 1992). Roussel et al. (1991) suggest that R&D is the key to developing new knowledge within a firm.

The positive relationship between R&D and firm performance has been documented in prior literature (Graversen and Mark 2005; Griliches 1995; Griffith et al. 2006; Mehran 1995; Wakelin 2001). The development of technological strength and accumulation of knowledge resulting from R&D efforts determines firm performance in high tech industries (Pegels and Thirumurthy 1996)[15]. Since IT industries are technologically intensive, innovation is the key to developing a source of sustained competitive advantage (Arora et al. 2001). Investment in R&D activities is expected to drive a firm's technological change and innovation capability (Cohen et al. 2013; Lerner and Wulf 2007). Therefore, it is imperative that firms increase their resource allocation to R&D investments so that their technological advantage over competitors is enhanced (Yanadori and Marler 2006). Therefore, the first hypothesis is that greater R&D investment will have a positive impact on IT firm profitability.

H3.1: R&D is positively associated with higher firm profitability in IT industries

3.2.2 Workforce Education and Firm Performance

Marshall (1920) suggests that the most valuable form of capital in which a firm can invest is that of human beings. Barney (1991) sees human capital as a resource that is valuable, scarce, non-substitutable, and incurs heavy replacement costs. As such, human capital has long been viewed as a critical resource in most firms (Pfeffer 1994). The rapid

[15] Many IT giants, like Apple and Microsoft, view R&D investments are directly linked to innovation of business which is critical to the growth of business and competitive advantages (Evans 2009; Lowensohn 2012).

development of technology has increasingly driven the demand for more highly skilled and educated employees (Colecchia and Papaconstantinou 1996; Doms et al. 1997; Falk and Seim 2001). Michaels et al (2013)'s results is supportive of the notion that technical change drives the rapid growth of the demand for more highly educated workforce. Therefore, a complementary relationship between information technology and human capital might be an important factor to explain the shift toward more highly skilled labor (Falk and Seim 2001). The importance of highly skilled workers is even more significant in IT industries that are knowledge intensive. As Ang et al. (2002) suggest, "IT jobs are complex, requiring knowledge of difficult technical concepts such as data modeling, process engineering, and design theory".

The organizational learning literature views employees as a primary repository of organizational knowledge (Argote 1999). The human capital theory suggests that people possess skills, knowledge, and abilities that provide economic value to firms (Becker 1964). Although human capital is measured in different ways (education, experience, and training), prior research has used education as the most common proxy (Carmeli and Tishler 2004; Romer 1990). Becker's (1964) seminal work on the human capital theory suggests that education builds human capital because education imparts knowledge to perform a specific task. Other theoretical frameworks also explain the positive impact of education. For example, the sorting and signaling framework (Spence 1973; Weiss 1995) suggests that people who are inherently more intelligent opt for and are selected for higher education.

Education enhances one's ability to receive, decode, and understand information (Nelson and Phelps 1966). Education also improves the ability to learn and adapt

(Leiponen 1997). It can strengthen ability, reduce uncertainty, and contribute to more efficient decision-making (Griliches 2000). The knowledge literature suggests that prior knowledge is useful for assimilating new knowledge and, therefore, that prior experience in learning and solving problems during schooling enhances learning on the job (Cohen and Levinthal 1989; Leiponen 1997).

Education is becoming more important in the presence of rapid technological change because it enhances employee skills that facilitate the gathering, processing, and interpreting of information (Bartel and Lichtenberg 1987). It is therefore not surprising that prior research shows evidence that IT drives the demand for skilled workers (Bresnahan et al. 2002). IT industries is operate in an environment of uncertainty due to the fast pace of technological change, intense competition, and high industry clock speed. Prior research shows that technology-oriented firms tend to employ a more highly educated workforce and have more productivity gains (Doms et al. 1997; Moretti 2004).

Employee education is found to have a positive impact on productivity improvement (Black and Lynch 1996). However, there has been very little discussion on the monotonicity of the relationship between education and firm performance. While there is empirical evidence that employees with higher education levels (i.e., master's and Ph.D. degrees) command higher pay (Mithas and Krishnan 2008) and more promotion opportunities (Wright 1988), it is still not clear whether firms optimally allocate these highly educated employees. In situations where there is oversupply of more higher educated labor, firms may hire them for jobs that traditionally require lower education levels. On the other hand, employees with higher education levels are likely to benefit firms due to an accumulation of superior managerial competencies (Mithas and Krishnan

2008). It is because higher education contributes to success by increasing specific types of knowledge and enhancing ones' ability to learn (Hunton et al. 2005).

Therefore, the second hypothesis on the relationship between employees' education levels and firm performance is as follows:

H3.2a: Education is positively associated with higher firm profitability in IT industries

H3.2b: Higher levels of education (such as master's and PhD degrees) are more positively associated with higher firm profitability than lower levels of education (such as bachelor's) in IT industries

3.2.3 Complementarities between Workforce Education and R&D

Investments in R&D and human capital are associated with new ideas and technologies, contributing to productivity growth (Griffith et al. 2004). A close link between a firm's human capital and R&D needs to be investigated to gain a holistic view of the sources of firm knowledge creation and innovation capabilities. R&D investments involve high levels of uncertainty, and the skills acquired through higher education allow an individual to perform higher value-added tasks more efficiently and more quickly (Berghiem 2005). Leiponen (1997) argues that while R&D is needed to develop technological knowledge internally, skilled employees are essential for applying the firm's resources in the right direction. Møen (2005) suggests that the R&D capital of firms is to a large extent embodied in the employees. Higher skill levels among firm employees are associated with a higher 'economic competence' (Eliasson 1990) or 'absorptive capacity' (Cohen and Levinthal 1990; Negassi 2004), both critical for a firm's innovativeness. Prior theoretical work (Aghion and Howitt 1998) suggests that human capital is complementary with R&D investments, but very little empirical research explores the complementarities. Therefore, the relationship between a firm's R&D capital and human capital should be closely examined.

Autor et al. (2003) and Wolff (1996) suggest that IT firms need a strong base of human capital to remain at the forefront of innovation. In technology (or knowledge) intensive industries such as IT, the knowledge of employees is directly related to a firm's ability to develop new product and services, which is a critical determinant of firm performance and survival (Smith et al. 2005). Teece (1986) suggests that R&D at innovative firms requires more knowledge and skills, than at non-innovative firms. In particular, prior research states that R&D employees are more valuable because their efforts directly influence the organization's innovation capabilities (Yanadori and Marler 2006). Therefore, for technology firms to take advantage of their R&D investments, they should make complementary investments in human capital.

One of the benefits of higher education is that it helps an individual perform value-added activities more efficiently (Berghiem 2005). Higher levels of education not only impart required knowledge but also increase the ability to identify and solve problems in a more efficient way. For example, a Ph.D. program enhances the individual's ability to recognize potential problems and identify new research opportunities. Firms that invest extensively in R&D in pursuit of innovation often face challenges involving high complexity and uncertainty. Previous research suggests that more highly educated workers are more receptive to new ideas and change, as well as better able to implement new ideas (Bartel and Lichtenberg 1987; Thomas et al. 1991). The level of employee education, associated with employee's knowledge bases and cognitive abilities, has a positive impact on firm’s knowledge creation capabilities (Hambrick and Mason 1984; Smith et al. 2005). In a knowledge economy where business niches often depend on seizing opportunities in a timely manner, firms will benefit from a more highly educated workforce that can recognize new opportunities and patterns and facilitate rapid development of innovative products and services.

Therefore, this study proposes that the returns to investment in innovation, measured by R&D intensity, will be higher for firms with a higher fraction of more highly educated employees. In particular, employees with higher education levels would have a higher impact on R&D productivity than employees with bachelor’s degrees. The third hypothesis with respect to the moderating impact of education on the association between R&D investment and firm performance is as follows:

H3.3a: Education positively moderates the relation between R&D investment and firm profitability in IT industries

H3.3b: The moderating impact of education on the relationship between R&D and firm profitability is higher for higher levels of education (master’s and Ph.D.) compared to lower levels of education (bachelor’s)

3.3 Research Design and Data

3.3.1 Empirical Model

The empirical analyses of the associations between investments in workforce capital and R&D investment and firm performance are based on the research model shown in Figure 3. The model aims to investigate the impacts of two key capitals, workforce capital and R&D capital, along with other firm characteristics variables that are expected to drive firm profitability. As discussed in the literature section, the direct impacts of workforce capital and R&D investment on firm performance are examined first. The study then examines whether the relationship between the intensity of R&D investment and firm performance is moderated by the level of workforce education.

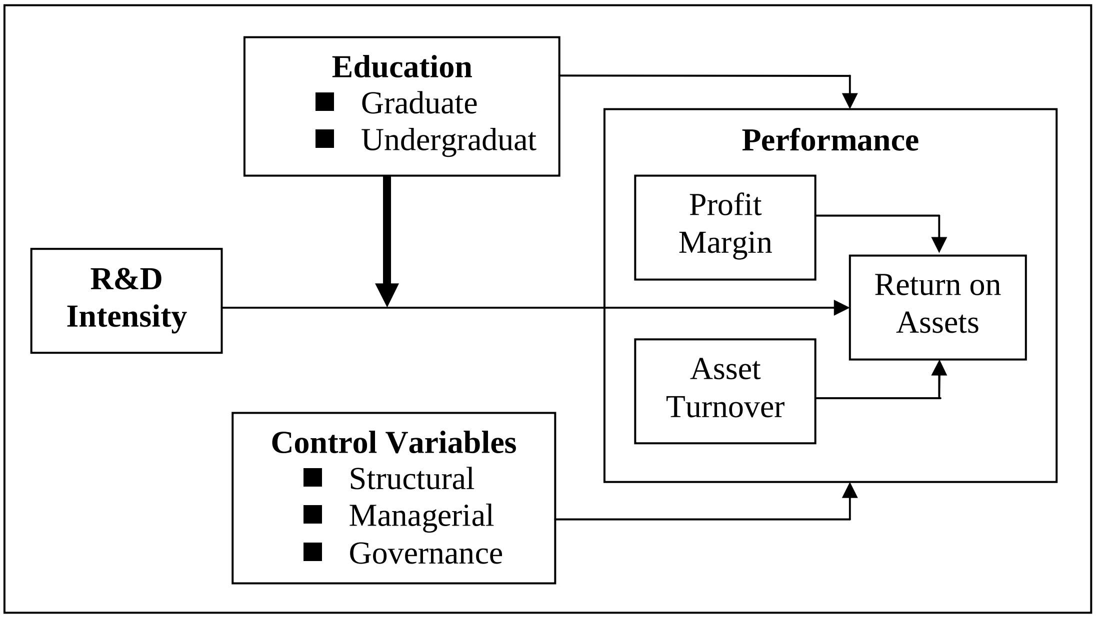

Figure 3. Impact of Workforce Education on Performance

3.3.2 Measurement of Variables

In this study, firm performance is proxied by measuring the industry-adjusted return on assets (ROA) (Larcker et al. 2007). Two main input capitals of interests included in the model are workforce capital and R&D capital. This study examines the first capital of interest, workforce capital, by looking at employee education level since education is an important signaling mechanism for employee competence (Spence 1973) Human capital theory also looks primarily at education as an important determinant of human capital (Becker 1964). In line with prior work (Bresnahan et al. 2002), this study measures education as the fraction of employees in the firm who are educated at a certain level. This study calculates two variables to measure the different levels of education – GRADUATES, which is the fraction of employees with a master's or Ph.D. degree, and UNDERGRADS, which is the fraction of employees with only a bachelor's degree. The omitted variable here is the fraction of employees who do not have a college education. The second input capital of interest, R&D capital, represents a firm's efforts to improve their innovation capabilities. Following previous research that examines the impact of R&D investment on firm performance, the intensity of R&D, RND_INT, is measured by the ratio of total R&D expenditure to total revenue (Hirschey and Weygandt 1985; Lev and Sougiannis 1996). As is common in models with interaction terms (Ang et al. 2002), the GRADUATES, UNDERGRADS, and RND_INT variables are mean-centered.

The model includes the following control variables that are commonly found to be associated with firm performance. Firstly, the model controls for variables associated with managerial discretion since this is an indicator of how managers allocate and coordinate business resources (Henderson and Fredickson 1996). In addition, certain discretionary expenses (e.g. advertising) can help promote a firm's brand name recognition and create a reputation premium that allows the firm to charge higher prices for its products and compete with its competitors (Ho et al. 2005). The following variables are used to control for managerial discretion: (1) advertising intensity, ADV_INT, calculated as the ratio of advertising expense to total revenues (Hirschey and Weygandt 1985); (2) employee intensity, LAB_INT, calculated as the ratio of total number of employees to total revenues (Chen et al. 2012); and (3) capital intensity, CAP_INT, calculated as the ratio of total property, plant, and equipment to total revenues

(Hsieh et al. 2003). Secondly, stock return volatility is employed as a control variable since it is an indicator of innovation activity at the firm level, which represents high risk and unpredictability (Anderson et al. 2000). Volatility is measured as the standard deviation of the previous three years of a firm's stock returns (VOLATILITY). Thirdly, compensation practices of a firm are likely to be a key indicator of its human capital policy. Two variables are used to control for compensation practices: (1) the salary received by employees in the firm (LABOR_COMP), which is the average salary (in '000 New Taiwan dollars - denoted by T$) received by employees in the firm[16], and (2) salary received by top management at the firm (EXEC_COMP). The latter value is measured as the logarithm of the average of all forms of compensation, including salary, cash bonus, stock options, and other kinds of compensation received by the firm executives.

Finally, this study controls for the corporate governance structure of a firm since prior research establishes a clear link between corporate governance and long term investments such as R&D (Baysinger et al. 1991; Chung et al. 2003). The separation of ownership and management in firms leads to an agency problem where managers can forgo long term investments in favor of short term profitability. Corporate governance is a mechanism to deal with this agency problem. The impact of corporate governance is measured using three different variables, including board size (BOARDSIZE), board independence (INDEP_DIR), and executive ownership (STOCKHELD) (Chen et al. 2012; Larcker et al. 2007; Morck et al. 1988). Board size is measured as the logarithm of the total number of board members. Previous literature finds that a greater ratio of outsiders on the board enhances the corporate governance mechanism (Fama and Jensen

[16] 1 US dollar is, on average, roughly equals 30 New Taiwan dollars over the past two decades

1983). Thus, the ratio of outside directors to total number of directors is calculated to measure board independence. Executive ownership is measured as the ratio of market value of stock held by inside directors to total equity. Table 7 summarizes the definitions of variables employed in this study. The model can be expressed mathematically in the following equation:

$$\begin{aligned} ROA_{it} = {} & \beta_0 + \beta_1 GRADUATES_{it} + \beta_2 UNDERGRADS_{it} + \beta_3 RND\_INT_{it} \\ & + \beta_4 GRADUATES_{it} * RND\_INT_{it} + \beta_5 UNDERGRADS_{it} * RND\_INT_{it} \\ & + \beta_6 ADV\_INT_{it} + \beta_7 LAB\_INT_{it} + \beta_8 CAP\_INT_{it} + \beta_9 VOLATILITY_{it} \\ & + \beta_{10} LABOR\_COMP_{it} + \beta_{11} EXEC\_COMP_{it} + \beta_{12} STOCKHELD_{it} \\ & + \beta_{13} INDEPDIR_{it} + \beta_{14} BOARDSIZE_{it} + \varepsilon_{it} \end{aligned} \tag{5}$$

Table 7. Variable Definitions for Chapter 3

Dependent Variable	
ROA	= the industry-adjusted return on assets by first calculating the ratio of operating income to total assets and then subtracting the median industry ROA from the firm ROA
PM	= the industry-adjusted profit margin by first calculating the ratio of operating income to total sales and then subtracting the median industry PM from the firm PM
ATO	= the industry-adjusted asset turnover by first calculating total sales to average operating assets and then subtracting the median industry ATO from the firm ATO
RET	= the market adjusted cumulative stock return over the 12-month period of the firm's fiscal year t lagged 4 months
Principal Explanatory Variables	
GRADUATES	= the fraction of employees with a master's or Ph.D. degree
UNDERGRADS	= the fraction of employees with only a bachelor's degree
RND_INT	= ratio of total R&D expenditure to total revenue

Control Variables	
ADV_INT	= ratio of advertising expense to total revenues
LAB_INT	= ratio of total number of employees to total revenues
CAP_INT	= ratio of total property, plant, and equipment to total revenues
VOLATILITY	= the standard deviation of previous three years of firm stock returns
LABOR_COMP	= the average salary (in ‘000 New Taiwan dollars - denoted by T$) received by employees in the firm
EXEC_COMP	= the logarithm of the average of all forms of compensation, including salary, cash bonus, stock options, and other kinds of compensation received by the executives of the firm
BOARDSIZE	= the logarithm of the total number of board members
INDEPDIR	= the ratio of outside directors to total number of board of directors
STOCKHELD	= the ratio of market value of stock held by inside directors to total equity
TURNOVER	= the average turnover rate of executives including Chairman, CEO, and CFO
FIRMSIZE	= the logarithm of total revenues

3.3.3 Sample Data

The data comes from two sources: (1) the Taiwan Economic Journal database, which includes data from financial statements and corporate governance; and (2) firms’ annual reports for collecting employee educational data. After eliminating the missing values in the data set, a total number of 713 firm-year observations, from 2000 to 2006, are obtained.[17] The final sample contains six distinct types of IT sectors. The largest

[17] I collected total 6,884 firm-year observations with financial and governance data from the Taiwan Economic Journal database I also collected educational data from firm annual reports during the sample period and got total 1,881 firm-year observations. I then matched initial sample data with collected educational data, and eliminated observations with missing value for calculating variables employed in the study. Total 713 firm-year observations are employed for this study.

sector is the electronic components and integrated circuits sector, which represents 36.1% of sample, followed by the general, consumer electronics and electronic channel sector (17.5%) and the photoelectric sector (17.5%). The firms in the sample range in size from 497 million to 461 billion New Taiwan dollars in revenues.

Taiwanese IT companies are selected in this study because the IT industry in Taiwan plays an important role in the global IT manufacturing value chain (The Economist 2013). Apart from being the world's biggest producers of computer components, Taiwan's global market share for communication equipment, such as wireless modems, D.S.L. modems, and personal digital assistants, is above 70% (Belson 2007). Taiwan IT industries first established their positions within global IT industries as component manufacturers producing mainstream IT products. However, Taiwanese IT firms are now being urged to shift their operating strategies to innovation because of globalization and the increasing competition of the business environment. They are currently investing heavily and consistently in R&D in order to gain and retain technology leadership (Lee et al. 2006).

More importantly, a key factor behind Taiwan's cutting edge in high tech industries is the availability of highly skilled talent, including the high education level of the citizens and the large number of overseas-educated Taiwanese who have returned to the island to work (Dunn 1995; Taiwan Review 2004). In addition, there is a close connection between Taiwan's academia, IT firms, and government in order to develop a highly educated and eligible workforce[3]. As Taiwanese IT firms increasingly focus on differentiating themselves from their competitors, the demand for skilled employees in Taiwan's high tech sector is rapidly increasing (Han et al. 2006). The selection of Taiwan

IT industries can provide insights on how R&D and employee education, in particular the moderating effect of education on the relationship between R&D and firm performance, influence firms' profitability when firms adopt a differentiation strategy. Figure 4 shows the trend of workforce education levels of the sample during the sample period. The ratio of employees with master's or Ph.D. degrees (GRADUATES) to employees with only bachelor's degree (UNDERGRADS) increases from 0.26 in 2000 to 0.37 in 2006. Table 8 presents the descriptive statistics of variables employed in the study.

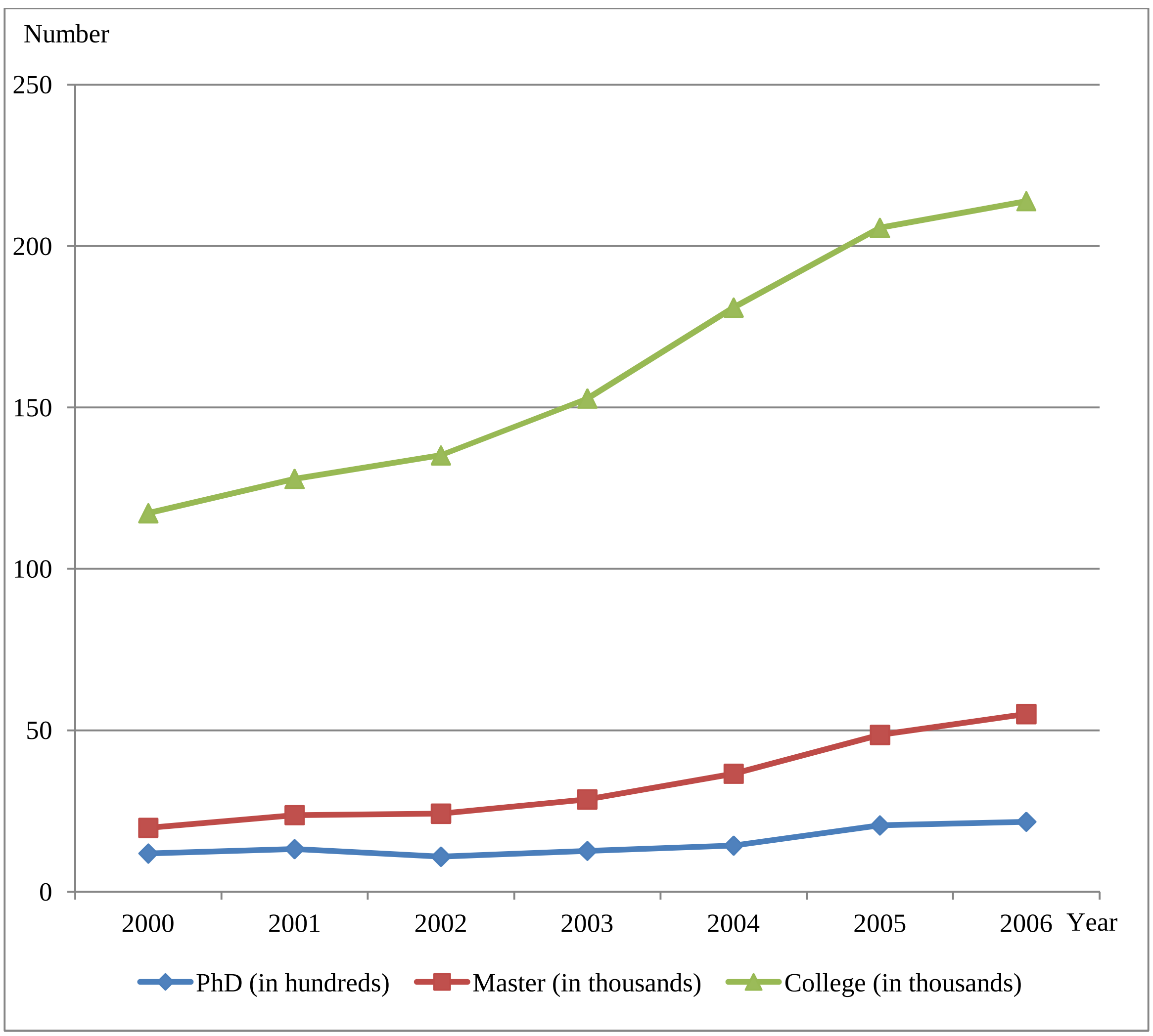

Figure 4. Trend of Workforce Education of Sample IT Firms

Table 8. Descriptive Statistics of Variables for Chapter 3

VARIABLES	Mean	Standard Deviation	Minimal	Maximum
ROA	0.074	0.055	-0.034	0.378
PM	0.106	0.099	-0.053	0.957
ATO	1.466	0.951	0.094	6.811
GRADUATES	0.120	0.145	0.000	0.897
UNDERGRADS	0.554	0.176	0.100	0.944
RND_INT	0.036	0.037	0.000	0.233
ADV_INT	0.002	0.005	0.000	0.049
LAB_INT	0.000	0.000	0.000	0.001
CAP_INT	0.329	0.385	0.015	2.166
VOLATILITY	0.221	0.477	-0.534	5.712
LABOR_COMP	258.22	215.652	7.897	1,187.803
EXEC_COMP	6.671	1.386	2.717	10.975
STOCKHELD	0.099	0.071	0.019	0.885
INDEPDIR	0.134	0.161	0.000	0.571
BOARDSIZE	2.205	0.205	1.609	2.944
TURNOVER	0.353	0.434	0.000	2.667
FIRMSIZE	23,769	53	497	461,524

Note: See Table 7 for variable definitions.

3.4 Empirical Results and Discussions

This study uses the Fama-Macbeth method to run the regressions and calculates Newey-West estimators to adjust the standard errors for autocorrelection issue (Cochrane 2001; Gujarati 2003). The problem with panel data is that cross-sectional and time serial correlations usually lead to underestimation of standard errors and subsequent spurious inflation of t-statistics. The Fama-Macbeth method is, therefore, commonly employed when dealing with cross-sectional financial data to account for cross-correlations in the residuals by using the time-series standard deviation of the coefficient estimates to compute robust standard errors (Fama and MacBeth 1973; Loughran and Ritter 1996; Skoulakis 2008). This conservative method allows the coefficients of the explanatory variables to vary across time (Chan et al. 1991). To mitigate the impact of outliers, all continuous variables employed in the models are winsorized at 1 and 99 percentage levels.

Table 9 presents the results of the main model. The coefficient of RND_INT is positive and significant, see column 2, suggesting that investments in R&D are associated with a higher performance in IT industries. This provides support for hypothesis H3.1. The coefficients of both GRADUATES and UNDERGRADS are positive and significant, suggesting that education has a positive impact on firm performance. This provides support for hypothesis H3.2a. The coefficients of GRADUATES and UNDERGRADS are compared using a t-test to determine whether coefficient of GRADUATES is significantly higher than UNDERGRADS. The coefficient of GRADUATES is significantly higher than that of UNDERGRADS, supporting hypothesis H3.2b.

The third column of Table 9 shows the results of the regression after adding two interaction terms to the model in equation 5. Both education variables are interacted with the RND_INT variable, resulting in two interaction terms – GRADUATES*RND_INT and UNDERGRADS*RND_INT. The interaction terms are both positive and significant, suggesting that higher levels of education are associated with even higher firm performance. This provides support for hypothesis H3.3a. Further, the coefficient for the interaction term is significantly higher for employees with higher education levels, suggesting that firms with employees having higher levels of education are in a better position to leverage their R&D investments, leading to better firm performance. This finding provides support for hypothesis H3.3b.

Labor intensity (LAB_INT) is also associated with higher returns for a firm, whereas capital intensity (CAP_INT) is negatively associated with firm performance. Volatility (VOLATILITY) has a significant positive coefficient, which suggests that volatile stock returns are positively associated with firm performance. The coefficient of executive compensation (EXEC_COMP) has a significant positive impact on firm performance. Executive ownership (STOCKHELD) is positively associated with higher returns, as greater executive ownership motivates executives to improve firm performance. Boards with more independent directors show a higher level of performance, as is evident from the positive coefficient of the INDEP_DIR variable. The coefficient of board size (BOARDSIZE) is negative and significant suggesting that smaller corporate boards are more effective in improving firm performance.

Table 9. Impact of Workforce Education on Profitability: Fama MacBeth Method

VARIABLES	ROA_{it}	
Constant	-0.012(-4.56)***	-0.015(-3.75)***
$GRADUATES_{it}$	0.099(2.10)**	0.073(1.50)*
$UNDERGRAD_{it}$	0.038(1.90)**	0.042(3.54)***
RND_INT_{it}	0.042(2.00)**	-0.301(-1.48)*
$GRADUATES_{it}*RND\_INT_{it}$		1.960(2.78)***
$UNDERGRAD_{it}*RND\_INT_{it}$		0.512(2.21)**
ADV_INT_{it}	0.482(0.95)	0.623(1.14)
LAB_INT_{it}	53.636(5.44)***	49.571(4.03)***
CAP_INT_{it}	-0.015(-1.86)*	-0.013(-1.63)*
$VOLATILITY_{it}$	0.012(2.49)**	0.014(2.75)**
$LABOR\_COMP_{it}$	-0.000(-0.96)	-0.000(-0.87)
$EXEC\_COMP_{it}$	0.007(7.73)***	0.008(10.24)***
$STOCKHELD_{it}$	0.153(5.10)***	0.137(2.74)**
$INDEPDIR_{it}$	0.039(4.87)***	0.039(4.33)***
$BOARDSIZE_{it}$	-0.023(-2.36)**	-0.024(-3.55)***
Adjusted R^2	0.231	0.235

Note: See Table 7 for variable definitions. The coefficients are based on the mean of the 7 yearly coefficients from 2000 to 2006. The coefficient estimates are based on Fama-MacBeth method with Newey-West adjustment. t-values are in parentheses. *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels respectively (one tailed).

In a regression with interaction terms, the impact of the independent variables is more evident through the marginal effects. The marginal impact of UNDERGRADS, GRADUATES, and RND_INT on firm performance, see Table 9, are individually calculated based on equation 5. The marginal impact is as given below.

$$\frac{\partial ROA}{\partial RND\_INT} = -0.301 + 1.960 * GRADUATES + 0.512 * UNDERGRADS \tag{6a}$$

$$\frac{\partial ROA}{\partial UNDERGRADS} = 0.042 + 0.512 * RND\_INT \tag{6b}$$

$$\frac{\partial ROA}{\partial GRADUATES} = 0.073 + 1.960 * RND\_INT \tag{6c}$$

It is interesting to note that the intercept in equation 6a is negative, whereas the intercepts in equations 6b and 6c are positive. This implies that IT firms need to achieve a critical mass of educated employees before investments in R&D yield a positive return. Furthermore, the intercepts of the marginal impact of both education variables are both positive, which suggests that a firm can benefit from an educated workforce even if it does not invest in R&D. All other things being equal, higher education contributes more to firm performance through R&D investment.

The Variance Inflation Factors (VIF) is estimated to check for multicollinearity. All the VIF values are less than 5, ruling out any collinearity problems (Belsley et al. 2005). To further alleviate concerns due to firm specific or year specific impact on the hypothesized relationships, this study assesses the stability of results by rerunning the models using fixed effect regressions models. The results in Table 10 show conclusions that are consistent with the hypothesized relations between firm performance, R&D intensity, and employee education.

Table 10. Impact of Workforce Education on Profitability: Fixed Effect Method

VARIABLES	ROA	
Constant	-0.014(-4.10)***	-0.016(-4.37)***
$GRADUATES_{it}$	0.068(3.30)***	0.058(2.44)***
$UNDERGRAD_{it}$	0.031(2.03)**	0.043(2.72)***
RND_INT_{it}	0.072(2.45)***	-0.070(-1.54)*
$GRADUATES_{it}$*RND_INT_{it}		0.789(2.40)***
$UNDERGRAD_{it}$*RND_INT_{it}		0.627(1.51)*
ADV_INT_{it}	0.541(1.39)*	0.655(1.67)**
LAB_INT_{it}	66.655(2.84)***	69.881(2.98)***
CAP_INT_{it}	-0.006(-0.99)	-0.005(-0.96)
$VOLATILITY_{it}$	0.015(3.81)***	0.014(3.81)***
$LABOR\_COMP_{it}$	-0.000(-0.62)	-0.000(-0.58)
$EXEC\_COMP_{it}$	0.008(4.99)***	0.008(5.12)***
$STOCKHELD_{it}$	0.167(5.67)***	0.171(5.81)***
$INDEPDIR_{it}$	0.055(4.73)***	0.053(4.52)***
$BOARDSIZE_{it}$	-0.027(-2.72)***	-0.027(-2.69)***
Firm Effect	Included	Included
Year Effect	Included	Included
Adjusted R^2	0.244	0.250

Note: See Table 7 for variable definitions. t-values are in parentheses. *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels respectively (one tailed).

Results shown in the second column of Table 9 indicate that R&D, GRADUATES, and UNDERGRADS have a direct, positive impact on firm performance. However, one can expect that firms with higher performance invest more in R&D or that firms with higher performance might be more willing to invest in human capital by recruiting more highly educated employees. In other words, an endogenous relationship might exist between firm performance and R&D or education. This study, therefore, employs a two stage least square regression (2SLS) model to test for a potential endogeneity concern that could affect the main findings. The EDUCATION variable is estimated in order to capture the percentage of employees with college or higher degrees. First, the study looks at whether firms with better performance tend to invest more in R&D activities. Second, another 2SLS model is performed to test whether firms with better performance are more likely to recruit or attract educated employees. The results shown in Table 11 are consistent with those shown in Table 9, after considering a firm's endogenous choices. On the whole, these additional analyses provide results that are qualitatively similar to the main findings in Table 9.

Table 11. Impact of Workforce Education on Profitability: Two Stage Least Square Method

	(1)		(2)	
VARIABLES	ROA_{it}	RND_INT_{it}	ROA_{it}	$EDUCATION_{it}$
Constant	-0.015(-3.83)***	0.000(0.22)	-0.017(-4.51)***	0.007(2.75)***
$EDUCATION_{it}$	0.039(2.60)***		0.066(3.96)***	
RND_INT_{it}	-0.047(-2.27)**		-0.058(-1.48)*	
$EDUCATION_{it}$*RND_INT_{it}	0.815(2.55)***		0.889(2.78)***	
ADV_INT_{it}	0.760(1.74)**		0.782(1.79)**	
LAB_INT_{it}	72.296(2.96)***		88.904(3.54)***	
CAP_INT_{it}	-0.007(-0.94)		-0.007(-1.22)	
$VOLATILITY_{it}$	0.014(3.42)***		0.014(3.39)***	
$LABOR\_COMP_{it}$	-0.000(-0.90)		-0.000(-0.87)	
$EXEC\_COMP_{it}$	0.008(5.33)***		0.008(4.90)***	
$STOCKHELD_{it}$	0.167(5.55)***		0.178(6.01)***	
$INDEPDIR_{it}$	0.056(4.60)***		0.056(4.65)***	
$BOARDSIZE_{it}$	-0.032(-2.87)***		-0.031(-2.91)***	
RND_INT_{it-1}		0.848(45.08)***		0.004(0.06)
$EDUCATION_{it-1}$		0.008(2.33)**		0.934(75.45)***
ROA_{it-1}		0.048(3.97)***		-0.057(-1.37)**
BTM_{it-1}		-0.018(-1.70)**		
$FIRMSIZE_{it-1}$				0.007(3.90)***
Adjusted R^2	0.243	0.803	0.240	0.912

Note: EDUCATION = the fraction of employees with bachelor's or more advanced degree. See Table 7 for variable definitions. t-values are in parentheses. *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels respectively (one tailed).

In order to further examine the impacts of R&D and employee education on a firm's strategic position, the DuPont analysis is conducted and decomposes the firm performance measure, ROA, into two variables: profit margin (PM), and Asset turnover (ATO) (Stickney and Brown 1999). Profit Margin is an indicator for the price premium a firm commands and signals product differentiation strategy. Asset turnover is an indicator of a firm's operational efficiency and signals the firm's cost leadership strategy. The results in Table 12 show that the coefficients of GRADUATES and UNDERGRADS have a significant positive association with profit margin, suggesting higher levels of employee education contribute to performance improvement. The significant and positive coefficients of the two interaction terms, GRADUATES*RND_INT and UNDERGRADS*RND_INT, in the third column of Table 12 further show that the moderating effect of education improves the relationship between R&D investment and profit margin. The coefficient of GRADUATES*RND_INT (= 1.955) is significantly greater than that of UNDERGRADS*RND_INT (= 0.969), suggesting a higher level of employee education improves R&D value. In the fourth column of Table 12, the coefficient of RND_INT (= -14.145) suggests that R&D has a negative impact on asset turnover. The coefficient of UNDERGRADS*RND_INT in the last column of Table 12 (= -20.035) has a significant negative association with asset turnover. This implies that the complementary relation between education levels of workforce and R&D intensity impedes firms' pursuit of higher asset utilization efficiency. Taken together, the DuPont analysis shows that the benefit of R&D contributes more in the way of differentiating firm's strategic position within the industry than pursuing operating excellence.

Table 12. Impact of Workforce Education on Performance: The DuPont Analysis

VARIABLES	PM_{it}		ATO_{it}	
Constant	-0.000(-0.06)	-0.005(-0.98)	-0.098(-0.31)	-0.120(-0.45)
$GRADUATES_{it}$	0.133(6.75)***	0.177(1.88)*	0.360(3.86)***	0.343(3.38)***
$UNDERGRAD_{it}$	0.073(2.18)**	0.054(3.10)***	0.845(3.57)***	0.334(1.42)*
RND_INT_{it}	0.106(1.15)	-0.117(-0.64)	-14.145(-6.91)***	-10.932(-5.47)***
$GRADUATES_{it}*RND\_INT_{it}$		1.955(5.28)***		-7.558(-0.57)
$UNDERGRAD_{it}*RND\_INT_{it}$		0.969(1.82)*		-20.035 (-6.01) ***
ADV_INT_{it}	0.258(0.35)	0.329(0.46)	6.631(0.64)	4.105(1.01)
LAB_INT_{it}	266.073(5.32)***	260.494(5.18)***	-2,844.2(-1.91)**	-2,074.4(-1.94)**
CAP_INT_{it}	0.021(2.64)**	0.017(2.37)**	-1.099(-2.78)**	-1.115(-3.39)***
$VOLATILITY_{it}$	0.013(2.63)**	0.014(2.56)**	0.487(2.10)**	0.459(1.90)**
$LABOR\_COMP_{it}$	0.000(0.58)	0.000(1.09)	-0.000(-1.13)	-0.001(-1.02)
$EXEC\_COMP_{it}$	0.014(17.35)***	0.014(13.65)***	0.019(1.20)	0.018(1.18)
$STOCKHELD_{it}$	0.087(1.62)*	0.085(1.60)*	-0.855(-1.59)*	-0.335(-1.48)*
$INDEPDIR_{it}$	0.051(2.81)**	0.040(2.84)**	0.382(1.60)*	0.392(1.60)*
$BOARDSIZE_{it}$	-0.030(-6.71)***	-0.027(-4.82)***	-0.232(-0.56)	-0.276(-0.64)
Adjusted R^2	0.381	0.392	0.320	0.335

See Table 7 for variable definitions. The coefficients are estimated based on the mean of the 7 yearly coefficients from 2000 to 2006. The coefficient estimates are based on Fama-MacBeth method with Newey-West adjustment. t-values are in parentheses. *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels respectively (one tailed).

This study runs additional analyses with alternate dependent variables using stock returns, a commonly employed dependent variable that captures how the market values a firm (Bharadwaj et al. 1999). The impact of intangible assets, such as R&D capital, on a firm's market valuation has drawn researchers' attention (Chan et al. 2001; Matolcsy and Wyatt 2008). In an efficient market, the stock performance should impound the values of R&D investment and education. Generally speaking, firms usually invest in R&D and workforce consistently over multiple years. Information about a firm's R&D and workforce investments is easily obtained because firms usually disclose this information in their annual reports. Therefore, if the market is efficient, there should be no association between these two capitals and future stock returns (Chan et al. 2001).

However, investors intend to have shorter time horizons, which may result in their failure to appreciate the rewards from long term investments such as R&D (Chan et al. 2001; Porter 1992). The results in Table 13 show that the coefficients of GRADUATES and RND_INT are both negative and significant (-0.527 and -0.557, respectively). Heavy investments in R&D or in retention of a skilled workforce suggest that managers are relatively optimistic about their firms' prospects. However, the market tends to discount these kinds of messages and it appears to be conservative in revising its expectations. The negative results are consistent with this notion. The results also show that the two interaction terms, GRADUATES*RND_INT and UNDERGRADS*RND_INT, are both positive and significant. The results here imply that the market does not appreciate the complementary relationship between R&D and education efficiently until the synergies of a combined R&D effort and skilled workforce are realized and reflected by firm profitability, such as better performance resulting from the successful launch of a new product or service. The negative and significant coefficient of R&D intensity in the last column of Table 13 suggests that firms that invest in R&D but do not emphasize attracting skilled employees will experience negative stock returns. [18]

Table 13. Impact of Workforce Education on Market Return

VARIABLES	RET_{it}	
Constant	0.092(6.17)***	0.077(6.69)***
$GRADUATES_{it}$	-0.527(-6.17)***	-0.536(-1.04)
$UNDERGRAD_{it}$	-0.116(-0.74)	0.026(0.15)
RND_INT_{it}	-0.557(-1.85)**	-1.598(-6.19)***
$GRADUATES_{it}*RND\_INT_{it}$		9.878(7.21)***
$UNDERGRAD_{it}*RND\_INT_{it}$		9.169(9.06)***
ADV_INT_{it}	-1.183(-0.39)	1.142(0.05)
LAB_INT_{it}	208.810(0.33)	235.371(1.59)*
CAP_INT_{it}	0.020(0.63)	0.028(0.91)
$VOLATILITY_{it}$	-0.252(-3.37)***	-0.257(-3.31)***
$LABOR\_COMP_{it}$	0.000(1.16)	0.000(1.03)
$EXEC\_COMP_{it}$	0.019(1.18)	0.017(1.10)
$STOCKHELD_{it}$	2.144(2.79)**	2.203(2.62)**
$INDEPDIR_{it}$	0.040(0.30)	0.019(0.20)
$BOARDSIZE_{it}$	-0.492(-4.42)***	-0.516(-4.95)***
Adjusted R^2	0.152	0.169

Note: See Table 7 for variable definitions. The coefficients are based on the mean of the 7 yearly coefficients from 2000 to 2006. The coefficient estimates are based on Fama-MacBeth method with Newey-West adjustment. t-values are in parentheses. *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels respectively (one tailed).

[18] I also rerun models in Tables 12 and 13 using 2SLS regression models and fixed effects models to test the stability of the main findings. Overall, I find qualitatively similar results as the reported ones in Tables 12 and 13.

Table 9 shows that the coefficient of LABOR_COMP is not significant, whereas the coefficient of EXEC_COMP is positive and significant. This implies that compensation of top executives plays a significant role in firm performance whereas compensation of the rest of the employees does not. Could it be that the highly significant coefficient of EXEC_COMP is due to simultaneity in the model, where firm performance and executive compensation both depend on each other, as has been shown in previous research (Anderson et al. 2000)? To address this concern, the study estimates a simultaneous equations model with both ROA and EXEC_COMP as dependent variables using three stage least squares. The results in Table 14 show that EXEC_COMP is no longer significant in this specification. The main results on the relationship between education, R&D and firm performance remain qualitatively the same. It is interesting to note, however, that the coefficients of education variables on executive compensation are negative. This suggests that firms whose employees have higher levels of education might pay lower compensation to their executives. A possible explanation is that higher workforce education reduces information-processing demands for the executives which in turn mitigates a firm's motivation to pay its executives higher compensation (Henderson and Fredrickson 1996).

Table 14. Impact of Workforce Education on Profitability: Simultaneous Equations Model

VARIABLES	ROA_{it}	$EXEC\_COMP_{it}$
Intercept	-0.015(-3.71)***	0.095(1.06)
$GRADUATES_{it}$	0.095(3.59)***	-0.248(-0.53)
$UNDERGRADS_{it}$	0.024(1.40)*	-1.168(-5.22)***
RND_INT_{it}	-0.033(-0.36)	
$GRADUATES_{it}*RND\_INT_{it}$	0.637(1.81)**	
$UNDERGRADS_{it}*RND\_INT_{it}$	0.624(1.42)*	
ADV_INT_{it}	0.970(2.30)**	
LAB_INT_{it}	6.613(0.24)	
CAP_INT_{it}	0.003(0.40)	
$VOLATILITY_{it}$	0.019(4.41)***	
$LABOR\_COMP_{it}$	-0.000(-1.16)	
$EXEC\_COMP_{it}$	-0.007(-0.31)	
$STOCKHELD_{it}$	0.209(6.46)***	0.820(0.88)
$INDEPDIR_{it}$	0.049(3.93)***	-0.212(-0.75)
$BOARDSIZE_{it}$	-0.019(-1.73)**	0.298(1.43)*
ROA_{it}		6.984(1.92)**
$TURNOVER_{it}$		-0.107(-1.17)
$FIRMSIZE_{it}$		0.582(18.91)***
Adjusted R^2	0.194	0.443

See Table 7 for variable definitions. t-values are in parentheses. *, **, and *** indicate statistical significance at 10%, 5%, and 1% levels respectively (one tailed).

3.5 Conclusion

This study investigates the impact of level of workforce education on firm performance, in particular addressing the issue of the complementary relationship between different levels of education and R&D investments in IT industries. This is an interesting area because, while the role of education and R&D has been studied in prior literature, there has been little research on how education moderates the relationship between R&D and firm performance. Moreover, while prior research associates human capital with innovativeness, absorptive capacity and other positive outcomes, there are very few studies that look at the impact of human capital on the overall profitability of a firm, in particular considering the potential strategic contributions of interdependence between human capital and R&D capital. This study addresses the issue by examining the impact of different levels of education separately.

The issue is especially relevant for IT industries because prior research in IT establishes that higher levels of education and experience are associated with higher compensation for IT professionals. This study shows that higher levels of education leads to higher returns for firms, suggesting that the benefits of having employees with higher levels of education outweighs the associated costs for firms in the sample. This study also compares the incremental benefit of different levels of education.

Consistent with previous research, this study finds that R&D intensity has a positive impact on firm performance. Firms operating in a highly competitive business environment, particularly IT firms, usually focus on R&D investments to increase their innovation ability and sustain their competitive advantage. Examination of the interactive relationship between R&D and level of employee education supports IT firms' investment in educated employees for innovation related jobs. The study shows that the moderating impact of education on the relationship between R&D and firm performance increases with higher education levels. Because R&D is one of the main factors influencing the success of innovation, firms need a high quality workforce to focus on the R&D process. Since a more highly educated workforce is viewed as having a greater ability to learn, a highly educated workforce will contribute more to increase the value of R&D outcomes. Therefore, firms are in a better position to leverage their R&D investments for higher profits if a higher percent of their employees have higher levels of education.

The study employs the DuPont analysis to examine the impact of level of workforce education on firm performance, considering firm pursues different business strategies. Firms adopting a differentiation strategy expect to command higher price by providing higher customer value which in turn reflects on the firm's profit margin ratio. The results show that the moderating impact of level of education on the relationship between R&D and profit margin is significant at higher education levels. However, there are no complementarities between level of education and R&D when firms adopt a cost leadership strategy (proxied by asset turnover ratio). This implies that R&D and level of education reinforce IT firms' differentiation strategies since their impact on ROA stems from profit margin.

In addition, the study shows that the stock market is inefficient in recognizing the complementary relationship between level of employee education and R&D. If the market recognized this interdependent relationship efficiently, there should be no surprise change because information about a firm's workforce and R&D investments are easily obtained. An efficient market should be able to incorporate the values of intangible capital such as R&D and skilled workforce appropriately. On one hand, due to the characteristics of R&D investment, such as high uncertainty and long waiting periods of rewards, or the implicit effect of a more highly educated workforce on firm performance, the stock market tends to underestimate the benefits of these two types of intangible capital. On the other hand, investors might overestimate the information about firms' intangible capital. Many IT firms that put intensive efforts in marketing their brands might make investors overly optimistic about the firm's future. The results show that although the market appreciates the main effects of R&D and level of workforce education, it does not capture the complementarities between education and R&D efficiently. Therefore, the market does not appropriately value firms that invest heavily in R&D and a skilled workforce until the complementary relationship between these two important drivers of innovation is reflected in a firm's financial performance.

The analyses also suggest that executive compensation is negatively related to level of education, suggesting that firms whose employees have higher levels of education pay less compensation to their top executives. Since executive compensation is not a main focus in this paper, future research can explore this interesting finding in more details. Future research can also look at how the use of information technology creates opportunities for firms to leverage the complementarities between R&D and human capital.

In summary, this study contributes to the human capital literature by examining the impact of two sources of firm value, human capital and R&D capital, in particular the complementarities between human and R&D capital in IT firms. The expansion of knowledge-intensive industries in today’s knowledge-based economy calls for a holistic view of the strategic contributions of the two sources together. This work examines human capital at multiple levels of employee education, and compares the moderating impact of different levels of education on the relationship between R&D and firm profitability. Finally, this study provides empirical evidence suggesting that investments in R&D and human capital reinforce a firm’s differentiation strategy.

CHAPTER 4

EVALUATING VALUE OF CHIEF AUDIT EXECUTIVE TURNOVER IN PUBLIC COMPANIES

4.1. Introduction

Increased emphasis on establishing a qualified internal control framework within organizations has significantly raised the demand for internal audit function (IAF) (Pforsich et al. 2006). Over the years, the internal audit function has evolved by increasingly expanding its role to focus on adding value to the organization (Ahlawat and Lowe 2004). The Chief Audit Executive (CAE) is the primary person in charge of the effectiveness of the internal audit function. In light of increased regulatory pressure on internal control disclosures, heightened competition, and complex industry dynamics, CAE is in a unique position to apply his/her professional and institutional knowledge and seek ways to exert greater influence over firm strategies for adding value within the organizational structure (Grant Thornton 2013).[19] Despite claims that the CAE adds value to a firm by evaluating internal control practices and risk management, the role and value of the CAE position is unclear and not fully documented in the governance literature. To shed light on the value of the CAE within organizational governance structure, this study explores: (1) the relationships between CAE turnover, executive turnover (including Chief Executive Officer [CEO] and Chief Financial Officer [CFO])

[19] Two major events stimulated the increased importance of internal auditing services: (1) Section 404 of the Sarbanes-Oxley Act (SOX) which mandated public companies to include an internal control report in their annual reports for assessing the effectiveness of the company's financial reporting internal control system, and (2) the New York Stock Exchange, in 2004, mandated all public companies to maintain an internal audit function for continuous assessments of a firm's risk management and internal control practices (Pforsich et al. 2006). Similarly, the NASDAQ Stock Market LLC in 2013 also proposes to require public companies maintain an internal audit function, see http://www.sec.gov/rules/sro/nasdaq/2013/34-69030.pdf.

and financial restatements; (2) its impact on firm performance; and (3) how the above relationships change in the period when a new governance law is passed for enhancing the quality of internal control disclosures.

The corporate governance literature has long acknowledged the internal audit function as a potentially valuable resource in the financial reporting process (Bailey at al. 2003; Cohen et al. 2004; Gramling et al. 2004; PCAOB 2007). Internal auditors play an important role in organizational governance by performing internal control assessment and evaluating enterprise risk (Bloom et al. 2009; IIA 2003)[20]. The importance of internal audit as a corporate monitoring function has also been recognized in the governance literature (Pei and Davis 1989). Higher quality of internal audit is expected to contribute to the increase of the effectiveness of internal control systems.

The CAE is in charge of the overall quality of IAFs and, therefore, bears ultimate responsibility for the effectiveness of the internal monitoring process. The CAE is, therefore, in a unique position to provide advisory services by working closely with the audit committee and top management team (Bloom et al. 2009). While the issue of CEO/CFO turnover has been studied at length, the importance of CAE turnover has been underappreciated in current literature despite the rise of internal control issues within corporate governance. Given that the IAF is increasingly regarded as a key internal monitoring process in corporate governance, there is also surprisingly little research on the impact of the CAE on firm value creation. This issue is of particular concern as the recent raise of the importance of the IAF in corporate governance research. The objective of this study is to shed light on the CAE issues by analyzing whether CAE turnover

[20] With the profound changes brought by SOX, the prominence of internal audit has gained its importance within the organization (McCann 2008).

correlates with management turnover (e.g., CEO and CFO) and whether CAE turnover can be utilized as a signal of firm performance.

To explore the role of the CAE and its impact on firm performance, this study investigates (1) the associations between CAE turnover, CEO and CFO turnover, and financial restatement; (2) the impact of CAE turnover on firm performance including profitability and market return; and (3) whether and how the mandatory regulation relating to improve the quality of internal control systems affects the aforementioned relationships. Firm-level governance and operational data are collected from Taiwanese public companies to address the above issues.

Despite increased recognition of the internal audit's importance in enhancing internal control quality, internal audit data is still difficult to obtain and often is collected through survey or conducting experiments. These limitations indirectly result in a scarcity of empirical studies examining relevant internal audit issues. This, in turn, leads to an incomplete understanding of the role of the internal audit within corporate governance mechanisms, in particular the role of the CAE and its impact on performance. By collecting and analyzing the governance data from Taiwan, this study investigates the information content of CAE turnover and the impact of enforced governance law on the relationship between CAE turnover and a firm's performance.

The results of this study show that CAE turnover is positively associated with CEO and CFO turnover and financial restatement. The study also suggests that poor firm performance causes a change of management or the issuing of a restatement. This, in turn, increases the possibility of CAE turnover because of a failure to monitor business operations through internal controls. These findings are consistent with previous research that shows a positive relationship between CEO and CFO turnover, financial restatements, and inferior firm performance. Financial restatements are the result of a poor financial reporting process while CEO and CFO turnover are the result of poor financial performance caused by ineffective internal control mechanisms. As the person who monitors the effectiveness of IAF, the CAE is responsible for failures in monitoring internal control and financial reporting process.

This study shows that CAE turnover has a significant negative correlation with profitability and market return. A failure to monitor internal control contributes to ineffective business operations and poor profitability. CAE turnover is found to have a long term negative impact on firm profitability. The CAE supervises the quality of the IAF and usually has more insights into and comprehensive understanding of a firm's operational processes and relevant risks. The existence of weak internal controls that indirectly cause poor performance increases the possibility of CAE turnover. In addition, replacing the CAE makes it more difficult to manage enterprise risk and internal control consistently, which in turn may prolong the negative impact of weak internal control on performance. The significant negative association between CAE turnover and market return provide evidence that CAE turnover can signal poor operational performance due to weak internal controls or risks. This suggests that CAE turnover can be employed as an indicator of poor performance. The negative perception of firm performance because of CAE turnover is found to be persistent over time.

Finally, this study examines the impact of Taiwan's enforced governance law on the above relationships. The law emphasizes increased internal control quality, and increases and tightens the monitoring and managing responsibilities of responsible management members. The results show that the positive associations between CAE turnover, CEO and CFO turnover, and restatements became stronger after the new governance law was enacted in 2002. The negative impact of CAE turnover on firm performance is also stronger in the post-law period. The results suggest that, with the enforcement of governance law on internal control practices, the importance of IAF has increased and therefore increases the responsibility and importance of the CAE's role and its impact on firm performance.

This study contributes to the growing stream of literature investigating the role of the IAF within corporate governance. It is of particular significance for several reasons. This is the first empirical study that explores the relationships between CAE turnover, CEO/CFO turnover, financial restatements, and firm performance. This study provides empirical evidence supporting the signaling ability of CAE turnover and how it is perceived by investors. The study also explores the effect of the Taiwan's enforced governance law on the relationship between CAE turnover, CEO/CFO turnover, restatements, and firm performance. This study helps fill a significant gap in the governance literature regarding the influence of internal audit on the quality of the financial reporting process, the effectiveness of internal governance mechanisms, and the regulatory influence on corporate governance practices.

The remainder of the paper is structured as follows: Section 4.2 reviews related literature and develops the hypotheses; Section 4.3 describes the research methods, including model specification, variable measurement, and sample; Section 4.4 presents the results and relevant explanations; Section 4.5 summarizes the findings and implications.

4.2. Literature Review and Hypotheses Development

4.2.1 Internal Audit and Corporate Governance

In the wake of corporate failures in the recent decade, regulators implemented many reforms (e.g. the U.S. enacted the Sarbanes-Oxley Act [SOX] in 2002) that recognize the importance of enhancing corporate governance mechanisms (Cohen et al. 2004; Gramling et al. 2004).[21] Previous research documents the role of internal audit in improving the quality of corporate governance (Bloom et al. 2009). For instance, internal audit has an impact on risk assessments, internal control evaluations, and financial statement evaluations (Beasley et al. 2000; Gramling et al. 2004; Lin et al. 2011; Prawitt et al. 2009). As such, the importance of internal audit has been elevated within organizational structures because of the enactment of SOX (Bloom et al. 2009). Managers' increased responsibility for internal control over financial reporting (ICFR) under Section 404 of SOX increases the importance of internal auditors since they assist the management team in the production of adequate internal control reports that comply with mandated reporting requirements (Gramling 2004; Lin et al. 2011).

Section 404 of SOX also requires that external auditor attest to, and report on, the internal control assessment report made by the management team.[22] Companies benefit from Section 404 compliance through increased quality of internal control structure and financial reporting, as well as preventing and detecting fraud (SEC 2009).[23] The compliance costs, however, are high (SEC 2009). To help alleviate these costs, as stated

[21] Schneider et al. (2009) provides a review of literature on internal control reporting issue under the influence of SOX enactment.
[22] Details of SOX section 404 is documented at the U.S. Government Printing Office website. Available at: http://www.gpo.gov/fdsys/pkg/PLAW-107publ204/pdf/PLAW-107publ204.pdf.
[23] ICFR disclosures required by Section 404 also have been found to be beneficial to financial statement users. Financial statement users believed that, through Section 404 compliance, managers understand financial reporting risks better, and are able to address internal control weakness in a timely manner (SEC 2009).

in Auditing Standard (AS) No.5, external auditors could use the work performed by or receive the assistance from, internal auditors.[24] In response to SOX requirements regarding the quality of internal control reporting, the Institute of Internal Auditors (IIA) issued a statement saying that the IAF should examine and evaluate the adequacy and effectiveness of an organization's internal control system (IIA 2003). To reduce the likelihood of misstatements and harmful internal controls, firm managers need to improve the quality of their internal control structures. Due to the expectations for maintaining adequate internal control practices, use of internal audit is considered an effective way to achieve this objective (Abbott et al. 2010; Ge and McVay 2005; IIA 2002).

The audit committee's role is also critical to the governance of the organization through its oversight of the financial reporting process. Previous research has shown that audit committees that review internal auditors' control programs and results are more likely to be perceived as knowledgeable about a firm's accounting and auditing issues (Raghunandan et al. 1998). Providing internal audit oversight, one of the important roles the audit committee plays within an organization, provides effective monitoring and contributes to value creation. Audit committees commonly rely on the quality of the IAF, in the hopes of reducing the possibility of financial misstatement and fraudulent financial reporting (Raghunandan et al. 2001).

The importance of internal audit can also be seen in external auditing practices.[25] Sections 302 and 404 of SOX imply an expanded role for ICFR for the IAF within the design of corporate governance. Statements on Auditing Standards (SAS) No.65, for example, instructs external auditors of public (private) companies to evaluate the work of

[24] The details of Auditing Standard No. 5 can be reviewed at: http://pcaobus.org/standards/auditing/pages/auditing_standard_5.aspx.
[25] Bame-Aldred et al. (2013) summarizes research on external auditor reliance on the internal audit function.

the internal auditor when conducting financial statement audits. Under SAS No.65, external auditors are allowed to (1) use internal auditors as direct assistants when performing the external audit and (2) use work previously performed by the internal auditors. AS No. 5 specifically allows external auditors to rely on the work of internal auditors while performing a financial statement audit to the extent that the internal auditors are competent, objective, and perform work that is relevant to the external audit (PCAOB 2007). Margheim (1986) found that external auditors can reduce their audit hours if the internal auditors have a high level of competence-work performance. Other research documents the financial benefits of relying on internal auditors' work (Felix et al. 2001). That is, external auditors can decrease their fees if they rely on the work of internal auditors (Prawitt et al. 2009).

In addition to the monitoring role, internal auditors are expected to provide management with independent and objective assurance that the organization's internal control system is effective and efficient (IIA 1999).Internal auditors evaluate the organization's internal control system and recommend improvement plans to minimize the internal control weaknesses. This process leads to more effective and efficient business performance. Internal auditors, therefore, not only enhance the organization's internal control system but add value by improving operation performance.

Some question the internal auditor's ability to be independent since they are hired by firms (DeZoort et al. 2001; Messier et al. 2011). Pei and Davis (1989) found that without appropriate organizational structure, both organizational-professional conflict and role stress can cause higher internal auditor turnover and lower job satisfaction. Ideally, internal auditors should report directly to the audit committee; however they often report to management as well (James 2003). The dual reporting roles can hamper the quality of internal control because of a lack of independence[26]. Given the issues regarding independence of internal auditors and the lack of empirical research on internal auditor turnover, it is worth investigating the role of internal auditors and their relationship to firm performance.

Internal auditors are increasingly recognized for their valuable roles as internal, full-time monitors of their organizations (PCAOB 2007). Internal auditing is generally expected to have a positive influence on the corporate governance mechanism by improving both the quality of financial reporting and firm performance (Gramling et al. 2004). While management bears the ultimate responsibility for the quality of the internal control structure, direct control monitoring and risk assessment are usually performed by IAF. Internal auditors must have broad operational skills in both assurance and consulting functions that address risks and evaluate the efficiency of business operations in order to meet management's strategic and operational needs. In addition, the audit committee is more interested in assuring the effectiveness of controls, which requires that internal auditors be equipped with significantly different functions and skill sets (Hermanson and Rittenberg 2003).

Prior research suggests that internal auditing is a critical component of high quality corporate governance and serves to mitigate earnings management (Prawitt et al. 2009), earnings manipulation (Prawitt et al. 2009), fraud (Beasley et al. 2000; Coram et al. 2008), and internal control problems (Krishnamoorthy 2002). Previous research shows

[26] The majority of CAEs in public companies split their duties between audit committees and management. They usually report issues of strategy and functionality to audit committees, however, report their administrative duties to management. The direct report to CFO, for example, has created a potential conflict of internal auditor's independence (Johnson 2006).

that internal auditors improve financial reporting quality by mitigating potential internal control weaknesses within an incentive system (Prawitt et al. 2009). Effective internal auditing is found to be more likely to detect and prevent fraud (Beasley et al. 2000). Lin et al. (2011) showed the positive influence of internal auditor's work in detecting and preventing internal control material weaknesses. There has been relatively little empirical research on the role and the impact of internal auditors in the financial reporting process (Gramling et al. 2004).

4.2.2 The Associations between CAE Turnover, CEO/CFO Turnover, and Restatements

Strategic management literature recognizes the role of top management teams in forming corporate strategy and organizational performance (Hambrick and Mason 1984). Very little research, however, investigates turnover of non-CEO executives in the corporate hierarchy (Fee and Hadlock 2004). These non-CEO executives who are expected to have a significant impact of firm value. To create value, people work as a team by combining their efforts and ability with other individuals in the firm (Hayes et al. 2006). Applying this theory to the associations among top management team, executives work together as a group because the incentives and careers of these managers tend to be affected by each other (Fee and Hadlock 2004). Literature in executive turnover suggests that an executive is evaluated not only on aggregate firm performance but also on individual performance and on to the extent they fit with other management team members (Fee and Hadlock 2004). The theory of complementarity among team members suggests that when a key team member leaves the firm, the probability that the other team members leaves the firm increases (Hayes et al. 2006).

In many organizations, the CAE has a dual reporting structure. That is, the CAE reports functionally to the board and administratively to the CEO and/or CFO (Deloitte 2013). CAE turnover, therefore, should also be taken into consideration in the governance literature that examining the information content of executive turnover. The relationship between CAE turnover and CEO/CFO turnover can be examined by linking the demand for effective internal monitoring and management controls with the quality of the internal control disclosures.

Since the main role of the CAE is to evaluate the effectiveness of internal controls and identify potential operating risks, changing CEO or CFO due to operational failure can increase the possibility of CAE turnover. The rationale behind such prediction is that, since the CAE monitors internal control systems, the CAE can be blamed for insufficient monitoring of internal control systems or evaluation of business risks that can compromise firm performance. Poor firm performance resulting from the failure of internal control systems will not only lead to the replacement of CEO or CFO, but also increase the possibility of replacing the CAE. Previous research finds that the non-CEO executive turnover rate is higher in periods around the change of CEO (Fee and Hadlock 2004; Hayes et al. 2006). The positive correlation between CAE turnover and CEO/CFO turnover is expected to increase due to the implementation of a new governance law aimed at improving the quality of corporate governance mechanisms.

Financial reporting problems (e.g. restatements) might, to some extent, cause extensive damage to a firm’s financial reporting credibility or imply that the firm faces a greater financial reporting risk (Carcello et al. 2005; Chen et al. 2013). The increasing trend in the number of restatements has drawn attention from related parties such as regulators and investors with respect to the quality of financial statements (Romanus et al. 2008; Wilson 2008). Prior research indicates that restating firms have a higher possibility of poor performance and declines in market value upon the announcement of the restatement when compared to non-restating firms (Collins et al. 2009). Restatements increase the possibility of management turnover (Burks 2010; Li et al. 2010). A decision to replace an executive is a way for company to show its effort in restoring credibility (Burks 2010).

Potential internal control weaknesses could also lead to restatements (Linn and Diehl 2005). Weak internal control results in decreased financial reporting quality and increases the possibility of fraudulent reporting. Since the CAE is responsible for providing corporate boards and management the evaluations of internal control system's effectiveness over the financial reporting process, CAE turnover is expected to be positively associated with the issue of financial restatements. If the enactment of a governance law is designed to improve the quality of internal control practices thereby improving the quality of financial reporting, the governance law is expected to put more pressure on the monitoring responsibility of top management. Increased mandatory corporate governance disclosure is found to be positively associated with executive turnover (Hermalin and Weisbach 2012). Burks (2010), for example, finds a higher executive turnover in the post-SOX period because corporate boards are under greater pressure in the face of greater scrutiny by the public after the passage of the SOX.

In addition, increased governance disclosure requirements reduce information asymmetry regarding the managerial talent of executives (Wang 2010). Considering executives are often evaluated as a team and the enacted governance law on internal control increases the pressure on the boards, the enactment of governance law on internal control quality should moderate the relationships between indicators that show signs of potential internal control weaknesses or problems. That is, the correlations among CAE turnover, CEO/CFO turnover, and restatement are expected to be stronger after the implementation of the new governance law. Accordingly, the following hypotheses are presented to examine the associations between CAE turnover, CEO and CFO turnover, and restatement:

H4.1a: CEO turnover, CFO turnover and financial restatement are positively associated with CAE turnover, respectively

H4.1b: The positive correlation between CAE turnover, and each of CEO turnover, CFO turnover, and financial restatement will be higher in the post-law period

4.2.3. The Relationship between CAE turnover and Firm Performance

Much of the research in the corporate governance literature examines the relationship between CEO/CFO turnover and firm performance with regard to aligning management's interests with those of the shareholders (Hermalin and Weisbach 2012; Laux 2008; Lee et al. 2012). Overall, the prior research shows that, other things being equal, poor firm performance and earnings restatements are associated with higher CEO and CFO turnover (Collins et al. 2009; Desai et al. 2006; Hennes et al. 2008; Leone and Liu 2010; Menon and Williams 2008; Warner et al. 1988). These results are understandable since top executives are held responsible for the preparation and filing of financial statements and for poor firm performance (Mian 2001). Underpeforming CEOs, for example, are replaced in order to increase corporate value (Denis and Denis 1995; Fee and Hadlock 2004).

Considering the issue of executive turnover across corporate hierarchy, Fee and Hadlock (2004) finds that CEO turnover is more linked to aggregate firm performance while non-CEO executive turnover is sensitive to a firm's stock return performance. They also find that the CEO turnover could cause the departure of non-CEO executives. The CEO is the person who takes ultimate responsibility of firm performance. In addition to replace a new CEO, the corporate board may decide to replace some non-CEOs when they feel the firm's top management team is doing an inadequate job in contributing to firm value. To secure their jobs and reputations, non-CEO executives, as part of management team, have incentives to take actions to help CEO improve firm performance.

To improve firm value, effective internal governance mechanisms are expected to enhance alignment of managers' behaviors with shareholders' interests and remove inefficient managers. Stockholders, therefore, rely on internal and external monitoring mechanisms to help resolve agency problems arising from the separation of ownership and control in modern corporations (Huson et al. 2001; Warner et al. 1988). According to the Institute of Internal Auditors (IIA 1999), "Internal audit is an independent, objective assurance and consulting activity designed to add value and improve an organization's operations. It helps an organization accomplish its objectives by bringing a systematic, disciplined approach to evaluate and improve the effectiveness of risk management, control, and governance processes." Prior research supports this view (Carcello et al. 2005).

More importantly, high quality IAF contributes to increased monitoring and governance transparency thereby reducing the potential bias in management's decision making process (Prawitt et al. 2009). Internal audit and effective monitoring mechanisms have, therefore, become critical factors in effective internal governance. The implementation of SOX section 404 has resulted in firms placing more weight on internal controls related to financial reporting quality (Prawitt et al. 2009). One of the ancillary consequences of SOX is the increase in market demand for internal auditors (Pforsich et al. 2006). Internal auditors now have a greater presence and hold important advisory role in companies.

Since the top management team to some degree will be evaluated as a group and CEO turnover might cause the change of non-CEO executives, the CAE will care, to some extent, for the firm's success. However, the circumstances around a departure are related to an executive's future employment prospects (Fee and Hadlock 2004). An executive may choose to leave the firm voluntarily in order to secure her likelihood of employing at a new firm. Because the CAE is the person who monitors the quality of IAF and provides suggestions and improvement solutions to management, CAE turnover could imply the existence of internal control weaknesses which could result in ineffective internal control and poor firm performance. Ineffective internal control could be severe and persistent over time which affects future performance as well.

In addition, the internal monitoring mechanism might be unstable because of CAE turnover. Change of management entails significant costs and benefits for a company. In general, a newly appointed manager is expected to improve poor performance caused by bad management. On the other hand, firm characteristics should be carefully considered in such managerial decisions. As the firm becomes larger and more diversified in either scope or scale, the construction and implementation of an effective internal control system becomes more complicated since the number and complexity of unknown risks that need to be identified by the internal audit function increases. A newly appointed CAE will need time to become familiar with the firm's operations. The learning curve will be even longer for larger, more complex firms. As a result, CAE turnover is expected to increase the cost of implementing effective internal control monitoring functions.

Taken as a whole, CAE turnover can indicate critical internal control weaknesses which could compromise firm performance. Investors, as a result, often become more conservative. With the enforcement of a new governance law, the role of the CAE is expected to have an increased impact on the effectiveness of internal control over firm operations and the financial reporting process. The negative association between CAE turnover and firm performance is expected to be greater in the post-law period. The hypotheses of the relationships between CAE turnover and firm performance are as follows:

H4.2a: CAE turnover is negatively associated with contemporaneous and lagged firm profitability

H4.2b: The negative impact of CAE turnover on firm profitability is higher in the post-law period

H4.3a: CAE turnover is negatively associated with contemporaneous and lagged firm market return

H4.3b: The negative impact of CAE turnover on firm market return is higher in the post-law period

4.3. Research Design and Data

4.3.1 Empirical Model and Measurement of Variables

The empirical model examined in the study is shown in Figure 5. present the This section presents the empirical model that estimate the relationship between CAE turnover, CEO and CFO turnover, restatements, and firm performance, including accounting return and market return. In particular, an indicator of the passage of the governance law is included in the models to investigate the impact of the law on CAE turnover and firm performance. Finally, the discussion of sample data is included.

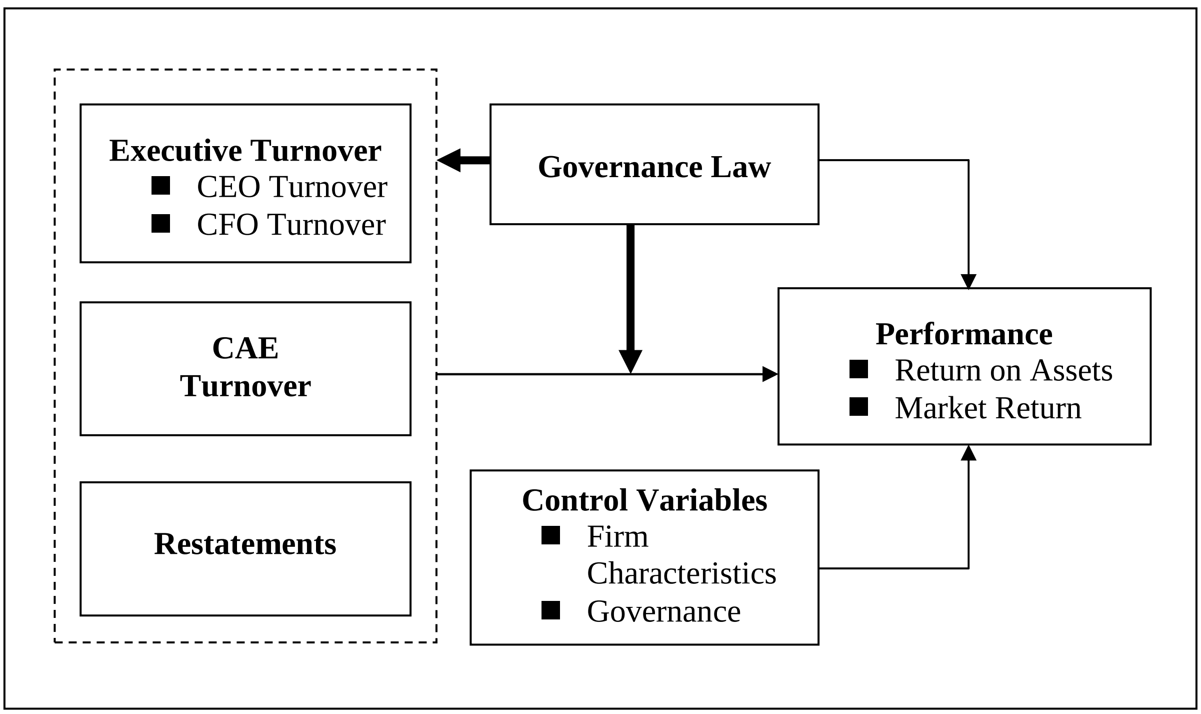

Figure 5. Impact of CAE Turnover on Performance

First, to investigate factors that are expected to influence the possibility of CAE turnover, the following logistic model is employed:

$$
\begin{aligned}
\Delta\, CAE_{it} = {} & \beta_0 + \beta_1 \Delta CEO_{it} + \beta_2 \Delta CFO_{it} + \beta_3 RESTATE_{it} + \beta_4 POST\_LAW_{it} \\
& + \beta_5 POST\_LAW_{it} * \Delta CEO_{it} + \beta_6 POST\_LAW_{it} * \Delta CFO_{it} \\
& + \beta_7 POST\_LAW_{it} * RESTATE_{it} + \beta_8 ROA_{it} + \beta_9 FIRMSIZE_{it} \\
& + \beta_{10} GROWTH_{it} + \beta_{11} LOSS_{it} + \beta_{12} LEVERAGE_{it} + \beta_{13} CEODUAL_{it} \\
& + \beta_{14} MGTSHARE_{it} + \beta_{15} FAMILYCTRL_{it} + \beta_{16} INSTSHARE_{it} \\
& + \beta_{17} BOARDSIZE_{it} + \beta_{18} INDEPDIR_{it} + \varepsilon_{it} \qquad (7)
\end{aligned}
$$

The variable of interest, CAE turnover (ΔCAE), is equal to 1 if a CAE turnover occurs for firm i in year t; the value is 0 if there was no change. Two management turnover variables are measured: CEO turnover (ΔCEO) and CFO turnover (ΔCFO). CEO turnover is equal to 1 if a CEO turnover occurs for firm i in year t and 0 otherwise. CFO turnover is equal to 1 if a CFO turnover occurs for firm i in year t and 0 otherwise. Similarly, a dummy variable is constructed to indicate the issue of financial restatement (RESTATE) for firm i in year t. RESTATE is equal to 1 if firm i issues financial restatement in year t, 0 if it does not. To capture the effect of governance law on the change of CAE, the variable of governance law, POST_LAW, is equal to 1 if year t is after year 2002 when the governance law was passed for mandating firms follow required internal control regulation.

The estimation model also includes control variables that are commonly employed in the corporate governance literature (Carcello et al. 2005; Collins et al. 2009; Dechow et al. 1996; Hennes et al. 2008). Five firm characteristics variables were included: return of assets (ROA), firm size (FIRMSIZE), growth opportunity (GROWTH), indicator of loss (LOSS), and leverage ratio (LEVERAGE). The model also controls management influence and board characteristics variables including CEO duality (CEODUAL), management ownership (MGTSHARE), family ownership (FAMILYCTRL), institutional ownership (INSTSHARE), board size (BOARDSIZE), and percentage of independent directors within board of directors (INDEPDIR).

The following estimation model is constructed to investigate the association between CAE turnover and firm performance while incorporating the impact of CEO and CFO turnover and financial restatement on firm performance. Two dimensions of firm performance are measured: (1) profitability measured by return on assets (ROA) and (2) market return (RET). The estimation model is expressed as follows:

$$\begin{aligned} PERFORMANCE_{it} = {} & \beta_0 + \beta_1\Delta\, CAE_{it} + \beta_2\Delta\, CEO_{it} + \beta_3\Delta\, CFO_{it} + \beta_4 RESTATE_{it} \\ & + \beta_5 POST\_LAW_{it} + \beta_6 POST\_LAW_{it}*\Delta CAE_{it} \\ & + \beta_7 POST\_LAW_{it}*\Delta CEO_{it} + \beta_8\, POST\_LAW_{it}*\Delta CFO_{it} \\ & + \beta_9 POST\_LAW_{it}*RESTATE_{it} + \beta_{10} GROWTH_{it} + \beta_{11} LOSS_{it} \\ & + \beta_{12} LEVERAGE_{it} + \beta_{13} CEODUAL_{it} + \beta_{14} FAMILYCTRL_{it} \\ & + \beta_{15} MGTSHARE_{it} + \beta_{16} INSTSHARE_{it} + \beta_{17} BOARDSIZE_{it} \\ & + \beta_{18} INDEPDIR_{it} + \varepsilon_{it} \end{aligned} \tag{8}$$

Since the sample is panel data, the results of employing ordinary least square regression method may be biased as residuals may be correlated across firms or across time. This study addresses potential autocorrelation problems by calculating two-way clustered standard errors for both estimation models (Gow et al. 2010). Table 15 provides the summary of variable definitions.

Table 15. Variable Definitions for Chapter 4

Dependent Variable	
ΔCAE	= 1 if there is change of Chief Audit Executive(CAE) for firm i at year t
ROA	= the industry-adjusted return on assets (ROA) by first calculating the ratio of operating income to total assets and then subtracting the median industry ROA from the firm ROA
RET	= the market adjusted cumulative stock return over the 12-month period of the firm's fiscal year t lagged 4 months
Principal Explanatory Variables	
ΔCEO	= 1 if there is change of Chief Executive Officer (CEO) in firm i at year t
ΔCFO	= 1 if there is change of Chief Finance Officer (CFO) in firm i at year t
RESTATE	= 1 if firm i issued financial restatement in year t
POST_LAW	= 1 if year i is after year 2002 when the government passed the enforcement of governance law
Control Variables	
SIZE	= logarithm of total assets
LOSS	= 1 if firm i has loss in t-1, 0 otherwise
GROWTH	= growth opportunity , calculated as market value to book value
LEVERAGE	= leverage ratio, calculated as total debts divided by total assets
BOARDSIZE	= board size, measured by total number of board members
INDEPDIR	= % of independent directors
INSTSHARE	= % of ownership of institutional shareholders
MGTSHARE	= % of ownership of management
CEODUAL	= 1 if CEO is chairman of board, 0 otherwise
FAMILYCTRL	= % of family controlled board members

4.3.2 Sample Data

To investigate the impact of CAE turnover on firm performance, this study collects governance and financial data from Taiwanese public companies for the years 1996-2006. Firms disclose data on CEO/CFO turnover, CAE turnover and issues of financial restatements to meet the public expectation of accessing the extent and quality of firm internal governance mechanism.

Increased globalized operations and intense competition as a result of globalization have pushed Taiwanese companies to provide at least the same quality of financial reporting as their global competitors in order to attract and retain investors' confidence. The globalization trend has also encouraged Taiwanese companies to emphasize the effectiveness of their corporate governance by voluntarily disclosing their governance practices. Therefore, the quality of corporate governance has increasingly gained attention from both regulators and researchers in Taiwan. The Taiwanese government plays an important role in the improvement of governance practices. Similar to the enactment of SOX in the United States due to the high-profile corporate failures in 2001-2002, the Taiwanese government implemented a new governance law in 2002 that was designed to enhance the quality of internal control disclosure as well as recognize the valuable role of IAF in providing better internal control monitoring mechanisms. [27]

The Taiwan's 2002 governance law provides specific guidelines requiring public companies to establish an appropriate internal control system. [28] The law mandates public

[27] In June 2002, the Taiwan Securities and Exchange Act added a provision regulating the establishment of internal control systems by public companies. In November 2002, the new governance law was regulated in accordance with the new provision. Before the new governance law was regulated, the Taiwanese government provided guidelines for the establishment of internal control system. The guidelines were repealed after the new governance law was enacted.

[28] The governance law regulates the establishment of public companies' internal control systems, including provisions on the design, implementation, and evaluation of internal control system and internal audit

companies to implement internal audit for assisting corporate boards and managers in: (1) evaluating internal control systems and operational performance, and (2) providing appropriate suggestions for improving the effectiveness of the internal control system. It also mandates that public companies establish an internal audit department that reports directly to the board of directors. The department's size should be based on the size of the firm, business complexity, management needs and other regulations. To maintain the quality of IAF, the law also mandates the requirements for internal auditor's job descriptions, qualifications, continuous trainings, and internal audit planning. The internal auditor's background (e.g. name, age, education, trainings, and experience) must be reported to the authority. CAE appointments and replacements must be approved by the board of directors and reported to the authority. In 2003, the Taiwan Stock Exchange Corporation regulated the announcement of CAE change as listed companies' material information.[29]

The required disclosure of corporate governance mechanisms in Taiwan provides a unique opportunity for investigating CAE turnover, including (1) the association between CAE turnover and indicators of poor firm performance (CEO/CFO turnover and restatements) due to weak internal control systems and (2) whether CAE turnover affects firm performance and valuation. For the estimation of the impact of CAE turnover on firm performance, data of executive turnover is matched with restatement data, as well as financial accounting information. All data is collected from the Taiwan Economic Journal database, firms' annual reports, as well as the Market Observation Post System

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function, external auditors' responsibility of evaluating firm's internal control system, and penalties for violations of mandated regulations. Details can be found on: http://law.moj.gov.tw/Eng/LawClass/LawAll.aspx?PCode=G0400045

[29] The Taiwan Stock Exchange Corporate (TSEC) is a financial institution which operates as a stock exchange in Taiwan.

supervised by the government. The collected sample data is then calculated for all variables employed in the study and missing values are deleted. The final sample consists of 5,426 firm-year observations.[30]

Figure 6 presents the trend of CAE turnover, CEO/CFO turnover, and financial restatements between 1996 and 2006.[31] CAE turnover fluctuates significantly between 2003 and 2004 most likely due to the enactment of the 2002 new governance law. Descriptive statistics of the variables are reported in Table 16. The average CAE turnover is 0.159 in the post-law period, compared to 0.024 in the pre-law period. This is consistent with the expectation that, due to the implementation of the new governance law, the increased regulatory pressure on internal control quality increases corporate boards' emphasis on internal audit and indirectly increases the possibility of CAE turnover. Sample means for CEO and CFO turnover are 0.115 and 0.124 respectively in the post-law period, compared to 0.164 and 0.217 in the pre-law period. The number of financial restatements is, on average, 0.059 in the post-law period and 0.106 in the pre-law period. Decreases in the change of CAE, CEO and CFO, as well as number of issued restatements, suggest that the enforcement of governance law has a positive impact on enforcing the quality and stability of governance of the sample firms.

[30] The initial list of firms with financial information data included total 20,686 firm-year observations. I then match financial data with firms' corporate governance data including disclosed executive turnover data. After excluding missing data, there are total 5,426 firm-year observations included in the sample.
[31] The Asia financial crisis beginning in 1997 could indirectly contribute to the relatively high CFO turnover and restatements around that period.

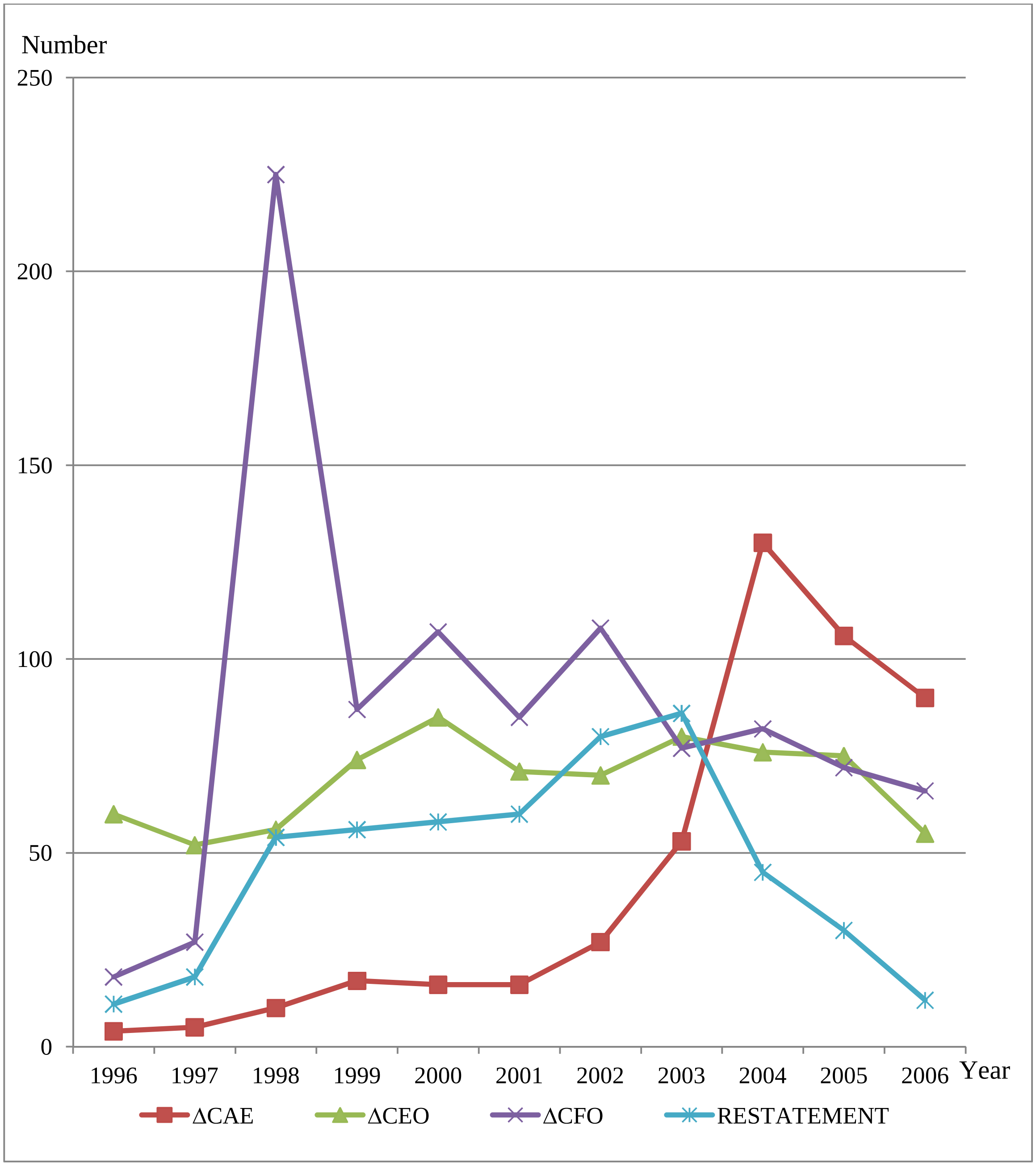

Figure 6. Trend of CAE Turnover, CEO/CFO Turnover, and Restatement

Table 16. Descriptive Statistics of Variables for Chapter 4

VARIABLES	Pre-Law Period (1996-2001) Mean	Post-Law Period (2003-2006) Mean	Mean Difference	P-value
ΔCEO	0.164	0.115	-0.049	<.0001
ΔCFO	0.217	0.124	-0.093	<.0001
ΔCAE	0.024	0.159	0.135	<.0001
RESTATE	0.106	0.059	-0.047	<.0001
ROA	0.045	0.053	0.007	<.0001
RET	0.056	0.226	0.235	<.0001
SIZE	15.588	15.674	0.086	0.0487
LOSS	0.160	0.198	0.038	0.1278
GROWTH	2.032	1.673	-0.359	<.0001
LEVERAGE	0.081	0.085	0.004	0.1159
BOARDSIZE	2.211	2.230	0.019	<.0001
INDEPDIR	0.001	0.107	0.106	<.0001
INSTSHARE	0.358	0.382	0.024	0.0207
MGTSHARE	0.014	0.013	-0.001	<.0001
CEODUAL	0.255	0.292	0.037	0.0750
FAMILYCTRL	0.238	0.225	-0.013	0.2440

Note: See Table 15 for variable definitions. T-tests are used to test differences in the pre- and post-law mean.

CEO and CFO turnover rates are slightly less than those found in prior research (e.g. 0.183 and 0.247 in Hennes et al. 2008). This could be explained by the fact that many Taiwanese firms are family controlled firms and executives usually have controlling power which may reduce executive turnover due to poor firm performance. In Table 17, the results of the Pearson correlation test show the associations between CAE, CEO/CFO turnover, and restatements. As expected, there are significant positive correlations between CAE turnover, CEO and CFO turnover, and restatements. The results suggest that both CEO and CFO turnover increase the possibility of CAE turnover. Since the CEO and CFO are often held responsible for operating or financial failure and the CAE usually works closely with these two executives with regard to internal control and risk assessment, changing either one of these two executives more likely leads to a change of CAE. On average, CAE turnover has a stronger correlation with CFO turnover, probably because weak internal control reflected in poor financial results will be more directly linked to the performance of the CFO. Similarly, there is a positive association between CAE turnover and financial restatements, suggesting that a failure to monitor the financial reporting process will increase the likelihood of CAE turnover.

The results further show that the correlations between CAE turnover, CEO/CFO turnover, and restatements are stronger in the post-law period. Under the governance law, weak internal control systems are expected to cause higher CAE turnover. Governance literature has documented that executive turnover (CEO and CFO) and restatements often indicate the existence of financial or operating problems. As increased emphasis on the quality of financial reporting mandated in the post-law period, the correlation between CFO turnover and CAE turnover is much higher. Evidence of higher correlations between CAE turnover, CEO/CFO turnover and restatements in the post law period suggests that CAE turnover can be used an indicator of potential business failure due to ineffective internal control mechanism or risk management.

Table 17. Correlations between CAE Turnover, Executive Turnover, and Restatement

VARIABLES	ΔCAE	
	Pre-Law Period 1996-2001	Post-Law Period 2003-2006
ΔCEO	0.002***	0.105***
ΔCFO	0.021***	0.128***
RESTATE	0.041**	0.053**

Note: See Table 15 for variable definitions. The association between each pair is estimated using the Pearson correlation analysis.

4.4. Empirical Results and Discussions

To gain a comprehensive understanding of the relationships between CAE turnover, CEO/CFO turnover and restatement, a logistic model is constructed to examine the driving forces that contribute to an increase in CAE turnover. All continuous variables employed in the models are winsorized at 1 and 99 percentage levels for mitigating the influence of outliers. Table 18 reports regression estimates for the logistic model and documents the influence of CEO and CFO turnover and restatement on CAE turnover. The results in Table 18 show that both CEO/CFO turnover and restatement are positively associated with CAE turnover in the current period, providing support for hypothesis H4.1a. The positive impacts of CEO and CFO turnover on CAE turnover continue to be significant in year t+1. The results can be explained in two ways. First, a failure of the internal control system leading to poor management and/or decision making can indirectly cause inferior financial performance which then results in a change of CEO or CFO. Because the main responsibility of the CAE is to directly monitor the effectiveness of internal control, assist management in recognizing and evaluating potential risks, and monitor financial reporting process, poor firm performance caused by poor internal control systems can be traced back to CAE performance. Second, incompetent management of a firm which results in poor firm performance increases the need for enhancing the quality of internal control systems and a more qualified CAE. As a result, the demand for increased quality of internal control systems will increase the occurrence of CAE turnover. In particular, the desire of hiring a better CAE to perform better monitoring function for firms will continue over periods.

The results in Table 18 further show that the positive associations between CAE turnover, CEO/CFO turnover, and restatement are stronger in the post-law period, supporting hypothesis H4.1b. The enactment of the governance law is positively associated with CAE turnover. The results are consistent with the expectation that the desire to improve the quality of internal governance is higher because of the passage of the new governance law. The CEO and CFO are not the only ones that will be blamed for the problems or failure of internal control systems. The CAE will also bear the responsibility for the failure of the monitoring function since the CAE is in a unique position that can monitor and assess organization’s internal control system closely and directly. Therefore, in the post law period, a change in CEO or CFO increases the likelihood of a change in CAE in order to improve the IAF. Similarly, the new law also moderates the impact of restatement on CAE turnover, implying there is increased chance of CAE turnover because of the undesired restatement outcome under high expectation of internal control quality.

Table 18. Impact of Executive Turnover and Restatement on CAE Turnover

VARIABLES	ΔCAE_{it}	ΔCAE_{it+1}
	Coefficient	Coefficient
Intercept	-2.5275 (11.299)***	-4.239(20.954)***
ΔCEO$_{it}$	0.371(7.759)***	0.358(14.484)***
ΔCFO$_{it}$	0.442(13.276)***	0.416(29.708)***
RESTATE$_{it}$	0.251(1.653)*	0.153(0.551)
POST_LAW$_{it}$	0.542(3.241)**	0.403(5.669)***
POST _LAW$_{it}$*ΔCEO$_{it}$	0.265(2.445)*	0.234(2.881)**
POST_LAW$_{it}$*ΔCFO$_{it}$	0.295(14.689)***	0.288(12.496)***
POST_LAW$_{it}$*RESTATE$_{it}$	0.132(1.999)*	0.103(1.653)*
ROA$_{it}$	0.140(0.072)	0.117(0.065)
FIRMSIZE$_{it}$	0.005(0.009)	0.025(0.234)
GROWTH$_{it}$	0.017(0.238)	0.070(4.702)**
LOSS$_{it}$	0.500(5.078)**	0.306(5.078)**
LEVERAGE$_{it}$	0.831(2.435)*	0.847(2.435)*
CEODUAL$_{it}$	-0.013(0.911)	-0.082(0.470)
MGTSHARE$_{it}$	-1.513(0.523)	-2.318(1.154)
FAMILYCTRL$_{it}$	0.150(0.290)	0.264(0.811)
INSTSHARE$_{it}$	0.151(0.346)	0.191(0.511)
BOARDSIZE$_{it}$	0.118(0.490)	0.065(0.111)
INDEPDIR$_{it}$	2.635(46.917)***	2.740(27.513)***
Pseudo R^2	0.182	0.197
Wald	<.0001	<.0001

Note: See Table 15 for variable definitions. The coefficient estimates are based on firm-year clustered standard errors. Z-statistics are in parentheses. *, **, ***, indicate statistical significance at 10%, 5%, and 1% levels respectively (one tailed).

Next, this study examines the association between CAE turnover and firm performance to explore the value of CAE turnover. Table 19 shows the relationship between CAE turnover and firm performance using accounting measure, ROA, as the proxy. Consistent with prior literature, CEO/CFO turnover and restatement are negatively associated with contemporaneous and future performance. The coefficients of CAE turnover on firm performance are significantly negative in year t and t+1, which provide support for hypothesis H4.2a. This is consistent with the notion that, given the CAE's monitoring responsibility, weak internal control systems that lead to CAE turnover have a subsequent negative impact on firm performance.

In addition, the significant positive coefficient of POST_LAW in Table 19 shows that the governance law designed to improve firm's internal control system contributes to the improvement of firm performance. The significant negative interactions, POST_LAW*ΔCAE, in Table 19, indicate that the passage of governance law moderates the negative impact of CAE turnover on firm performance, which provide support for hypothesis H4.2b. That is, the negative impact of CAE turnover on performance is higher in the post-law period because of the increased emphasis on establishing effective internal control. The negative interaction diminishes over time.

Taken together, a qualified CAE is expected to provide effective internal control monitoring and risk management which can indirectly contribute to firm value. Replacement of the CAE implicitly suggests an ineffective or weak internal control system which could directly affect current firm performance and/or indirectly influence performance in the subsequent period. Replacing the CAE also affects the stability of internal control monitoring mechanisms because of the learning curve. A newly appointed CAE needs time to become familiar with a firm's operations, particularly in larger, more complex firms. It might take time to realize the value of appointing a new CAE.

Table 19. Impact of CAE Turnover on Profitability

VARIABLES	ROA_{it}	ROA_{it+1}
Intercept	0.111(5.81)***	0.069(3.26)***
ΔCAE_{it}	-0.006(-2.81)***	-0.003(-2.01)**
ΔCEO_{it}	-0.026(-6.88)***	-0.022(-5.52)***
ΔCFO_{it}	-0.013(-3.89)**	-0.012(-4.16)***
$RESTATE_{it}$	-0.007(-1.57)*	-0.006(-1.93)**
$POST\_LAW_{it}$	0.024(3.92)***	0.018(3.52)***
$POST\_LAW_{it}*\Delta CAE_{it}$	-0.003(-3.77)***	-0.002(-3.84)***
$POST\_LAW_{it}*\Delta CEO_{it}$	-0.013(-2.85)***	-0.011(-2.07)**
$POST\_LAW_{it}*\Delta CFO_{it}$	-0.014(-1.99)**	-0.010(-1.51)*
$POST\_LAW_{it}*RESTATE_{it}$	-0.006(-2.27)**	-0.004(-2.03)**
$GROWTH_{it}$	0.024(9.99)***	0.030(3.50)***
$LEVERAGE_{it}$	0.176(12.58)***	0.141(3.91)***
$CEODUAL_{it}$	0.010(3.43)***	0.002(1.67)**
$FAMILYCTRL_{it}$	0.016(2.28)**	0.004(1.51)*
$MGTSHARE_{it}$	0.188(3.77)***	0.203(3.66)***
$INSTSHARE_{it}$	0.057(8.81)***	0.032(4.46)***
$BOARDSIZE_{it}$	0.006(1.43)*	0.010(2.33)***
$INDEPDIR_{it}$	0.106(9.20)***	0.159(12.42)***
Adjusted R^2	0.261	0.150

Note: See Table 15 for variable definitions. The coefficient estimates are based on firm-year clustered standard errors. t-values are in parentheses. *, **, ***, indicate statistical significance at 10%, 5%, and 1% levels respectively (one tailed).

In addition to examining the impact of CAE turnover on firm profitability, this study examines the market's reaction to the announcement of CAE turnover. Table 20 shows a significant negative association between CAE turnover and market return in year t, partially supporting hypothesis H4.3a. The finding is consistent with the expectation that replacing the CAE delivers a message to the market that the firm might have internal problems, either financially or operationally. In addition, CFO turnover and restatements are found to have a significant negative impact on market return, suggesting that the market reacts negatively to CFO turnover and restatements as they indicate financial troubles within firm.

The passage of governance is found to have a positive impact on market return. More importantly, the negative impact of CAE turnover on market return is greater in the post-law period, supporting hypothesis H4.3b. The negative impact of CEO/CFO turnover and restatement are also stronger in the post-law period. Since the demand for effective internal control systems as well as the quality of internal audit function become more important in the post-law period, the market reacts strongly to a change in CAE, CEO/CFO, or issue of restatement than in the pre-law period. The governance law views replacement of CAE and CEO/CFO and issue of restatement as relevant and material company information that affects investors' interests. The significant negative results of the interaction term, POST_LAW*ΔCAE, shown in Table 20 provide support to the notion that in the post-law period, a change in CAE delivers a significant bad signal of firm performance. As such, the results imply that the market views CAE turnover as an indicator of internal control issues that might affect firm performance, and therefore reacts negatively whenever a firm replaces its CAE.

Table 20. Impact of CAE Turnover on Market Return

VARIABLES	RET_{it}	RET_{it+1}
Intercept	-2.447(-1.88)**	-2.190(-0.69)
ΔCAE_{it}	-0.050(-1.79)**	-0.003(-1.15)
ΔCEO_{it}	-0.026(-1.09)	-0.032(-1.20)
ΔCFO_{it}	-0.142(-6.71)***	-0.153(-6.44)***
$RESTATE_{it}$	-0.087(-3.13)***	-0.068(-2.18)**
$POST\_LAW_{it}$	0.091(2.44)***	0.074(1.73)**
$POST\_LAW_{it}$ *ΔCAE_{it}	-0.076(-2.44)*	-0.042(-2.35)**
$POST\_LAW_{it}$ *ΔCEO_{it}	-0.071(-1.53)**	-0.054(-1.41)*
$POST\_LAW_{it}$ *ΔCFO_{it}	-0.705(-2.25)**	-0.651(-2.52)**
$POST\_LAW_{it}$ * $RESTATE_{it}$	-0.064(-1.43)*	-0.050(-2.42)**
ROA_{it}	0.602(6.95)***	0.547(5.58)***
$GROWTH_{it}$	0.152(8.81)***	0.126(1.32)*
$LEVERAGE_{it}$	0.191(5.22)***	0.116(5.12)***
$CEODUAL_{it}$	0.108(3.59)***	0.096(0.47)
$FAMILYCTRL_{it}$	0.601(1.59)*	0.533(1.10)
$MGTSHARE_{it}$	0.176(5.67)***	0.388(3.10)***
$INSTSHARE_{it}$	0.101(2.50)***	0.180(3.40)***
$BOARDSIZE_{it}$	0.132(1.72)**	0.059(2.02)**
$INDEPDIR_{it}$	0.078(1.43)*	0.071(3.78)***
Adjusted R^2	0.103	0.093

Note: See Table 15 for variable definitions. The coefficient estimates are based on firm-year clustered standard errors. t-values are in parentheses. *, **, ***, indicate statistical significance at 10%, 5%, and 1% levels respectively (one tailed).

4.5. Conclusion

This study explores the value of CAE by investigating whether CAE turnover is associated with CEO/CFO turnover and financial restatements, and how CAE turnover influences firm performance measured by profitability and market return using governance data collected from Taiwan public companies. Taiwan's 2002 governance law, which mandates that CAE turnover be treated as material company information, reported to the authority, and made announces to the public, provides a unique research setting for this study to explore the value of CAE turnover.

Results indicate that both CEO and CFO turnover and restatement increase the likelihood of CAE turnover. The passage of the governance law, which was issued for the purpose of enhancing the effectiveness of internal control system and internal audit function, also increases possibility of CAE turnover. The positive impact of CEO/CFO turnover and restatements on CAE turnover become stronger in the post-law period. The results also find negative impact of CAE turnover on firm profitability and market return, respectively. The negative impact is stronger in the post-law period and persistent over time. Taken together, the results of this study suggest that CAE turnover delivers a bad signal to firm performance. The market treats CAE turnover as an indication of serious internal control problems which could cause poor firm performance. Moreover, regulation designed to improve the quality of internal control system and internal audit function reinforces the impact of CAE turnover.

This is the first study to provide empirical evidence that explores the impact of CAE turnover by examining its relationship with CEO/CFO turnover and restatement, and investigating its impact on firm performance. To the extent that a qualified CAE can effectively monitor internal control, evaluate enterprise risk, and add value to financial reporting process, the research findings explore the information content of CAE turnover within the scope of corporate governance.

The findings of this study increase the understanding of the value of internal audit, in particular the value of the CAE within internal governance. Given that claims of potential value creation could be made through emphasizing internal audit function, the findings of this study have important implications for managers and boards of directors who rely on the professional advisory services provided by the CAE regarding the effectiveness of internal control and operating risk assessment, and for regulators and practitioners who together determine the extent of the internal audit's contributions to the quality of financial reporting and internal control system.

CHAPTER 5

CONCLUSION

Over the past several decades, the world economy has witnessed a transformation of its source of value creation, shifting toward more knowledge intensive production mainly driven by knowledge and information production and dissemination. The rapid rise of the knowledge-based economy has forced companies to find ways of measuring firm capital that generates key capabilities for contributing to firm value. Firm value steaming from investing in crucial capitals of companies is the outcome of a dynamic business operational process where companies strive to compete with their rivals, creating operational pressures for continued improvements. To retain competitive advantages, managers need to take a close look at their organizational design, to ensure that investments in key firm capitals are truly adding value to the organization.

This dissertation looks at three important valuation issues that challenge firm managers in today's knowledge-based economy: (1) impact of investments in technology on firm short term and long term performance, (2) impact of level of workforce education on firm innovation capability and performance, and (3) impact of a change of the head of the internal audit function on firm valuation. Three studies are conducted to gain a more comprehensive understanding of these valuation issues. Each study follows these steps: (1) develop hypotheses that examine the impact of key firm capital, (2) construct theoretical and regression models given the hypothesized relationships between key firm capitals and performance, (3) collect and analyze relevant financial and non-financial data from companies in different industries, and (4) interpret empirical findings and provide implications addressing the examined valuation issue.

This dissertation documents several interesting findings. First, related to the impact of investments in technology, results of examining the service infrastructure in the banking industry show that there are complementarities between service channels. Given their aggressive IT investment strategies, banks have repositioned the traditional branch channel to serve the needs of different customer segments with more personalized, value added services. IT-based channels such as Internet banking and ATMs are designed to extend bank's service coverage in a more cost effective fashion. They are, therefore, positioned to provide more convenient, fast channel access for customers to process relatively simple, routine transactions. Independence between channels enables banks to not only improve productivity but also increase market competition capability. Overall, the findings provide empirical evidence to support the notion of implementing a multichannel strategy in a competitive business environment.

The increasingly rapid adoption of IT has fostered competitive pressure in IT industries. R&D capital and human capital are the two most important assets for companies competing in innovation. Results of examining the value of hiring and retaining a more highly educated workforce in IT industries show that a more highly educated talent pool has a positive impact on firm performance. Investment in R&D is also found to contribute to firm value. More importantly, the study finds that more highly educated employees can contribute to a firm's innovation capability driven by R&D activities. Results show that the complementary effect between a more highly educated workforce and investment in R&D capital has a positive impact on firm performance. As education is the source of knowledge stock, the findings of this study provide empirical evidence of the positive impact of the level of workforce education and its interdependence with innovation capability through R&D activities.

The final focus of this dissertation is to examine the change of the head of internal audit function, CAE turnover, as it relates to internal governance issues. Since the CAE is responsible for the quality of internal audit function, CAE turnover could be a red flag indicating potential operating problems or business failure. Analyses of CAE turnover in Taiwanese public companies show that CAE turnover is highly correlated with changes in the top management team (CEO and CFO) and restatements. The results also show that CAE turnover has a negative impact on firm performance. The study also finds a significant negative association between CAE turnover and firm performance in the post governance law period. The findings suggest that the market, to some extent, does value this position and reacts negatively to CAE turnover as it may implicitly suggest that the firm could be in the trouble.

This dissertation makes important contributions to both the managerial accounting and information systems disciplines, in particular in the valuation of IT, human capital, and corporate governance literature streams. In terms of valuation of IT literature, this study provides a holistic view of how firm managers should invest in IT and adjust firm resources strategically to help improve firm performance. This study also contributes to the human capital literature by providing evidence to support the notion that a more highly educated workforce can contribute to firm value in general, and specifically, how education complements a firm’s innovation capability. Finally, related to the corporate governance literature, this study is the first to explore the value of the internal audit function by examining the impact of CAE turnover and suggesting that it can be used as a proxy to evaluate a firm's internal control and risk assessment practices.

The findings of this dissertation advance our understandings of the value of key investment issues that challenge mangers today as to how to make effective investment decisions in this competitive knowledge-based economy. This dissertation provides strategic implications for company managers to better align their business objectives with appropriate investment strategies to compete successfully. It also informs policy makers of regulatory implications as they make and adjust relevant policies to respond to companies' changes in their business and investment strategies.

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